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Effect of fertilizer and sulphur levels on nutrient uptake, yield and nutrients available in soil of kharif sesame (*Sesamum indicum* L.)

Gaurav Rajendra Birade and VT Jadhav

Abstract
The field experiment on kharif sesame 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 significantly more seed yield (kg ha^{-1}) and straw yield (kg ha^{-1}) was recorded by sulphur level 30 kg ha^{-1} than rest of the sulphur level under study. However, it was at par with sulphur 20 kg ha^{-1}. The fertilizer level F_4 50:20:20 NPK kg ha^{-1} have maximum straw yield plant^{-1}, seed yield kg ha^{-1} at harvest with the same level of sulphur S_4 30 kg ha^{-1}. It was revealed from the uptake of N, P and K in seed and straw was significantly influenced by different sulphur levels. Significantly higher uptake of N, P and K were recorded with application of sulphur 30 kg ha^{-1} than rest of the treatments. It was revealed from the data of available nitrogen, phosphorus and potassium was significantly influenced by different fertilizer levels. The application of fertilizer dose 50:20:20 NPK kg ha^{-1} recorded the lowest available nitrogen, phosphorus and potassium in soil after harvest of sesame. Application of sulphur 30 kg ha^{-1} recorded the lowest available nitrogen, phosphorus and potassium in soil after harvest of sesame.

Keywords: Sulphur and fertilizer levels, nutrient uptake and availability, sesame yield

Introduction
Sesame is an important oilseed crop belonging to the family Pedaliaceae. It is generally photosensitive crop. In Maharashtra, it is mainly grown during kharif season. 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 is the major 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 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 shriveled seed (Troeh and Thompson, 1993) [16]. Potassium is the 'quality element' in crop production. Therefore, it improves many quality aspects of the crops including oil content in oilseed crops. Sulphur plays a remarkable role in protein metabolism. It is required for the synthesis of proteins, vitamins and chlorophyll and also S containing amino acids such as cystine, cysteine and methionine which are essential components of protein (Tisdale *et al*., 1999) [15]. Sulphur plays a vital role in chlorophyll formation (Singh *et al*., 2000) [14] and constituent of a number of organic compounds (Shamina and Imamul, 2003) [13]. Sulphur deficiency cause decrease in nitrate reductase activity and in accumulation of chlorophyll, soluble protein, amino acid and sugar (Jamal *et al*., 2010) [4]. 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) [4]. Sesame nutrition remained very controversial for long time (Okpara *et al*., 2007) [10].

Sesame oil is useful for dry cough, asthama diseases of lungs, burning sensation, diseases of ear and eyes. Recently omega-6 fatty acid desatures also got from sesame which is helpful for heart patients (Jin *et al*., 2001) [8]. 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 effects on yield. Among the agronomic manipulation, proper nutrient management plays a vital role in getting higher yield. Therefore, the present investigation was carried out to find response of different levels of fertilizer and sulphur level application on nutrient uptake and yield of sesame.

Material and Methods

The field experiment was conducted in the field of Agronomy Farm, College of Agriculture, Pune during kharif season of 2018. 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 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 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 nutrient uptake and availability of nutrients in soil estimated and seed 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 of sesame

Effect of fertilizer levels

Significantly more number of seed yield (kg ha^{-1}) and straw yield (kg ha^{-1}) were recorded by fertilizer level 50:20:20 NPK kg ha^{-1} than rest of the fertilizer levels under study. As per the present finding, yield was significantly increased with increased in fertilizer level. The positive effect of fertilizer dose on seed and straw yield may be due to the pronounced role of increased fertilizer dose in carbohydrates synthesis, photosynthesis and cell elongation. Similar results were supported by Patra (2001) [11] and Vaghani *et al.* (2010) [17].

Table 1: Seed and straw yield of sesame as influenced by different treatments

Treatment		Yield plant^{-1} (g)		Yield (kg ha^{-1})	
		Seed	Straw	Seed	Straw
A. Fertilizer Levels (NPK kg ha^{-1})					
F_1	50:00:00	5.02	8.57	767.63	1620.37
F_2	50:10:10	5.29	8.95	792.30	1768.52
F_3	50:15:15	5.49	9.54	871.11	1909.79
F_4	50:20:20	5.77	10.01	909.10	1955.79
S.Em±		0.20	0.05	12.30	9.67
C.D. at 5%		0.60	0.18	42.58	33.45
B. Sulphur Levels (kg ha^{-1})					
S_1	00	5.32	9.07	812.50	1782.58
S_2	10	5.37	9.25	832.31	1802.08
S_3	20	5.42	9.36	835.29	1826.03
S_4	30	5.45	9.41	860.04	1843.78
S.Em±		0.20	0.06	6.77	13.95
C.D. at 5%		0.70	0.16	19.75	40.73
C. Interaction (A×B)					
S.Em±		0.05	0.11	13.54	27.91
C.D. at 5%		0.15	0.32	39.51	81.46
General Mean		5.39	9.27	835.03	1813.62

Effect of sulphur levels

Significantly more seed yield (kg ha^{-1}) and straw yield (kg ha^{-1}) was recorded by sulphur level 30 kg ha^{-1} than rest of the sulphur level under study. However, it was at par with 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 claimed by Allam (2000) [1] Jadav *et al.* (2010) [6] and Nagavani *et al.* (2001) [9].

Table 1 (a): Interaction effect between fertilizer and sulphur levels on seed yield and straw yield kg ha^{1} of sesame at harvest

Fertilizer levels / Sulphur levels	At harvest				
	F_1	F_2	F_3	F_4	Mean
	Seed yield (kg ha^{-1})				
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})				
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				

Interaction effect

The seed yield and straw yield were significantly influenced due to interaction effect between fertilizer and sulphur levels at harvest. The fertilizer level F_4 50:20:20 NPK kg ha^{-1} have maximum straw yield $plant^{-1}$, seed yield kg ha^{-1} at harvest with the same level of sulphur S_4 30 kg ha^{-1}. The fertilizer level F_4 50:20:20 NPK kg ha^{-1} have maximum straw yield kg ha^{-1} at harvest with the same level of sulphur S_3 20 kg ha^{-1}.

Nutrient Uptake of N, P, K and S

Effect of fertilizer levels

The uptake of N, P, K and S in seed and straw was significantly influenced by different fertilizer levels. Significantly higher uptake of N, P, K and S were recorded with application of fertilizer dose 50:20:20 NPK kg ha^{-1} than rest of the treatments (Table 2).

Table 2: N, P, K and S uptake (kg ha^{-1}) by seed and straw of sesame as influenced by different treatments.

Treatments		Nutrient uptake (kg ha^{-1})							
		Seed				Straw			
		N	P	K	S	N	P	K	S
A. Fertilizer Levels (NPK kg ha^{-1})									
F_1	50:00:00	23.34	4.78	6.22	0.99	14.41	2.09	24.38	1.77
F_2	50:10:10	24.07	5.13	6.50	1.16	15.93	2.59	26.80	2.24
F_3	50:15:15	26.83	5.97	7.21	1.30	17.19	2.85	29.35	2.47
F_4	50:20:20	28.13	6.51	7.71	1.52	17.93	3.26	30.04	2.87
S.Em±		0.35	0.10	0.11	0.04	0.12	0.07	0.17	0.07
C.D. at 5%		1.21	0.36	0.39	0.15	0.40	0.24	0.59	0.24
B. Sulphur Levels (kg ha^{-1})									
S_1	00	24.89	5.46	6.67	1.20	16.08	2.63	27.03	2.28
S_2	10	25.49	5.59	6.91	1.23	16.23	2.65	27.41	2.29
S_3	20	25.56	5.60	6.93	1.25	16.55	2.72	27.89	2.36
S_4	30	26.43	5.74	7.13	1.30	16.59	2.78	28.24	2.41
S.Em±		0.20	0.05	0.07	0.03	0.14	0.06	0.23	0.06
C.D. at 5%		0.60	0.15	0.21	NS	0.39	NS	0.68	NS
C. Interaction (A×B)									
S.Em±		0.41	0.10	0.15	0.07	0.27	0.21	0.46	0.13
C.D. at 5%		1.20	0.30	NS	NS	0.79	NS	1.35	NS
General Mean		25.59	5.60	6.91	1.24	16.36	2.70	27.64	2.34

Table 2 (a): Interaction effect between fertilizer and sulphur levels on N uptake (kg ha^{-1}) by seed of sesame at harvest.

Fertilizer levels / Sulphur levels	At harvest				
	F_1	F_2	F_3	F_4	Mean
	N uptake (kg ha^{-1}) by seed of sesame at harvest.				
S_1	23.62	22.41	25.90	27.64	24.89
S_2	23.01	23.93	27.19	27.81	25.49
S_3	23.24	24.51	26.17	28.32	25.56
S_4	23.47	25.45	28.05	28.76	26.43
Mean	23.34	24.07	26.83	28.13	25.59
S.Em±	0.41				
C.D.at 5%	1.20				
	P uptake (kg ha^{-1}) by seed of sesame at harvest.				
S_1	4.95	4.72	5.72	6.43	5.46
S_2	4.80	5.13	5.97	6.45	5.59
S_3	4.66	5.27	5.86	6.61	5.60
S_4	4.73	5.38	6.32	6.54	5.74
Mean	4.78	5.13	5.97	6.51	5.60
S.Em±	0.10				
C.D.at 5%	0.30				

Table 2 (b): Interaction effect between fertilizer and sulphur levels on N uptake (kg ha^{-1}) by straw of sesame at harvest.

Fertilizer levels / Sulphur levels	At harvest				
	F_1	**F_2**	**F_3**	**F_4**	**Mean**
	N uptake (kg ha^{-1}) by straw of sesame at harvest				
S_1	14.26	15.06	17.11	17.90	16.08
S_2	14.07	16.11	16.95	17.79	16.23
S_3	14.63	15.64	17.48	18.43	16.55
S_4	14.66	16.92	17.21	17.59	16.59
Mean	14.41	15.93	17.19	17.93	16.36
S.Em±	0.27				
C.D.at 5%	0.79				
	K uptake (kg ha^{-1}) by straw of sesame at harvest				
S_1	24.16	25.03	28.82	30.10	27.03
S_2	23.97	26.86	29.02	29.80	27.41
S_3	24.62	26.55	29.49	30.90	27.89
S_4	24.75	28.77	30.07	29.36	28.24
Mean	24.38	26.80	29.35	30.04	27.64
S.Em±	0.46				
C.D.at 5%	1.35				

Effect of sulphur levels

It was revealed from the data presented in table 2 that uptake of N, P and K in seed and straw was significantly influenced by different sulphur levels. Significantly higher uptake of N, P and K were recorded with application of sulphur 30 kg ha^{-1} than rest of the treatments.

Interaction effect

The N and P uptake in seed and N and K uptake in straw was significantly influenced due to interaction effects between fertilizer and sulphur levels at harvest. The fertilizer level F_4 50:20:20 NPK kg ha^{-1} have highest N uptake in seed with the same level of sulphur S_4 30 kg ha^{-1}. The fertilizer level F_4 50:20:20 NPK kg ha^{-1} have highest N and K uptake in straw and P uptake in seed with the same level of sulphur S_3 20 kg ha^{-1}.

Available nitrogen, phosphorus, potassium and sulphur in soil after harvest

Effect of fertilizer levels

It was revealed from the data that the available nitrogen, phosphorus and potassium was significantly influenced by different fertilizer levels. The application of fertilizer dose 50:20:20 NPK kg ha^{-1} recorded the lowest available nitrogen, phosphorus and potassium in soil after harvest of sesame. Similar results were supported by Hanumanthappa and Dalavai (2008) [5].

Effect of sulphur levels

It was revealed from the data that the available nitrogen, phosphorus, potassium and sulphur was not statistically influenced by different sulphur levels. Application of sulphur 30 kg ha^{-1} recorded the lowest available nitrogen, phosphorus and potassium in soil after harvest of sesame. Similar results were supported by Sangale and Sonar (2004) [12].

Interaction effect

The interaction effect between different fertilizer and sulphur levels on available nitrogen phosphorus, potassium and sulphur of soil after harvest of sesame was found non-significant.

Table 3: Available N, P, K and S in soil after harvest of Kharif sesame as influenced by different treatments.

Treatment	Available nutrients (Kg ha^{-1})			
	N	**P**	**K**	**S**
Initial	162.52	22.58	383.20	11.74
A. Fertilizer Levels (NPK kg ha^{-1})				
F_1: 50:00:00	154.14	21.31	373.85	9.68
F_2: 50:10:10	150.34	20.81	371.07	9.15
F_3: 50:15:15	146.82	20.34	368.43	8.82
F_4: 50:20:20	144.10	19.44	366.68	8.51
S.Em±	1.11	0.31	1.06	0.24
C.D. at 5%	3.84	1.07	2.95	NS
B. Sulphur Levels (kg ha^{-1})				
S_1: 00	149.62	20.49	371.38	9.04
S_2: 10	149.09	20.45	370.68	8.98
S_3: 20	148.98	20.36	369.98	8.73
S_4: 30	147.69	20.60	369.19	8.39
S.Em±	1.41	0.39	0.92	0.18
C.D. at 5%	NS	NS	NS	NS
C. Interaction (A×B)				
S.Em±	2.82	0.36	0.61	0.35
C.D. at 5%	NS	NS	NS	NS
General Mean	148.85	20.48	370.01	9.04

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