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Effect of sources and levels of sulphur on yield and quality of *kharif* soybean [*Glycine max* (L.) Merrill]

Janaki Movalia and SG Savalia

Abstract
A field experiment was conducted at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh to assess the effect of sources and levels of sulphur on nutrient composition, yield and quality of *kharif* soybean [*Glycine max* (L.) Merrill] during two *kharif* seasons (2018-19 and 2019-20). The results revealed that the yield and quality parameters were significantly influenced by the different sources and levels of sulphur. The results of experiment indicated that yield and quality parameters were recorded maximum with application of cosavet fertis at 20 kg S ha^{-1} during both the seasons and also in pooled results.

Keywords: Soybean, sulphur sources, levels, yield, quality

Introduction
Soybean [*Glycine max* (L.) Merrill] is a leguminous crop. It is one of the leading oil and protein containing crop in the world. Soybean has become the miracle crop of the 21st century. It is a triple beneficiary crop, which contains about 40 percent protein, possessing high level of essential amino-acids methionine and cystine, 20 per cent oil rich in poly unsaturated fatty acids especially omega-6 and omega-3 fatty acids, 6-7 per cent total minerals, 5-6 per cent crude fibre and 17-19 per cent carbohydrates (Chauhan *et al.*, 1988) [1]. Besides, it has good amount of iron, vitamin B-complex and isoflavones such as daidzein, genistein of clycitin. Soybean grows in the varied agro-climatic conditions. In recent years, great interest has been evidenced in the cultivation and the use of soybean, mainly on account of its dietic, industrial and agricultural importance. So, it has emerged as an important commercial crop in many countries and international trade of soybean is spread globally (Movalia, 2020) [14].
Sulphur is an essential macronutrient in plant growth and development. Sulphur (S) is now recognized as the fourth major plant nutrient (Tandon, 2004; Morris, 2007) [18, 13]. Sulphur plays key role in protein synthesis, chlorophyll formation and oil synthesis (Tisdale *et al.*, 2002) [19]. Cysteine and methionine are the most important sulphur containing amino acids in plants, where they both occur as free acids and as building blocks of proteins (Mengel and Kirkby, 1996) [10]. Besides it is involved in various metabolic and enzymatic process including photosynthesis, respiration and legume rhizobium symbiotic nitrogen fixation (Rao *et al.*, 2001) [16]. Research evidences revealed that sulphur nutrition is essential in increasing the oil content in soybean (Dixit *et al.*, 2009) [2].

Materials and Methods
A field experiment entitled "Effect of sources and levels of sulphur on nutrient composition, yield and quality of *kharif* soybean [*Glycine max* (L.) Merrill]" was carried out during *kharif* season of the year 2018 and 2019 at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh, Gujarat, India. The experiment was conducted in C-7 plot of Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during *Kharif* season of 2018 and 2019. The soil of experimental site was medium black calcareous soils. The details of the methodology followed during the course of study are as below:

Experimental details
Randomized Block Design having factorial concept with total thirteen treatments replicated thrice was employed in this study. The treatments were assigned to each replication by randomization process. The details about experiment are given below:

1. Design: Randomized Block Design (Factorial)
2. No. of replications: Three
3. Total No. of treatments: Thirteen
4. Total No. of plots: Thirty nine
5. Experimental area: 666.9 m2
6. Plot size: Gross: 5.0 m x 2.70 m
7. Plot size: Net: 4.0 m x 1.8 m
8. Spacing: 45 cm x 10 cm
9. Crop and Variety: Gujarat Junagadh Soybean-3 (GJS-3)
10. Seed rate: 60 kg ha-1
11. Dose of fertilizer: 30-60-0 kg N-P2O5-K2O/ha, where S as per treatment

Details of treatments

The experiment comprising of total twelve treatment combinations in which four sources of sulphur and three levels of sulphur. Absolute control was compared with these combinations in RBD.

(a) Sources of sulphur

(1) S_1 – Gypsum (18-20% S)
(2) S_2 – Cosavet Fertis (80% S)
(3) S_3 – Elemental sulphur (100% S)
(4) S_4 – Bentonite (90% S)

(b) Levels of sulphur

(1) L_1 – 10 kg S/ha
(2) L_2 – 20 kg S/ha
(3) L_3 – 30 kg S/ha

Note

- The crop was fertilized with nitrogen and phosphorus as per recommended dose 30: 60 of N: P_2O_5 kg ha^{-1} and sulphur as per treatment. The required quantities of these nutrients for gross plot area were calculated as per treatment. Nitrogen, phosphorus and sulphur were applied in the form of Urea, DAP, Gypsum, Cosavet, Elemental sulphur and Bentonite respectively. This all nutrients were applied as a basal dose.
- Soybean variety Gujarat Junagadh Soybean -3 was used for sowing with seed rate of 60 kg ha^{-1} on 21st July during 2018 and 25th June 2019. The seeds were placed at of 3-5 cm depth, keeping inter row spacing of 45 cm and covered with the soil.

Treatment Combination

Sr. No.	Treatment
1	Absolute control
2	S_1L_1
3	S_1L_2
4	S_1L_3
5	S_2L_1
6	S_2L_2
7	S_2L_3
8	S_3L_1
9	S_3L_2
10	S_3L_3
11	S_4L_1
12	S_4L_2
13	S_4L_3

Results and Discussion

Seed Yield

Effect of sulphur sources: The results presented in Table 1 clearly showed that different sources of sulphur produced significant effect on seed yield. The application of cosavet fertis (S_2) produced significantly highest seed yield (2323, 2411 and 2367 kg ha^{-1}) as compared to other sources during year 2018, 2019 and pooled result, respectively. It was statistically at par (2200 kg ha^{-1}) with application of bentonite (S_4) during year 2018.Yadav *et al.*, 2018 [24]

Effect of sulphur levels

A significant increase in seed yield was observed under different level of sulphur (Table 1). The significantly the highest seed yield was registered at 20 kg S ha^{-1} (L_2) (2267, 2320 and 2294) during both years and pooled result, respectively. It was found at par (2232, 2291 and 2262 kg ha^{-1}) with sulphur at 30 kg S ha^{-1} (L_3). These results are agreement with reports of Layek *et al.*, (2014) [7].

Interaction effect of sulphur sources and levels

The interaction effect of sulphur sources and their levels on seed yield was found significant (Table 2). The maximum seed yield (2466 and 2421 kg ha^{-1}) was observed under application of cosavet fertis @ 30 kg S ha^{-1} (S_2L_3) recorded during year 2019 and pooled result, respectively (Table 2). It was statistically (2466 kg ha^{-1}) at par under application of gypsum @ 20 kg S ha^{-1} (S_1L_2), cosavet fertis @ 10 and 20 kg S ha^{-1} (S_2L_1 and S_2L_2), elemental sulphur @ 10 and 30 kg S ha^{-1} (S_3L_1 and S_3L_3) and bentonite @ 20 and 30 kg S ha^{-1} (S_4L_2 and S_4L_3) during year 2019. While, application of gypsum with 20 kg S ha^{-1} (S_1L_2), cosavet fertis with 10 and 20 kg S ha^{-1} (S_2L_1 and S_2L_2), elemental sulphur with 30 kg S ha^{-1} (S_3L_3) and bentonite with 20 kg S ha^{-1} (S_4L_2) were found at par in pooled result. Similar, results were also obtained by Verma *et al.*, (2013) [23].

Control V/s rest treatments

The combined application of sulphur sources and levels (Table 2) significantly influenced on seed yield of soybean as compared to control. The seed yield of soybean was significantly higher (2383 kg ha^{-1}) with application of sulphur @ 20 kg ha^{-1} as a source of cosavet fertis at (S_2L_2) during year 2018 and application of cosavet fertis @ 30 kg S ha^{-1} (S_2L_3) produced the highest value of seed yield (2466 and 2421 kg ha^{-1}) during year 2019 and pooled result as compared to control (1928, 1936 and 1932 kg ha^{-1}), respectively. It was remaining at par with application of gypsum @ 20 kg S ha^{-1} (S_1L_2), cosavet fertis @ 10 and 30 kg S ha^{-1} (S_2L_1 and S_2L_3) and bentonite @ 20 and 30 kg S ha^{-1} (S_4L_2 and S_4L_3) during year 2018. The application of gypsum @ 20 kg S ha^{-1} (S_1L_2), cosavet fertis @ 10 and 20 kg S ha^{-1} (S_2L_1 and S_2L_2), elemental sulphur @ 30 kg S ha^{-1} (S_3L_3) and bentonite @ 20 kg S ha^{-1} (S_4L_2) was found at par with application of cosavet fertis at 30 kg S ha^{-1} (S_2L_3) were found during year 2019 and application of gypsum @ 20 kg S ha^{-1} (S_1L_2), cosavet fertis @ 20 kg S ha^{-1} (S_2L_2) and bentonite @ 20 kg S ha^{-1} (S_4L_2) were remaining at par in pooled result.

Straw yield

Effect of sulphur sources

A significant increased in straw yield was observed under different sources of sulphur application (Table 3). The significantly the highest straw yield (2791, 2934 and 2862 kg ha^{-1}) was registered at application of cosavet fertis (S_2) as compared to other sources of sulphur in both years and pooled, respectively. Similar findings reported by Mir *et al.*, (2013) [12].

Effect of sulphur levels

The results presented in Table 3 clearly showed that different levels of sulphur produced significant effect on straw yield. The application of sulphur at 20 kg S ha^{-1} (L_2) produced the highest straw yield (2693 and 2731 kg ha^{-1}) during year 2018 and pooled result, respectively. It was statistically at par (2611 and 2712 kg ha^{-1}) with application of sulphur at 30 kg ha^{-1} (L_3). While, the application of sulphur at 30 kg ha^{-1} (L_3) noted highest straw yield (2813 kg ha^{-1}) and was at par (2770 kg ha^{-1}) with application of sulphur at 20 kg ha^{-1} (L_2) during year 2019. Result confirmed with Singh *et al*., (2013) [17].

Interaction effect of sulphur sources and levels

The combined effect of application of sulphur sources and their levels on straw yield was found significant (Table 4). The application of cosavet fertis @ 20 kg ha^{-1} (S_2L_2) recorded maximum straw yield (3040 kg ha^{-1}) during year 2018 and application of cosavet fertis @ 30 kg ha^{-1} (S_2L_3) produced the highest straw yield (3147 and 2953 kg ha^{-1}) during year 2019 and pooled result, respectively. It was remain at par with application of gypsum with 20 kg S ha^{-1} (S_1L_2) during year 2019. The application of gypsum with 20 kg S ha^{-1} (S_1L_2), cosavet fertis with 20 kg S ha^{-1} (S_2L_2) and elemental sulphur with 20 kg S ha^{-1} (S_3L_2) were remain at par in pooled result. Varun *et al*., (2011) [22]

Control V/s rest treatments

The combined application of sulphur sources and levels (Table 4) significantly influenced on straw yield of soybean as compare to control. The significantly highest straw yield (3040 kg ha^{-1}) was registered with application of cosavet fertis @ 20 kg S ha^{-1} (S_2L_2) during year 2018 and application of cosavet fertis @ 30 kg S ha^{-1} (S_2L_3) produced the highest straw yield (3147 and 2953 kg ha^{-1}) during year 2019 and pooled result over that of control (2190, 2340 and 2265 kg ha^{-1}), respectively. It was found at par with application of cosavet fertis @ 20 kg S ha^{-1} (S_2L_2) in pooled result.

The sulphur fertilization played a vital role in improving the three major aspects of yield determination i.e. formation of vegetative structure, there by photosynthesis strong sink strength through development of reproductive structure and production of assimilates to fill economically important sink. Judicial supply of sulphur along with sources, contributes to better growth, thereby affectively increasing the yields. Thus cumulative influence of S application maintained balance source - sink relationship and ultimately resulted in increased seed yield. Increased straw yield as a result of greater accumulation of dry matter under cosavet as a source of sulphur.

Quality parameter

Protein content (%)

Effect of sulphur sources

The data furnish in Table 5 revealed that the application of different sources of sulphur significantly influenced on the protein content of soybean. Maximum protein content (32.97, 34.59 and 33.78%) was observed with application of cosavet fertis (S_2) during 2018, 2019 and pooled, respectively which was at par (32.32, 33.95 and 33.13%) with application of bentonite (S_3) during 2018, 2019 and pooled, respectively. Tomar *et al*., (2004) [21]

Effect of sulphur levels

The perusal of the data in Table 5 indicated that different level of sulphur produced significant effect on the protein content of soybean. Application of sulphur @ 20 kg ha^{-1} (L_2) sulphur registered the highest (32.72, 34.35 and 33.54%) protein content during 2018, 2019 and pooled results, respectively. These results confirmed with the reports of Mamatha *et al*., (2018) [8].

Interaction effect of sulphur sources and levels

Interation effect of sulphur sources and levels on protein content in soybean was found significant (Table 6). Application of cosavet fertis with 20 kg S ha^{-1} (S_2L_2) recorded significantly the highest value (33.77, 35.40 and 34.59%) of protein content during 2018, 2019 and pooled, respectively. It was statistically at par with application of gypsum with 20 kg S ha^{-1} (S_1L_2), cosavet with 10 and 30 kg S ha^{-1} (S_2L_1 and S_2L_3), elemental sulphur with 20 kg S ha^{-1} (S_3L_2) and bentonite with 10 and 20 kg S ha^{-1} (S_4L_1 and S_4L_2) during 2018 and 2019. While, application of cosavet fertis with 30 kg S ha^{-1} (S_2L_3) and bentonite with 10 and 20 kg S ha^{-1} (S_4L_1 and S_4L_2) remained at par in pooled results. Varun *et al*., (2011) [22].

Control V/s rest treatments

The combined application of sulphur sources with levels (Table 6) significantly influenced the protein content in soybean. Application of cosavet fertis source with 20 kg ha^{-1} (S_2L_2) recorded significantly the highest value (33.77, 35.40 and 34.59%) of protein content during 2018, 2019 and pooled, respectively. It was statistically at par with application of cosavet fertis with 30 kg S ha^{-1} (S_2L_3) and bentonite sulphur with 10 and 20 kg S ha^{-1} (S_4L_1 and S_4L_2) during 2018 and 2019. While, in pooled result it was remain at par with application of cosavet fertis with 30 kg S ha^{-1} (S_2L_3) and bentonite sulphur with 20 kg S ha^{-1} (S_4L_2).

Oil content (%)

Effect of sulphur sources

The data furnished in Table 7 revealed that different sources of sulphur produced significant effect on oil content (%). Application of cosavet fertis (S_2) noted the highest oil content (19.95, 20.24 and 20.09%) during 2018, 2019 and pooled result, respectively followed by (19.59, 19.88 and 19.74%) with application of bentonite (S_4). Similar result obtained by Gokhale *et al*., (2005) [4].

Effect of sulphur levels

A perusal of the data (Table 7) showed that different levels of sulphur produced significant effect on oil content (%). The highest oil content (19.78, 20.07 and 19.92%) was registered with application of sulphur at 20 kg ha^{-1} (L_2) during 2018, 2019 and pooled result, respectively. It was remained at par (19.54, 19.83 and 19.69%) with application of sulphur at 30 kg ha^{-1} (L_3). Meshram *et al*., (2017) [11]

Interaction effect of sulphur sources and levels

The interaction effect of sulphur sources and levels was found non- significant in respect of oil content in soybean (Table 8).

Control V/s rest treatments

The combined application of sulphur sources with levels (Table 8) was found significant in case of oil content in soybean. Application of cosavet fertis with 20 kg S ha^{-1} (S_2L_2) recorded the highest oil content (20.35, 20.64 and 20.50%) as compare to control during 2018, 2019 and pooled result, respectively. It was statistically at par with application of cosavet fertis with 10 and 30 kg S ha^{-1} (S_2L_1 and S_2L_3) and bentonite with 20 kg S ha^{-1} (S_4L_2) during 2018 and 2019. Whereas, application of bentonite with 20 kg S ha^{-1} (S_4L_2) was remain at par in pooled result.

Test weight (g)

Effect of sulphur sources

The data furnish in Table 9 revealed that the application of different sources of sulphur significantly influenced the test weight of soybean. Maximum test weight (10.08, 10.93 and 10.51 g) was observed under application of cosavet (S_2) during 2018, 2019 and pooled, respectively. It was at par (9.73 and 1058 g) with application of bentonite (S_4) during year 2018 and 2019. The results are confirmed the reports of Tomar *et al*., (2004) [21].

Effect of sulphur levels

The result presented in Table 9 showed that test weight was significantly affected by different levels of sulphur. Application of 20 kg S ha^{-1} (L_2) sulphur noted higher (9.91, 10.76 and 10.34 g) test weight during 2018, 2019 and pooled results, respectively. It was found at par with application of 30 kg ha^{-1} (L_2) during year 2018 and 2019. The present findings are in close agreement with Meshram *et al.*, (2017) [11].

Interaction effect of sulphur sources and levels

The interaction effect of sulphur sources and levels on test weight was found significant (Table 10). The highest test weight (11.28, 12.13 and 11.71 g) was recorded under application of cosavet fertis source with 20 kg S ha^{-1} (S_2L_2) during 2018, 2019 and pooled, respectively. Farhad *et al.*, (2010) [3]

Control V/s rest treatments

The combined application of sulphur sources with levels (Table 10) significantly influenced the test weight in soybean. Application of cosavet fertis source with 20 kg S ha^{-1} (S_2L_2) recorded significantly the highest value (11.28, 12.13 and 11.71 g) of test weight over to control during 2018, 2019 and pooled, respectively.

Oil seed crops responsed to liberal application of sulphur because it is involved in the synthesis of fatty acids and also increased protein quality through the synthesis of certain amino acids such as cystine, cysteine and methionine (Havlin *et al.*, 1999) [5]. The beneficial effect of sulphur levels on protein content may be due to increase in cation exchange capacity of the roots which would enable the plant to extract more nutrients from soil (Tomar, 2012) [20].

The increased in oil content with increase in sulphur might be due to the involvement of sulphur in electron- transport chain (Margatham and Chellamuthu, 2000) [9]. The higher oil content might be due to influence of sulphur in rapid conversion of nitrogen to crude protein and finally to oil. The acetic thiolinase, a sulphur based enzyme in the presence of sulphur converts acetyl Co A to melonyl Co-A rapidly resulting in higher oil content (Krishnamurthi and Mathan, 1996 and Nagavani *et al.*, 2001) [6, 15]. Increased in seed weight might be due to higher translocation of plant food material in seed formation with higher availability of plant nutrient under higher level of fertility.

Table 1: Mean effect of sulphur sources and their levels on seed yield of soybean

Treatments	Seed yield (kg ha^{-1})		
	2018	2019	Pooled
Sulphur sources			
S_1 – Gypsum	2172	2205	2189
S_2 – Cosavet Fertis	2323	2411	2367
S_3 – Elemental sulphur	2112	2173	2143
S_4 - Bentonite	2200	2238	2219
S.Em+	49	52	36
C.D. at 5%	145	151	102
Sulphur levels (kg S/ha)			
L_1 – 10	2107	2159	2133
L_2 – 20	2267	2320	2294
L_3 – 30	2232	2291	2262
S.Em+	43	45	31
C.D. at 5%	125	131	88

Table 2: Combined effect of sulphur sources and their levels on seed yield of soybean

Treatments	Seed yield (kg ha^{-1})		
	2018	2019	Pooled
T_1: Control	1928	1936	1932
T_2: S_1L_1	2031	2029	2030
T_3: S_1L_2	2363	2433	2398
T_4: S_1L_3	2124	2154	2139
T_5: S_2L_1	2208	2356	2282
T_6: S_2L_2	2383	2411	2397
T_7: S_2L_3	2377	2466	2421
T_8: S_3L_1	2154	2233	2194
T_9: S_3L_2	1980	1982	1981
T_{10}: S_3L_3	2204	2304	2254
T_{11}: S_4L_1	2033	2017	2025
T_{12}: S_4L_2	2343	2456	2400
T_{13}: S_4L_3	2224	2241	2232

S x L Interaction			
S.Em+	86	89	62
C.D. at 5%	NS	262	176
Control v/s Rest			
S.Em+	61	66	44
C.D. at 5%	178	192	126
C.V. %	9.90	9.02	9.73
Y x T			
S.Em+	85		
C.D. at 5%	NS		

Table 3: Mean effect of sulphur sources and their levels on straw yield of soybean

Treatments	Straw yield (kg ha^{-1})		
	2018	2019	Pooled
Sulphur sources			
S_1 – Gypsum	2579	2711	2645
S_2 – Cosavet Fertis	2791	2934	2862
S_3 – Elemental sulphur	2533	2722	2627
S_4 - Bentonite	2482	2623	2553
S.Em+	53	48	36
C.D. at 5%	154	140	101
Sulphur levels (kg S/ha)			
L_1 – 10	2485	2660	2572
L_2 – 20	2693	2770	2731
L_3 – 30	2611	2813	2712
S.Em+	46	41	31
C.D. at 5%	134	121	88

Table 4: Combined effect of sulphur sources and their levels on straw yield of soybean

Treatments	Straw yield (kg ha^{-1})		
	2018	2019	Pooled
T_1 Control	2190	2340	2265
T_2 S_1L_1	2470	2509	2489
T_3 S_1L_2	2665	2910	2788
T_4 S_1L_3	2601	2714	2658
T_5 S_2L_1	2574	2825	2700
T_6 S_2L_2	3040	2828	2934
T_7 $S2L_3$	2760	3147	2953
T_8 S_3L_1	2348	2620	2484
T_9 S_3L_2	2725	2878	2802
T_{10} S_3L_3	2525	2667	2596
T_{11} S_4L_1	2546	2684	2615
T_{12} S_4L_2	2341	2462	2401
T_{13} S_4L_3	2559	2724	2641
S x L Interaction			
S.Em+	91	83	62
C.D. at 5%	267	243	175
Control v/s Rest			
S.Em+	66	61	44
C.D. at 5%	194	177	126
C.V. %	9.12	9.25	8.97
Y x T			
S.Em+	87		
C.D. at 5%	NS		

Table 5: Mean effect of sulphur sources and their levels on protein content of soybean

Treatments	Protein content (%)		
	2018	2019	Pooled
Sulphur sources			
S_1 – Gypsum	30.88	32.50	31.69
S_2 – Cosavet Fertis	32.97	34.59	33.78
S_3 – Elemental sulphur	30.79	32.41	31.60
S_4 - Bentonite	32.32	33.95	33.13
S.Em+	0.36	0.39	0.26
C.D. at 5%	1.06	1.08	0.73
Sulphur levels (kg S/ha)			

L_1 – 10	30.70	32.32	31.51
L_2 – 20	32.72	34.35	33.54
L_3 – 30	31.79	33.42	32.60
S.Em+	0.31	0.33	0.22
C.D. at 5%	0.92	0.93	0.63

Table 6: Combined effect of sulphur sources and their levels on protein content of soybean

Treatments	Protein content (%)		
	2018	2019	Pooled
T_1: Control	30.40	32.02	31.21
T_2: S_1L_1	29.54	31.17	30.35
T_3: S_1L_2	31.94	33.56	32.75
T_4: S_1L_3	31.15	32.77	31.96
T_5: S_2L_1	32.14	33.77	32.95
T_6: S_2L_2	33.77	35.40	34.59
T_7: S_2L_3	32.99	34.62	33.81
T_8: S_3L_1	28.40	30.02	29.21
T_9: S_3L_2	32.31	33.94	33.13
T_{10}: S_3L_3	31.65	33.28	32.47
T_{11}: S_4L_1	32.72	34.34	33.53
T_{12}: S_4L_2	32.87	34.49	33.68
T_{13}: S_4L_3	31.38	33.00	32.19
S x L Interaction			
S.Em+	0.63	0.65	0.44
C.D. at 5%	1.84	1.87	1.26
Control v/s Rest			
S.Em+	0.46	0.48	0.32
C.D. at 5%	1.34	1.40	0.91
C.V. %	3.42	3.26	3.34
Y x T			
S.Em+	0.62		
C.D. at 5%	NS		

Table 7: Mean effect of sulphur sources and their levels on oil content of soybean

Treatments	Oil content (%)		
	2018	2019	Pooled
Sulphur sources			
S_1 – Gypsum	19.39	19.68	19.54
S_2 – Cosavet Fertis	19.95	20.24	20.09
S_3 – Elemental sulphur	19.09	19.38	19.23
S_4 - Bentonite	19.59	19.88	19.74
S.Em+	0.17	0.19	0.12
C.D. at 5%	0.51	0.62	0.35
Sulphur levels (kg S/ha)			
L_1 – 10	19.20	19.49	19.34
L_2 – 20	19.78	20.07	19.92
L_3 – 30	19.54	19.83	19.69
S.Em+	0.15	0.18	0.11
C.D. at 5%	0.44	0.50	0.30

Table 8: Combined effect of sulphur sources and their levels on oil content of soybean

Treatments	Oil content (%)		
	2018	2019	Pooled
T_1: Control	18.48	18.77	18.63
T_2: S_1L_1	19.28	19.57	19.43
T_3: S_1L_2	19.40	19.69	19.54
T_4: S_1L_3	19.50	19.79	19.65
T_5: S_2L_1	19.72	20.01	19.87
T_6: S_2L_2	20.35	20.64	20.50
T_7: S_2L_3	19.77	20.06	19.92
T_8: S_3L_1	18.66	18.95	18.81
T_9: S_3L_2	19.37	19.66	19.51
T_{10}: S_3L_3	19.23	19.52	19.38
T_{11}: S_4L_1	19.13	19.42	19.28
T_{12}: S_4L_2	19.99	20.28	20.13
T_{13}: S_4L_3	19.66	19.95	19.81

S x L Interaction			
S.Em+	0.30	0.32	0.21
C.D. at 5%	NS	NS	NS
Control v/s Rest			
S.Em+	0.22	0.26	0.15
C.D. at 5%	0.64	0.72	0.43
C.V. %	2.69	2.65	2.67
Y x T			
S.Em+	0.29		
C.D. at 5%	NS		

Table 9: Mean effect of sulphur sources and their levels on test weight of soybean

Treatments	**Test weight (g)**		
	2018	**2019**	**Pooled**
Sulphur sources			
S_1 – Gypsum	9.05	9.90	9.48
S_2 – Cosavet Fertis	10.08	10.93	10.51
S_3 – Elemental sulphur	9.57	10.42	10.00
S_4 - Bentonite	9.73	10.58	10.15
S.Em+	0.16	0.17	0.11
C.D. at 5%	0.45	0.49	0.31
Sulphur levels (kg S/ha)			
L_1 – 10	9.38	10.23	9.80
L_2 – 20	9.91	10.76	10.34
L_3 – 30	9.53	10.38	9.96
S.Em+	0.13	0.15	0.09
C.D. at 5%	0.39	0.42	0.27

Table 10: Combined effect of sulphur sources and their levels on test weight of soybean

Treatments	**Test weight (g)**		
	2018	**2019**	**Pooled**
T_1: Control	8.52	9.37	8.95
T_2: S_1L_1	8.81	9.66	9.23
T_3: S_1L_2	8.82	9.67	9.24
T_4: S_1L_3	9.53	10.38	9.96
T_5: S_2L_1	9.61	10.46	10.03
T_6: S_2L_2	11.28	12.13	11.71
T_7: S_2L_3	9.36	10.21	9.78
T_8: S_3L_1	9.56	10.41	9.99
T_9: S_3L_2	9.71	10.56	10.14
T_{10}: S_3L_3	9.43	10.28	9.86
T_{11}: S_4L_1	9.53	10.38	9.96
T_{12}: S_4L_2	9.84	10.69	10.27
T_{13}: S_4L_3	9.81	10.66	10.24
S x L Interaction			
S.Em+	0.27	0.27	0.19
C.D. at 5%	0.79	0.79	0.54
Control v/s Rest			
S.Em+	0.21	0.21	0.14
C.D. at 5%	0.60	0.60	0.41
C.V. %	4.84	4.45	4.64
Y x T			
S.Em+	0.28		
C.D. at 5%	NS		

Fig 1: Graphical abstract

Declaration of Competing Interest

The authors declare that they have no conflict of interest

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