

Original Research Article

<https://doi.org/10.20546/ijcmas.2019.808.061>

Isotopic Investigation on the Utilization of Applied Sulphur in Groundnut

S. Meena* and D. Amirtham

Radioisotope Laboratory, Department of Soil Science and Agricultural Chemistry, TNAU,
Coimbatore – 3, Tamil Nadu, India

*Corresponding author

ABSTRACT

A pot culture experiment was conducted in the Radioisotope Laboratory, Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore to study the effect of sulphur (S) on changes in bio chemical composition, protein and oil content of groundnut. Also, the utilization of applied S and per cent sulphur derived from fertilizer (%Sdff) was studied using radiotracer technique employing sulphur -35 (³⁵S) radioisotope. The pot culture experiment was carried out in completely randomized block design in an S deficient soil (7.19 ppm) with twelve replications and S was applied @ 0, 20, 40, 60 and 80 kg ha⁻¹. Per cent sulphur derived from fertilizer increased with increasing doses of sulphur and lower utilization of applied S was noticed at higher levels of applied sulphur [15.89 % (S₂₀) - 5.45 % (S₈₀)]. Sulphur application resulted in increased synthesis of methionine, cysteine and resulted in increased protein content. Sulphur application at 60 kg ha⁻¹ remained on par with S @ 40 kg ha⁻¹ in influencing the oil and protein content.

Keywords

Groundnut, Oil,
Protein, Sulphur,
Use Efficiency

Article Info

Accepted:
07 July 2019
Available Online:
10 August 2019

Introduction

Groundnut (*Arachis hypogaea* L.), the king of oilseed crops is the third most important oilseed crop of the world cultivated in 96 countries of world (Upadhaya *et al.*, 2003). In India, though the share of groundnut to total oil seed production has been falling since 1950, from 70 percent to the present level of 33 per cent, groundnut is still the major oil seed crop in India. Sulphur (S) is considered to be the fourth major plant nutrient after

nitrogen, phosphorus and potassium which is indispensable for the appropriate plant growth and development (Anjum *et al.*, 2012). It is involved in various metabolic and enzymatic processes including photosynthesis, respiration and legume-Rhizobium symbiotic N₂ fixation (Kumar *et al.*, 2008).

Sulphur is inevitable for oilseed crops as it is involved in the synthesis of essential amino acids and is a vital component of co-enzyme involved in oil synthesis (Chaudhary, 2009).

Areas of sulphur deficiency are becoming widespread throughout the world due to the use of high-analysis low S fertilizers, low S returns with farmyard manure, high yielding varieties and intensive agriculture, declining use of S containing fungicides, and reduced atmospheric inputs caused by stringent emission regulations (Nader and Nadia, 2011). In India, as early as 1963, Kanwar (1963) observed that 75 per cent of the groundnut growing soils of Punjab are deficient in S and contain less than 10 ppm of extractable sulphate S. Extensive surveys made to delineate S deficient areas in different parts of the country revealed that sulphur deficiency varied from 5 to 83 per cent with an overall average of 41 per cent (Singh, 2001).

As the intensity of cropping is gradually increasing, the response of oilseeds to S is also increasing (Ghosh *et al.*, 2002) and variable response of groundnut to S has been reported by many workers (Kumar *et al.*, 2008; Giri *et al.*, 2011). Little work has been carried out on assessing the SUE of groundnut using tracer technique. Hence, this study was attempted to study the SUE of groundnut using radiotracer technique and the changes in bio chemical composition, protein and oil content of groundnut as influenced by various levels of sulphur fertilization.

Materials and Methods

A pot culture experiment was conducted in the Radioisotope Laboratory of Department of Soil Science and Agricultural Chemistry, TNAU, Coimbatore during 2016 -2017 with groundnut (CO 7) as the test crop. The experiment was laid out in a Completely Randomised Block Design with 5 treatments and 12 replications. The crop was applied with recommended dose of N: P₂O₅: K₂O (25:50:75 kg ha⁻¹). Sulphur was applied as elemental sulphur (tagged with ³⁵S @ 0.50 mCi/g S) @ 0, 20, 40, 60 and 80 kg S ha⁻¹. The

experimental soil was sandy loam in texture with soil reaction of 7.3 and CEC of 13.09 C mol (P⁺) kg⁻¹. The soil was medium in nitrogen (300 kg ha⁻¹), high in phosphorus (53.10 kg ha⁻¹), high in potassium (526 kg ha⁻¹) and low in sulphur (7.19 ppm).

To understand the biochemical and chemical changes, sampling was done on 15, and 30 days after podding (DAP) and at maturity. The period of 8 days after pegging (DAP) was considered as 0 DAP. The kernels collected at periodical intervals were analysed for nitrogen, sulphur, radioactive sulphur, starch, protein, cysteine, methionine and oil content. With the analytical data obtained for radioactive sulphur, per cent sulphur derived from fertilizer (%Sdff) was calculated. With the computed value, S uptake from fertilizer and Sulphur Use Efficiency (SUE) was calculated.

Results and Discussion

Per cent sulphur derived from fertilizer (% Sdff)

Sulphur derived from fertilizer estimated with radiotracer S (³⁵S) showed that per cent sulphur derived from fertilizer (%Sdff) ranged from 25.16 (S₂₀) -34.18 (S₈₀). The increase of per cent Sdff with increasing levels of S was attributed mainly to higher availability of fertilizer S in soil at higher rate of S application. Similar results were reported by Bhattacharyya and Ghosh (2000) in Brinjal.

Per cent sulphur derived from soil (% Sdfs)

This trend of result for % Sdfs was quite reverse to the trend observed with % Sdff. This was but only a logical trend since % Sdff and % Sdfs are mutually exclusive parameters and an increase in one would naturally mean a corresponding decrease in the other.

Sulphur use efficiency

Increasing S level resulted in decrease in SUE from 15.89 % (S₂₀) – 5.45 % (S₈₀) (Table 1). This was an expected trend because the utilization of nutrients decreased as the rate of nutrient application was increased, as stated by the Law of Limiting Factors (Blackman, 1905) and Liebig’s Law of the Minimum (Liebig, 1840). Higher utilization of applied S through root absorption at lower level of applied S might be the reason for higher SUE. Lower utilisation at higher S application was mainly due to dilution effect.

Starch and protein content

A gradual decline in starch and increase in protein content was noticed from 15 DAP to

maturity (Table 2). Sulphur application up to 60 kg ha⁻¹ resulted in increase in starch and protein content at all stages of development. In matured kernels S@ 60 kg ha⁻¹ resulted in significantly higher starch (16.81 %) content. S @ 60 kg ha⁻¹ (21.90%) and S @ 40 kg ha⁻¹ (21.75 %) recorded comparable protein content.

Starch is broken to produce glucose - 1 phosphate which ultimately enters the glycolytic pathway resulting in formation of acetyl Co A. Sulphur being an essential component of enzymes helps in bringing about a higher turnover of starch to oil and protein leaving behind less starch in the grain. A decrease in starch content with advancement in kernel development stage was also reported by Sukhija *et al.*, (1987) in groundnut.

Table.1 Per cent sulphur derived from fertiliser (%Sdff), Per cent sulphur derived from soil (%Sdfs) and sulphur use efficiency (SUE) in groundnut kernel as influenced by levels of sulphur fertilization

Sulphur levels (kg ha ⁻¹)	Per cent sulphur derived from fertilizer (% Sdff)	Per cent sulphur derived from soil (% Sdfs)	SUE (%)
S ₀	-	100.00	-
S ₂₀	25.16	74.84	15.89
S ₄₀	28.45	71.55	12.14
S ₆₀	32.76	67.24	10.13
S ₈₀	34.18	65.82	5.45

Table.2 Starch and protein content of groundnut kernels at various stages of development

Sulphur levels (kg ha ⁻¹)	Starch (%)			Protein (%)		
	15 DAP	30 DAP	Maturity	15 DAP	30 DAP	Maturity
S ₀	16.27	12.93	11.01	20.06	19.42	17.45
S ₂₀	19.20	14.47	12.79	26.96	21.85	20.81
S ₄₀	21.83	16.77	13.71	30.75	23.11	21.75
S ₆₀	22.57	18.03	16.81	31.13	24.58	21.90
S ₈₀	19.01	15.77	14.87	28.69	21.84	19.95
SEd	0.77	0.62	0.70	2.42	0.48	0.48
CD	1.63	1.31	1.48	5.16	1.02	1.02

Table.3 Cysteine and methionine content of groundnut kernels at various stages of development as influenced by sulphur fertilization

Sulphur levels (kg ha ⁻¹)	Cysteine			Methionine		
	15 DAP	30 DAP	Maturity	15 DAP	30 DAP	Maturity
S ₀	0.066	0.265	0.599	0.48	0.68	1.02
S ₂₀	0.264	0.545	0.725	0.60	1.08	1.68
S ₄₀	0.436	0.599	0.998	0.80	1.44	2.00
S ₆₀	0.599	0.659	1.035	0.88	1.40	2.00
S ₈₀	0.329	0.545	0.817	0.64	1.00	1.68
SEd	0.020	0.015	0.052	0.05	0.03	0.08
CD	0.042	0.031	0.110	0.11	0.07	0.17

Table.4 Oil content of groundnut kernels at various stages of development as influenced by sulphur fertilization

Sulphur levels (kg ha ⁻¹)	Oil content (%)			Per cent increase over initial content	
	15 DAP	30 DAP	Maturity	30 DAP	Maturity
S ₀	24.76	29.14	30.16	17.69	3.50
S ₂₀	28.12	35.92	37.48	27.74	4.34
S ₄₀	30.76	39.78	42.48	29.32	6.79
S ₆₀	32.09	41.98	43.68	30.82	4.05
S ₈₀	29.86	38.34	40.64	28.40	6.00
SEd	0.87	0.92	0.87		
CD	1.86	1.95	1.85		

Improvement in protein content is of paramount importance as it is considered as the building block of the living system. Sulphur is a constituent of the essential amino acid viz., methionine, cysteine, and cystine. It also helps in conversion of these amino acids into high quality protein. Accumulation of soluble protein in developing seeds during the early stages of seed development is indicative of synthesis of enzymes and membrane proteins required for the synthesis and accumulation of oil. Sulphur application resulted in increased synthesis of methionine, cysteine and resulted in increased protein content which is in accordance with the findings of Babhulkar *et al.*, (2000) and Tathe (2008). Application of sulphur increased the protein content of groundnut kernel by 36.90 per cent in S@60 kg ha⁻¹ and 32.6 per cent in

S @ 40 kg ha⁻¹. Sulphur content in kernel was positively correlated to protein content ($r = 0.888^{**}$)

Cysteine and methionine content

Sulphur nutritional deficiency has previously been reported to have strong negative effect on cysteine concentration (Table 3). In the absence of sulphur, the content of sulphur containing amino acid was affected and the work of Jarvan *et al.*, (2008) lends support to this.

Oil content

Maximum value of oil content in kernel was observed with S@ 60 kg ha⁻¹ and was on par with S @ 40 kg ha⁻¹ (Table 4). The increase in

oil content due to sulphur fertilisation might be the outcome of better availability of nutrients owing to the favourable environment created by sulphur application. As sulphur is an integral part of oil, the increased availability of sulphur might have favourably influenced the synthesis of essential metabolites responsible for higher oil content. Sulphur is also known to be involved in the increased conversion of primary fatty acids, several enzymes catalysing metabolic process which promotes biosynthesis of lipids. According to Kumar and Yadav (2007) the increase in oil content with increase in sulphur dose might be due to the involvement of sulphur in electron transport chain. The strong correlation between kernel sulphur content with oil content ($r = 0.959^{**}$) draws support to the finding. Increase in oil content with sulphur application has earlier been reported by many workers (Jena (2006); Noman *et al.*, (2015)).

Thus, the study emphatically brought out that sulphur application at 60 kg ha^{-1} remained on par with S @ 40 kg ha^{-1} in influencing the oil and protein content of groundnut. Per cent sulphur derived from fertilizer increased with increasing doses of sulphur and lower utilization of applied sulphur was noticed at higher levels of applied sulphur. As the SUE ranged from 5 – 15 % the residual effect of S is of paramount importance in deciding the S fertilization of a cropping sequence.

References

- Anjum, N. A., S. S. Gill, S. Umar, I. Ahmad, A. C. Duarte and E. Pereira. 2012. Improving growth and productivity of oleiferous Brassicas under changing environment: Significance of nitrogen and sulphur nutrition, and underlying mechanisms. *Science World Journal*. <http://www.hindawi.com/journals/tswj/2012/657808/>.
- Babulkar, P. S., Dineshkar, W. P. Badole and S. S. Balpande. 2000. Effect of sulphur on yield and quality and nutrient uptake by safflower in Vertisol. *Journal of Indian Society of Soil Science*. 48(3): 541-543.
- Bhattacharyya, P and G.Ghosh. 2000. Isotopic Investigation on the Utilisation of sulphur in combination with phosphorus and FYM by Brinjal (*Solanum melongena* L.). *Journal of Nuclear Agriculture and Biology*. 29 (3-4): 158-166.
- Blackman, F. F. 1905. Optima and limiting factors. *Ann. Abot*. 19: 281-295.
- Chaudhary, A.K. 2009. Role of sulphur in oilseeds and its management. *Indian Farmers Digest*. 42 (12): 9 – 12.
- Ghosh, P. K., K. G. Mandal, K. K. Bandyopadhyay, K. M. Hati, S. Rao and A. K. Tripathi, 2002. Role of plant nutrient management in oil seed production. *Fertilizer News*. 47: 67-77.
- Giri. U., P. Kundu, A. Chakraborty and P. Bandyopadhyay. 2011. Effect of sulphur and different irrigation regimes on groundnut. *Journal of Crop and Weed*. 7(2): 80-83.
- Jarvan, M., L.Edesi, A. Adamson, L. Lukme and A. Akk. 2008. The effect of sulphur fertilization on yield quality of protein and baking quality of winter wheat. *Agronomy Research*. 6(2): 459-469
- Jena, D., R. Sahoo, D. R. Sarangi and M. V. Singh. 2006. Effect of different sources and levels of sulphur on yield and nutrient uptake by Groundnut-Rice cropping system in an Inceptisol of Orissa. *Journal of Indian Society of Soil Science*. 54(1): 126-129.
- Kanwar, J. S. 1963. Investigation on sulphur in soils. 1. Sulphur deficiency in groundnut soils of semrala (Ludhiana). *Indian Journal of Agricultural Science*. 33(1): 196-198.
- Kumar, A., M. Sharma and R. K. Mehra.

2008. Effect of phosphorus and sulphur on yield and nutrient uptake by groundnut in inceptisols. *Asian Journal of Soil Science*. 3(1): 139-141.
- Kumar, H and D.S. Yadav. 2007. Effect of phosphorus and sulphur levels on growth, yield and quality of Indian mustard (*Brassica juncea*) cultivars. *Indian Journal of Agronomy*. 52 (2): 154-157.
- Liebig, J. 1840. *Chemistry and its Application to Agriculture and Physiology*. Taylor and Walton, London
- Nader, R. H. and M. H. Nadia. 2011. Effect of elemental sulphur and partial substitution of N mineral fertilizer by organic amendments on some properties of slight saline soils. *Journal of Applied Sciences Research*. 7(12): 2102-2111.
- Noman, H. M., D. S. Rana and K. S. Rana. 2015. Influence of sulphur and zinc levels and zinc solubilizer on productivity, economics and nutrient uptake in groundnut (*Arachis hypogaea* L.). *Indian Journal of Agronomy*. 60(2): 301-306.
- Singh, M. V. 2001. Importance of sulphur in balanced fertilizer use in India. *Fertilizer News*. 46: 13-35.
- Tathe, A. S. 2008. Response of different levels of sulphur and zinc fertilization on yield and uptake of nutrients by groundnut. *Asian Journal of Soil Science*. 3(1): 133-136.

How to cite this article:

Meena, S. and Amirthamm D. 2019. Isotopic Investigation on the Utilization of Applied Sulphur in Groundnut. *Int.J.Curr.Microbiol.App.Sci*. 8(08): 523-528.
doi: <https://doi.org/10.20546/ijcmas.2019.808.061>