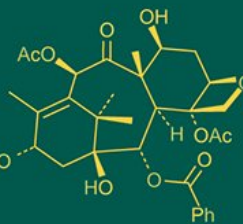


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Response of groundnut to sulphur and iron fertilization in Typic Ustifluvents soil

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Abstract

A field experiment was conducted during 2023 at Kuttalam, Tamil Nadu, to evaluate the response of groundnut to sulphur and iron fertilization with emphasis on crop growth, nutrient uptake and available soil nutrients. The soil was sandy clay loam and initially deficient in available sulphur and iron. Eight treatments were evaluated in a randomized block design with three replications. The treatments consisted of a recommended fertilizer dose alone, sulphur at 40 kilograms per hectare through gypsum, iron chelate at 5 kilograms per hectare through soil, and combinations of sulphur with soil and foliar iron at 0.5 and 1 percent. Sulphur and iron fertilization significantly improved plant height, leaf area index, chlorophyll status, crop growth rate, relative growth rate and dry matter production. The integrated treatment comprising a recommended fertilizer dose, 40 kilograms sulphur per hectare, 5 kilograms iron chelate per hectare through soil and 1 percent foliar iron chelate recorded the highest growth response and pod yield. It produced 57.2 centimetres plant height at harvest and pod and haulm yields of 2475.6 and 4576.5 kilograms per hectare, respectively. The same treatment recorded the highest uptake of nitrogen, phosphorus, potassium, sulphur and iron in the assessed plant components. At harvest, available nitrogen, phosphorus, potassium, sulphur and iron reached 244.7 kilograms per hectare, 15.2 kilograms per hectare, 272.4 kilograms per hectare, 12.9 kilograms per hectare and 3.63 milligrams per kilogram, respectively. The findings demonstrated that integrated soil and foliar management of sulphur and iron improved groundnut growth, nutrient acquisition and soil nutrient availability under the experimental conditions.

Keywords: Groundnut, sulphur fertilization, iron nutrition, nutrient uptake, soil nutrient availability, crop growth

Introduction

Groundnut is an important oilseed crop cultivated for edible oil, protein-rich kernels and several food and industrial products. Its productivity is strongly influenced by balanced plant nutrition because nutrient supply affects vegetative growth, photosynthetic activity, reproductive development and nutrient partitioning. Sulphur is particularly important in oilseed crops because it participates in the formation of sulphur-containing amino acids, proteins and enzymes and contributes to oil formation. Iron is required in smaller quantities but is essential for chlorophyll formation, electron transport, respiration and several redox reactions. In legumes, iron nutrition is also closely associated with biological nitrogen fixation and efficient nitrogen metabolism.

Continuous cultivation and fertilizer use dominated by nitrogen, phosphorus and potassium can lead to secondary and micronutrient imbalance. Groundnut grown on soils with inadequate sulphur or iron may therefore show reduced growth, chlorophyll development, dry matter accumulation and nutrient acquisition. Field studies have demonstrated that sulphur fertilization improves groundnut growth and nutrient uptake, while iron application can further improve physiological activity and yield-related traits ^[1-4].

Ravikumar *et al.* reported that 40 kilograms sulphur per hectare through gypsum improved plant height, leaf area index, dry matter production and nutrient uptake in irrigated groundnut ^[5]. Yadav *et al.* found that sulphur and foliar iron increased nitrogen, phosphorus, potassium, sulphur and iron concentration and uptake in groundnut ^[1]. More recent work has also shown that combined sulphur and iron management can improve nutrient acquisition, while integrated micronutrient fertilization can enhance growth and productivity ^[2, 6].

Iron application deserves particular attention because the availability of soil iron can be restricted by soil chemical conditions and rapid conversion of soluble iron into less available forms. Foliar application provides a direct route for nutrient delivery to the photosynthetic tissues and may complement soil application. Recent research has demonstrated that sulphur can also alleviate iron-deficiency yellowing in peanut by improving iron transport, photosynthetic pigment accumulation and nutrient interactions^[7].

The interaction between nutrient application, soil nutrient availability and plant uptake is therefore important for understanding the productivity response of groundnut. The present investigation was undertaken to evaluate the effect of soil-applied sulphur combined with soil and foliar iron on growth parameters, nutrient uptake and available soil nutrients of groundnut grown under field conditions. The study was specifically aimed at identifying the treatment that provided the most consistent improvement in crop growth and nutrient acquisition while maintaining a favourable soil nutrient status.

Materials and Methods

Experimental site and soil

The field experiment was conducted during 2023 in a farmer's field at Kuttalam, Mayiladuthurai district, Tamil Nadu, India, located at approximately 11.07° N latitude and 79.55° E longitude. The soil belonged to the Padugai series and was sandy clay loam. The initial soil had a pH of 6.4 and electrical conductivity of 0.25 decisiemens per metre. Initial available nitrogen, phosphorus, potassium, sulphur and iron were 232.5 kilograms per hectare, 16.4 kilograms per hectare, 271.3 kilograms per hectare, 9.2 milligrams per kilogram and 2.5 milligrams per kilogram, respectively. Available sulphur and iron were classified as deficient in the original soil characterization^[8-11].

Experimental design and treatments

The experiment was laid out in a randomized block design with eight treatments and three replications. Groundnut variety G-7 was used as the test crop. The experimental duration was approximately 110 days and each plot measured 5 m × 4 m. All treatments received a uniform recommended fertilizer dose of major nutrients. Sulphur was supplied through gypsum at 40 kilograms sulphur per hectare. Soil-applied iron was supplied through iron ethylenediaminetetraacetic acid chelate at 5 kilograms per hectare. Foliar iron chelate was applied at 0.5 or 1 percent at flowering and peg formation stages according to treatment. The treatments were T₁, recommended fertilizer dose alone; T₂, recommended fertilizer dose plus 40 kilograms sulphur per hectare through gypsum; T₃, recommended fertilizer dose plus 5 kilograms iron chelate per hectare through soil; T₄, recommended fertilizer dose plus 40 kilograms sulphur per hectare and 5 kilograms iron chelate per hectare through soil; T₅, recommended fertilizer dose plus 40 kilograms sulphur per hectare and 0.5 percent foliar iron chelate; T₆, recommended fertilizer dose plus 40 kilograms sulphur per hectare and 1 percent foliar iron chelate; T₇, recommended fertilizer dose plus 40 kilograms sulphur per hectare, 5 kilograms iron chelate per hectare through soil and 0.5 percent foliar iron chelate; and T₈, recommended fertilizer dose plus 40 kilograms sulphur per hectare, 5 kilograms iron

chelate per hectare through soil and 1 percent foliar iron chelate.

Crop management and observations

The crop was established at 30 cm × 15 cm spacing. Nitrogen was applied through urea in two equal splits, while phosphorus was applied as basal fertilizer. Sulphur was applied through gypsum and soil iron through iron ethylenediaminetetraacetic acid chelate according to treatment. Foliar iron sprays were applied at flowering and peg formation stages. Plant height, leaf area index, chlorophyll content, crop growth rate, relative growth rate and dry matter production were recorded at the appropriate stages. Yield attributes and pod and haulm yields were recorded at harvest.

Soil and plant analysis

Soil samples were collected at maximum flowering, peg formation and harvest. Samples were shade dried, powdered gently and passed through a 2 millimetre sieve. Available nitrogen was determined by the alkaline permanganate method, available phosphorus by the sodium bicarbonate extraction procedure, available potassium by the neutral ammonium acetate method, available sulphur by turbidimetric estimation and available iron by the diethylenetriaminepentaacetic acid extraction procedure^[8-11]. Plant samples were collected at the same stages, washed with tap water, dilute hydrochloric acid and distilled water, dried at 65 °C, powdered and digested using appropriate acid mixtures. Nitrogen, phosphorus, potassium, sulphur and iron concentrations were estimated using the procedures described in the experimental record^[12].

Nutrient uptake and statistical analysis

Nutrient uptake was calculated from nutrient concentration and the corresponding dry matter, pod or haulm yield, as applicable. The treatment effects were analysed using analysis of variance for a randomized block design. Treatment means were compared using the critical difference at the five percent probability level. The statistical values presented in the tables were retained from the thesis data and no new statistical inference was introduced.

Results

Growth parameters

Sulphur and iron fertilization significantly influenced growth parameters. Plant height increased from 38.4 centimetres in the control to 57.2 centimetres under T₈ at harvest. The same treatment recorded the highest plant height at flowering and peg formation. Leaf area index, chlorophyll content, crop growth rate, relative growth rate and dry matter production were also highest under T₈ at the measured stages. The control recorded 0.76 and 1.96 leaf area index at flowering and peg formation, respectively, whereas T₈ recorded 1.55 and 3.49. Chlorophyll content increased from 31.5 and 40.4 SPAD units in the control to 42.3 and 64.4 SPAD units under T₈. Crop growth rate increased from 1.73 and 2.33 grams per square metre per day to 8.04 and 8.86 grams per square metre per day, while relative growth rate increased from 0.44 and 0.54 to 0.82 and 0.94 milligrams per gram per day at flowering and peg formation, respectively.

Nutrient uptake at harvest

Harvest-stage nutrient uptake was highest under T₈. Nitrogen uptake in the kernel and haulm reached 93.2 and 92.5 kilograms per hectare, respectively, compared with 53.0 and 41.3 kilograms per hectare under the control. Phosphorus uptake increased from 6.72 and 5.76 kilograms per hectare in the control to 17.31 and 12.82 kilograms per hectare in T₈. Potassium uptake increased from 19.7 and 57.2 kilograms per hectare to 39.7 and 92.0 kilograms per hectare in kernel and haulm, respectively.

Sulphur uptake also increased substantially. T₈ recorded 8.29 kilograms sulphur per hectare in kernel and 2.91 kilograms per hectare in haulm compared with 3.80 and 0.38 kilograms per hectare in the control. Iron uptake reached 3334.7 grams per hectare in kernel and 2310.8 grams per hectare in haulm under T₈, compared with 1992.3 and 734.6 grams per hectare in the control.

Available soil nutrients at harvest

Available soil nutrients were significantly influenced by sulphur and iron fertilization. At harvest, available nitrogen increased from 218.4 kilograms per hectare in the control to 244.7 kilograms per hectare under T₈. Available phosphorus increased from 8.9 to 15.2 kilograms per hectare, while available potassium increased from 236.6 to 272.4 kilograms per hectare. Available sulphur increased from 7.2 to 12.9 kilograms per hectare and available iron increased from 2.02 to 3.63 milligrams per kilogram. T₈ recorded the highest available status for all five nutrients at harvest.

Discussion

Growth response to sulphur and iron fertilization

The consistent increase in plant height, leaf area index, chlorophyll status, crop growth rate, relative growth rate and dry matter production under T₈ indicated a strong response to integrated sulphur and iron nutrition. Sulphur contributes to amino acid and protein synthesis and is particularly important in oilseed crops, whereas iron participates in chlorophyll formation, electron transport and several metabolic reactions. The observed increase in growth under sulphur and iron fertilization is consistent with earlier groundnut studies reporting improved plant height, canopy development and dry matter production following sulphur application [3, 5].

The improvement in chlorophyll status under combined soil and foliar iron was biologically consistent with the role of iron in chlorophyll formation and photosynthetic electron transport. The higher chlorophyll status was accompanied by higher crop growth rate and dry matter production, indicating that improved nutrient supply supported greater biomass accumulation. Similar improvements in groundnut growth following micronutrient fertilization have been reported by Abhigna *et al.* [6].

Nutrient uptake response

The greater uptake of nitrogen, phosphorus and potassium under T₈ reflected the higher biomass and yield produced

under integrated sulphur and iron management. Sulphur nutrition is closely associated with nitrogen metabolism and protein synthesis, while improved root and shoot growth increases the soil volume explored by the crop. The present results agree with Yadav *et al.* [1], who reported higher nitrogen, phosphorus, potassium, sulphur and iron uptake in groundnut with sulphur and foliar iron application. Ravikumar *et al.* [5] similarly observed improved nutrient uptake with 40 kilograms sulphur per hectare through gypsum.

Sulphur uptake responded directly to sulphur fertilization and was further enhanced when iron was supplied through soil and foliage. The increase in iron uptake under T₈ was expected because the treatment provided iron through both root and foliar pathways. The combined nutrient supply also produced greater dry matter and yield, thereby increasing the amount of nutrient accumulated by the crop. A recent study in the International Journal of Advanced Biochemistry Research reported higher nutrient content and uptake under increased sulphur and iron supply in groundnut, supporting the present interpretation [2].

Available soil nutrients

The higher available nutrient status under T₈ at harvest indicated that integrated sulphur and iron application influenced not only plant nutrient acquisition but also the residual available nutrient pool. The effect was particularly evident for available sulphur and iron because these nutrients were directly supplied. The increase in available nitrogen, phosphorus and potassium under the integrated treatment may be associated with improved nutrient cycling and a more favourable rhizosphere environment resulting from better crop growth.

The present results also agree with the broader evidence that balanced nutrient management can improve soil nutrient availability and crop productivity. Recent research has shown that sulphur can improve iron acquisition and transport in peanut, thereby improving chlorophyll development and yield under iron-limited conditions [7]. Thus, the present field response supports an integrated approach in which sulphur and iron are managed together rather than considered as isolated nutrient inputs.

Treatment superiority and agronomic implication

Among the treatments, T₈ consistently recorded the highest growth, yield, nutrient uptake and harvest-stage available nutrient values. The superiority of T₈ over the soil-only treatment T₄ indicated that foliar iron supplementation provided an additional benefit after basal sulphur and soil iron application. The response was also stronger at 1 percent foliar iron than at 0.5 percent, although the thesis reported T₇ and T₆ as statistically comparable for several traits. Under the experimental soil and crop conditions, the combined treatment therefore provided the most consistent response.

Table 1: Effect of sulphur and iron fertilization on selected growth parameters of groundnut.

Tr. No.	Plant height at harvest (cm)	Leaf area index at Flowering	Leaf area index at Peg formation	Chlorophyll at Flowering (SPAD)	Chlorophyll at Peg formation (SPAD)	Dry matter at Flowering (kg ha ⁻¹)	Dry matter at Peg formation (kg ha ⁻¹)
T ₁	38.4	0.76	1.96	31.5	40.4	1048.8	2585.5
T ₂	43.7	1.05	2.35	33.4	48.6	1875.6	3466.6
T ₃	41.5	0.86	2.15	32.8	44.6	1335.7	2679.1
T ₄	46.4	1.25	2.55	34.8	54.6	2149.6	3696.8
T ₅	50.2	1.32	2.77	35.6	57.5	2349.7	3916.6
T ₆	53.1	1.42	3.25	39.7	60.2	2427.1	4118.6
T ₇	54.0	1.46	3.28	39.4	61.1	2465.9	4144.5
T ₈	57.2	1.55	3.49	42.3	64.4	2583.6	4256.8
SE(m)	0.93	0.03	0.06	0.42	1.50	35.2	73.2
CD at 5%	2.02	0.06	0.12	0.92	3.25	76.4	158.4

RDF = recommended fertilizer dose; SA = soil application; FS = foliar spray at flowering and peg formation stages. The table contains growth observations reported in the thesis; plant height is shown at harvest, while leaf area index, chlorophyll and dry matter are shown at the stages at which they were recorded.

Table 2: Effect of sulphur and iron fertilization on yield attributes of groundnut.

Tr. No.	Pods plant ⁻¹	100-seed weight (g)	Shelling (%)
T ₁	16.4	41.2	66.3
T ₂	21.7	41.6	69.1
T ₃	18.7	42.0	67.7
T ₄	23.8	42.4	70.6
T ₅	25.6	42.8	71.9
T ₆	27.2	43.2	73.3
T ₇	27.4	43.9	73.4
T ₈	29.5	44.3	74.9
SE(m)	0.92	—	0.73
CD at 5%	1.99	NS	1.58

RDF = recommended fertilizer dose; SA = soil application; FS = foliar spray at flowering and peg formation stages.

Table 3: Harvest-stage primary macronutrient uptake in groundnut.

Tr. No.	N uptake Kernel	N uptake Haulm	P uptake Kernel	P uptake Haulm	K uptake Kernel	K uptake Haulm
T ₁	53.0	41.3	6.72	5.76	19.7	57.2
T ₂	66.7	61.7	9.29	9.1	26.5	71.9
T ₃	58.3	47.9	7.26	7.6	22.2	62.2
T ₄	72.1	68.0	10.71	9.93	29.6	77.3
T ₅	77.9	80.9	12.72	10.71	33.1	80.7
T ₆	84.4	86.8	14.71	11.52	36.2	86.0
T ₇	85.2	87.6	15.12	11.71	36.7	86.7
T ₈	93.2	92.5	17.31	12.82	39.7	92.0
SE(m)	1.54	1.44	0.23	0.32	0.70	1.70
CD at 5%	1.93	3.12	0.23	0.51	1.50	3.65

Table 4: Available soil nutrients at harvest under sulphur and iron fertilization.

Tr. No.	Available N (kg ha ⁻¹)	Available P (kg ha ⁻¹)	Available K (kg ha ⁻¹)	Available S (kg ha ⁻¹)	Available Fe (mg kg ⁻¹)
T ₁	218.4	8.9	236.6	7.2	2.02
T ₂	227.3	11.9	246.3	8.8	2.45
T ₃	224.4	11.1	242.0	8.1	2.24
T ₄	230.5	12.2	253.0	9.4	2.77
T ₅	233.4	12.9	258.7	10.5	3.0
T ₆	238.0	13.5	264.7	11.5	3.33
T ₇	239.5	13.9	265.9	11.8	3.37
T ₈	244.7	15.2	272.4	12.9	3.63
SE(m)	0.88	0.30	0.67	0.24	0.02
CD at 5%	1.906	0.60	0.05	0.53	0.10

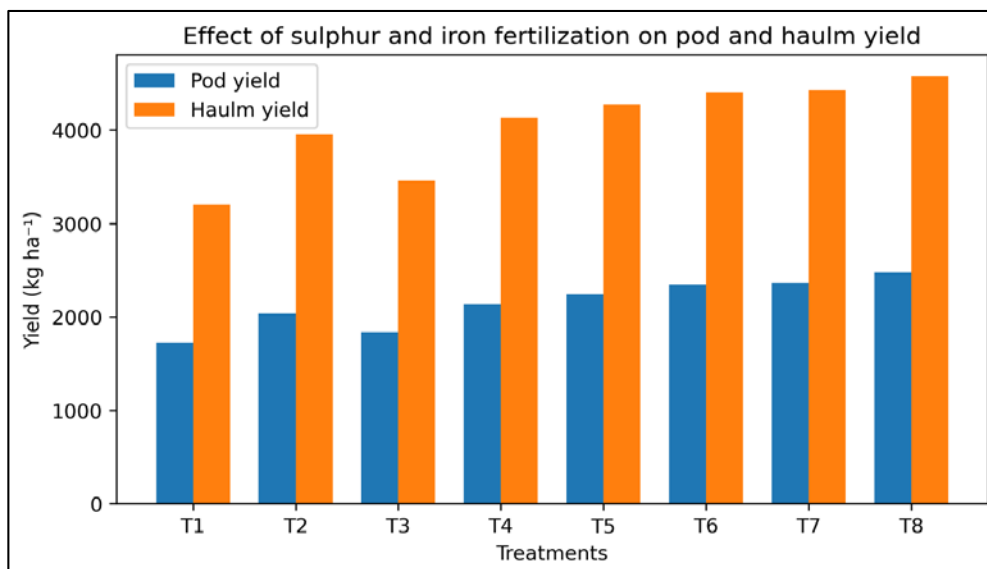


Fig 1: Effect of sulphur and iron fertilization on pod and haulm yield of groundnut.

Conclusion

The field experiment demonstrated that sulphur and iron fertilization substantially improved growth, yield, nutrient uptake and available soil nutrients in groundnut. The integrated treatment consisting of the recommended fertilizer dose, 40 kilograms sulphur per hectare through gypsum, 5 kilograms iron chelate per hectare through soil and 1 percent foliar iron chelate recorded the highest overall response. It produced the maximum plant height, canopy development, chlorophyll status, crop growth rate, relative growth rate, dry matter production, pod yield and haulm yield. It also resulted in the highest uptake of nitrogen, phosphorus, potassium, sulphur and iron and maintained the highest available soil nutrient status at harvest. Under the conditions of the present experiment, integrated soil and foliar management of sulphur and iron was therefore the most effective treatment for improving groundnut productivity and nutrient acquisition.

References

- Yadav S, Verma R, Yadav PK, Bamboriya JS. Effect of sulphur and iron on nutrient content, uptake and quality of groundnut. *J Pharmacogn Phytochem*. 2020;9(1):1605-1609.
- Chauhan KJ, Jat JR, Patel RM, Patel KK, Asodariya SR. Effect of prom, sulphur and iron on nutrient content and uptake by groundnut. *Int J Adv Biochem Res*. 2025;9(1S):201-214. doi:10.33545/26174693.2025.v9.i1Sc.3458.
- Yadav S, Verma R, Yadav K. Effect of sulphur and iron on chlorophyll content, leghaemoglobin content, soil properties and optimum dose of sulphur for groundnut. *Int J Curr Microbiol Appl Sci*. 2019;8(6):291-297. doi:10.20546/ijcmas.2019.806.033.
- Shingare MN, Bhakher R, Vishwajna R. Influence of sulphur and iron on growth and yield of groundnut. *Pharma Innov J*. 2023;12(8):1659-1661.
- Ravikumar C, Ariraman R, Ganapathy M, Karthikeyan A. Effect of different sources and levels of sulphur on growth and nutrient uptake of irrigated summer groundnut. *Plant Arch*. 2020;20(1):1947-1952.
- Abhigna D, Lakshman K, Sree Rekha M, Latha M. Growth, yield and economics of groundnut as influenced by micronutrient fertilization on coastal sandy soils of Andhra Pradesh. *Pharma Innov J*. 2021;10(9):312-315.
- Zhang XY, Hou WF, Gou ZC, Jia SR, Li H, Gao Q, *et al*. Exogenous sulfur application can effectively alleviate iron deficiency yellowing in peanuts and increase pod yield. *Eur J Agron*. 2024;159:127252. doi:10.1016/j.eja.2024.127252.
- Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. *Curr Sci*. 1956;25:259-260.
- Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Washington: United States Department of Agriculture; 1954. Circular 939.
- Chesnin L, Yien CH. Turbidimetric determination of available sulfates. *Soil Sci Soc Am Proc*. 1951;15:149-151.
- Lindsay WL, Norvell WA. Development of a DTPA soil test for zinc, iron, manganese, and copper. *Soil Sci Soc Am J*. 1978;42(3):421-428.
- Piper CS. Soil and plant analysis. Adelaide: University of Adelaide; 1966.
- Damor VC, Patel JM, Chaudhary PP. Effect of Fe and Zn enriched organics on yield, quality and nutrient uptake by summer groundnut. *Int J Chem Stud*. 2019;7(5):1998-2003.
- Kamalakannan P. Effect of integrated plant nutrients supply through organic and inorganic sources on productivity of groundnut in loamy sand soil. *J Pharmacogn Phytochem*. 2017;6(Special Issue 6):1182-1184.
- Shingare MN, Mehera B, Kumar P, Yallaling C. Effect of sulphur and foliar application of iron on growth and yield of groundnut. *Int J Environ Clim Change*. 2023;13(9):1893-1896. doi:10.9734/ijec/2023/v13i92420.
- Panse UG, Sukhatme PV. Statistical methods for agricultural workers. 4th ed. New Delhi: Indian Council of Agricultural Research; 1985.