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Effect of nitrogen and sulphur on yield, quality and economics of groundnut (*Arachis hypogaea* L.)

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Abstract
A field experiment was carried out at the Experimental farm, Annamalai University during the *Kharif* season of 2022 to study the effect of nitrogen and sulphur on yield, quality and economics of groundnut. The experiment consisted of sixteen treatments and was laid out in a factorial randomized block design with three replications. The treatment consisted of Factor A (nitrogen levels): N_1- 0 Kg N/ha, N_2 - 17 Kg N/ha, N_3 - 25 Kg N/ha, N_4- 34 Kg N/ha and Factor B (sulphur levels): S_1- 0 Kg S/ha, S_2 - 20 Kg S/ha, S_3 - 40 Kg S/ha, S_4 - 60 Kg S/ha. The results revealed that yield, quality and economics were significantly influenced by different nitrogen and sulphur levels. Among the different nitrogen levels tried, the application of 34 kg N/ha (N_4) registered higher yield, quality characters and economics of groundnut. Regarding sulphur levels, maximum yield, quality characters and economics of groundnut were influenced by the application of sulphur @ 60 kg/ha (S_4). For various interaction effects, the application of 34 kg N/ha along with 60 kg S ha^{-1} has a significant effect on yield, quality characters and economics which ultimately results in maximum yield and higher net return of groundnut.

Keywords: Yield, quality, economics, sulphur

Introduction
Oilseeds are the second most important agricultural crop in India, after food grains, in terms of area, production, and value. Groundnut (*Arachis hypogaea* L.) is one of India's most important oilseed crops, grown extensively under rainfed conditions. Groundnut is known as the "King of Oilseeds" and belongs to the Leguminous family. It is the most prominent and important oilseed crop, grown primarily for human consumption and animal feed (Ravikumar *et al*., 2020) [10]. Domestic demand for vegetable oils and fats has been rapidly increasing, at 6% per year, while domestic output has increased at only about 2% per year. In India, the average yield of most oilseeds is extremely low compared to others.
Primary macronutrients have a significant impact on crop yield and quality. Three major elements, nitrogen, phosphorus, and potassium (N, P, and K), are required abundantly. Nitrogen is one of the most important and limiting elements for the growth and development of most plants. Nitrogen is also an essential component of chlorophyll, which is the primary absorber of light energy required for photosynthesis. It aids in the synthesis of metabolites and their transportation to the seeds (Patel *et al*. 2022) [8].
Sulphur is the fourth most important plant nutrient, after nitrogen, phosphorus, and potassium. Sulphur is an important constituent of three amino acids that are essential components of proteins: cystine, cysteine, and methionine (Sujatha *et al*. 2021) [12]. It is an important prerequisite for improving groundnut productivity and quality. The combined application of nitrogen and sulphur had the greatest effect on nitrogen and sulphur concentrations and uptake on growth parameters as well as nutrient absorption.

Material and Methods
The present investigation was carried out during the *Kharif* season of 2022 at the Experimental farm, Faculty of Agriculture, Annamalai University to assess the effect of nitrogen and sulphur on yield, quality and economics of groundnut. The maximum temperature during the cropping

period ranges from 36.11 to 28.57 °C with a mean of 33.16 °C and the minimum temperature fluctuates between 25.42 and 22.14 °C with a mean of 23.67 °C. During the crop period, 65.10 mm of rainfall was recorded with 25 rainy days. The soil of the experimental field was sandy loam in texture. The soil was low in available nitrogen, medium in available phosphorous and potassium and low in available sulphur. The groundnut variety VRI 8 was chosen for the study. The experiment was laid out in a factorial randomized block design with three replications. The treatment consisted of two factors *viz.*, Factor A (nitrogen levels): N_1- 0 Kg N/ha, N_2 – 17 Kg N/ha, N_3 -25 Kg N/ha, N_4- 34 Kg N/ha and Factor B (sulphur levels): S_1- 0 Kg S/ha, S_2 – 20 Kg S/ha, S_3 - 40 Kg S/ha, S_4 - 60 Kg S/ha. The requirements of nitrogen, phosphorous, potassium and sulphur were met through urea, DAP, MOP and gypsum. The crop harvested from each plot was bundled up and the pods were stripped off. The pods were dried in sunlight to bring the moisture content to 10% and individual plot yields were recorded. The pods are then shelled to obtain the kernel yield. The estimated data were analyzed as per the procedure outlined by Panse and Sukhatme (1978) [7]. The critical difference was worked out at five per cent probability level for significant results.

Results and Discussion

Yield (Table 1)

Application of 34 kg N/ha (N_4) resulted in significantly higher pod yield, kernel yield, and haulm yield. Nitrogen plays a vital role in the synthesis of amino acids and chlorophyll, which also increases the translocation of nutrients to reproductive organs and, ultimately, increases groundnut yield. These findings are consistent with the results of Chaudhary *et al.* (2015) [3] and Waghmode *et al.* (2017) [13].

The higher values of pod yield, kernel yield and haulm yield were registered under the application of 60 kg S/ha (S_4). Because sulphur is involved in the development of S-containing amino acids and vitamins, it has a direct impact on root development and formative activities, resulting in increased pod yields. The increase in kernel and haulm yield could be attributed to the stimulatory effect of applied sulphur on protein synthesis, which may have accelerated photosynthesis and improved most of the yield-contributing characters, resulting in significantly higher kernel and haulm yield. This was similar to the results of Abilash *et al.* (2019) [2].

Regarding the interaction effects, the application of 34 kg N/ha along with S at 60 kg/ha registered higher yield of groundnut. Higher nitrogen and sulphur application promotes good growth of the plants, and the availability of adequate nitrogen and sulphur may have led to increased accumulation of amino acid and amide substances, which were then translocated to the reproductive organs, improving groundnut yield through increased seed setting and filling. Nitrogen is an integral part of chlorophyll and plays an important role in photosynthesis and carbohydrate production, whereas sulphur application promotes the process of tissue differentiation from somatic to reproductive, meristematic activity, and the development of floral primordial, resulting in more flowers and yields. Similar findings have also been reported by Ahmed *et al.* (2016) [1].

Quality

Among the different levels of nitrogen tried, application of 34 kg N/ha registered higher oil content, oil yield and crude protein content of groundnut (Table 1). Nitrogen increases the vegetative growth and the production of carbohydrates and its transfer to seeds which increases the oil content of groundnut. This was reported by Mollashahi *et al.* (2013) [6] in sunflower.

Application of 60 kg S/ha (S_4) significantly increased the oil content, oil yield and crude protein content. As sulphur is an integral part of oil, the increased availability of sulphur might have favourably influenced the synthesis of essential metabolism responsible for higher oil content. It is a constituent of three amino acids *viz.* methionine (21% S), cysteine (26% S) and cystine (27% S), which are building blocks of protein. It also helps in the conversion of these amino acids into high-quality protein. Appropriate structure was essential for protein formation and sulphur provides di-sulphide (S-S) bonds for cross linkage of two polypeptide chains and thus helps in the formation of proteins. Similar results were earlier reported by Yadav *et al.* (2019) [14].

The interaction effect between nitrogen and sulphur levels was found to influence the quality characters of groundnut. The higher quality characters of groundnut were observed under the treatment combination of application of 34 kg N/ha along with 60 kg S/ha (N_4S_4) could be because N is an integral part of protein and the protein contains relatively large quantities of the S containing amino acids like methionine and cystine. These results were in agreement with the findings of Mohiuddin *et al.* (2011) [5].

Table 1: Effect of nitrogen and sulphur on yield and quality of groundnut

Treatments	Pod yield (kg/ha)	Kernel yield (kg/ha)	Haulm yield (kg/ha)	Oil content	Oil yield (kg/ha)	Protein content
Factor A-Nitrogen levels						
N_1	1683	1120	2707	47.01	526.64	22.97
N_2	2274	1579	3409	48.15	762.46	25.15
N_3	2504	1771	3678	48.90	867.64	26.02
N_4	2579	1835	3761	49.10	902.66	26.31
C.D	43.30	36.16	55.67	0.13	17.82	0.20
S.Ed	20.42	17.05	28.62	0.06	08.40	0.09
Factor B-Sulphur levels						
S_1	2998	2998	2998	47.47	608.21	23.76
S_2	3316	3316	3316	48.01	731.02	24.83
S_3	3513	3513	3513	48.56	813.87	25.53
S_4	3727	3727	3727	49.12	906.31	26.33
C.D	43.31	36.16	55.67	0.14	17.82	0.20
S.Ed	20.43	17.05	28.62	0.07	08.40	0.09

Economics

Among the different treatments imposed, the application of 34 kg N/ha along with 60 kg S/ha (N_4S_4) recorded a higher net return and BCR (Table 2). Increasing levels of nitrogen increased the net returns and benefit-cost ratio. This might be due to maximum recovery from the application of nitrogen with less expenditure. Sulphur through gypsum yielded significantly higher net returns and B: C ratio due to its cost-effective nature. Similar findings were reported by Dileep *et al.* (2021) [4].

Table 2: Effect of nitrogen and sulphur on economics of groundnut

Treatments	Net income (Rs.)	Benefit Cost Ratio
N_1S_1	13106	1.29
N_1S_2	20474	1.45
N_1S_3	23289	1.50
N_1S_4	28082	1.60
N_2S_1	32399	1.71
N_2S_2	43860	1.94
N_2S_3	50519	2.07
N_2S_4	63123	2.33
N_3S_1	37668	1.82
N_3S_2	54366	2.16
N_3S_3	66474	2.41
N_3S_4	76857	2.61
N_4S_1	40630	1.88
N_4S_2	57389	2.22
N_4S_3	69465	2.46
N_4S_4	78016	2.62

Conclusion

Based on the experimental results, it could be concluded that application of 34 kg N/ha along with 60 kg S/ha was agronomically and economically superior for over other treatments. Hence, it is a fitting practice for obtaining higher growth and yield of groundnut.

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