__Original Research Article__

Effect of Sulphur Sources and Sulphur Oxidizing Bacteria (SOB) on Yield and Quality of Summer Soybean in Junagadh, Gujarat, India

ABSTRACT

Sulphur and sulphur oxidizing bacteria required by oilseed and pulses crop in sulphur deficient soil for maintaining soil fertility and stabilized crop production with this the present experiment was conducted on medium black calcareous soil to study the effect of sulphur sources and sulphur oxidizing bacteria (SOB) on yield, quality of summer soybean and soil nutrient status in FRBD using three replications during year 2022 at Instructional Farm, Krishigadh, Junagadh Agricultural University, Junagadh (Gujarat). The treatments consisted three sources of sulphur (SS) viz., gypsum, elemental sulphur and cosavet (fertis) each of 20 kg ha^{-1} and sulphur oxidizing bacteria (SOB) viz., 0.0, 2.0, 3.0 and 4.0 lit ha^{-1} with three replication. The experiment consisted of twelve treatment combinations. The results indicated that yield attributes as well as seed and stover yield, oil and protein content were significantly higher with application of cosavet (fertis) and SOB @ 3 lit ha^{-1}. The seed yield of soybean increased to the tune of 14.26 and 19.72 per cent with application of cosavet (fertis) (SS_3) and SOB @ 3 lit ha^{-1} (SOB_3) compared to treatment of elemental sulphur (SS_2) and control (SOB_1), respectively. The higher availability of S nutrient with application of cosavet (Fertis) and SOB @ 3 lit. ha^{-1} as compared to other sulphur sources and control treatment, respectively. The significantly higher sulphur oxidizing bacteria count also higher with 4.0 lit ha^{-1} (SOB_4) as compared to control (SOB_1).

Keywords - *Soybean, sulphur sources, SOB, yield, quality. available nutrients status*

1. INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is considered as a miracle leguminous crop because of its dual qualities *viz.*, high protein (40-42%) and oil content (20%) in seed. It is a good source of dietary fiber, calcium, magnesium, phosphate, thiamine, riboflavin, niacin, lecithin, potassium, sulphur, vitamins A, B & E and essential amino acids like lysine, leucine, methionine and threonine, which are required for human body. In India, area and production of soybean during year 2021 is 11.8 M ha and 13.5 MT, respectively (Anon., 2021). Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Uttar Pradesh, Andhra Pradesh, Nagaland and Gujarat are major soybean production states in India. In Gujarat, the area and production under soybean were 221.27 ha and 376.34 tonnes, respectively (Anon., 2023).

Sulphur is the "Master Nutrient" for all oilseeds and pulses crop and is rightly being called the "Forth Major Plant Nutrient", along with nitrogen, phosphorus and potassium. Like

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all the seed legumes, soybean also responded markedly to S application because, it is both a seed legume as well as an oilseed crop but response of sulphur varies with sources & levels of sulphur and sulphur-based balance fertilization (Pasricha, 2010). Among the sulphur supplying sources, gypsum, elemental sulphur and cosavet (fertis) are being abundantly used in sulphur deficient soils. Generally, sulphur oxidizing bacteria (SOB) improves the production or the conversion of the elemental sulphur to the sulphate (SO_4^{-2}) for absorption and results in the plant growth promotion and production process. No work has so far been done on effect of suphur sources and SOB on yield, quality and available nutrients status after harvest of summer soybean particularly in Junagadh region of Gujarat state.

2. MATERIALS AND METHODS

The field experiment was conducted on clayey soil at Junagadh during summer 2022 with soybean var.GJS-3. The crop was grown with spacing of 45 x 10 cm. The net plot size 4.0 x 1.80m for the experiment. The experimental field was cultivated by ploughing with tractor drawn plough followed by rotavator ploughing to achieve fine tilth for proper germination and crop establishment. Later the land was converted into required sized plots and levelling was ensured within each plot. The treatments consisted three sources of sulphur viz., gypsum, elemental sulphur and cosavet (fertis) each of 20 kg ha^{-1} and sulphur oxidizing bacteria (SOB) viz., 0.0, 2.0, 3.0 and 4.0 lit. ha^{-1} with three replication. Common basal dose of N and P in the form of urea and DAP, while, each sources of sulphur treatment was applied in the form of gypsum and elemental sulphur prior to 30 days before sowing of crop and cosavet (fertis) at the time of sowing @ 20 kg ha^{-1}. Soybean was sown by drilling with seed @ 60 kg ha^{-1} keeping inter row spacing of 45 cm.

Before start of the experiment, initial soil sample (0-15cm) depth was drawn and analyzed for various soil physic-chemical properties. The initial soil was having alkaline in reaction ($pH_{2.5}$ 8.2), with low electrical conductivity ($EC_{2.5}$ 0.30 dSm^{-1}) and medium organic carbon (0.62 %). The soil available N (230 kg ha^{-1}) low, P (32.50 kg ha^{-1}) medium, K (280 kg ha^{-1}) medium and S (9.55 (mg kg^{-1}) low in status.

2.1 Analysis of quality parameters

At maturity, seed and stover yield data were recorded. The protein content (%) of seeds worked out by multiplying nitrogen content of seed by a factor of 6.25 as suggested by Gupta *et al*. (1972). The oil content of seed was determined by NMR as per the method suggested by Tiwari *et al*. (1974).

2.2 Statistical Analysis

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The analysis of variance will be carried out according to the method given by Panse and Sukhatme (1985) for Randomized Block Design (Factorial) and results was tested at 5% probability level of significance.

Table 1. Different soil properties and methods employed for analysis

Sr. No.	Soil property	Method followed
1.	Soil pH (1:2.5)	pH meter (Richards, 1954)
2.	EC (1:2.5) (dS/m) at 25 ^{0}C	EC meter (Jackson, 1974)
3.	Organic carbon (%)	Walkley and Black's method (Jackson, 1974)
4.	Available N (kg ha^{-1})	Alkaline $KMnO_4$ method (Subbiah and Asija, 1956)
5.	Available P_2O_5 (kg ha^{-1})	Olsen's method (Olsen *et. al.*, 1954)
6.	Available K_2O (kg ha^{-1})	Flame photometric method (Jackson, 1974)
7.	Available Sulphur (mg kg^{-1})	Terbidimetric method (Chaudhary and Cornfield, 1966)

3.0 RESULTS AND DISCUSSION

The results obtained from the present investigation are presented in Table 2 and 3.

3.1 Yield, yield attributes and quality parameters

Effect of Sulphur Sources (SS)

The result (Table 2) indicated that the seed and stover yield of soybean significantly influenced by various sources of sulphur. The higher seed (1538 kg ha^{-1}) and stover (2128 kg ha^{-1}) yields were recorded with treatment of cosavet (fertis), which was 14.26 and 15.34 per cent higher, respectively over elemental sulphur treatment (SS_1). The response of crop to applied sulphur source cosavet (Fertis) in the present study may be attributed to the fact that soil under investigation was deficient in sulphur. The result conformed to reports of Yadav *et al*. (2018) in soybean crop.

Growth and yield attributes were also significantly influenced by sources of sulphur application. Among the different sources of sulphur gave significantly higher plant height (44.10 cm), pod number $plant^{-1}$ (46.14), whereas, seeds per pod was found non significant. This increased in plant height due to cosavet (fertis) may be due to the fact that cosavet (fertis) has smaller particle size, there by having greater surface area which hastens the oxidation of sulphur to sulphate which is available form of sulphur to plants. These results were also reported by Patel *et al*. (2022) in mustard. The increase in number of pods per plant might be

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due to the sulphur plays vital and important role in energy storage and transformation, carbohydrate metabolism and activation of enzymes also increase the photosynthetic activity of plant. These findings endorse the result in groundnut by Kader and Mona (2013).

The significantly the higher protein (36.06%) and oil (19.16%) content in seed were recoreded with cosavet (fertis) application (SS_3). Oilseed crops response 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. The results are confirmed the reports of Movalia and Savalia (2021) in soybean.

Effect of Sulphur Oxidizing Bacteria (SOB)

The yields, yield attributes and quality parameters of soybean were significantly influenced by sulphur oxidizing bacteria (Table 2). Among the different levels of SOB the yields (seed and stover), growth and yield attributes (plant height, pod number plant^{-1}) and quality parameters (protein and oil content) of soybean were significantly higher with application of SOB @ 3.0 lit ha^{-1} (SOB_3). Significantly higher seed (1566 kg ha^{-1}) and stover (2164 kg ha^{-1}) yield were recorded @ 3.0 lit SOB ha^{-1}. However, it was at par with 4.0 lit ha^{-1}. The magnitude of increase in seed and stover yield was by 19.72 and 19.03 per cent with 3.0 and 4.0 lit. SOB ha^{-1}, respectively, over that of control. Use of SOB enhanced the rate of natural oxidation of sulphur and production of sulphates and makes them available to plants at their critical stages of growth, resulting in increasing plant yield of onion (Wainright, 1984) and these results close to conformity with Gilani *et al.* (2020) in sesame.

. The application of SOB significantly increased quality parameters (Table 2). Significantly higher protein (36.56%) and oil (19.20%) content in seed were recorded with 3 lit. SOB ha-^{1}, which was at par with 4 lit. SOB ha^{-1}. Similar results also observed by Chaudhary *et al.* (2019) in mustard.

The interaction effect of different sources of sulphur and SOB levels in relation to plant height, pod number plant^{-1}, seeds number pod^{-1}, seed and stover yield as well as quality parameters were found statistically non-significant.

3.2 Available nutrients status and SOB count in soil

Effect of sulphur sources

The available S content in soil increased significantly with application of different sources of sulphur (Table 3). The highest available S (17.41 ppm) was found with application of cosavet (fertis), however it was at par with gypsum application. The application of different

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sources of sulphur did not produce any significant effect on available N, P_2O_5 and K_2O content and SOB cont in soil. The results reported by Meshrum *et al.* (2017) after harvest of soybean.

Table 2: Effect of sulphur sources and SOB on yield, yield attributes and quality of soybean

Treatments	kg ha^{-1}		Yield attributes			Quality parameters	
	Seed yield	Stover yield	Plant height (cm)	No. of pods / plant	No. of seeds/ pod	Protein content (%)	Oil content (%)
Sulphur sources (20 kg ha^{-1})							
SS_1	1456	1996	43.94	43.21	2.70	35.30	19.08
SS_2	1346	1845	40.85	41.62	2.66	33.49	18.09
SS_3	1538	2128	44.10	46.14	2.72	36.06	19.16
S.Em. ±	43.4	69.4	0.90	1.12	0.07	0.50	0.27
C.D. (P=0.05)	127	203	2.63	3.29	NS	1.47	0.79
Sulphur oxidizing bacteria (Lit. ha^{-1})							
SOB_1	1308	1818	39.74	40.07	2.51	33.45	17.98
SOB_2	1441	1947	42.12	42.50	2.66	34.38	18.82
SOB_3	1566	2164	45.32	47.03	2.81	36.56	19.20
SOB_4	1471	2031	44.67	45.02	2.79	35.42	19.11
S.Em. ±	50.1	80.1	1.04	1.29	0.08	0.58	0.31
C.D. (P=0.05)	147	235	3.04	3.80	NS	1.70	0.91

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Table 3:Effect of sulphur sources and SOB on available nutrients and SOB count in soil after harvest of soybean

Treatments	Available nutrients (kg ha^{-1})			ppm	10^6 cfu g^{-1} soil
	N	P_2O_5	K_2O	S	SOB count

Sulphur sources (20 kg ha^{-1})					
SS_1	243	35.07	268	16.38	3.65
SS_2	241	34.22	265	14.90	3.61
SS_3	246	36.86	271	17.41	3.71
S.Em. ±	4.5	0.97	4.8	0.53	0.06
C.D. (P=0.05)	NS	NS	NS	1.55	NS
Sulphur oxidizing bacteria (Lit. ha^{-1})					
SOB_1	238	33.25	264	13.93	3.45
SOB_2	243	34.63	266	15.41	**3.60**
SOB_3	247	37.28	272	**18.57**	**3.78**
SOB_4	245	36.37	271	**17.02**	**3.79**
S.Em. ±	5.2	1.12	5.5	0.61	0.07
C.D. (P=0.05)	NS	NS	NS	1.79	0.22

Effect of SOB

The available S and SOB count significantly increased with application of various levels of SOB in soybean (Table 3). The significantly higher available S (18.57 ppm) was recorded with application of 3.0 lit. SOB ha^{-1} (SOB_3), which was at par with 4 lit. SOB ha^{-1} (SOB_4). The SOB count (3.79 10^6 cfu g^{-1}) significantly higher with application of 4.0 lit. SOB ha^{-1}, which was at par with 2.0 and 3.0 lit. SOB ha^{-1}.

The sulphur oxidizing bacteria count increase might be due to microbes decompose the organic material and release different nutrients and organic carbon into soil. Due to this reason significantly increase bacterial population by absorbing these nutrients and favourable environment increase multiplication rate of bacteria in soil. These results were also in agreement with Kaur *et al.* (2020) in mustard.

The interaction effect of different sources of sulphur and SOB levels in relation to soil available nutrients and SOB count in soil were found statistically non-significant.

4. CONCLUSION

Based on the experimental results, it can be concluded that application of sulphur in form of cosavet (fertis) and 3 lit ha^{-1} sulphur oxidizing bacteria (SOB) significantly improved

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the yield and yield attributes as well as quality parameters of soybean. It is found efficient for higher and qualitative yield of summer soybean. Whereas, soil nutrients status in terms of sulphur higher status with application of cosavet (fertis) and sulphur oxidizing bacteria count was recorded higher with 4.0 lit.SOB ha^{-1}.

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