# Influence of sulphur and bio-regulators on growth, yield and oil content of cumin (*Cuminum cyminum*)

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### ABSTRACT

Sulphur and bio-regulators influence various physiological and biochemical activities inside the plant. The present study aimed to evaluate the effect of sulphur and bio-regulators (ascorbic acid, thioglycolic acid and salicylic acid) on growth, yield and essential oil content in cumin (*Cuminum cyminum* L.). A field experiment was conducted during *rabi* 2013–14, 2014–15 and 2015–16 at Agricultural Research Station, Mandor (Agriculture University, Jodhpur). Factorial randomised block design with three replications was used. Four levels of sulphur (0, 15, 30 and 45 kg/ha) and four sprays of bio-regulators (Ascorbic acid, TGA and salicylic acid) @100 ppm at vegetative and flowering stage were applied. Pooled data revealed that application of sulphur @45 kg/ha significantly increased number of branches/plant, plant height (cm), number of umbels/plant, umbelletes/umbel, seeds/umbellete, test weight and also seed yield over control. Foliar application of bio-regulators @100 ppm at vegetative and flowering stage significantly increased the seed yield and oil content of cumin. The highest net return ₹ 93250 and benefit: cost ratio 3.32) was observed on application of sulphur @45 kg/ha followed by thioglycolic acid (net return ₹ 86120/ha, B:C ratio 3.12). Thus, we can recommend the application of sulphur and TGA bioregulator to the farmers in western arid zone for doubling the farmers' income in a sustainable way.

Keywords: Bio-regulators, Cumin, Net return, Sulphur, Yield

India is the largest producer, consumer and exporter of cumin (Cuminum cyminum L.) in the world. India accounts for 70% of the global cumin production. A total volume of 2.1 lakh tonnes of cumin valued at ₹3225 crore was exported from India in 2019–20 (Spices Board India 2020). It is an important seed spice crop of arid region of Rajasthan and Gujarat. Cumin is grown on 6.76 lakh ha area with an annual production of 3.79 lakh tonnes in Rajasthan with an average productivity of 560 kg/ha (DOA Rajasthan 2019). The climatic conditions prevailing in arid and semi-arid regions of Rajasthan (i.e. moderately cool, dry and frost free winters) are best suited for cumin cultivation. Cumin is a source of carbohydrates, proteins, amino-acids and dietary fibres. Cumin aldehyde, cymene, and terpenoids are the major volatile components in cumin (Bettaieb et al. 2011).

Sulphur is one of the plant nutrients deficient in aridisol of western Rajasthan. Kumar *et al.* (2017) reported that S content in arid soil of western Rajasthan was about 11

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mg S/kg of soil. It has a specific role in the synthesis of amino acids like methionine (20%) and cystine (27%) and synthesis of proteins, chlorophyll and oil. Foliar application of bio-regulators acts as a powerful tool in enhancing the growth, productivity, quality and also in combating the ill effects generated by various biotic and abiotic stresses in plants. These bio-regulators also improve the physiological and metabolic activities of plants and enhance the flowering efficiency in the plants (Sumeriya et al. 2000). Some researchers reported that foliar application of bio-regulators enhances the dry matter and numbers of umbels per plant, resulting in higher seed yield (Gour et al. 2012). Thioglycolic acid (TGA) is also a sulphuric compound. It contains both thiol (mercaptan) and carboxylic acid. Bioregulators improve drought tolerance of plants because of the unique role of sulphydryl group in photosynthesis and dry matter partitioning (Sahu et al. 1991). The objective of this study was to assess the effect of sulphur and bio-regulators on seed yield and quality of cumin.

### MATERIALS AND METHODS

Soil characterization: The three primary elements (N, P, K) present in soil were analysed by using alkali potassium permanganate method (Subbiah and Asija 1956), Olsen method (Olsen 1954) and flame photometer method (Standfold and English 1949), respectively. The

pH (Singh et al. 1999a) and organic carbon (Walkley and Black 1934) were also measured. Besides, the available sulphur in soil was determined by using CaCl<sub>2</sub>-extractable S method (Williams and Steinbergs 1969). The soil of experimental area was slightly alkaline in reaction (pH 7.45). Organic carbon content was 0.43%. The available nitrogen, phosphorus and potassium content were 184 kg/ha, 7.5 kg/ha and 260.6 kg/ha, respectively. Besides, available sulphur content was 9.24 mg S/kg of soil.

A field experiment was conducted during *rabi* 2013–14, 2014–15 and 2015–16 at Agricultural Research Station, Mandor (Agriculture University, Jodhpur) to study the effect of different doses of sulphur and bio-regulators @100 ppm on seed yield and quality of cumin. Factorial randomised block design with three replications was used to design field experiment. Fig 1 shows weather parameters during crop season. In the study, four levels of sulphur (0, 15, 30 and 45 kg/ha) and four sprays of bio-regulators (Ascorbic acid, TGA and salicylic acid) @100 ppm at vegetative and flowering stage were applied. Water spray was used

as control treatment. Sowing dates were 18<sup>th</sup> November in 2013, 13<sup>th</sup> November in 2014 and 6<sup>th</sup> November in 2015. Cumin (var GC-4) seeds were sown manually 30 cm apart, two lines per plots; seed rate was 12–15 kg/ha. Plant to plant distance was 7 cm, plot size was 4  $\times$  3 m and total area of plot was 12 m². General recommended dose of nitrogen and phosphorus (30 kg N and 20 kg  $P_2O_5/ha$ ) was applied through Diammonium phosphate (DAP) and urea. Nitrogen was applied in two splits at sowing and first irrigation; whole phosphorus was applied at the time of sowing.

Analyses of plant growth, biomass and yield: The observations on plant height, dry matter accumulation, no. of umbels/plant were recorded manually by randomly selecting five representative plants from each plot of each replication. Yield and yield attributes were also recorded. Harvesting was carried out on 13<sup>th</sup> march in 2014, 15<sup>th</sup> march in 2015 and 8<sup>th</sup> march in 2016. The seed and straw yield was recorded from net plot area of each treatment.

Estimation of volatile oil: The volatile oil in cumin was estimated using Clevenger's apparatus (AOAC 1988).

Calculation of Benefitcost ratio: Economics were also calculated and compared for the selection of superior treatment combination.

Statistical analysis: The mean values of the each year's experimental data of three replications were pooled to obtain pooled mean values, and then statistically analysed by SAS software using oneway analysis of variance (ANOVA).

## RESULTS AND DISCUSSION

Effect of sulphur on plant growth, yield and yield attributes: In present study, application of different doses of sulphur significantly increased the growth and yield parameters, viz. plant height (cm), number of branches/ plant, number of umbels/ plant, number of umbelletes/ umbel, number of seeds/ umbellete and test weight (g) during all three experimental years. Highest plant height was recorded with sulphur @45 kg/ha which was 6.08% higher over the control. Number of branches/plant were significantly increased by the sulphur application

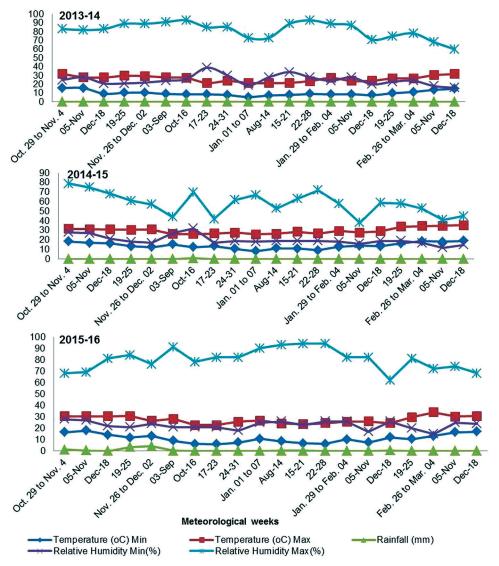


Fig 1 Meteorological parameters during crop season.

@30 kg and 45 kg/ha over the control (Table 1). Application of sulphur @45 and 30 kg/ha significantly increased number of umbels/plant by 17.59 and 14.95%, respectively, over the control. Numbers of umbelletes/umbel were significantly increased by the application of all doses of sulphur over the control but all treatments of sulphur were statistically similar. Test weight of cumin seeds was significantly increased with the application of sulphur @45 kg/ha and per cent increase in test weight was 4.76% over the control. The seed yield of cumin significantly increased with the application of different levels of sulphur over the control (Table 1). Maximum seed yield was recorded with application of sulphur @45 kg/ha followed by sulphur @30 kg/ha during the all three years. The results are in agreement with the study of Solanki et al. (2017) who reported that sulphur fertilization @40 kg/ha increased the plant height, number of branches/plant, number of umbels/plant, test weight, number of seeds/umbellete, and seed yield. The results of Kucha et al. (2019) also revealed that sulphur @40 kg/ha showed significant influence on plant growth and yield of spice crops. Meena et al. (2014) found that application of sulphur up to 40 kg/ha significantly increased plant height, dry matter accumulation/plant, number of branches/plant, number of umbels/plant, umbelletes/umbel, seeds/umbellete, seed, straw and biological yields of coriander over control. Thus, sulphur @40-45 kg/ha may be recommended to farmers to enhance the yield of seed spice.

Effect of sulphur application on oil content in cumin seed: In present study, the highest oil content in cumin

seed was observed with application of 45 kg S/ha which was statistically significant over the control and 15 kg S/ha (Table 1). This application of 45 kg S/ha increased the oil content by 3.11% and 7.37%, respectively, over the control and 15 kg S/ha. Varényiová *et al.* (2017) found maximum oil content in seed rapeseed oil with 40 kg S/ha. Abdulrazaq *et al.* (2018) also used four different levels of sulphur (0, 15, 30 and 45 kg S/ha) in coriander crop and reported that sulphur application @45 kg/ha significantly increased vegetative growth, relative growth rate, seeds/ umbel, seed yield (16.93 q/ha) and essential oil content in seed over control.

Net return and benefit:cost ratio with respect to S application: The highest net return and benefit:cost ratio (₹93250 and 3.32) was observed in sulphur application @45 kg/ha from mean of years. The lowest value of net return and benefit:cost ratio (₹68,480 and 2.75) was observed in control treatment (Table 2). Our results were in close conformity with Patel et al. (2013) in coriander and Verma et al. (2014) in fenugreek.

Effect of bio-regulators on plant growth, yield and yield attributes: In present study, number of umbels/plant were significantly influenced by spray of thioglycolic acid (TGA) at vegetative & flowering stage and increased by 6.92% over the control. Only foliar spray of TGA significantly increased seed yield over the control during mean of experimental years. Pooled data showed that spray of ascorbic acid, TGA and salicylic acid at vegetative and flowering stage significantly increased the seed yield over

Table 1 Effect of sulphur and bio regulators on growth, yield, yield attributes and quality of cumin.

Treatment	*Plant stand ('000/ha)	*Branches/ plant	*Plant height (cm)	*Umbels/ plant	*Umbelletes/ umbel	*Seeds/ umbellete	*Test weight (g)	Seed yield (kg/ha)				*Oil
								2013- 14	2014- 15	2015- 16	Pooled	content (%)
Level of sulphur												
0 kg/ha	477	4.7	29.4	34.1	4.7	5.1	4.2	708	774	998	827	3.39
15 kg/ha	474	4.8	30.4	36.6	4.9	5.2	4.3	775	812	1055	881	3.53
30 kg/ha	482	5.0	30.9	39.2	5.0	5.4	4.4	852	882	1195	976	3.60
45 kg/ha	478	5.0	31.4	40.1	5.0	5.4	4.4	911	896	1267	1025	3.64
SEm±	8.3	0.1	0.3	0.5	0.1	0.1	0.04	25	26	32	13	0.03
CD at 5 %	NS	0.2	1.0	1.5	0.2	0.2	0.13	71	76	94	39	0.09
Bio regulators												
Control (Water spray)	476	4.9	30.3	36.1	4.8	5.2	4.3	774	799	1049	874	3.43
Ascorbic acid (100 ppm)	472	4.8	30.6	37.6	4.9	5.3	4.3	790	840	1142	924	3.53
TGA (100 ppm)	482	4.9	31.0	38.6	4.9	5.3	4.4	853	899	1169	974	3.62
Salicylic acid (100 ppm)	481	4.8	30.2	37.7	4.9	5.3	4.3	829	826	1155	937	3.57
SEm±	8.3	0.1	0.3	0.5	0.1	0.1	0.04	25	26	32	13	0.03
CD at 5 %	NS	NS	NS	1.5	NS	NS	NS	71	76	94	39	0.09
CV (%)	6.0	5.9	3.9	4.8	4.0	4.8	3.5	10.5	10.8	10.0	5.0	2.9

<sup>\*</sup>Pooled data of three years (2013-14 to 2015-16).

Table 2 Effect of sulphur and bio-regulators on economics of cumin#

Treatment	Cost of cultivation (×10 <sup>3</sup> ₹/	Gross returns (×10 <sup>3</sup> ₹/	Net returns (×10 <sup>3</sup> ₹/	B:C ratio
Level of Sulphur	ha)	ha)	ha)	
-	39.14	107.63	68.48	2.75
0 kg/ha	39.14	107.03	00.40	2.73
15 kg/ha	39.81	114.53	74.72	2.88
30 kg/ha	40.02	127.17	87.15	3.18
45 kg/ha	40.24	133.49	93.25	3.32
SEm±	-	-	-	-
CD at 5 %	-	-	-	-
Bio-regulators				
Water spray	39.14	113.66	74.52	2.90
Ascorbic acid (100ppm)	41.16	120.48	79.32	2.93
TGA (100 ppm)	40.54	126.66	86.12	3.12
Salicylic acid (100ppm)	40.39	122.02	81.63	3.02
SEm±	-	-	-	-
CD at 5 %	-	-	-	-

#Values pooled for three years (2013-14 to 2015-16).

the control. Foliar spray of TGA showed more pronounced effect on yield as compared to ascorbic acid and salicylic acid which enhanced the yield by 11.44% over the control (Table 1). Similar types of significant influence of exogenous spray of salicylic acid on growth, yield and essential oil content in fennel were found by Askari and Ehsanzadeh (2015). Present results are in agreement with the study of Meena *et al.* (2014) who found that spray of thiourea and thioglycolic acid increased the dry matter accumulation and translocation in clusterbean. NICRA (2011) reports also indicated that application of thiourea and thioglycolate also significantly influenced the yield of heat stress tolerant varieties of wheat and barley (Venkateswarlu *et al.* 2011).

Effect of bio-regulators on oil content: Oil content was significantly affected by the bio-regulators (Table 1). Foliar spray of TGA, ascorbic acid and salicylic acids significantly increased oil content in cumin over the control. There was no significant difference among the treatments. Highest oil content was recorded with foliar application of TGA. Nasiri and Morshedloo (2018) suggested that application of salicylic acid and ascorbic acid improved the quality and quantity of the essential oil content of dragonhead. Singh et al. (2017) reported that thiourea @100 ppm and salicylic acid application increased protein content and essential oil in seeds of coriander crop. Enhancement of essential oil content by foliar spray of bio-regulators might be due to the increase in nutrient uptake, number of oil glands and biosynthesis of monoterpenes, mono and/or sesquiterpene (Abdou and Mohamed 2014).

Net return and benefit:cost ratio with respect to bio-regulator application: In terms of application of bio-regulators, the highest net return (₹86,120/ha) and benefit:

cost ratio (3.12) was observed with the application of TGA @100 ppm at vegetative and flowering stage. Sulphur application @45 kg/ha showed maximum net return (₹93,250/ha) and benefit:cost ratio followed by TGA application (Table 2). These findings are in agreement with Singh *et al.* (2017) who reported that thiourea @100 ppm and thiourea @500 ppm gave higher seed, straw yield and net return over control. Similar results were also reported by Godara *et al.* (2012) with respect to benefit:cost ratio and net return.

Sulphur and TGA-bioregulator played a crucial role in increasing the growth and seed yield of cumin. The sulphur treatment @ 45 kg/ha was observed to be the more suitable dose for cumin cultivation in western arid zone of Rajasthan, India. Whereas, TGA @100 ppm is significant over the control with respect to seed yield and oil content of cumin. Sulphur treatment @45 kg/ha was economically more feasible as compared to other treatments.

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