Agriculture Association of Textile Chemical and Critical Reviews Journal (2024) 141-144

AATCC Review

02 May 2024: Received
10 June 2024: Revised
08 July 2024: Accepted
24 August 2024: Available Online

www.aatcc.peerjournals.net

Research Article Open Access

Assessment of the Impact of Sulphur Levels on Soil Chemical Properties in S-deficient Sandy Loam Soil of Amritsar

Damini*, Mamta Devi, Manpreet Singh and Shailja

Department of Agriculture, Khalsa College Amritsar, Punjab-143002.

ABSTRACT

Limited understanding of how varying sulphur levels affect soil chemical properties in S-deficient sandy loam soil specifically found in Amritsar. A pot experiment was conducted on mustard cv. RLC 3 and broccoli cv. Palam Samridhi in a factorial completely randomized design with three replications. Four levels of sulphur were applied to the soil, and plants were harvested 30 and 60 days after germination. The study aimed to investigate the impact of sulphur levels on soil chemical properties. The results showed that the value of soil pH was reduced significantly with an increase in the S level. The highest soil pH (8.12) was recorded where no sulphur was applied, whereas the least (7.65) was found in 60 mg S kg^{-1} soil treatment. There was no significant variation in electrical conductivity and soil organic carbon during the study. Soil available sulphur increased linearly with a simultaneous increase in levels of sulphur resulting in a maximum value (12.75 mg kg^{-1}) at 60 mg S kg^{-1} soil treatment, compared to no sulphur application (4.31 mg kg^{-1}). Notably, soil properties significantly improved with the application of 60 mg S kg^{-1} soil, particularly under mustard followed by broccoli crop.

Keywords: *Broccoli, Mustard, Days after germination, Pot experiment, Soil chemical properties, S-deficient soil, Sulphur levels*

INTRODUCTION

Sulphur is considered an essential plant nutrient and the fourth major nutrient after nitrogen, phosphorous, and potassium [1]. Sulphur-containing amino acids like cysteine, cystine, and methionine make up one of the most crucial factors in plant growth [2]. An optimal S supply can lead to increased nutrition and yields while, its deficiency could result in an approximate 50 % decrease in yield. S deficiency has become more prevalent in crop agriculture worldwide due to intensive agricultural systems, high-yielding crop cultivation, and limited supply of S fertilizers. These factors have accelerated S deficiency in arable lands [3].

Among the various districts of Punjab, deficiency of soil-available sulphur was reported as severe in districts of Amritsar (29.7%) and Rupnagar (29.1%), respectively [4]. Soils, which are deficient in sulphur are unable to supply enough sulphur on their own to meet crop demand, leading to sulphur-deficient crops and suboptimal yields [5].

Mustard and broccoli crops belong to the Cruciferae family, which requires sulphur preferentially for their growth and development. For better productivity as well as quality of oilseeds, sulphur plays a multifaceted role. The application of sulphur in the soil also significantly impacts its properties and can be used as soil amendments like pyrite and gypsum to improve the soil reaction and increase the availability of other nutrients. Considering the paramount significance of sulphur, this study was designed to investigate the impact of sulphur levels on soil chemical properties under mustard and broccoli crops.

Corresponding Author:* ***Damini*

DOI: https://doi.org/10.58321/AATCCReview.2024.12.03.141

MATERIALS AND METHODS

A pot culture experiment was conducted at Students' Research Farm, Agriculture Department, Khalsa College, Amritsar during *rabi* season of 2022-23 to determine soil chemical properties under mustard (*Brassica juncea* L. cv. RLC 3) and broccoli (*Brassica oleracea* var. *italica* cv. Palam Samridhi) crops. Sulphur-deficient surface soil (0-15 cm) of Sandy loam texture, with pH 8.30, EC 0.32 dS m^{-1}, organic carbon 0.36 %, available nitrogen 85.89 mg kg^{-1}, available phosphorous 8.83 mg kg^{-1}, available potassium 117.37 mg kg^{-1}, and available sulphur 6 mg kg^{-1}, was used for the pot experiment. The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with four treatments replicated thrice. The seeds of crops viz., mustard and broccoli were sown in earthen pots of 5 kg capacity filled with S-treated soils during the morning hours after 24 hours of respective treatment, as shown in Table 1. A basal dose of recommended N, P, and K was applied to the soils separately for each crop in the form of Urea [$CO(NH_2)_2$], SSP ($Ca(H_2PO_4)_2.2H_2O$), and MOP (KCl), respectively, and S was applied through gypsum (18% S).

Soil samples were collected at 30 and 60 days after germination (DAG). Soil pH and EC were measured using digital pH and conductivity meter [6], organic carbon by Walkley and Black's rapid titration method [7], and sulphur by the turbidimetric method [8].

RESULTS AND DISCUSSION

Impact of sulphur levels on soil pH

The soil pH data presented in Table 2 indicate that several factors, including individual S treatments, crop types, and growth stages, significantly influence soil pH. Notably, the highest soil pH (7.97) was recorded in the soil associated with the mustard crop.

Regarding the S treatments, the control condition exhibited the highest pH (8.12), while the lowest pH (7.65) was observed in the soil treated with 60 mg S per kilogram of soil. The decrease in soil pH resulting from sulphur application can be attributed to the oxidation of applied sulphur, leading to the production of acid and subsequently decreasing the soil pH [9]. Concerning the growth stages, the highest soil pH (7.89) was observed during the first growth stage, while the lowest pH (7.86) was noted during the second growth stage. This variation may be attributed to changes in the pH of the root zone, as suggested by [10]. The results are consistent with the findings of [11] and underscore the dynamic nature of soil pH influenced by factors such as crop type, sulphur treatment, and crop growth stage.

Impact of sulphur levels on soil EC

The data in Table 3 revealed a minor change in the salt concentration of the soil after harvest. None of the treatments were found to influence the EC status of the soil. Even the interaction effect of different treatments on the EC status of the soil was non-significant. The maximum EC value of soil was under the mustard crop (0.27 dS m^{-1}). In the case of S application, the highest EC was observed under 0 mg S kg^{-1} (0.30 dS m^{-1}), which was on par with the rest of the sulphur treatments except 60 mg S kg^{-1}. For the growth stages, the maximum EC value was found at the first growth stage (0.27 dS m^{-1}), while the minimum salt concentration was observed at the second growth stage (0.25 dS m^{-1}). Throughout the entire growth stage, the salt concentration in the soil remained normal.

Impact of sulphur levels on soil organic carbon

It is evident from the data furnished in Table 4 that there was a minor change in OC (%) of the soil after harvest. None of the treatments were found to influence the organic carbon status of the soil. Even the interaction effect of different treatments on soil OC status was non-significant. However, numerically the highest value was observed under 60 mg S kg^{-1} (0.39 %), while the lowest was under no sulphur application (0.35 %). Regarding the growth stages, the maximum value was found at the first growth stage (0.38 %), and the minimum was observed at the second growth stage (0.36 %). The decrease in organic carbon over the investigation period was attributed to organic carbon mineralization and loss of carbon from the soil system in the form of CO_2. An analogous pattern of results was previously noted by [12]. During the entire growth stage, the organic carbon status of the soil was categorized as low.

Impact of sulphur levels on soil available sulphur

The S treatment significantly improves the sulphur content in the soil after the harvest of mustard and broccoli (Table 5). Notably, the highest sulphur content was observed following broccoli harvest (9.91 mg kg^{-1}), while the lowest was found in soil associated with mustard (8.49 mg kg^{-1}).

Regarding sulphur treatments, 60 mg of S kg^{-1} of soil exhibited the highest content (12.75 mg kg^{-1}). In comparison, the minimum content was recorded when no sulphur was applied (4.31 mg kg^{-1}). The enhanced sulphur availability post-harvest, resulting from the sulphur application, can be attributed to the formation of specific bonds with soil clay particles during sowing, making it gradually available through slow solubilization. This interpretation is consistent with the conclusions drawn by [13]. Concerning growth stages, the sulphur content was significantly higher at the second growth stage (9.33 mg kg^{-1}), with the lowest sulphur content observed during the first growth stage (9.06 mg kg^{-1}). The application of gypsum led to an increase in available sulphur content in the post-harvest soil, primarily due to the solubility of applied gypsum, which dissociates and releases a significant amount of sulphate ions (SO_4^{2-}) into the soil solution. This finding follows the research conducted by [14], [15] and [16], all of which highlighted that sulphur application significantly elevates the available sulphur status in the soil.

CONCLUSION

The results of this study demonstrated that S application had a positive effect on soil pH and available sulphur content in mustard soil compared to broccoli, while the imposed treatments had no significant impact on soil EC and organic carbon status. Among various sulphur levels, the application of 60 mg of S kg^{-1} soil treatment improved the properties of soil as well as S content in the soil of mustard and broccoli crops at both growth stages. However, future research should be focus on validating the results of this trial under actual field conditions.

Author contributions: Conceptualization and design of the research work (Manpreet Singh); Execution of field and laboratory experiments, and data collection (Mamta Devi, Damini, and Shailja); Data analysis, interpretation, and manuscript preparation (Damini and Shailja).

Acknowledgements: This research is part of the first author's M.Sc. Thesis. The first author expresses deep gratitude to Dr. Saurabh Sharma for their patient guidance, enthusiastic encouragement and useful critiques of this research. The authors are deeply grateful to the P.G. Department of Agriculture, Khalsa College, Amritsar, for providing the laboratory and field facilities.

Conflicts of Interest: The authors declare no conflict of interest.

Future scope of the study: Future research could explore the long-term effects of sulphur application on diverse crops and soil properties, extending beyond the initial 60-day period, aiming to optimize nutrient management strategies for resilient agricultural systems.

Table 1: Experimental set-up for rabi crops in pots

Crop species	Treatment level (mg kg^{-1} soil)	Number of plants to be kept for harvesting for stage	
	S in S-deficient soil	1st (30 DAG)	2nd (60 DAG)
Mustard	0	10	4
	20	10	4
	40	10	4
	60	10	4
Broccoli	0	5	2
	20	5	2
	40	5	2
	60	5	2

Table 2: Effect of different levels of sulphur application on soil pH of mustard and broccoli crops at both growth stages

	Stage I (30 DAG)			Stage II (60 DAG)		
S level (mg kg-1)	**Mustard**	**Broccoli**	**Mean**	**Mustard**	**Broccoli**	**Mean**
0	8.13	8.10	**8.11**	8.08	8.18	**8.13**
20	8.09	7.90	**7.99**	7.98	7.84	**7.91**
40	7.92	7.70	**7.81**	7.91	7.66	**7.78**
60	7.88	7.42	**7.65**	7.82	7.48	**7.65**
Mean	**8.00**	**7.78**	**7.89**	**7.94**	**7.79**	**7.86**

Overall mean						Parameter	CD ($p \le 0.05$)
S	**Mean**	**Crop**	**Mean**	**Stage**	**Mean**	S	0.07
0	8.12	Mustard	7.97	1	7.89	C	0.05
20	7.95	Broccoli	7.78	2	7.86	ST	0.05
40	7.79					S × ST	0.10
60	7.65					C × ST	0.07
						S × C	0.10
						S × C × ST	0.14

S – Sulphur, C – Crop, ST – Stages

Table 3: Effect of different levels of sulphur application on soil EC (dS m-1) of mustard and broccoli crops at both growth stages

	Stage I (30 DAG)			Stage II (60 DAG)		
S level (mg kg-1)	**Mustard**	**Broccoli**	**Mean**	**Mustard**	**Broccoli**	**Mean**
0	0.31	0.30	**0.30**	0.30	0.30	**0.30**
20	0.29	0.28	**0.28**	0.27	0.26	**0.27**
40	0.27	0.26	**0.26**	0.25	0.23	**0.24**
60	0.25	0.23	**0.24**	0.23	0.22	**0.22**
Mean	**0.28**	**0.26**	**0.27**	**0.26**	**0.25**	**0.25**

Overall mean						Parameter	CD ($p \le 0.05$)
S	**Mean**	**Crop**	**Mean**	**Stage**	**Mean**	S	NS
0	0.30	Mustard	0.27	1	0.27	C	NS
20	0.27	Broccoli	0.26	2	0.25	ST	NS
40	0.25					S × ST	NS
60	0.23					C × ST	NS
						S × C	NS
						S × C × ST	NS

Table 4: Effect of different levels of sulphur application on soil OC (%) in mustard and broccoli crops at both growth stages

	Stage I (30 DAG)			Stage II (60 DAG)		
S level (mg kg-1)	**Mustard**	**Broccoli**	**Mean**	**Mustard**	**Broccoli**	**Mean**
0	0.38	0.36	**0.37**	0.35	0.33	**0.34**
20	0.39	0.38	**0.38**	0.36	0.36	**0.36**
40	0.39	0.40	**0.39**	0.37	0.38	**0.37**
60	0.40	0.41	**0.40**	0.37	0.38	**0.37**
Mean	**0.39**	**0.38**	**0.38**	**0.36**	**0.36**	**0.36**

Overall mean						Parameter	CD ($p \le 0.05$)
S	**Mean**	**Crop**	**Mean**	**Stage**	**Mean**	S	NS
0	0.35	Mustard	0.377	1	0.38	C	NS
20	0.37	Broccoli	0.375	2	0.36	ST	NS
40	0.38					S × ST	NS
60	0.39					C × ST	NS
						S × C	NS
						S × C × ST	NS

Table 5: Effect of different levels of sulphur application on soil available sulphur (mg kg^{-1}) of mustard and broccoli crops at both growth stages

	Stage I (30 DAG)			Stage II (60 DAG)		
S level (mg kg^{-1})	**Mustard**	**Broccoli**	**Mean**	**Mustard**	**Broccoli**	**Mean**
0	4.18	4.88	**4.53**	3.90	4.28	**4.09**
20	7.57	9.06	**8.31**	7.79	8.94	**8.36**
40	10.27	12.10	**11.18**	10.66	12.59	**11.62**
60	11.36	13.14	**12.25**	12.22	14.31	**13.26**
Mean	**8.34**	**9.79**	**9.06**	**8.64**	**10.03**	**9.33**

Overall mean						Parameter	CD ($p \leq 0.05$)
S	**Mean**	**Crop**	**Mean**	**Stage**	**Mean**	S	0.60
0	4.31	Mustard	8.49	1	9.06	C	0.42
20	8.34	Broccoli	9.91	2	9.33	ST	0.42
40	11.40					S × ST	0.85
60	12.75					C × ST	0.60
						S × C	0.85
						S × C × ST	1.20

REFERENCES

1. Singh P D, Kumar P, Pathak A, Singh A and Singh S (2019). Effect of different levels and sources of sulphur on soil properties and yield of mustard (*Brassica juncea* L.). *Journal of Pharmacognosy and Phytochemistry* 8(5): 1868-1871.

2. Parmar N N, Patel A P and Choudhary M (2018). Effect of sources and levels of sulphur on growth, yield and quality of summer sesame under South Gujarat condition (*Sesamum indicum* L.). *International Journal of Current Microbiology and Applied Science* 7(2): 2600-2605.

3. Yesmin R, Hossain M, Kibria M G, Jahiruddin M, Solaiman Z M, Bokhtiar S M, Hossain M B, Satter M A and Abedin M A (2021). Evaluation of critical limit of soils for wheat (*Triticum aestivum* L.) and mustard (*Brassica napus* L.). *Sustainability* 13(15): 8325.

4. Dhaliwal S S, Shukla A K, Sharma V, Behera S K, Choudhary O P, Chaudhary S K, Kumar A, Patra A K, Prakask C, Sikaniya Y and Tripathi A (2020). Status of sulphur and micronutrients in soils of Punjab-Blockwise Atlas. *ICAR-Indian Institute of Soil Science, Bhopal publication.*

5. Kumar V, Tyagi S, Pual S C, Dubey S K and Suman S (2018). Effect of sources and doses of sulphur on S uptake and yield of mustard (*Brassica juncea* L.). *International Journal of Current Microbiology and Applied Science* 7: 5042-5047.

6. Jackson M L (1967). *Soil chemical analysis*, Prentice Hall of India Pvt. Ltd., New Delhi.

7. Walkley A and Black I A (1934). An examination of Degtjareff methods for determining soil organic matter and proposed modification of the chromic acid titration method. *Soil Sci*ence 37: 29-38.

8. Chesnin L and Yien C H (1950). Turbidimetric determination of available sulphates. *Soil Science Society of American Journal* 15: 149-151.

9. Rahman M M, Soaud A A, Darwish F H A and Sofian-Azirun M A (2011). Effects of sulfur and nitrogen on nutrients uptake of corn using acidified water. *African Journal of Biotechnology* 10(42): 8275-8283.

10. Saroha M S and Singh H G (1979). Effect of prevention of iron chlorosis on the quality of sugarcane grown on vertisols*. Plant and Soil* 52: 467-473.

11. Besharati H, Atashnama K and Hatami S (2000). Biosuper as a phosphate fertilizer in a calcareous soil with low available phosphorus. *African Journal of Biotechnology* 6(11): 1325-1329.

12. Basumatari A, Talukdar M C and Ramchiary S (2008). Sulphur forms and their relationship with soil properties in rapeseed growing soils of upper Assam. *International Journal of Tropical Agriculture* 26: 69-72.

13. Parasuraman P (2008). Studies on integrated nutrient requirement of hybrid maize (*Zea mays* L.) under irrigated conditions*. Madras Agriculture Journal* 92(1): 89-94.

14. Yadav B K (2011). Interaction effect of phosphorus and sulphur on yield and quality of clusterbean in typic haplustept. *World Journal of Agricultural* Sciences 7(5): 556- 560.

15. Raja A, Hattab A O, Gurusamy L and Suganya S (2007). Sulphur levels on nutrient uptake and yield of sesame varieties and nutrient availability. *International Journal of Soil Science* 2(4): 278-285.

16. Das A and Biswas P (2020). Effect of sulphur and biofertilizer in nutrient uptake by sesame and microbial population in red and lateritic soil of West Bengal. *Agriculture Science Digest* 40(3): 226-233.