

RESEARCH PAPER

Study the Response of Various Doses of Phosphorus and Sulphur on Growth, Yield Attributes, Yield and Quality of Sesame (*Sesamum indicum* L.)

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ABSTRACT

An examination was conducted to ascertain the “Study the Response of Various Doses of Phosphorus and Sulphur on Growth, Yield Attributes, Yield and Quality of Sesame (*Sesamum indicum* L.)”, The experiment took place throughout the *kharif* season of 2023. The student instructional field managed by the Department of Agronomy at the School of Agriculture, GD Goenka University, Gurugram, Haryana, served as the research site. The experiment itself employed three duplicate blocks in a randomized block design, and researchers evaluated ten different treatment options *viz*, T₁ (NPKS @ 50:20:30:10), T₂ (NPKS @ 50:20:30:15), T₃ (NPKS @ 50:20:30:20), T₄ (NPKS @ 50:40:30:10), T₅ (RDF) (NPKS @ 50:40:30:15), T₆ (NPKS @ 50:40:30:20), T₇ (NPKS @ 50:60:30:10), T₈ (NPKS @ 50:60:30:15), T₉ (NPKS @ 50:60:30:20) and T₁₀ Control (NPKS @ 50:0:30:0). Sesame seeds of the variety: HERO MS-543, were planted at 45.0 × 15.0 cm spacing. Researchers investigated how varying levels of phosphorus and sulfur impact sesame. The study aimed to assess the effects on multiple aspects, including plant growth parameters, yield attributes, yield, overall sesame quality and economic returns. For maximum profit in sesame crops, treatment T₉ (NPKS @ 50:60:30:20) emerged as the superior choice due to its increased economic returns (net and gross) and benefit-cost ratio compared to other treatments. Further exploration of this topic through additional research is warranted for better understanding.

HIGHLIGHTS

- ① Applying phosphorus and sulphur together improved sesame growth, achieving a peak grain yield of 1,014.31 kg ha⁻¹ and 43.87 capsules per plant.
- ① Higher phosphorus and sulphur levels increased seed oil content to 49.89% and enhanced seed P and S concentration.
- ① The NPKS @ 50:60:30:20 kg ha⁻¹ treatment (T₉) performed best across all growth parameters and proved most profitable, yielding maximum net returns of INR 92,918.63 ha⁻¹ with a 2.04:1 B:C ratio.
- ① Application of NPKS @ 50:60:30:20 kg ha⁻¹ is recommended for farmers in semi-arid subtropical areas, to achieve optimal sesame production, higher oil quality, and maximum economic returns.

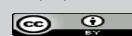
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India cultivates sesame (*Sesamum indicum*) alongside peanuts and mustard, and it's a prized possession. Nicknamed the “Queen of oilseeds,” sesame boasts an impressive oil content of 45-51 % and delivers a significant amount of dietary energy for healthy life. Research by Sanjay Kumar and Goel (1994) confirms these qualities. Sesame oil stands out for its stability

among vegetable oils, thanks to an abundance of natural antioxidants like sesamin, sesamol,

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and sesamol. The oil extracted from sesame seeds finds uses in cooking, salads, and even margarine. Interestingly, the oil's composition includes nearly 47% oleic acid and 39% linoleic acid. Perhaps the availability of these powerful antioxidants is reason that sesame seeds earned the title "seeds of immortality" (Bhardwaj *et al.* 2013).

Plants rely heavily on phosphorus, a vital nutrient, to thrive. It plays a critical role in various cellular processes, including respiration, photosynthesis, and membrane formation (Lal, 2002). By providing energy for these processes, phosphorus helps plants achieve higher yields and improve the quality and quantity of their produce, such as oilseeds (Hemalatha *et al.* 2013). Phosphorus fertilization promotes seed development by increasing seed weight and encouraging the growth of robust root systems. It also influences seed setting and maturity. Importantly, phosphorus also boosts protein content and fatty acid synthesis. Moreover, it ensures balanced growth by working in conjunction with other essential plant nutrients. While most soils hold abundant reserves of phosphorus, a large portion is unavailable for plants.

Plants need many different nutrients to survive and thrive. One particularly important nutrient is sulfur. Scientists like Justus von Liebig recognized this over 150 years ago. Sulfur plays a critical role in helping oilseed plants grow and produce more seeds. It also significantly impacts the quality of those seeds. Sulfur is essential for the production of oils and vitamins within the plant. It's also a building block of three amino acids, which are the foundation of proteins in plants (Takker, 1987).

MATERIALS AND METHODS

During the kharif season of 2023, the research experiment was conducted at the School of Agricultural Sciences (SoAS) research farm of GD Goenka University (GDBGU) located in Sohna, Gurugram, Haryana, India. The farm is located at a height of 211 meters above mean sea level at latitude 28°15'44.1" N and longitude 77°03'53.0" E. The experiment consists of varying doses of Phosphorus and Sulphur along with recommended dose of Nitrogen and Potassium. To ensure robust results, For each of the ten treatments, we used a Randomized Block Design (RBD) with three replications. viz. T₁ (NPKS @ 50:20:30:10), T₂ (NPKS

@ 50:20:30:15), T₃ (NPKS @ 50:20:30:20), T₄ (NPKS @ 50:40:30:10), T₅ (RDF) (NPKS @ 50:40:30:15), T₆ (NPKS @ 50:40:30:20), T₇ (NPKS @ 50:60:30:10), T₈ (NPKS @ 50:60:30:15), T₉ (NPKS @ 50:60:30:20) and T₁₀ Control (NPKS @ 50:0:30:0). Sesame variety HERO MS-543 was used in this experiment. Planted in a grid pattern, There were spaces of 45 cm between rows and 15 centimeters between individual plants within each row of sesame seeds. The recommended fertilizer dose (RDF) was applied at sowing: 50 kilograms of nitrogen per hectare through urea and 30 kilograms of potassium oxide per hectare through Muriate of Potash (MOP). Phosphorus, applied as elemental phosphorus, and sulfur, applied as elemental sulfur, were incorporated at sowing and one to two weeks before sowing, respectively. Plant growth parameters, yield components, total yield, and sesame oil content were monitored throughout the growing season. To ascertain these observations' statistical significance, analysis of variance (ANOVA) was employed. (F-value) at 5% level (Gomez and Gomez, 1984). Based on current market pricing for inputs and outputs, a cost-effectiveness analysis of production during the Kharif season was carried out.

RESULTS AND DISCUSSION

Growth attributes

The experiment investigated how various treatments of P and S affected sesame plant's growth parameters. The results are presented in Table 1. The treatment combination T₉ resulted in higher plant height (147.957 cm), number of branches per plant (3.6), fresh weight per plant (200.007 g) and dry weight per plant (48.235 g). Whereas treatment combination T₈ showed number of branches (3.533) which was comparable statistically to treatment T₉. The growth parameters mentioned increase with increase in Phosphorus and Sulphur levels. Phosphorus and sulfur significantly enhance sesame plant growth through their roles in vital cellular processes. Phosphorus promotes growth and stem elongation by aiding ATP production, cell division, and cell wall synthesis, while sulfur supports protein synthesis and enzyme activity. These nutrients improve plant population, branching, fresh and dry weight, and growth rates by enhancing photosynthesis, nutrient uptake, and metabolic efficiency. Optimal levels are

**Table 1:** Impact of *P* and *S* levels on sesame growth characteristics

Treatments	Plant height (cm)			Number of branches		
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
T ₁	43.908	76.625	134.153	1.533	2.333	2.933
T ₂	45.045	79.972	131.665	1.467	2.4	3.067
T ₃	44.733	82.184	134.393	1.333	2.4	3.133
T ₄	47.431	79.753	130.049	1.267	2.4	3.133
T ₅	46.983	80.633	135.751	1.333	2.4	3.267
T ₆	46.512	82.259	133.444	1.333	2.333	3.267
T ₇	47.967	89.461	138.013	1.533	2.467	3.333
T ₈	51.602	86.053	138.653	1.533	2.533	3.533
T ₉	52.715	95.916	147.957	1.733	2.8	3.6
T ₁₀	40.712	81.587	126.327	1.133	2.4	3.267
Sem+-	1.09	3.053	1.988	0.1	0.075	0.073
CD (0.05)	3.263	9.141	5.951	0.299	0.225	0.218

Treatments	Fresh weight (g)			Dry weight (g)		
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
T ₁	13.922	104.662	185.399	2.86	18.458	32.501
T ₂	14.737	123.385	179.151	2.861	24.369	36.681
T ₃	14.909	121.052	171.791	3.044	23.553	38.715
T ₄	15.068	112.781	171.049	2.681	23.771	37.267
T ₅	15.242	120.438	176.113	2.895	24.479	35.305
T ₆	15.314	128.621	172.096	3.007	26.553	37.579
T ₇	15.469	136.373	172.512	3.071	28.246	38.315
T ₈	15.723	135.929	181.791	3.066	27.589	39.543
T ₉	17.346	144.495	200.007	3.288	33.584	48.235
T ₁₀	13.317	116.918	164.638	2.709	25.281	34.786
Sem+-	0.491	3.086	2.41	0.109	0.585	1.069
CD (0.05)	1.471	9.24	7.216	0.328	1.753	3.2

crucial for maximizing benefits without adverse effects. Pagal *et al.* (2017); Shukla *et al.* (2023); Heidari *et al.* (2021) and Salame *et al.* (2020) also found that sesame responds positively when the *P* and *S* levels increased.

Yield and Yield attributes

The experiment's various treatment combinations significantly impacted yield components. The outcomes of *P* and *S* on the yield and yield characteristics of the sesame crop plant are shown in Table 2. Higher numbers of capsules plant-1 (43.867), seeds capsule-1 (51.547), grain yield (1,014.31 kg ha⁻¹), stover yield (4,076.94 kg ha⁻¹), biological yield (5,091.25 kg ha⁻¹), and test weight (4.68 g) were the outcomes of treatment combination T₉. However treatment T₆ resulted in higher test weight (20.678 g). Phosphorus and sulfur emerge as the unsung heroes in the sesame yield narrative,

orchestrating a symphony of growth and seed quality. Their influence transcends conventional boundaries, shaping the very fabric of sesame prosperity. Phosphorus takes the lead, conducting root development and nutrient absorption with precision, fostering robust stems and prolific capsules. Meanwhile, sulfur assumes the role of the artisan, crafting intricate pathways of protein synthesis and oil formation within each seed, transforming them into treasures of nutrition and potential. As sesame plants sway to this unique melody, they yield not mere seeds, but jewels of unmatched richness and market value. Recent revelations from Jalal *et al.* (2020) shed light on this intricate dance, unveiling phosphorus's prowess in nurturing root vigor and seed abundance, while sulfur paints a canvas of vibrant growth and abundant biomass. Together, in this uncharted territory of agricultural exploration, phosphorus,

sulfur, and their guardians of knowledge, Jalal *et al.* illuminate the path towards unlocking the true essence of sesame cultivation.

Quality Attributes

This study investigated how various treatment combinations affected the quality of sesame seeds, including oil content, phosphorus levels, and sulfur levels. The results are presented in Table 3. The treatment combination T₉ resulted in higher oil content (49.89 %) and phosphorus (0.786 %) and sulphur (1.20 %) content in sesame grain. Phosphorus (P) acts as the overseer, facilitating energy flow and resource allocation, while Sulphur (S) serves as a foundational element. Phosphorus, essential for fatty acid synthesis, drives the metabolic processes converting carbohydrates into vital sesame oil constituents, enhancing oil content. Additionally,

it promotes seed development, yielding plump, oil-rich seeds. Sulphur, a key component of essential amino acids, influences protein synthesis, yet its availability directs the plant towards prioritizing oil production over protein synthesis. Both elements embed within sesame seeds, enriching them with nutrition. The synergy of phosphorus and sulphur elevates sesame seed oil content and enhances their nutritional value. This dynamic is supported by Balasubramaniyan and Palaniappan (2001), and further confirmed by Sharma and Abrol (2007), highlighting the importance of balanced nutrient application for improving sesame grain quality and quantity.

Economic Returns

Table 4 presents the economic performance of the experiment for each fertilizer treatment. On doing

Table 2: Impact of P and S levels on sesame yield and yield characteristics

Treatments	Capsules plant ⁻¹	Seeds capsule ⁻¹	Grain yield (Kg ha ⁻¹)	Stover yield (Kg ha ⁻¹)	Biological yield (Kg ha ⁻¹)	HI %	Test weight (g)
T ₁	39.267	41.692	652.986	3,329.17	3,982.15	16.451	4.02
T ₂	39.667	40.367	678.911	3,425.28	4,104.19	16.571	4.19
T ₃	40.933	43.32	737.003	3,308.61	4,045.61	18.223	4.31
T ₄	40.333	39.74	704.192	3,028.06	3,732.25	18.929	3.99
T ₅	40.067	44.077	728.95	3,703.89	4,432.84	16.46	3.89
T ₆	40.2	45.048	879.7	3,375.83	4,255.53	20.678	4.41
T ₇	39.2	45.214	927.786	4,021.11	4,948.90	18.75	4.43
T ₈	42.067	48.254	899.217	3,898.61	4,797.83	18.771	4.58
T ₉	43.867	51.547	1,014.31	4,076.94	5,091.25	19.926	4.68
T ₁₀	38.867	38.97	636.272	2,925.28	3,561.55	17.861	3.98
SEm±	0.866	0.947	14.57	104.734	103.046	0.559	0.043
C.D. (0.05)	2.592	2.836	43.625	313.591	308.538	1.673	0.128

Table 3: Impact of P and S levels on sesame qualitative attributes

Treatments	Oil content %	Phosphorus % in grain	Sulphur % in grain
T ₁	43.137	0.634	0.87
T ₂	43.087	0.656	0.881
T ₃	44.51	0.662	0.891
T ₄	45.79	0.681	0.892
T ₅	44.343	0.685	0.896
T ₆	46.83	0.701	0.909
T ₇	47.107	0.711	1.03
T ₈	48.277	0.763	1.12
T ₉	49.89	0.786	1.20
T ₁₀	40.927	0.608	0.855
SEm±	0.604	0.001	0.004
C.D. (0.05)	1.809	0.004	0.011

**Table 4:** Impact of *P* and *S* levels on sesame economy

Treatments	Cost of cultivation (INR ha ⁻¹)	Gross return (INR ha ⁻¹)	Net Return (INR ha ⁻¹)	B:C ratio
T ₁	44376.95	89,132.60	44,755.66	1.009
T ₂	44640.1	92,671.37	48,031.27	1.076
T ₃	44903.25	100,600.90	55,697.63	1.24
T ₄	44692.55	96,122.16	51,429.61	1.151
T ₅	44955.7	99,501.66	54,545.98	1.213
T ₆	45218.85	120,079.10	74,860.20	1.656
T ₇	45008.15	126,642.80	81,634.66	1.814
T ₈	45271.3	122,743.10	77,471.77	1.711
T ₉	45534.45	138,453.10	92,918.63	2.041
T ₁₀	41900.05	86,851.16	44,951.11	1.073

the analysis of the given data, it is observed that the application of treatment combination T₉ resulted in higher gross return (INR 138, 453.10 ha⁻¹), net return (INR 92, 918.63 ha⁻¹) and B:C ratio (2.041:1). Research has shown a significant increase in economic returns with higher doses of phosphorus and sulfur application in agricultural settings at required ratio. Studies showed results in the favor of the fact that elevated levels of phosphorus and sulfur lead to improved crop yields and quality, thereby enhancing overall profitability for farmers. Phosphorus, acting as a crucial component in energy transfer and seed development, fuels metabolic processes essential for maximizing crop productivity. Similarly, sulfur, a key building block for proteins and oil formation, also improves the efficiency of nitrogen uptake and plant growth. By optimizing the application of phosphorus and sulfur, farmers can achieve higher yields and better-quality crops, resulting in increased economic returns per hectare of cultivated land. This underscores the importance of balanced nutrient management strategies in agricultural practices to maximize profitability and sustainability. Smith *et al.* (2018) also concluded similar observation on sesame.

CONCLUSION

The experiment revealed that increasing phosphorus and sulfur levels significantly boosted the crop's growth, its yield, yield components, and the quality factors of sesame, ultimately leading to better financial returns. Treatment T₉, consisting of 50kg ha⁻¹ nitrogen+ 60kg ha⁻¹ phosphorus+ 30kg ha⁻¹ potassium+ 20kg ha⁻¹ sulfur, emerged as an optimal

combination for maximizing sesame growth. This specific nutrient application (T₉) resulted in higher net income, finalizing it as a profitable choice for the farmers seeking to optimize their yields and better returns.

FUTURE SCOPE

Phosphorus and Sulphur are important nutrients which are important for sesame crop. Further study is necessary on the same topic to extend the clarification for the output and to access even more positive results using variety of doses of *P* and *S*.

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