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# Yield, Nutrient Content and their Uptake by Groundnut (*Arachis hypogeae* L.) as Affected by Sulphur and Planting Methods in Course Textured Soil of South-west Haryana, India

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The groundnut, scientifically known as *Arachis hypogea* L., is a summer legume plant with rising importance in food, industry, and medicine. Sulphur is the master nutrient for oil seed crop production because it helps in the synthesis of cysteine, methionine, vitamins (B, biotin, and thiamine), metabolism of carbohydrates, oil content, protein content and also associated with

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growth and metabolism. The experiment was laid out in randomized complete block design in triplications on groundnut cultivar GNH 804 in Bawal utilizing three sulphur levels (0, 25, and 50 kg/ha) and three planting methods (flatbed, flatbed with earthing up, and ridge-furrow). The treatment with 50 kg/ha sulphur in the ridge-furrow method yielded the highest pod yield (2652 kg/ha) and superior nutrient content, including nitrogen, phosphorus, potassium, and sulphur, in both seeds and stover. This treatment also showed superior quality parameters such as oil and protein content and shelling percentage for groundnut. The treatment with 50 kg/ha of sulphur and the flatbed with earthing up method followed closely in performance.

*Keywords: Yield nutrient; Groundnut; nutrient uptake; feed crop.*

## 1. INTRODUCTION

"Groundnut (*Arachis hypogaea* L.) is an important oil, food, and feed crop of the world and belongs to the Leguminosae (Fabaceae) family" [1]. It is also known as 'King of oilseeds' [2], peanuts, earthnuts, manila nuts, jack nuts, and monkey nuts. In India groundnut was introduced in the middle of the nineteenth century on east coast of the South Arcot district in Tamil Nadu. Groundnut seed contain 43-55% oil content [3], 24-26% protein, 45-48% fat, 3% fiber, and 15-18% carbohydrate [4]. It is also used as fodder, seeds, straw, and hay [5,6,7,8]. "It is also known as wonder nut and poor men's cashew nut. Besides, the kernels are also rich in vitamins E, K, and all B vitamins except B12" [9]. "It is the richest plant source of thiamine and is also rich in niacin, which is low in cereals. It can be used as food (cooking oil, raw, roasted), feed (green material, straw, seed pressings), and in the industry for raw material" [10].

"India is the second largest producer of groundnut in the world after China, followed by the USA and Nigeria. About 80% of the total area and 84 % of the total production in the country is confined to the states of Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, and Maharashtra but also grown in the states of Rajasthan, Haryana, and Punjab. In India, during 2020-2021, the area under groundnut was 8528 thousand hectares with a production of 10244 thousand tonnes with productivity of 1703 kg $ha^{-1}$" [11]. Whereas in Haryana, the area under groundnut was 9.25 thousand hectares and the production was 9.44 thousand tonnes with an average productivity of 1020 kg $ha^{-1}$ during 2020-21 [12]. "Balanced use of fertilizer is a key component of any oilseed production technology. Groundnut is an energy-rich crop therefore it requires the right quantity and source of nutrients. Nutrients most often recommended for successful oilseed farming are nitrogen (N), phosphorus (P), potassium (K), sulphur (S), zinc (Zn), and boron (B).

Sulphur is a secondary macronutrient recognized as the fourth most important nutrient for plant growth and root development after nitrogen, phosphorus, and potassium" [12]; Jamal et al. [13]. "It plays an important role in the catalytic and electrochemical functions of biomolecules in the plant cells. The overall requirement of sulphur for oil seed crops is as high as phosphorus, so considered as master nutrient for oilseed production and enhances yield as well as crop quality because it helps in the synthesis of cysteine, methionine, vitamins (B, biotin, and thiamine), metabolism of carbohydrates, oil and protein content, and also associated with growth and metabolism, especially by its effect on the proteolytic enzymes" [14]. "The application of sulphur to the soil improves nitrogenase activity, nitrogen fixation, plant dry matter, and the quality of crops in sulphur-deficient soils" [15]. "It helps in the formation of plant proteins and is essential for chlorophyll formation, nodulation, microbial activity, improves root growth, and increases the availability of other nutrients" [16].

"Groundnuts can be planted using a number of methods which include planting on flat ground (FG), earthing up after planting on flat ground (EFG), planting on raised bed (RB) and planting on ridge (R)" [17]. "The performance of crop management techniques like nutrient application, irrigation and weed control, among others, is highly dependent on the design of the land. Due to the groundnut's peculiar mechanism, geotropism, a loose and well-aerated soil surface has an advantageous effect on peg penetration and pod development. Earthing up is the raising of the soil around the plant in order to cover the pegs, depending on the cultivar" [18]. Jadhav et al. [19] found higher growth, yield, and yield attribute parameters in ridge and furrow system over flat sowing planting method.

## 2. MATERIALS AND METHODS

The field experiment was conducted at the Regional Research Station, CCS HAU Bawal during *kharif* 2022 in district Rewari at 28.10° N latitude and 76.50° E longitude with 266 m above mean sea level in south-western area of Haryana, India. The climate of Bawal is semi-arid with average rainfall of 577 mm. The soil of experimental field had loamy sand texture with a pH of 8.17, electrical conductivity (EC) 0.18 dS/m, organic carbon (OC) 0.17 %, available nitrogen (113.10 kg/ha), available phosphorus (11.90 kg/ha) and available potassium (162.10 kg/ ha), respectively as macronutrients in 0-15 cm depth. The experiment was laid out in randomized complete block design in triplications on groundnut cultivar GNH 804. Nine treatments were assigned consisting of three sulphur application levels [0 ($S_0$), 25 ($S_{25}$), 50 ($S_{50}$) kg S/ha] in plot and three planting methods (flatbed, flatbed with earthing up, and ridge-furrow). The recommended dose of fertilizer (RDF) was 15:50:25 kg for N, $P_2O_5$ and $K_2O$ /ha, respectively as par package and practices. The fertilizers (RDF, $K_2O$ and $ZnSO_4$) were applied at the time of sowing through soil application. The soil samples were collected at random from the experiment area up to the depth of 0-15 cm from selected plots before overlaying the treatments and after harvesting the crop and analyzed for its various chemical properties. Soil pH and EC were determined in (1:2) soil: water suspension using digital pH meter and direct read type conductivity meter [20], respectively. Soil OC was determined by the Walkley and Black [21] method. Available nitrogen was determined by alkaline permanganate method [22], available P by spectrophotometer at 420 nm [23], available K by ammonium acetate method using a flame photometer [17]. Available sulphur was extracted using a calcium chloride solution at 420 nm [24].

## 2.1 Collection and Analysis of Plant Samples

Samples of seed and stover were collected at the time of harvesting and dried (65±2 °C for 48 hr). The dried samples thus obtained were ground to a fine powder and processed further for estimation of various macronutrients (N, P, K and S). Total nitrogen content in the digested plant material was determined by colorimetric method using Nessler's reagent as described by Lindner [25]. Total phosphorus in plant sample was determined by Vanadomolybdophosphoric acid yellow colour method as proposed by Koenig and Johnson [26]. Potassium in the acid digest of plant samples was determined by using flame photometer. The data on concentration of NPKS, pod yield and stover yield was used to determine the uptake of nitrogen (N), phosphorus (P), potassium (K), and sulphur (S) using the following formula:

Nutrient uptake (kg $h^{-1}$) = (Nutrient concentration in pod/stover (%) stover yield (kg x pod / $ha^{-1}$)) / 100

## 2.2 Statistical Analysis

The data recorded during the experiment was subjected to statistical analysis by proper methods using online statistical package OPSTAT developed by Sheoran et al. (1998)**.**

## 3. RESULTS AND DISCUSSION

## 3.1 Effect of Sulphur

### 3.1.1 Pod and stover yield

The pod yield was significantly increased due to the application of sulphur up to $S_{50}$ treatment. The highest pod yield (2652kg $ha^{-1}$) was recorded with $S_{50}$ treatment, followed by (2372kg $ha^{-1}$) with $S_{25}$ treatment. Both treatments were statistically different from each other and significantly superior over the control ($S_0$). The increase in pod yield of groundnut was 6.84% and 19.45% due to the application of $S_{25}$ and $S_{50}$ treatment, respectively, over the control $S_0$ (Table 1).

Applying varying levels of sulphur resulted in an increase in the groundnut stover yield, as illustrated in Table 1. Stover yield ranged from 2937 to 3483 kg $ha^{-1}$. Notably, the stover yield saw a significant increase with the application of sulphur, particularly up to the $S_{50}$ treatment. The highest stover yield was observed with the $S_{50}$ treatment at 3483 kg $ha^{-1}$, followed closely by the $S_{25}$ treatment at 3189 kg $ha^{-1}$. These two treatments showed statistically similar results. In contrast, the control ($S_0$) yielded the lowest stover at 2937 kg $ha^{-1}$. Comparatively, the $S_{50}$ and $S_{25}$ treatments resulted in 18.59% and 8.58% higher stover yield, respectively, compared to the control.

Moreover, this is the role of S in various metabolic and enzymatic processes including photosynthesis, respiration, legume-Rhizobium symbiotic N-fixation, protein synthesis, and more over higher nutrient uptake resulted in higher plant height and number of branches per plant and ultimately helped in realization of higher crop yield. These results can also be ascribed to the effect of sulphur application on cell division, enlargement, and elongation resulting in an overall improvement in plant organs associated with faster and uniform vegetative growth of the crop. The above results are in conformity with the results of Banu et al. [27], Patel et al. [28] and Noman et al. [29] in their work.

#### 3.1.2 Nutrient content and uptake by seed and stover

Sulphur application caused a significant increase in the nutrient content (N, P, K and S) of the groundnut seed. However, the content of nutrients increased with the highest level i.e.,50 kg S $ha^{-1}$and it significantly differed with 25 kg and 0 kg S $ha^{-1}$. Results showed that total nitrogen, phosphorous, potassium, and sulphur uptake and content in seed were significantly influenced by different sulphur levels. Both $S_{25}$ and $S_{50}$ treatments recorded significantly higher N (3.43 and 3.56 %), P (0.31 and 0.32 %), K (1.09 and 1.18 %), and S (0.18 and 0.21 %) content and uptake of N (81.87 and 94.54 kg $ha^{-1}$), P (7.40 and 8.61 kg $ha^{-1}$), K (26.16 and 31.41 kg $ha^{-1}$), and S (4.26 and 5.45 kg $ha^{-1}$) in seed as compared to control.

In case of stover, $S_{25}$ and $S_{50}$ treatments recorded significantly higher N (1.22 and 1.41 %), P (0.17 and 0.20 %), K (0.88 and 0.92 %), and S (0.23 and 0.25 %) content and uptake of N (39.29 and 49.34 kg $ha^{-1}$), P (5.59 and 7.16 kg $ha^{-1}$), K (28.26 and 33.89 kg $ha^{-1}$) and S (7.28 and 9.04 kg $ha^{-1}$) in stover over the control.

Sulphur might have shown a synergistic effect in increasing the P and K uptake in the crop. The probable reason for higher uptake of S under higher application of sulphur might have increased their concentration in soil solution, which increased the availability and uptake of sulphur by plant. Sulphur availability may influence photosynthetic rate since ferredoxin and acetyl-CoA contain S and play a significant role in the reduction of $CO_2$ and the production of organic compounds. Also, sulphur is necessary for enzymatic reactions, chlorophyll formation, synthesis of certain amino acids and vitamins, hence, it helps to have a good vegetative growth leading to have a high yield. The results found are in confirmation with the results of Patel and Zinzala [30], Longkumer et al*.* [31], Yadav et al*.* [32], Prustyet al*.* [33] and Mehmood et al*.* [34] in their work.

### 3.2 Effect of Planting Methods

#### 3.2.1 Pod and stover yield

The application of different planting methods also significantly affected the pod yield of groundnut. Significantly, the highest pod yield (2775kg $ha^{-1}$) was recorded with Ridge and Furrow treatment followed by Flatbed with earthing up (2450kg $ha^{-1}$), both treatments were statistically different. The lowest pod yield (2019kg $ha^{-1}$) was recorded with control (Flatbed). The Ridge and Furrow and Flatbed with earthing up treatment produced 37.44 and 21.34 % higher pod yield over control. The interacting effect between sulphur and planting methods was found significant (Table 1).

Similarly, in the case of stover yield, the higher stover yield was recorded with Ridge and Furrow treatment (3655kg $ha^{-1}$), followed by Flatbed with earthing up treatment (3247kg $ha^{-1}$). However, treatment Ridge and Furrow is statistically different with other methods. The lowest stover yield (2707kg $ha^{-1}$) was recorded with control (flat bed). The increased in stover yield was 35.02% and 19.94% due to application of Ridge and Furrow and Flatbed with earthing up treatments, respectively over control.

**Table 1. Effect of S levels and planting method on yields and quality parameters of groundnut**

| Treatment | Pod yield (q/ha) | Stover yield (q/ha) | Oil (%) | Protein (%) | Shelling (%) |
|---|---|---|---|---|---|
| **S levels (kg/ha)** | | | | | |
| 0 | 22.20 | 29.37 | 45.36 | 19.51 | 64.70 |
| 25 | 23.72 | 31.89 | 45.65 | 21.42 | 66.08 |
| 50 | 26.52 | 34.83 | 47.80 | 22.26 | 67.85 |
| CD (p=0.05) | 1.25 | 3.27 | 1.51 | 0.63 | 1.55 |
| **Planting Methods** | | | | | |
| Flat Bed | 20.19 | 27.07 | 44.82 | 20.14 | 64.51 |
| Flat bed with earthing up | 24.50 | 32.47 | 45.75 | 20.99 | 66.27 |
| Ridge and Furrow | 27.75 | 36.55 | 46.25 | 22.06 | 67.85 |
| CD (p=0.05) | 1.25 | 3.27 | NS | 0.63 | 1.55 |
| Interaction | 2.16 | NS | NS | NS | NS |

**Table 2. Effect of S levels and planting method on nutrient content and their uptake in groundnut**

| Treatment | Content in seed (%) | | | | Uptake (kg/ha) | | | |
|---|---|---|---|---|---|---|---|---|
| | N | P | K | S | N | P | K | S |
| **S levels (kg/ha)** | | | | | | | | |
| 0 | 3.12 | 0.29 | 0.99 | 0.16 | 69.75 | 6.57 | 22.21 | 3.64 |
| 25 | 3.43 | 0.31 | 1.09 | 0.18 | 81.87 | 7.40 | 26.16 | 4.26 |
| 50 | 3.56 | 0.32 | 1.18 | 0.21 | 94.54 | 8.61 | 31.41 | 5.45 |
| CD (p=0.05) | 0.11 | 0.01 | 0.07 | 0.01 | 4.36 | 0.46 | 2.39 | 0.41 |
| **Planting Methods** | | | | | | | | |
| Flat Bed | 3.20 | 0.29 | 0.96 | 0.17 | 65.56 | 5.94 | 19.52 | 3.52 |
| Flat bed with earthing up | 3.33 | 0.31 | 1.10 | 0.18 | 82.59 | 7.64 | 27.15 | 4.53 |
| Ridge and Furrow | 3.53 | 0.32 | 1.19 | 0.19 | 98.01 | 9.01 | 33.10 | 5.30 |
| CD (p=0.05) | 0.10 | 0.02 | 0.07 | NS | 4.35 | 0.46 | 2.39 | 0.41 |
| Interaction | NS | NS | NS | NS | NS | NS | NS | NS |

**Table 3. Effect of S levels and planting methods on nutrient content and their uptake in groundnut**

| Treatment | Content in stover (%) | | | | Uptake (kg/ ha) | | | |
|---|---|---|---|---|---|---|---|---|
| | N | P | K | S | N | P | K | S |
| **S levels (kg/ha)** | | | | | | | | |
| 0 | 1.12 | 0.16 | 0.85 | 0.20 | 33.65 | 4.75 | 25.09 | 5.97 |
| 25 | 1.22 | 0.17 | 0.88 | 0.23 | 39.29 | 5.59 | 28.26 | 7.28 |
| 50 | 1.41 | 0.20 | 0.92 | 0.25 | 49.34 | 7.16 | 33.89 | 9.04 |
| CD (p=0.05) | 0.18 | 0.02 | NS | 0.01 | 7.50 | 0.60 | 4.83 | 0.82 |
| **Planting Methods** | | | | | | | | |
| Flat Bed | 1.11 | 0.17 | 0.79 | 0.19 | 30.17 | 4.49 | 21.46 | 5.18 |
| Flat bed with earthing up | 1.27 | 0.18 | 0.88 | 0.22 | 41.67 | 5.77 | 29.69 | 7.28 |
| Ridge and Furrow | 1.37 | 0.20 | 0.98 | 0.27 | 50.43 | 7.25 | 36.09 | 9.82 |
| CD (p=0.05) | 0.18 | 0.02 | 0.08 | 0.01 | 7.50 | 0.60 | 4.83 | 0.82 |
| Interaction | NS | NS | NS | 0.02 | NS | NS | NS | 1.23 |

The increase in pod and stover yield might be due to ridges provide loose friable soil with and less mechanical compaction that permitted roots to grow profusely with more length compared to flat bed. This treatment offered more opportunity for peg proximity to the soil surface. For instance, it was observed that pegs produced at the upper parts of the branches had a shorter distance to travel and therefore ended up forming pods as a result of the uniform distance that was maintained between the pegs and the soil surface as the branches extend outward from the main stem. It is also because excess rainfall is properly directed through furrows. It also increases water-use efficiency both under rainfed and irrigated scenarios because water moves laterally from furrows into beds thereby reducing evaporation losses. Similar results were found by Mathukia et al. [35], Olayinka et al. [17], Mvumi et al. [36], Olayinka et al. [37], and Chowdary et al. [38].

### 3.2.2 Nutrient content and uptake by seed and stover

Results showed that nutrient content was found to be influenced significantly by the planting methods and their uptakes were also influenced significantly. The application of the Ridge and Furrow method showed significantly higher values of uptake of nitrogen (98.01 kg $ha^{-1}$ and 50.43 kg $ha^{-1}$) , phosphorus (9.01 kg $ha^{-1}$ and 7.25 kg $ha^{-1}$); potassium (33.10 kg $ha^{-1}$ and 36.09 kg $ha^{-1}$); sulphur (5.30 kg $ha^{-1}$ and 9.82 kg $ha^{-1}$) by seed and stover in Table 2 and Table 3. Ridge-furrow plays a vital role in enhancing growth, which may be attributed to more conducive soil conditions like proper aeration and adequate availability of moisture essential for emergence that resulted in more crop productivity. Better nutrient uptake in ridge-furrow planting might be due to the fact that ridge-furrow planting resulted in better utilization of available resources like water, nutrients, and sunlight due to favourable microclimate. Similar findings were also illustrated by Singh et. al. [39], and Dodwadiya and Sharma [40] in their work.

From the findings, it can be concluded that both the seed and stover yield of groundnut significantly increased over the control with the application of S @ 50 kg $ha^{-1}$ and ridge-furrow method. Also, the application of sulphur @ 50 kg $ha^{-1}$ and ridge-furrow planting method significantly increases the nutrient content and uptake in seed and stover of groundnut in coarse-textured medium S status soil.

## 3.3 Quality Parameters

### 3.3.1 Effect of sulphur

The quality parameters such as protein content, oil content and shelling percentage are presented in Table 3. Application of sulphur significantly increased the protein, oil content and shelling %. Significantly, higher protein, oil content and shelling (22.26 ,47.80 and 67.85 %) was recorded with $S_{50}$ treatment, followed by (21.42, 45.65 and 66.08 %) with $S_{25}$ treatment respectively over control. These both the treatments were statistically differ with each other and significantly superior over control. The lowest protein, oil content and shelling (19.51, 43.36 and 64.70%) were recorded with control ($S_0$), respectively. This might be due to the fact that sulphur application improved over all nutritional environment of the Rhizosphere as well as plant system which could be more advantageous for profused vegetative and root growth which activated higher absorption of nutrients from the soil and improved metabolic activities inside the plant. These results may be attributed to the sulphur plays an important role in synthesis of essential amino acids like cysteine, methionine and certain vitamin like biotin, thymine as well as the formation of ferrodoxin (iron-containing plant protein) that act as an electron carrier in the photosynthetic process and chlorophyll which required for the production of oil. Sulphur besides being a structural component of protein is also directly involved in protein bio-synthesis This might be due to the synergistic effect of sulphur on nitrogen uptake which facilitates protein synthesis and activates different enzymes. The results are found to be similar with the results from Rao et al. [41], Kannan et al. [42], Patel et al. [43] and Prusty et al. [44].

### 3.3.2 Effect of planting methods

The quality parameters such as protein content, oil content and shelling percentage are presented in Table 3. Significant differences were observed among the different planting methods evaluated. The findings revealed that the application of ridge-furrow method significantly influences the protein, oil content and shelling of groundnut. Protein, oil content and shelling varied from 22.06, 46.25 and 67.85 percent under the treatment ridge-furrow followed by the treatment flat bed with earthing up (20.99, 45.75 and 66.27%) while, the minimum value of protein, oil content and shelling (20.14, 44.82 and 64.51%) were observed under control (flatbed) respectively. The results are in agreement with the findings of Olayinkaet al. [17].

## 4. CONCLUSION

The research findings indicate that varying levels of sulphur and different planting techniques have a significant impact on growth parameters. Among these, employing the ridge-furrow planting method along with a higher application of 50kg sulphur per hectare proves to be the most effective approach for enhancing both the quality and yield parameters of groundnut. This method surpasses the flat bed and flat bed with earthing up planting methods, as well as lower sulphur application rates. However, it's worth noting that the flat bed with earthing up technique, particularly when combined with 50kg sulphur, also yields favourable results compared to the control method. The highest yields of groundnut seed and stover are achieved through ridge-furrow planting with 50 kg sulphur, outperforming all other treatments.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Variath MT, Janila P. Economic and academic importance of peanut. In: The Peanut Genome, Springer. 2017;7:26.
2. Priya RS, Chinnusamy C, Manickasundaram P, Babu C. A review on

weed management in groundnut (*Arachis hypogaea* L.). International Journal Agricultural Science Research; 2013;3(1): 163-172

3. Din UN., Mehmood A, Khattak GS, Saeed I, Hassan MF. High yielding groundnut variety "Golden". Pakistan Journal of Botany. 2009;41(5):2217-2222.
4. Shokunbi OS, Fayomi ET, Sonuga OS, Tayo GO. Nutrient composition of five varieties of commonly consumed Nigerian groundnut (*Arachis hypogaea* L.). Grasas Y Aceites. 2012;63(1):14–18.
5. Smith AF. Peanuts: The Illustrious history of the goober pea. 2002;20:234.
6. Priya P, Singh S, Mohan M. Influence of Organic Nutrients on Growth and Yield of Summer Greengram (Vigna radiata). Journal of Experimental Agriculture International. 2024;46(6):333–339. Available:https://doi.org/10.9734/jeai/2024/v46i62485
7. Singh M, Singh A, Singh V, Azam K, Kumar R, Nand V. Effect of Planting Geometry and Inorganic Fertilizers with Nano Urea on Growth Indices of Rice Crop (*Oryza sativa* L.). J. Adv. Biol. Biotechnol. 2024 May 17 [cited 2024 May 22];27(6): 474-82. Available:https://journaljabb.com/index.php/JABB/article/view/907
8. Dhaliwal SS, Gupta R, Singh AK, Naresh RK, Mandal A, Singh UP, Kumar Y, Tomar SK, Mahajan NC. Impact of cropping systems on pedogenic distribution and transformations of micronutrients, plant accumulation and microbial community composition in soils: a review. Tropical Ecology. 2023 Sep;64(3):391-407.
9. Naiknaware MD, Pawar GR, Murumkar SB. Effect of varying levels of boron and sulphur on growth, yield and quality of summer groundnut (*Arachis hypogea* L.). International Journal of Tropical Agriculture. 2015;33(2 (Part I)):471-474.
10. Onyeike EN, Oguike JU. Influence of heat processing methods on the nutrient composition and lipid characterization of groundnut (*Arachis hypogaea* L.) seed pastes. Biokemistri. 2003;15(1):34-43.
11. Anonymous. Third advanced estimates. Area, production and yield of different pulses in India. E- pulses data book. ICAR-Indian Institute of Pulses Research; 2020-21.
12. Tandon HLS, Messick DL. Practical sulphur guide: By HLS Tandon and DL Messick. Sulphur Institute; 2002.
13. Jamal A, Moon YS, Zainul Abdin M. Sulphur-a general overview and interaction with nitrogen. Australian Journal of Crop Science. 2010;4(7):523-529
14. Najar GR, Singh SR, Akhtar F, Hakeem SA. Influence of sulphur level on yield, uptake and quality of soybean (*Glycine max* L.) under temperate conditions of Kashmir valley. Indian Journal of Agricultural Sciences. 2011;81(4):340-3.
15. Kandpal BM, Chandel AS. Effect of gypsum and pyrite as sources of sulphur on nitrogen fixation, dry-matter yield and quality of soybean (*Glycine max* L.). Indian Journal of Agronomy. 1993;38:137-137.
16. Singh RA. Effect of variable doses of potassium, sulphur and calcium on pod yield of short duration summer groundnut (*Arachis hypogaea* L.). International Journal of Agricultural Sciences. 2007;3(1):196-198
17. Olayinka BU, Yusuf BT, Etejere EO. Growth, yield and proximate composition of groundnut (*Arachis hypogaea* L.) as influenced by land preparation methods. Notulae Scientia Biologicae. 2015;7(2): 227-231.
18. Mhungu S, Chiteka ZA. The effect of timing of earthing up on the performance of four Bambara groundnut landrace cultivars in the Mutasa District of Manicaland Province in Zimbabwe. Second RUFORUM Biennial Meeting. 2010;20–24.
19. Jadhav SC, Salvi VG, Kasture MC, More SS, AA W. Influence of different levels of Sulphur and biofertilizers on soil properties and yield of mulched Groundnut (*Arachis hypogaea* L.) in lateritic soils of Konkan region. The Pharma Innovation Journal. 2022;11(1):1040-1045.
20. Jackson ML. Soil chemical analysis. Prentice Hall of India Pvt. Ltd. New Delhi, India. 1973;327-350
21. Walkley AJ, Black CA. Estimation of soil organic carbon by the chromic acid titration method. Soil Science. 1934;37:29-38.
22. Subbiah, B.V. and Asija, G.L. A rapid procedure for the determination of available nitrogen in soils. Current Science; 1956;25:259-60.
23. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium

bicarbonate. Circular U.S. Department of Agriculture. 1954;939.
24. Chesnin L, Yien CH. Turbidimetric determination of available sulfates. Soil Science Society of America Journal. 1951; 15(C):149-151.
25. Lindner RC. Rapid analytical method for some of the more common inorganic constituents of plant tissues. Plant Physiology. 1944;19:76-89.
26. Koenig R, Johnson C. Colorimetric determination of phosphorus in biological materials. Industrial & Engineering Chemistry Analytical Edition. 1942;14(2):155-156.
27. Banu R, Shroff JC, Shah SN. Effect of sources and levels of sulphur and bio-fertilizer on growth, yield and quality of summer groundnut. International Journal of Agricultural Sciences. 2017;13(1):67-70.
28. Patel PK, Viradiya MB, Kadivala VH, Shinde RD. Effect of potassium and sulphur on yield attributes, yield and quality of summer groundnut (*Arachis hypogaea* L.) under middle Gujarat condition. International Journal of Current Microbiology and Applied Sciences. 2018; 7:2268-2273.
29. Noman HM, Rana DS, Choudhary AK, Dass A, Rajanna GA, Pande P. Improving productivity, quality and biofortification in groundnut (*Arachis hypogaea* L.) through sulfur and zinc nutrition in alluvial soils of the semi-arid region of India. Journal of Plant Nutrition. 2020;44(8):1151-1174.
30. Patel AR, Zinzala VJ. Effect of sulphur and boron on nutrient content and uptake by summer groundnut (*Arachis hypogaea* L.). The Pharma Innovation Journal. 2018;7(4): 47-50.
31. Longkumer LT, Singh AK, Jamir Z, Kumar M. Effect of sulfur and boron nutrition on yield and quality of soybean (*Glycine max* L.) grown in an acid soil. Communications in soil science and plant analysis. 2017;48(4):405-411.
32. Yadav S, Verma R, Yadav PK, Bamboriya JS. Effect of sulphur and iron on nutrient content, uptake and quality of groundnut (*Arachis hypogaea* L.). Journal of Pharmacognosy and Phytochemistry. 2020;9(1):1605-1609.
33. Prusty M, Alim MA, Swain D, Panda D, Ray M. Effect of sources and doses of Sulphur and Boron application on Yield, nutrient content and nutrient uptake of Groundnut (*Arachis hypogea* L.). International Journal for Innovative Engineering and Management Research. 2020;9(12):495-505.
34. Mehmood MZ, Afzal O, Ahmed M, Qadir G, Kheir AM, Aslam MA, Ahmad S. Can sulphur improve the nutrient uptake, partitioning, and seed yield of sesame. Arabian Journal of Geosciences. 2021; 14(10):865.
35. Mathukia RK. Response of kharif groundnut (*Arachis hypogaea* L.) to land layouts, mulches and nutrient management. International Journal of Sciences; 2014.
36. Mvumi C, Washaya S, Ruswa C. The effects of planting methods on growth and yield of groundnut (*Arachis hypogaea* L.) cultivar natal common in Africa South of the Sahara; 2018.
37. Olayinka BU, Abdulbaki AS, Mohammed RT, Alsamadany H, Murtadha RB, Alzahrani Y, Etejere EO. Effect of planting methods on growth and yield of groundnut cultivars. Legume Research-An International Journal. 2021;44(1):74-80.
38. Chowdary KR, Jyotsna MK, Jyothi I. Impact of Ridge and Furrow Method of Planting on Groundnut Yield Attributes in Chittoor District of Andhra Pradesh, India. International Journal of Environment and Climate Change. 2022;12(9):151-156.
39. Singh SP, Mahapatra BS, Pramanick B, Yadav VR. Effect of irrigation levels, planting methods and mulching on nutrient uptake, yield, quality, water and fertilizer productivity of field mustard (Brassica rapa L.) under sandy loam soil. Agricultural Water Management. 2021;244: 106539.
40. Dodwadiya KS, Sharma AR. Effect of tillage and method of sowing on performance of greengram (Vigna radiata) varieties during summer and rainy seasons. Indian Journal of Agricultural Sciences. 2012;82(5):462-465.
41. Rao KT, Rao AU, Sekhar D. Effect of sources and levels of sulphur on groundnut. Journal of Academia and Industrial Research. 2013;2(5):268-270.
42. KannanP., Swaminathan C, Ponmani S. Sulfur nutrition for enhancing rainfed groundnut productivity in typical alfisol of semi-arid regions in India. Journal of Plant Nutrition. 2017;40(6):828-840.
43. Patel PK, Viradiya MB, Kadivala VH, Shinde RD. Effect of potassium and sulphur on yield attributes, yield and quality

of summer groundnut (*Arachis hypogaea* L.) under middle Gujarat condition. International Journal of Current Microbiology and Applied Sciences. 2018; 7:2268-2273.

44. Prusty M, Alim MA, Swain D, Panda D, Ray M. Effect of sources and doses of Sulphur and Boron application on Yield, nutrient content and nutrient uptake of Groundnut (*Arachis hypogea* L.). International Journal for Innovative Engineering and Management Research. 2020;9(12):495-505.



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