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Effect of sulphur and phosphorus on growth and yield of groundnut

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Abstract
In 2023, a field experiment was carried out at the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.) during the kharif season. The experimental soil had a sandy loam texture with a pH of 7.3, organic carbon at 1.13%, nitrogen at 278.48 kg/ha, phosphorus at 48.1 kg/ha, and potassium at 253.5 kg/ha in terms of soil reactivity. Along with control, the treatments include phosphorus (40, 50, and 60 kg/ha) and sulphur (30, 40, and 50 kg/h). Ten treatments, each replicated three times, were used in the experiment, which was set up using a randomised block design. The growth characteristics, such as the maximum plant height (50.03 cm), dry weight (38.97 g), number of nodules per plant (60.00), and yield features, such as the number of kernels per pod (2.00), pods per plant (17.00), kernel yield (2422.22 Kg/ha), and haulm production (3583.33 Kg/ha), were demonstrated by the results were recorded significantly higher with application of treatment 50 Kg/ha Sulphur + 60 Kg/ha Phosphorus in groundnut crop.

Keywords: Groundnut, sulphur, phosphorus, growth, yield and yield attributes

Introduction
Around the world, groundnuts are a significant oilseed and supplemental food crop. It is the third most significant source of vegetable protein and the fourth most significant source of edible oil. It is a member of the Leguminaceae family. It is also referred to as peanut, manila nut, and monkey nut in India. After China, India is ranked first in terms of area and second in terms of production. 38.6 MT of the crop are produced worldwide on an area of 26.4 million hectares. It is grown on 4596.33 hectares of land in India, producing 6733.33 MT. The state of Rajasthan in India was expected to have the highest yield (2051 kg/ha), followed by Gujarat (1421, kg/ha), Maharashtra (1361, kg/ha), Andhra Pradesh (883, kg/ha), and Maharashtra (750, kg/ha) and 750 kg/ha for Karnataka. The average yield was estimated at 1336 kg/ha (APEDA, 2018). 13 different vitamins, including the A, B, C, and E groups, as well as 26 necessary minerals, including zinc, boron, iron and calcium, are found in peanuts. Because groundnuts are high in healthy fats and low in sodium, they naturally decrease appetite.

One important and necessary nutrient for crop growth and high-quality output is phosphorus (P). Phosphorus mostly affects the root systems of plants. Because P is essential to nodule development and atmospheric nitrogen fixation, nodulating legumes have a greater P need than non-nodulating crops. Application of P to soil lacking in this nutrient increases groundnut yield since P is essential to plant physiological activities (Islam *et al*. 2013) [4].

Sulphur is essential for seed development and for enhancing the quality of oil. Because groundnuts are abundant in protein and oils, they have a significant need for sulphur. Groundnuts were tested with sulphur levels ranging from 20 to 70 kg/ha. A greater sulphur level of 60 kg/ha was associated with taller plants, a larger leaf area index, a higher number of dry matter production pods, a higher pod yield, and better oil quality. The use of 400 kg/ha of gypsum (200 kg as a base and an additional 200 kg/ha during earthing up) has resulted in an increase in groundnut pod production, oil content, and yield. Thus, the total amount of sulphur needed for oil seed crops is equal to the amount of phosphorus (Bhadiyatar *et al*. 2022) [1].

Materials and Methods

The field trial was carried out in the Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, U.P. during the kharif season of 2023. The farm is situated at 250 09' 03" N latitude, 810 45' 14" E longitude, and 98 m above mean sea level. The location is 10 km from Prayagraj city on the right bank of the Ganga River. Soil has a pH of 7.3. The soil has a sandy loam texture and contains accessible phosphorus (48.1 kg/ha), potassium (253.5 kg/ha), and nitrogen (278.48 kg/ha).The experiment was laid out in Randomized Block Design consisting of ten treatment combinations *viz*., T1-30 Kg/ha Sulphur + 40 Kg/ha Phosphorus, T2-30 Kg/ha Sulphur + 50 Kg/ha Phosphorus, T_3-30 Kg/ha Sulphur + 60 Kg/ha Phosphorus, T_4-40 Kg/ha Sulphur + 40 Kg/ha Phosphorus, T_5-40 Kg/ha Sulphur + 50 Kg/ha Phosphorus, T_6-40 Kg/ha Sulphur + 60 Kg/ha Phosphorus, T_7-50 Kg/ha Sulphur + 40 Kg/ha Phosphorus, T_7-50 Kg/ha Sulphur + 40 Kg/ha Phosphorus, T_8-50 Kg/ha Sulphur + 50 Kg/ha Phosphorus, T_9-50 Kg/ha Sulphur + 60 Kg/ha Phosphorus, T_{10}- Control were replicated thrice. The experimental field was ploughed, and stubble removed to a fine tilth. After opening the furrows and ensuring sufficient coverage, the recommended nutrients were applied in a 20:60:40 kg/ha proportion to all treatments using urea, SSP, and mop. The Malika (ICHG00440) variety was sowed 30 cm apart from 10 cm. Plant height (cm) and dry weight (g/plant), the growth parameters, were measured at 25-day intervals until physiological maturity. The data was statistically evaluated using the ANOVA approach (Gomez and Gomez, 1994) [3].

Results and Discussion

Growth parameters

The information in Table 1 demonstrates how various treatments impact the groundnut's growth components. The number of nodules per plant, dry weight (g/plant), and plant height (cm) all showed substantial variations. According to the results, the application treatment (9) of 50 kg/ha sulphur + 60 kg/ha phosphorus resulted in noticeably taller plants. Nonetheless, it was discovered that treatments (8) and (7), which combined 50 kg/ha of sulphur with 50 kg/ha of phosphorus and 40 kg/ha of phosphorus respectively, were statistically equivalent to treatment (9). The increased availability of sulphur and related nutrients may have aided in the quick division of cells and the production of more chlorophyll, which in turn enhanced the rate and activity of photosynthesis and, in the end, increased the amount of assimilates available to plants, contributing to the height rise of the plants that in turn increased the growth in terms of a greater canopy, plant height at the successive growth stages. The results confirm with Nagesh Yadav *et al.* (2018) [7]. According to the observed data, treatment (9) 50 kg/ha sulphur + 60 kg/ha phosphorus recorded the considerably highest dry weight (38.97 g/plant). Nonetheless, it was discovered that treatment (8) 50 kg/ha sulphur plus 50 kg/ha phosphorus was statistically equivalent to treatment (9). Applying sulphur has been shown to increase the availability of other nutrients as well as sulphur, which is thought to be crucial for plant growth and development. The photosynthetic surface appears to have grown and expanded to its maximal apical extent due to the promotion of meristematic processes. It has also been noted that sulphur contributes to reducing soil pH, which is the primary cause of increased nutrient availability and mobility, particularly for P, Fe, Mn, and Zn (Dileep *et al*. 2021) [2]. The application of P may have resulted in increases in plant growth and total dry weight because P is known to aid in the establishment of more extensive root systems and nodulation, which allows plants to absorb more water and nutrients from the soil's depth. The increased dry weight was indicative of the plant's potential to produce more assimilates as a result (Kabir *et al*. 2013) [5]. The number of nodules per plant (60.00) was also significantly larger in treatment (9) when 50 kg/ha of sulphur and 60 kg/ha of phosphorus were applied.

Yield parameters

The data in Table 2 shows how different treatments affect the groundnut yield attributes. There were noticeable differences in test weight, kernel yield, haulm yield, number of pods per plant, and number of kernels per pod. Based on the results observed, the treatment group receiving 50 kg/ha of sulphur and 60 kg/ha of phosphorus had more kernels per pod (2.00). Nonetheless, it was discovered that treatment (8) 50 kg/ha sulphur + 50 kg/ha phosphorus was statistically equivalent to treatment (9). A sufficient supply of sulphur also aids in the growth of floral primordial, or the reproductive sections of the plant, which leads to the production of kernels. (Rajanarasimha *et al*. 2021) [8]. According to the observed data, the treatment containing 50 kg/ha of sulphur and 60 kg/ha of phosphorus had the largest number of pods per plant (17.00). Nonetheless, it was discovered that treatments (8) and (7), which combined 50 kg/ha of sulphur with 50 kg/ha of phosphorus and 40 kg/ha of phosphorus respectively, were statistically equivalent to treatment (9). Plants took longer to mature, most likely as a result of water shortages during the stage of pod filling, which resulted to poorly filled pods and delayed maturity. In both seasons, applying phosphorus fertilizer generally resulted in an increase in total dry weight. The application of phosphorus causes an increase in dry weight because it promotes the growth of a more extensive root system, which allows plants to absorb more water and nutrients from the soil's depth. Thus, this could further improve the plant's capacity to generate more assimilates into the pods, leading to a rise in the quantity of filled pods and the percentage of shelling (Kamara *et al*. 2011) [6]. Based on the data, the treatment with the highest test weight (216.00 g) was 50 kg/ha sulphur + 40 kg/ha phosphorus. No significant difference was found between the other treatments. Similar to this, the data showed that the treatment of (9) 40 kg/ha sulphur + 40 kg/ha phosphorus produced a greater seed yield (2442.22 kg/ha). Nonetheless, it was discovered that treatment (8) 50 kg/ha sulphur plus 50 kg/ha phosphorus was statistically equivalent to treatment (9). Since sulphur is directly involved in the manufacture of oil, an increase in oil content following sulphur application may result from sulphur's direct involvement in oil synthesis. Protein and enzyme synthesis was also linked to higher yield and oil content with increased sulphur application because sulphur contains the amino acids methonine, cysteine, and cystine. Moreover, it contributes to the synthesis of glucocides and glucosinolates, which upon hydrolysis raise the oil content. Likewise, it is crucial for the synthesis of vitamins and chlorophyll. (Sisodiya *et al.* 2016) [9]. P fertilizer may have increased output because it activated metabolic processes, where it is known to play a role in the synthesis of phospholipids and nucleic acid. P is a crucial component of ATP, plays a major role in the energy transformation of plants, and is essential for the development of seeds in legumes in particular. It is also a crucial nutrient for all crops (Kabir *et al*. 2013) [5]. Higher haulm yield (3583.33 kg/ha) was seen in treatment (9) 50 kg/ha sulphur + 60 kg/ha phosphorus, according to the data. Nonetheless, it was discovered that treatment (8) 50 kg/ha sulphur plus 50 kg/ha phosphorus was statistically equivalent to treatment (9). Due to their extensive use of significant amounts of nutrients through their well-developed root system and nodules, which may have resulted in both plant development and eventual straw production at maturity, the increased haulm output may have been caused by the synergistic action of calcium and sulphur. The outcomes are consistent with (Yadav *et al.* (2015) [10]. According to the statistics, there was no discernible difference between treatments 9 and 50 kg/ha of sulphur and 60 kg/ha of phosphorus, which had the highest harvest index (40.58%).

Table 1: Effect of Sulphur and Phosphorus on growth attributes of Groundnut

S. No.	Treatments	100 DAS		
		Plant height (cm)	Plant Dry weight (g/plant)	Nodules/plant (No.)
1.	30 Kg/ha Sulphur+40 Kg/ha Phosphorus	42.80	29.65	48.00
2.	30 Kg/ha Sulphur + 50 Kg/ha Phosphorus	43.36	31.54	48.33
3.	30 Kg/ha Sulphur + 60 Kg/ha Phosphorus	44.83	32.94	49.67
4.	40 Kg/ha Sulphur + 40 Kg/ha Phosphorus	45.13	33.95	51.00
5.	40 Kg/ha Sulphur + 50 Kg/ha Phosphorus	45.43	34.36	52.33
6.	40 Kg/ha Sulphur + 60 Kg/ha Phosphorus	46.28	35.21	54.67
7.	50 Kg/ha Sulphur + 40 Kg/ha Phosphorus	47.84	35.96	56.33
8.	50 Kg/ha Sulphur + 50 Kg/ha Phosphorus	48.45	37.38	57.00
9.	50 Kg/ha Sulphur + 60 Kg/ha Phosphorus	50.03	38.97	60.00
10.	Control	39.79	28.64	46.67
	S.Em(+)	0.88	0.95	1.14
	CD (P=0.05)	2.61	2.83	3.40

Table 2: Effect of Sulphur and Phosphorus on yield attributes and yield of Groundnut

S. No	Treatments	Kernel/pod (No.)	Pods/Plant (No.)	Seed yield (kg/ha)	Haulm yield (kg/ha)	Harvest index (%)
1.	30 Kg/ha Sulphur + 40 Kg/ha Phosphorus	1.60	13.00	1427.13	2750.00	34.08
2.	30 Kg/ha Sulphur + 50 Kg/ha Phosphorus	1.67	13.33	1507.38	2816.67	34.77
3.	30 Kg/ha Sulphur + 60 Kg/ha Phosphorus	1.70	13.66	1589.08	2916.67	35.22
4.	40 Kg/ha Sulphur + 40 Kg/ha Phosphorus	1.77	14.00	1719.05	3000.00	36.42
5.	40 Kg/ha Sulphur + 50 Kg/ha Phosphorus	1.80	14.33	1821.60	3120.00	36.69
6.	40 Kg/ha Sulphur + 60 Kg/ha Phosphorus	1.83	14.66	1893.77	3216.00	37.06
7.	50 Kg/ha Sulphur + 40 Kg/ha Phosphorus	1.87	15.33	2022.31	3340.00	37.72
8.	50 Kg/ha Sulphur + 50 Kg/ha Phosphorus	1.90	16.00	2175.43	3403.33	39.00
9.	50 Kg/ha Sulphur + 60 Kg/ha Phosphorus	2.00	17.00	2442.22	3583.33	40.58
10.	Control	1.50	12.66	1280.05	2550.00	33.45
	S.Em(+)	0.04	0.56	100.0	78.68	1.67
	CD (P=0.05)	0.13	1.68	297.1	233.7	-

Conclusion

The results show that the groundnut crop achieved its greatest yield and benefit-cost ratio when 50 kg of sulphur and 60 kg of phosphorus were applied together.

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Conflict of interest

No

Ethical statement

Not applicable

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Authorship statement

Name of Author: Amjith Mohan M L - Experimentation, Manuscript writing, Data analysis, Idea conceptualizing manuscript editing.

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