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Influence of fertility and sulphur management on growth parameters, yield attributes and production potential of Sesame (*Sesamum indicum* L.)

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Abstract
A field experiment was conducted during *kharif* 2024 at the Agricultural Research Farm, School of Agriculture, Suresh Gyan Vihar University, Jaipur, to study the "Influence of Fertility and Sulphur Management on growth parameters, yield attributes and production potential of Sesame (*Sesamum indicum* L.)". The experiment was laid out in a factorial randomized block design with 16 treatment combinations, comprising four fertility levels (control, 50%, 75% and 100% RDF) and four sulphur levels (0, 20, 40 and 60 kg ha^{-1}), replicated three times. The results indicated that the conjunctive application of 100% RDF and 40 kg S ha^{-1} significantly improved growth parameters *viz.*, plant height, dry matter accumulation, branches plant^{-1} and chlorophyll content, while yield attributing traits also responded positively, with the highest capsules plant^{-1}, seeds capsule^{-1} and test weight. This treatment produced the maximum seed yield, stalk yield and biological yield in the test variety RT-351, representing a yield advantage of over 30% compared to control. The findings highlight the significance of balanced NPK fertilization in conjunction with sulphur for enhancing growth, yield attributes and productivity of sesame under semi-arid eastern platue zone of Rajasthan.

Keywords: Sesame, fertility levels, sulphur, growth attributes, yield

Introduction
Sesame (*Sesamum indicum* L.), one of the oldest cultivated oilseed crops, is widely grown in tropical and temperate regions and is valued for its edible oil and nutritional qualities. Belonging to the family Pedaliaceae, sesame is known by various names such as til, gingelly and simsim. Globally, it is regarded as the "queen of oils" due to its stability, antioxidant properties and wide industrial applications. Sesame seeds contain 46–52% oil, 25% protein and lignans such as sesamol and sesamolin, which contribute to antioxidative, antimicrobial and medicinal properties (Pathak *et al.*, 2014) [9]. Its oil, rich in unsaturated fatty acids, is used in food, pharmaceuticals, cosmetics and traditional medicine, while the protein-rich sesame cake serves as a valuable livestock and poultry feed (Pagal *et al.*, 2017) [7].
Globally, Sudan and India are leading sesame producers, with India cultivating 1.80 million hectares and producing 0.75 million tonnes at an average productivity of 458 kg ha^{-1} (Statica, 2023–24). Major producing states include West Bengal, Madhya Pradesh, Gujarat, Uttar Pradesh, Rajasthan and Tamil Nadu. Despite its economic and nutritional significance, sesame productivity in India remains far below its potential due to cultivation on marginal lands, inadequate fertilizer use and poor crop management.
Nutrient management is a critical factor influencing sesame yield and oil quality. Balanced application of nitrogen, phosphorus and potassium plays a vital role in growth, root development, flowering, seed formation and oil biosynthesis (Shehu *et al.*, 2010) [11]. However, deficiencies in soil fertility, particularly of macronutrients and beneficial microorganisms, are widespread in sesame-growing areas. Integrated use of inorganic fertilizers with organic sources such as farmyard manure (FYM), compost and biofertilizers (*Azotobacter*, *PSB*, *Azospirillum*) has been shown to enhance soil fertility, nutrient uptake and crop productivity while sustaining

soil health (Jaishankar & Wahab, 2005) [4].

Among secondary nutrients, sulphur plays a pivotal role in oilseed crops as a constituent of essential amino acids (cystine, cysteine, methionine) and chlorophyll and its deficiency reduces protein metabolism, oil yield and quality (Ajai Singh *et al.*, 2000) [1]. Sesame, being rich in sulphur-containing proteins, has higher requirements compared to cereals. Thus, adequate sulphur fertilization improves seed yield, oil content and stress tolerance (Patel & Shelke, 1995; Jaggi *et al.*, 2000) [8, 3]. Despite its potential, sesame continues to be managed with low and imbalanced fertilizer inputs, contributing to suboptimal yields. Hence, there is a research gap in developing integrated nutrient management practices combining NPK, organic manures, biofertilizers and sulphur to enhance productivity, oil quality and sustainability in sesame cultivation.

Materials and Methods

The experiment was concluded during *kharif* season of 2024 at Agricultural Research Farm, School of Agriculture, Suresh Gyan Vihar University, Jaipur, Rajasthan. The soil of the experimental site was sandy in texture, slightly alkaline in reaction (pH 8.1), low in organic carbon (0.27%), low in available nitrogen (137.8 kg ha^{-1}), medium in available phosphorus (16.3 kg ha^{-1}), high in available potassium (250.12 kg ha^{-1}) and deficient in available sulphur (0.59 ppm). The experiment was laid out in a factorial randomized block design with three replications, comprising 16 treatment combinations of four fertility levels (control, 50% RDF, 75% RDF and 100% RDF) and four sulphur levels (0, 20, 40 and 60 kg ha^{-1}). The gross and net plot sizes were 4.0 × 3.0 m and 3.0 × 1.8 m, respectively, with a spacing of 30 × 10 cm and the sesame variety RT-351 was used at a seed rate of 2.5 kg ha^{-1}. The recommended dose of fertilizer NPK (40:30:20 kg ha^{-1}) was supplied through urea, DAP and MOP, with half of nitrogen applied as basal along with the full dose of phosphorus, potassium and sulphur and the remaining nitrogen top-dressed at 30 DAS. FYM @ 10 t ha^{-1} was applied uniformly during field preparation and seeds were treated with Thiram @ 2 g kg^{-1} before sowing. Standard agronomic practices such as gap filling, thinning, weeding, irrigation and plant protection were carried out as required.

Plant height was recorded from five randomly selected plants in the net plot area, which were permanently tagged. Measurements were taken from the ground level to the top of the plant at 30, 60 DAS and at harvest and the average was expressed in cm. Dry matter accumulation was estimated from five randomly sampled plants per plot at the same intervals. The plants were cut at ground level, chopped into small pieces and oven-dried at 65°C until a constant weight was attained; the mean dry weight was then calculated and expressed as g plant^{-1}. Yield attributes were assessed at maturity, where the number of capsules plant^{-1} was counted from the tagged plants, the number of seeds capsule^{-1} was recorded from ten randomly selected capsules and test weight was determined by recording the weight of 1000 well-dried seeds per treatment.

Results and Discussion

Growth Attributes

Plant height of sesame increased significantly with fertility levels and sulphur application (Table 1). At harvest, the maximum plant height (112.23 cm) was recorded with 100% RDF, which was 8.7% higher than the control (102.42 cm). Similarly, sulphur application up to 60 kg ha^{-1} recorded the highest plant height (112.42 cm) compared with 102.49 cm under no sulphur, showing an improvement of 8.8%. The increase can be ascribed to better nutrient availability, especially nitrogen, which promoted cell elongation and vegetative growth. Similar findings were reported by Shehu *et al.* (2010) [11], who observed that higher N levels improved plant height in oilseed crops. Dry matter accumulation followed a similar trend, with 100% RDF recording 15.22 g plant^{-1}, significantly higher than the control (9.71 g plant^{-1}). Sulphur application also improved dry matter production from 11.80 g plant^{-1} at control to 13.58 g plant^{-1} at 60 kg ha^{-1}. The positive effect of sulphur may be linked to its role in chlorophyll formation and protein synthesis, leading to higher biomass production (Ajai Singh *et al.*, 2000) [1]. These results agree with Patel & Shelke (1998) [8], emphasing that adequate N and S improve nutrient assimilation and carbohydrate synthesis, thus resulting in greater biomass. The number of branches plant^{-1} was also improved by nutrient application. The highest branches (2.46 plant^{-1}) were obtained under 100% RDF, compared with only 1.91 plant^{-1} in the control, registering a 22.4% increase. With sulphur, branches increased from 1.99 to 2.41 plant^{-1}, reflecting a gain of 17.4%. Branching is a function of better nitrogen nutrition, which stimulates cytokinin activity and promotes lateral bud differentiation. These observations are consistent with Vaishnav *et al.* 2024 [14]. Chlorophyll content also improved with fertility and sulphur, rising from 2.76 mg g^{-1} in control to 3.09 mg g^{-1} with 100% RDF and from 2.75 to 3.03 mg g^{-1} with sulphur, indicating enhanced photosynthetic activity. The rise in chlorophyll content can be attributed to nitrogen's direct role in chlorophyll biosynthesis and sulphur's role in stabilizing chloroplast proteins. These findings corroborate with earlier reports by Shehu *et al.* (2010) [11] and Vaishnav *et al.* (2024) [14], they distinguished that improved chlorophyll levels under adequate nutrient supply translated into higher assimilation rates and crop vigor.

Yield Attributes

Yield contributing traits such as capsules plant^{-1}, seeds capsule^{-1} and test weight were significantly influenced by fertility and sulphur levels (Table 2). The maximum number of capsules plant^{-1} (33.05) was observed with 100% RDF, whereas the control produced only 25.47 capsules, showing a relative increase of 22.9%. Likewise, sulphur application increased capsules plant^{-1} from 27.72 at control to 30.91 at 60 kg S ha^{-1} (and10.3%). The increase in capsule formation may be attributed to improved nutrient supply, particularly phosphorus, which is vital for reproductive growth. The number of seeds capsule^{-1} also improved markedly, rising from 40.03 in control to 59.17 with 100% RDF and from 46.88 to 52.96 with sulphur application. This improvement suggests that balanced fertilization enhanced pollination efficiency and seed setting. The role of phosphorus and sulphur in energy transfer and enzymatic processes has been well established, with similar outcomes demonstrated in sesame by Parmar *et al.* (2018) and Thentu *et al.* (2014) [13], where the application of sulphur improved reproductive efficiency and seed development in oilseed crops. Test weight followed a similar pattern, with the maximum test weight (3.11 g) recorded under 100% RDF compared with 2.81 g in the control. Sulphur application also raised test weight from 2.79 g at control to 3.15 g at 60 kg S ha^{-1}. The improvement may be linked to enhanced assimilate translocation and greater accumulation of seed reserves under balanced fertilization. Parallel trends have been noted by Raja *et al.* (2007) [10].

Yield

Seed yield of sesame was markedly influenced by fertility and sulphur application (Table 3). The maximum seed yield (933 kg ha^{-1}) was obtained with 100% RDF, which was 31.4% higher than the control (640 kg ha^{-1}). Sulphur application also increased seed yield from 696 kg ha^{-1} at control to 889 kg ha^{-1} at 60 kg S ha^{-1}, representing a gain of 21.7%. The increase in yield can be attributed to the significant improvement in yield attributes such as capsules plant^{-1}, seeds capsule^{-1} and test weight under balanced nutrient management. These findings are in agreement with Jat *et al.* (2017) [7] and Jaishankar & Wahab (2005) [4]. Stalk yield also followed a similar trend, where the highest stalk yield (1989 kg ha^{-1}) was recorded under 100% RDF compared with 1264 kg ha^{-1} in the control, showing an increase of 36.5%. With sulphur, stalk yield rose from 1325 to 1921 kg ha^{-1}, reflecting an improvement of 31.0%. The enhancement in stalk yield could be ascribed to better vegetative growth and dry matter accumulation due to improved nutrient uptake. Similar observations were also reported Mondal (2023) [6], who emphasized that nutrient management enhances both aboveground biomass and photosynthetic efficiency. Consequently, biological yield, being the sum of seed and stalk yield, was significantly influenced by treatments. The highest biological yield (2922 kg ha^{-1}) was registered under 100% RDF, while the control recorded only 1905 kg ha^{-1}, reflecting a 34.8% improvement. Sulphur application also improved biological yield from 2021 to 2810 kg ha^{-1} (and28.1%). This confirms the synergistic effect of NPK and sulphur, which ensures balanced nutrient uptake and higher assimilate production for both seed and biomass yield. Harvest index, however, remained almost unaffected by fertility levels, while with sulphur it declined slightly from 34.96% without sulphur to 31.90% at 60 kg ha^{-1}, indicating proportionally greater vegetative growth relative to seed yield. A similar decline in HI under high sulphur application was noted by Ibrahim *et al.* (2014) [2], suggesting that while sulphur enhances biomass, a part of it is more directed towards vegetative rather than reproductive structures. Nevertheless, the overall improvement in absolute yield highlights the importance of balanced fertilization for sesame productivity.

Table 1: Effect of fertility levels and sulphur application on growth attributes of sesame

Treatments	Plant height (cm)			Dry matter accumulation (g plant^{-1})			Total no. of branches plant^{-1}	Chlorophyll content (mg g^{-1}) at 40 DAS
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest		
Fertility levels								
Control	25.93	76.52	102.42	0.62	3.81	9.71	1.91	2.76
50% RDF	28.32	83.77	108.65	0.74	4.80	11.48	2.19	2.88
75% RDF	30.94	85.47	110.12	0.78	5.92	13.75	2.37	2.93
100% RDF	32.94	88.43	112.23	0.81	7.03	15.22	2.46	3.09
S.Em±	0.67	1.80	2.46	0.01	0.14	0.26	0.05	0.07
CD (P=0.05)	1.93	5.21	7.10	0.04	0.41	0.75	0.15	0.19
Sulphur application								
Control (kg ha^{-1})	26.76	78.20	102.49	0.68	4.79	11.80	1.99	2.75
20 (kg ha^{-1})	28.87	82.79	108.00	0.74	5.07	12.17	2.19	2.93
40 (kg ha^{-1})	30.46	86.20	110.51	0.76	5.63	12.61	2.33	2.95
60 (kg ha^{-1})	32.03	87.00	112.42	0.77	6.07	13.58	2.41	3.03
S.Em±	0.67	1.80	2.46	0.01	0.14	0.26	0.05	0.07
CD (P=0.05)	1.93	5.21	7.10	0.04	0.41	0.75	0.15	0.19
CV (%)	7.84	7.48	7.86	6.41	9.04	7.20	8.25	7.86

Table 2: Effect of fertility levels and sulphur application on yield attributes of sesame

Treatments	Number of capsules plant^{-1}	Number of seeds capsule^{-1}	Test Weight (g)
Fertility levels			
Control	25.47	40.03	2.81
50% RDF	27.76	47.50	3.01
75% RDF	30.54	52.83	3.04
100% RDF	33.05	59.17	3.11
S.Em±	0.59	1.03	0.05
CD (P=0.05)	1.71	2.96	0.15
Sulphur application			
Control (kg ha^{-1})	27.72	46.88	2.79
20 (kg ha^{-1})	28.62	49.22	2.98
40 (kg ha^{-1})	29.57	50.47	3.05
60 (kg ha^{-1})	30.91	52.96	3.15
S.Em±	0.59	1.03	0.05
CD (P=0.05)	1.71	2.96	0.15
CV (%)	7.03	7.13	6.02

Table 3: Effect of fertility levels and sulphur application on yield of sesame

Treatments	Seed yield kg ha^{-1}	Stalk yield kg ha^{-1}	Biological yield kg ha^{-1}	Harvest Index
Fertility levels				
Control	640	1264	1905	34.10
50% RDF	793	1602	2395	33.40
75% RDF	881	1864	2746	32.18
100% RDF	933	1989	2922	32.03
S.Em±	17	43	45	0.79
CD (P=0.05)	50	124	131	NS
Sulphur application				
Control (kg ha^{-1})	696	1325	2021	34.96
20 (kg ha^{-1})	794	1658	2452	32.50
40 (kg ha^{-1})	868	1816	2684	32.34
60 (kg ha^{-1})	889	1921	2810	31.90
S.Em±	17	43	45	0.79
CD (P=0.05)	50	124	131	2.29
CV (%)	7.46	8.82	6.30	8.32

Conclusion

The experiment conducted at School of Agriculture, Suresh Gyan Vihar University, Jaipur demonstrated that fertility and sulphur application had a significant impact on the growth, yield attributes and productivity of sesame. The treatment 100% RDF combined with 60 kg S ha^{-1} proved superior, producing the highest seed yield of 933 kg ha^{-1} in the test variety RT-351. Enhanced plant vigour, greater capsule formation, improved seed setting and superior seed weight under the above treatment highlighted the importance of balanced NPK fertilization along with sulphur for maximizing sesame productivity under the agro-climatic conditions of Rajasthan.

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