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Effect of Sulfur Levels on Two Sesame (*Sesamum indicum* L.) Varieties under Climatic Conditions of Pakistan

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Authors' contributions

This work was carried out in collaboration between all authors. Author MT was the chief Investigator. He designed the project. Author MAI collected useful data and helped to finalize and submit the manuscript provided the literature cited. Authors MT, ST and AA helped in analyzing the quality parameters. Authors AT and HR were involved in field trials, data analysis and critically reviewed the manuscript and the experimental design. All authors read and approved the final manuscript

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ABSTRACT

Present study was carried out at Agronomic Research Area, University of Agriculture Faisalabad during summer season, 2011 to determine the best variety and optimum sulfur level to get higher yield of sesame crop. The experiment was laid out in randomized complete block design (RCBD) with factorial arrangement. The experiment comprised of; two varieties, (TH-6, T-89) and six sulfur levels (0, 10, 20, 30, 40 and 50 kg ha-1). It has been observed that the variety TH-6 was more responsive to the sulfur application than the variety T-89. The collected data showed that variety V1 (TH-6) gave significantly maximum number of seeds plant-1, number of capsules plant-1, 1000-seed weight, seed yield, oil content and protein content. Similarly, the sulfur level S6 (when 50 kg sulfur was applied) gave significantly maximum plant height, number of capsules per plant, number of seeds per capsules, 1000-seed weight, seed yield and oil content of sesame. For obtaining higher yield and good nutritional value, sulfur fertilizer should apply at the rate of

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50 kg ha-1 and the variety TH-6 should grow under the irrigated condition of Faisalabad.

Keywords: Sulfur; Variety; Sesame; level; seed.

1. INTRODUCTION

Sesame (*Sesamum indicum* L.) family Pedaleaceae is the most ancient oil seed crop of the world. Simsim, Biniseed, Gingly, Till and Gergelim are the different names of Sesame in the world. It is called the “Queen of the Seeds”. Due to the presence of stable unsaturated fatty acid which causes resistance to rancidity, its seeds are called “Seeds of Immortality”. Among the oil seed crops, sesame has the highest oil content of 46-64% with 25% protein [1]. Area and production of sesame in 2010-11 was 93.4 thousand hectares and 42.8 thousand tons respectively, with average yield of 456 kg per hectare [2]. Our average yield is very low than the production in developed countries like U.S.A, Mexico and Egypt. So the gap of yield should be filled to save revenue which is used to import the edible oil. This can be achieved by optimizing the fertilizer level which is one of the major yields controlling factors [3].Pakistan is suffering from acute deficiency in edible oil because of its increased consumption. Available edible oil in Pakistan was about 2.821 million tons. Domestic end product of edible oil remained at 0.68 million tons, that is 24 % to the total value of the oil that is available to the country. The left over 76 percent was made available through imports [4].Sesame is grown in tropical and subtropical region of the world. Its seeds are rich source of food, nutrition, edible oil, health care and bio medicine [5].Numerous wild relatives occur in Africa and a smaller number in India. It is widely naturalized in tropical regions around the world and is cultivated for its edible seeds, which grow in pods. Sesame seed is considered to be the oldest oilseed crop known, domesticated well over 5000 years ago. Sesame is very drought-tolerant. It has been called a survivor crop, with an ability to grow where most crops fail. TH-6 and T-89 sesame varieties of AARI (Pakistan) not only give high yields but are also disease-resistant as compared to other varieties. Both are erect type having pods on single stem [6].

Oilseed crops are particularly sensitive to sulfur deficiency because it has a high demand for sulfur for example, oilseed crops produces seeds with a high yield of protein with relatively large quantities of S-containing amino acids [7]. Sulfur plays diverse important roles for the synthesis of many proteins as well as in catalytic or electrochemical functions of bio molecules in the cells [5]. In recent times, it has been observed that lower sulfur release to the atmosphere, lowers the quantity of sulfur in soil and caused sulfur deficiency for crop plants. It has long been identified that in region where sulfur lacking soil occurs, legumes, especially pulses are mainly responsive to sulfur containing fertilizers and that necessary sulfur or sulfates increase the fraction of nitrogen available to plant as well as yield on such deficient soils [8]. However, until 15 years ago there was little known for sulfur deficiency, even though the capacity of soil to hold on and to release sulfur to crops is minute and the input of high analysis through sulfur containing fertilizers increased and the SO_2 emission from industrial sources were reduced. Now areas of sulfur deficiency are becoming extensive throughout the world [9]. Sulfur containing secondary product often have a typical smell and are considered only as defensive compound against herbivores and pathogenic micro-organisms but also as signaling element for basic cellular molecules [10].

Present study was under taken to trace the best level of sulfur for the improvement of yield and quality of sesame.

2. MATERIALS AND METHODS

Experiment was carried out in three replications by the use of randomized complete block design (RCBD) with factorial arrangement. The climate of the region is sub-tropical to semi-arid. The experimental area is located at 73 ^{0} East longitude, 31 ^{0} North latitude and at an altitude of 135 meters. 50 Kg N/ha and 60kgP/ha was applied in research trail.Ammonium sulphate used as a source of sulphur. Nitrogen received from ammonium sulphate was excluded and remaining nitrogen was applied from urea and SSP (Single Super Phosphate) was used as source of phosphorous. The amount of sulphur as Gypsum added through SSP was also added in control treatment to nullify the effect of Sulphur in fertilized treatment. Detail of fertilizer calculation is as under:

Sr #	Treatments Sulphur Kg/ha	Ammonium Sulphate applied to obtain required Sulphur Level Kg/ha	Amount of N obtain from Ammonium Sulphate	Amount of N required from Urea (46%)	Amount of Urea applied to obtain 50 kg N level Kg/ha	Amount of SSP applied to obtain 60 kg P level (46%) Kg/ha
	0	0	0	50	108.7	333.3
	10	41.6	9.2	40.8	88.8	333.3
	20	83.2	18.3	31.7	68.9	333.3
	30	124.8	27.5	22.5	49.0	333.3
	40	166.4	36.6	13.4	29.1	333.3
	50	208.0	45.8	4.2	9.3	333.3

The initial soil analysis showed that soil was sandy clay loam in texture having pH 7.7, available nitrogen (0.41 %) and phosphorus (5.25 ppm) was in deficient condition and sulfur content was 5.5 ppm. Experiment was containing two factors. Factor A: Varieties $V_{1 =}$ TH-6, $V_{2=}$ T-89 and Factor B: Sulfur Levels (kg ha^{-1}) S_1 = Control (0), S_2= 10, S_3=20, S_4= 30, S_5= 40, S_6= 50. Net plot size was 5 m x 2.7 m. The plant to plant distance was 10 cm which was maintained by thinning and removing the weak plants by hand. The optimum seed rate 6 kg per ha was applied. The total number of plots was 36. Sulfur was applied as per the treatment to the corresponding plot. The yield and quality attributes which were observed during the experiment includes, plant height at harvest (cm), number of capsules plant^{-1}, number of seed plant^{-1}, 1000-seed weight (g), seed yield (kg ha^{-1}), oil content (%) and protein content (%). Plant height was recorded with the help of meter rod while oil content was measured by Soxhlet apparatus method. Nitrogen content in seed was measured by Kjeldahl's method and protein content was calculated by multiplying the nitrogen content with the factor 6.25.

Data collected on all parameters were analyzed statistically by using Fisher's Analysis of Variance Technique and Least Significant Difference (LSD) test at 5% probability level was employed to compare the treatments' means [11].

RESULTS AND DISCUSSION

Data (Table 1 & 2) depicted that varieties had non-significant effect on plant height. Sulfur levels showed highly significant effect on plant height. Significantly maximum plant height (130.4 cm) was observed where 50 kg sulfur ha^{-1}applied; however, this treatment was statistically at par to S_5 and S_4, respectively. Significantly minimum plant height (118.5 cm) was obtained when no sulfur applied. This increase in plant height might be due to interaction of sulfur with nitrogen which enhanced the vegetative growth of the plant. These results were supported by the findings of [12] who stated that optimum level of sulfur significantly enhanced the plant height, this significant effect might be due to increase in chlorophyll content which leads to maximum plant growth. Two way interactive effects of varieties and different sulfur levels was also non-significant.

Data (Table 1 & 2) showed that significantly maximum number of capsule per plant (25.9) was observed in V_1 (TH-6) followed by V_2 with 25.1 capsule per plant. The increase in number of capsule per plant might be due to genetic potential of the cultivar and the environmental factors. These results were supported by the [13] who reported the similar findings. Different Sulfur levels showed highly significant effect on number of capsule per plant as shown in the table. Significantly maximum number of capsule per plant (26.68) was observed where 50 kg sulfur applied. This value is statistically at par (26.5, 25.8) to the treatments where 40 and 30 kg sulfur ha^{-1} applied, respectively. Significantly minimum number of capsules per plant (24.2) was calculated when no sulfur was applied. The increase in number of capsules per plant might be due to the increase in the photosynthetic activity of the plant and maximum crop growth rate. These finding are supported by [14] who reported the similar results. Two way table depicted that the interaction between varieties and different sulfur levels was non-significant.

Data (Table 1 & 2) revealed that two varieties showed highly significant effect on number of seeds per plant. Significantly maximum number of seeds per plant (1020.6) was observed in V_1 (TH-6). Significantly minimum value (886.6) was seen in V_2 (TH-6). This was might be due to some genetic potential. Different Sulfur levels had highly significant effect on number of seeds per plant. It was clear from the data that significantly maximum number of seeds per plant (1088.4) was observed where 50 kg sulfur ha^{-1}applied. This was statistically at par (1050.2) to the treatment where 40 kg sulfur ha-^{1} was applied. Significantly minimum number of capsules per plant (829.3) was calculated when no sulfur was applied. These significant findings are the results of better crop growth, higher chlorophyll contents and better light interception. These findings are supported by [15]. The table depicted that the interaction between varieties and different sulfur levels was non-significant.

Data (Table 1 & 2) revealed that varieties had significant effect on 1000-seed weight (g). Significantly maximum 1000-seed weight (3.7 g) was observed in V_1 (TH-6) followed by (3.7 g) in V_2 (T-89). The increase in 1000-seed weight might be due to more seed formation and more storage of nutrients in the seed. The same findings was observed by [16] in which he concluded that different varieties showed different 1000-seed weight (g). Different Sulfur levels showed highly significant effect on 1000-seed weight (g) as shown in the data. It is clear from the table that significantly maximum 1000-seed weight (4.21 g) was observed when 50 kg sulfur ha^{-1} (S_6) was applied. Significantly minimum 1000-seed weight (3.3 g) was calculated when no sulfur was applied (S_1). The increase in 1000-seed weight might be due to rule of sulfur in activating the growth and yield components. [15] Performed an experiment in which they concluded that as the sulfur level increased the 1000-seed eight is increased in sesame. The data elucidated that the interaction between varieties and different sulfur levels was non-significant.

Data (Table 1 & 2) showed that varieties had highly significant effect on seed yield. Significantly maximum seed yield (814.7 kg ha^{-1}) was observed in V_1 variety (TH-6). Significantly minimum seed yield (647.8 kg ha^{-1}) was seen in V_2 variety (T-89). The increase in seed yield might be due to genetic differences of the varieties [17] performed an experiment in which they concluded that different varieties showed different seed yield. Sulfur levels showed highly significant effect on seed yield. It is clear from the data that significantly maximum seed yield (948.6 kg ha^{-1}) was observed where 50 kg sulfur ha^{-1} (S_6) was applied. Significantly minimum seed yield (562.2 kg ha^{-1}) was calculated when no sulfur was applied (S_1). The increase in seed yield might be due to the reason that sulfur promotes the photosynthesis, net assimilation rate and crop growth rate which cause the more seed yield. [18] performed an experiment in which they concluded that as the sulfur level increased the seed yield is increased. The table depicted that the interaction between varieties and different sulfur levels was non-significant.

Data (Table 1 & 2) clearly showed that varieties had highly significant effect on oil content. Significantly maximum oil content (49.9%) was observed in V_1 variety (TH-6). Significantly minimum oil content (48.7%) was seen in V_2 variety (T-89). The increase in oil content might be due to more fatty acid composition. Some varieties have more fatty acid as compared to other and they showed more oil content. The same result was observed by [19]. Significantly maximum oil content (51.7%) was observed where 50 kg sulfur (S_6) ha^{-1} applied. Significantly minimum oil content (47.6%) was calculated when no sulfur was applied (S_1). The increase in oil content might be due to more sulfur storage in the plant. Sulfur is the integral part of the biological molecule like cysteine, methionine and cysteine which cause variation in oil content. [20] concluded that as the sulfur level increased the oil content is increased in sesame. This is because the availability of sulfur enhances the sulfur storage which involve in oil formation. The data depicted that the interaction between varieties and different sulfur levels was non-significant.

Data (Table 1 & 2) showed that varieties had highly significant effect on protein content. Significantly maximum protein content (20.6) was observed in V_1 variety (TH-6). However, significantly minimum value (19.0) was seen in V_2 variety (T-89). The increase in protein content might be due to accumulation of biological molecule like cysteine, methionine and cysteine. The same result was observed by [20] in which he concluded that different varieties showed different protein content. Different sulfur levels showed highly significant effect on protein content as shown in the data. It is clear from the table that significantly maximum protein content (20.9%) was observed when no sulfur (S_1) was applied. This treatment is statistically at par (19.9, 19.9) to the treatments where 10 kg sulfur ha^{-1} (S_2) and 20 kg sulfur ha^{-1} (S_3) were applied respectively. Significantly minimum protein content (19.1%) was calculated when 50 kg sulfur ha^{-1} was applied (S_6). This is because sulfur is the essential component of cysteine, methionine and cysteine which are the protein builder amino acids and as the oil content increase the protein content decrease. [21] findings were in line to this experiment which concluded that as the sulfur level and oil content increased the protein content is decreased in sesame. The data showed that the interaction between varieties and different sulfur levels was non-significant.

Table 1. Analysis of variance

SOV	d.f	Plant height (cm)	Number of capsules per plant	Number of seeds per plant	1000-seed weight (g)	Seed yield (kg per ha)	Oil content (%)	Protein content (%)
Sulfur	5	5.7	0.9	2.5	0.2	66.0	0.7	1.1
Varieties	1	NS	0.5	1.4	0.1	38.1	0.4	0.6
S X V	5	NS	NS	NS	NS	NS	NS	NS

*NS= non-significant, * Significant at 0.05 probability level, ** Significant at 0.01 probability level.*

Table 2. Effect of ammonium sulfate (sulfur) levels and varieties on yield and quality of sesame

	Plant height (cm)	Number of capsules per plant	Number of seeds per plant	1000-seed weight (g)	Seed yield (kg per ha)	Oil content (%)	Protein content (%)
Variety							
TH-6	125.2A	25.9 A	1020.6 A	3.7 A	814.7 A	49.9 A	20.6 A
T-89	124.4 B	25.1 B	886.6 B	3.6 B	647.8 B	48.7 B	19.0 B
LSD	0.6521	0.3765	38.587	0.1358	38.126	0.4230	0.6176
Sulfur levels (kg ha^{-1})							
S_1=0	118.5 D	24.2 C	829.3 D	3.3 E	562.2 E	47.6 D	20.9 A
S_2=10	121.1 CD	24.4 C	861.7 CD	3.4 DE	597.4 E	47.6 D	19.9 AB
S_3=20	123.8 BCD	25.4 B	922.3 BC	3.5 CD	671.1 D	48.3 D	19.9 AB
S_4=30	126.5 ABC	25.8 AB	969.6 B	3.8 BC	751.3 C	49.6 C	19.8 B
S_5=40	128.53 AB	26.5 A	1050.2 A	3.9 B	857.1 B	50.9 B	19.3 B
S_6=50	130.4 A	26.7 A	1088.4 A	4.2 A	948.56A	51.7 A	19.1 B
LSD	5.6664	0.6521	66.834	0.2352	66.035	0.7326	1.0697

Means not sharing the same letters differ significantly at 5% probability.

CONCLUSION

On the basis of one year experiment, it is concluded that sesame variety TH-6 should preferably be grown and ammonium sulfate (sulfur) application should be applied @ 50 kg ha^{-1} under the agro-climatic condition of Faisalabad, Pakistan for obtaining higher yield of good quality.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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