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Effect of fertilizer and sulphur levels on yield and monetary returns of *kharif* sesame (*Sesamum indicum* L.)

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Abstract
An experiment was conducted at College of Agriculture, Pune during *kharif*, 2018. The experiment was laid out in split plot design with four fertilizer levels as main plot treatments viz., (50:00:00, 50:10:10, 50:15:15 and 50:20:20 NPK kg ha^{-1}) and four sulphur levels as subplot treatments viz., 0 kg S ha^{-1}, 10 kg S ha^{-1}, 20 kg S ha^{-1} and 30 kg S ha^{-1} in variety AKT-101. There were sixteen treatment combinations replicated three times. The soil was clayey in texture with pH 7.7 indicating slightly alkaline in reaction. The results revealed that the significantly higher seed and straw yields, as well as quality parameters were obtained at application of fertilizer level 50:20:20 NPK kg ha^{-1} and sulphur level 30 kg ha^{-1}.

Keywords: Sesame, fertilizer, sulphur, yield and monetary returns

Introduction
Sesame is an important oilseed crop in the tropics major source of high quality unique edible oil. India ranks first in area (45%), production (36%) and export (45%) of the sesame in the world. The annual area in India was about 1.95 million hectares and total production was 8.11 lakh tonnes having productivity of 4.15 q ha^{-1} during 2020-21 (Anonymous, 2021) [3]. The area under sesame in Maharashtra was 0.17 million ha with production of 0.74 million tones having productivity of 3.41 q ha^{-1} during 2016-2017 (Anonymous, 2017) [2]. Nitrogen plays a vital role as a constituent of protein, nucleic acid and chlorophyll. It is the essential element required by the plant for their growth and vigour. It is also the most difficult element to manage in a fertilization system. Phosphorus and potassium are among limiting nutrients. Phosphorus is an important plant nutrient which helps in growth and development of plant and ultimately improves crop yield. It involves in many biochemical functions in the physiological system of plant. It is an essential nutrient both as a part of several key plant structure compounds and as catalysis in the conversion of numerous key flower formation and seed production, more uniform and earlier crop maturity, improvements in crop quality and increased resistance to plant diseases. A seed needs enough phosphorus and its deficiency therefore causes shrivelled seed (Troeh and Thompson, 1993) [11]. Potassium is the 'quality element' in crop production. Therefore, an adequate potassium nutrition improves many quality aspects of the crops including oil content in oilseed crops. Sulphur deficiency cause decrease in nitrate reductase activity and in accumulation of chlorophyll, soluble protein, amino acid and sugar (Jamal *et al.*, 2010) [7]. The relationship of N and S in plant metabolism and maximum yield response to these element is achieved when supply of them are balanced in oilseed crops (Fazli *et al.*, 2010) [5]. Sesame nutrition remained very controversial for long time (Okpara *et al.*, 2007) [9]. In most areas, fertilizers are not utilised in sesame hence reduces growth and yield of sesame crop. The lack of nutrients reduces plant growth and affects on yield. The objective of this study was to investigate the effect of different levels of fertilizer and sulphur level application on growth and yield of sesame.
A field experiment was conducted at Agronomy Farm, College of Agriculture, Pune during kharif season of 2018. The experiment was laid out in split plot design with three fertilizer levels viz., four fertilizer levels as F_1- 50:00:00 NPK kg ha^{-1}, F_2 - 50:10:10 NPK kg ha^{-1}, F_3 - 50:15:15 NPK kg ha^{-1}, F_4- 50:20:20 NPK kg ha^{-1} and four sulphur levels S_1- 00 sulphur kg ha^{-1}, S_2 – 10 sulphur kg ha^{-1}, S_3 – 20 sulphur kg ha^{-1} and S_4 – 30 sulphur kg ha^{-1} as sub plot treatments with 16 treatment combinations replicated three times with sesame variety AKT-101. The soil of experimental plot was clayey in texture, neutral to slightly alkaline in reaction (pH 7.7), medium in organic carbon (0.50 %), low in available nitrogen (162.52 kg ha^{-1}), medium in available phosphorus (22.58 kg ha^{-1}), very high in available potassium (383.20 kg

ha^{-1}) and low in available Sulphur (11.74 kg ha^{-1}) as regards to fertility status and the soil of the experiment field was clayey in texture and with reaction of pH 7.7. The gross and net plot sizes were 3.00 x 2.70 m and 2.60 x 1.80 m, respectively. The experimental crop was sown by dibbling at 45×10 cm spacing on 9th July, 2018 and harvested on 13th October, 2018. The half dose of nitrogen (25 kg ha^{-1}) and full dose of phosphorus and potash (as per treatment) were added through urea, DAP and MOP as basal application in each plot. The remaining half dose of nitrogen (25 kg ha^{-1}) was applied at 21 DAS. Elemental sulphur was added 15 days before sowing in each plot as per the treatment. The crop was raised with standard package of practices. At the time of harvesting number of capsules plant^{-1}, weight of capsule^{-1}, seed yield plant-1 (g), seed weight plant^{-1} (g), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) were also recorded. In order to represent the plot, five plants of sesame from each net plot in every net plot were selected randomly for various biometric observations on growth and at harvest studies. The selected five plants were labeled and all biometric observations were recorded. The experimental results were analysed by using Indo Stat Programme.

Result and Discussion

Yield attributing characters

a) Effect of fertilizer levels on Seed, straw and biological yield of sesame: The results pertaining to effect of fertilizer levels on seed, straw and biological yield kg/ha were presented in Table 1. The treatment F4 fertilizer level 50:20:20 NPK kg ha^{-1} recorded significantly more seed yield (909.10 kg ha^{-1}), straw yield (1955.79 kg ha^{-1}), biological yield (2864.90bkg ha^{-1}) by than rest of the fertilizer levels at harvesting of sesame. As per the present finding, yield attributes were significantly increased with increased in fertilizer level. The positive effect of fertilizer dose on yield attributes may be due to the pronounced role of increased fertilizer dose in carbohydrates synthesis, photosynthesis and cell elongation. Similar results were in conformity with the results reported by Patra (2001) [10] and Vaghani *et al.* (2010) [12].

Table 1: Seed, straw yield and biological yield (kg ha^{-1}) of sesame as influenced by different treatments

Treatment		Yield (kg ha^{-1})		
		Seed	Straw	Biological
A. Fertilizer Levels (NPK kg ha^{-1})				
F_1	50:00:00	767.63	1620.37	2387.99
F_2	50:10:10	792.30	1768.52	2560.81
F_3	50:15:15	871.11	1909.79	2780.90
F_4	50:20:20	909.10	1955.79	2864.90
S.Em±		12.30	9.67	15.37
C.D. at 5%		42.58	33.45	53.20
B. Sulphur Levels (kg ha^{-1})				
S_1	00	812.50	1782.58	2595.08
S_2	10	832.31	1802.08	2634.39
S_3	20	835.29	1826.03	2661.32
S_4	30	860.04	1843.78	2703.82
S.Em±		6.77	13.95	14.89
C.D. at 5%		19.75	40.73	41.46
C. Interaction (A×B)				
S.Em±		13.54	27.91	29.78
C.D. at 5%		39.51	81.46	86.91
General Mean		835.03	1813.62	2648.65

Effect of sulphur levels on seed, straw and biological yield of sesame

The results pertaining to effect of sulphur levels on seed, straw and biological yield kg/ha were presented in Table 1. The treatment S_4 sulphur level 30 kg ha^{-1} recorded maximum seed (860.04 kg/ha), straw yield (1843.78 kg/ha) and biological yield (2703.82 kg/ha) than rest of the sulphur level treatments which was at par with treatment S_3 - sulphur 20 kg ha^{-1}. The favourable effect of sulphur in the fruiting of plants is due to beneficial effect of sulphur on metabolites activities therefore synthesize more food material thus, ultimately resulted in greater number of capsules plant^{-1}. Similar results were reported by the earlier research workers Allam (2000) [1] Jadav *et al.* (2010) [6] and Nagavani *et al.* (2001) [8].

Table 2: Interaction effect between fertilizer and sulphur levels on yield attributing characters of sesame at harvest`

Fertilizer levels / Sulphur levels	Yield attributing characters at harvest				
	F_1	F_2	F_3	F_4	Mean
	Weight of capsules plant^{-1} (g)				
S_1 :	110.99	121.25	130.74	141.27	126.06
S_2	113.01	129.80	134.27	138.44	128.88
S_3	118.49	123.62	137.50	145.13	129.96
S_4	114.22	126.21	133.40	144.95	131.18
Mean	114.18	125.22	133.98	142.69	128.96
S.Em±	1.79				
C.D.at 5%	5.23				
	No. of capsules plant^{-1}				
S_1	53.47	53.07	56.20	65.78	57.13
S_2	53.53	55.63	57.30	65.07	57.88
S_3	55.07	55.77	60.40	67.63	59.12
S_4	52.40	54.03	61.40	71.00	59.71
Mean	53.62	54.63	58.83	67.37	58.61
S.Em±	0.96				
C.D.at 5%	2.79				
	Seed yield kg ha ^{1} of sesame				
S_1	777.06	737.18	841.88	893.87	812.50
S_2	762.11	789.88	881.96	895.30	832.31
S_3	764.24	810.54	849.00	917.38	835.29
S_4	767.09	831.58	911.61	929.87	860.04
Mean	767.63	792.30	871.11	909.10	835.03
S.Em±	13.54				
C.D.at 5%	39.51				
	Straw yield kg ha ^{1} of sesame				
S_1	1614.67	1660.97	1887.46	1967.23	1782.58
S_2	1594.02	1782.76	1883.90	1947.63	1802.08
S_3	1637.46	1750.00	1927.35	1989.31	1826.03
S_4	1635.33	1880.34	1940.45	1919.00	1843.78
Mean	1620.37	1768.52	1909.79	1955.79	1813.62
S.Em±	27.91				
C.D.at 5%	81.46				

	Biological yield kg /ha				
S_1	2391.73	2398.15	2729.34	2861.11	2595.08
S_2	2356.12	2572.65	2765.86	2842.92	2634.39
S_3	2401.71	2560.54	2776.35	2906.69	2661.32
S_4	2402.42	2711.92	2852.06	2848.87	2703.82
Mean	2387.99	2560.81	2780.90	2864.90	2648.65
S.Em±	29.78				
C.D.at 5%	86.91				

Interaction effect of fertilizer levels and sulphur levels on yiled attributing characters of sesame: The yield attributes characters viz., weight of capsules per plant and number of capsules per plant, seed, straw and biological yield kg per ha

were significantly influenced due to interaction effect between fertilizer and sulphur levels at harvest (Table 2) The interaction treatment F4 S4 (fertilizer level F_4 50:20:20 NPK kg ha^{-1} with sulphur levels S_4 30 kg ha^{-1}) have reported highest number of capsules per plant (71.00), seed yield (929.87 kg ha^{-1}) at harvest than the rest of interaction treatments. The interaction treatment F4 S3 (fertilizer level F_4 50:20:20 NPK kg ha^{-1} with sulphur levels S_4 20 kg ha^{-1}) have reported maximum weight of capsules per plant (145.13 g), straw yield (1989.31kg ha^{-1}) and biological yield 2906.69) kg ha^{-1} at harvest than the rest of interaction treatments.

Economics of sesame

Gross Monetary returns (ha^{-1}) and Benefit: Cost ratio: The results of gross monetary returns and B : C ratio is presented in Table 3.

Effect of fertilizer levels: Maximum monetary returns (₹ 62,093 ha^{-1}) and net returns (₹ 28,020 ha^{-1}) was obtained with the application of fertilizer dose (50:20:20 kg NPK ha^{-1}) than rest of the treatments. Under different fertilizer levels the benefit: cost ratio was higher (2.06) with the the application of fertilizer dose (50:20:20 kg NPK ha^{-1}) among rest of the treatments.

Effect of sulphur levels: Maximum monetary returns (₹ 58,730 ha^{-1}) and net returns (₹ 29,940 ha^{-1}) was obtained with the application of 30 kg sulphur ha^{-1} as compared to 20, 10 and 0 sulphur kg ha^{-1} which was high over rest of the treatments. Similar findings were reported by Duary and Mandal (2006). Under different sulphur levels treatments, the benefit: cost ratio was higher (2.04) with the application of sulphur @ 30 kg ha^{-1} as compared to 20, 10 and 00 kg sulphur ha^{-1}.

Table 3: Economics of *Kharif* sesame as influenced by different treatments

Treatment	Cost of cultivation (₹ ha^{-1})	Monetary returns (₹ ha^{-1})		B:C Ratio
		Gross	Net	
A. Fertilizer Levels (NPK kg ha^{-1})				
F_1: 50:00:00	28844	52369	23525	1.82
F_2: 50:10:10	29522	54244	24722	1.84
F_3: 50:15:15	29864	59570	29707	1.99
F_4: 50:20:20	30206	62093	31888	2.06
B. Sulphur Levels (kg ha^{-1})				
S_1: 00	28190	55565	27375	1.97
S_2: 10	28390	56872	28482	1.99
S_3: 20	28590	57110	28521	1.99
S_4: 30	28790	58730	29940	2.04
General Mean	29049	57069	28020	1.97

Conclusion

It may be concluded that application of fertilizer dose 50:20:20 NPK kg ha^{-1} and 20 kg sulphur ha^{-1} is beneficial for achieving higher productivity and profitability in sesame during *kharif* season.

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