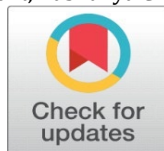
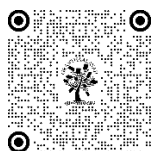


EFFECT OF DIFFERENT SOURCES AND LEVELS OF SULPHUR ALONG WITH FOLIAR SPRAY OF MICRONUTRIENTS ON GROWTH YIELD AND NUTRIENT UPTAKE BY SAFFLOWER (*CARTHAMUS TINCTORIUS* L.).

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ABSTRACT

A field experiment conducted during the rabi season of January 2024 in Narayangaon, Maharashtra, India investigated the effects of various sulphur sources combined with micronutrient spray on the growth and yield of safflower (*Carthamus tinctorius* L.). A Randomized Block Design for eight treatments in four replications each having either elemental sulphur or gypsum in combination with NPK and micronutrient spray (Cu 1.0%, Zn 3.0%, Mn 1.0%, Fe 2.5%, B 0.5%, Mo 0.1%) were tested. The treatment (T4) combination of 45 kg/ha elemental sulphur with NPK and micronutrient produced significantly higher plant height (110.64 cm), number of branches (22.33), yield (1483.9 kg/ha), and chlorophyll content (1.08 mg/g). While the dry weight per plant (39.2gm), 1000-seed weight (56.19 g), oil content (28.86%), and protein content (15.24%), were exhibited at par with (T7). These treatments (T4) indicating a direct correlation between higher elemental sulphur application rates and improved plant growth, yield and seed quality. These findings indicate that optimizing balanced fertilization strategies that include appropriate sulphur and other micronutrient applications can substantially improve safflower productivity in sulphur-deficient regions.

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Keywords: Safflower, Elemental Sulphur, Gypsum, Soil, fertilizers.



1. INTRODUCTION

Safflower (*Carthamus tinctorius* L.), an oilseed crop from the Asteraceae family, is an essential agricultural product in India (Gomashe et al., 2021), particularly in the states of Maharashtra, Karnataka, Gujarat, Andhra Pradesh, and Telangana. India leads global safflower cultivation, contributing 41% of the area and 29% of the production worldwide, although national productivity (726 kg/ha) lags behind the global average of 820 kg/ha (Visespedia, 2024). Maharashtra is a major safflower-growing state, cultivating the crop primarily under rainfed conditions on black soils (vertisols) during the winter Rabi season, however, Maharashtra's safflower productivity, much like other states, remains below potential due to these constraints (Salve et al., 2018). The state faces significant challenges in boosting safflower productivity, with yields typically much lower than expected due to inadequate rainfall, poor soil nutrition, and insufficient use of secondary nutrients like sulphur and micronutrients (Sanghavi et al., 2022).

Safflower seeds contain 24-36% oil, rich in linoleic acid (73-79%), which has health benefits, including lowering cholesterol levels, making it a valuable crop for both the food and industrial sectors (Patel et al., 2022). Sulphur (S) is an essential macronutrient required for plant growth and development. Sulphur deficiency has been reported in many agricultural soils, particularly in Asia, which has the highest sulphur fertilizer requirement (Baviskar et al., 2005).

Sulphur plays a crucial role in the synthesis of essential amino acids, chlorophyll, and other organic compounds in plants. Applying appropriate levels of sulphur can improve soil properties and crop yields. (Yeshpal et al., 2017). In addition to sulphur, micronutrients such as copper (Cu), manganese (Mn), Molybdenum (Mo), boron (B), zinc (Zn), and iron (Fe) are also essential for safflower growth and productivity. However, the intensive cultivation of high-yielding varieties have exacerbated nutrient deficiencies, particularly sulphur, Zn, Cu, Mn, Fe, B and Mo which is crucial for oilseed development and overall Safflower plant growth. Foliar application of micronutrients can be an effective way to ensure their adequate availability to the crop, especially during critical growth stages (Ravi et al., 2010).

To address these issues, a focused study titled "Effect of Sulphur along with Foliar Spray of Micronutrients on Growth and Yield of Safflower" is urgently needed. Such a study would examine the impact of sulphur supplementation and micronutrient foliar sprays on safflower's growth parameters, yield, and oil quality. By improving nutrient management, especially under rainfed conditions, this research could significantly enhance safflower productivity in Maharashtra and other safflower-growing regions, ensuring better economic returns and sustainable cultivation practices for farmers.

2. MATERIAL AND METHODS

2.1 STUDY PLAN: A field experiment was executed in the village Narayangaon, Maharashtra, during the Rabi season of 2024 on safflower (*Carthamus tinctorius* L.). The objective of this experiment was to investigate the impact of applying different levels of elemental sulphur and gypsum at a rate of 15kg/ha, 30 kg/ha and 45kg/ha in combination with the recommended dose of fertilizer (NPK) and foliar spray of micronutrients (Cu 1.0%, Zn 3.0%, Mn 1.0%, Fe 2.5%, B 0.5%, Mo 0.1%) on the growth parameters of safflower (*Carthamus tinctorius* L.).

2.2 EXPERIMENTAL DESIGN: The experiment was laid out in a randomized block design. Eight treatments (six square meter area. Each plot had approximately 66 plants. NPK at ratio of 50:25:0 was used as recommended dose fertilizer (RDF). At the time of sowing, N50: P:25 K0 with four replicates were set up on a field for the rabi season (Table 1) In addition, a basal dose of compost and elemental Sulphur and gypsum as a source of sulphur were combined and applied. Furthermore, the primary nutrients urea (source of nitrogen), and single super phosphate (source of phosphorous) were employed. After a period of sixty days, during the blossoming stage, micronutrients were applied through spraying. Following this stage, a random selection of twelve plants from each treatment was chosen for analysis of their chemical and physical properties.

Table 1. Treatments details

S. No	Treatment	Treatment name
1	100% RDF	T1
2	100% RDF + 15 kg/ha Elemental S+ Foliar spray of Micronutrients	T2
3	100% RDF + 30kg/ha Elemental S + Foliar spray of Micronutrients	T3
4	100% RDF + 45kg/ha Elemental S+ Foliar spray of Micronutrients	T4
5	100% RDF + 15 kg/ha Gypsum+ Foliar spray of Micronutrients	T5
6	100% RDF + 30kg/ha Gypsum + Foliar spray of Micronutrients	T6
7	100% RDF + 45kg/ha Gypsum + Foliar spray of Micronutrients	T7
8	100% RDF + Foliar spray of Micronutrients	T8

2.3 STATISTICAL METHOD

The data obtained were statistically analyzed following the procedures outlined by Panse and Sukhatme (1985).

2.4 GROWTH ATTRIBUTES: Manual measurements were done to find the height of the plant in centimetres and the number of Branches per plant. Whole plants and seeds of plants were sun-dried for 8 to 10 days and the dry weight of each plant was measured in gm.

2.5 YIELD ATTRIBUTES: The yield of the safflower seed (kg/ha), dry weight per plant (gm) and weight of 1000 seed were measured to find the yield attribute.

Chlorophyll content was measured using Witham et al (1971) method and expressed in mg per gram of leaf sample. The Soxhlet extraction method, using petroleum ether as a solvent, was used to find the percent oil contents (Fornasari et al., 2017). The percent protein contents were measured using a folin phenol reagent (Waterborg et al., 2009).

3. RESULTS AND DISCUSSION

The data present in table 2 and 3 indicate the effects of different sulphur treatments, both elemental and gypsum-based, along with foliar sprays of micronutrients on key growth, yield, and quality parameters. The application of foliar sprays (T8) improved yield (1078.28 kg/ha) and other attributes compared to the control but was less effective than sulphur treatments, indicating that sulphur plays a more critical role in safflower productivity and quality than foliar micronutrients alone. The results demonstrated a significant positive influence of either of sulphur supplementation along with micronutrient foliar sprays on growth and yield of safflower. This might be due to the superior availability of sulphur and micronutrients from these sources, improved nutritional environment, and better carbohydrate metabolism, leading to enhanced translocation of photosynthates towards seeds and leaves, the formation of larger plant with more number branches, dry weight per plant and seed quality (Narayana et al., 2020). The importance of sulphur and micronutrients, particularly at higher doses in improving safflower growth, yield, and oil content was also

demonstrated by Ravi et al., 2008; Ravikumar et al., 2021. The present study is in accordance with previous studies and noted that 45 kg/ha doses of gypsum and elemental sulphur are best for safflower growth.

Among the treatments, T4 (100% RDF + 45 kg elemental sulphur) recorded the highest performance, with the tallest plants (110.64 cm), the highest yield (1483.90 kg/ha), maximum branches (21.53), and greatest dry weight per plant (39.20 g/plant) (Table 2). This treatment also showed the highest chlorophyll content (1.08), While the dry weight per plant exhibited at par with T6 and T7, also the 1000-seed weight (56.19 g), oil content (28.76%), and protein content (15.24%) were found at par with T7. Treatment (T2-T8) indicating a direct correlation between higher sulphur application rates and improved plant growth and quality (Table 3). It may be because elemental sulphur application supports plant growth by expanding the assimilative surface area, which facilitates greater photosynthate production and net carbon translocation to the sink, thus increasing seed number per capitulum (Shekhawat and Shivay, 2008). Another study by Paslawar et al. (2012) also noted a similar trend in safflower.

Treatments with gypsum-based sulphur (T5-T7) also demonstrated significant improvements compared to the control (T1), but elemental sulphur (T2-T4) was more effective across all parameters. For instance, T7 (100% RDF + 45 kg gypsum) produced a yield of 1384.35 kg/ha and oil content of 27.49%, which was lower than that of T4 but still substantially higher than the control (821.38 kg/ha yield and 24.68% oil content). This improvement may be attributed to sulphur's role in protein synthesis, which potentially enhances photosynthesis and optimizes yield-contributing traits, resulting in significantly higher seed yields (Tulasi et al., 2014). Additionally, sulphur application facilitates the accumulation and translocation of amino acids and amides to reproductive organs, positively influencing growth and yield (Gudadhe et al., 2005). Several studies also suggests that sulphur and other micronutrients deficiency are a key limiting factor in safflower productivity, particularly in nutrient-poor soils. Ravi et al., 2008; Ravikumar et al., 2021 and Singh et al., 2013, also noted similar results.

Table 2: Growth attributes of Safflower plant after different treatments

Treatment	Height of the plant (cm)	Yield (kg/ha)	Number of Branches per plant	Dry weight/plant (gm)
100% RDF (N:P:K)	92.05	913.83	16.3	34.72
100 % RDF + 15 kg elemental S + Foliar spray of Micronutrients	99.48	1162.98	18.33	35.95
100 % RDF + 30 kg elemental S + Foliar spray of Micronutrients	107.16	1252.9	20.03	37.84
100 % RDF + 45 kg elemental S + Foliar spray of Micronutrients	110.64	1483.9	22.33	39.2
100 % RDF + 15 kg Gypsum + Foliar spray of Micronutrients	95.24	1024.93	14.3	35.0
100 % RDF + 30 kg Gypsum + Foliar spray of Micronutrients	103.18	1252.63	16.3	36.85
100 % RDF + 45 kg Gypsum + Foliar spray of Micronutrients	104.56	1384.35	20.39	38.91
100 % RDF + Foliar spray of Micronutrients	95.24	1078.28	16.98	35.15
SEM+₁	1.35	24.29	0.47	0.47
CD (.05)	3.97	71.43	1.38	1.38
CV %	2.67	4.07	5.18	5.18

Table 3: Yield attributes of Safflower plant after different treatments

Treatment	Chlorophyll content (mg/g)	Weight in gm/1000 seed	Oil content (%)	Protein content (%)
100% RDF	0.92	43.33	25.28	12.93
100 % RDF + 15 kg elemental S + Foliar spray of Micronutrients	0.97	47.75	26.32	13.91
100 % RDF + 30 kg elemental S + Foliar spray of Micronutrients	1.02	52.97	27.26	14.65
100 % RDF + 45 kg elemental S + Foliar spray of Micronutrients	1.08	56.19	28.86	15.24
100 % RDF + 15 kg Gypsum + Foliar spray of Micronutrients	0.93	49.4	25.12	13.94
100 % RDF + 30 kg Gypsum + Foliar spray of Micronutrients	1.01	50.27	27.00	14.63
100 % RDF + 45 kg Gypsum + Foliar spray of Micronutrients	1.04	55.2	28.53	15.11
100 % RDF + Foliar spray	0.94	47.14	27.05	14.07
SEM+₁	0.01	0.43	0.29	0.22
CD (.05)	0.02	1.27	0.86	0.63
CV %	1.63	1.71	2.18	3.01

4. CONCLUSION

The study concludes that the application of 45 kg/ha of elemental sulphur, in combination with the recommended dose of NPK and foliar micronutrient sprays, significantly enhances safflower growth, yield, and seed quality compared to gypsum-based treatments

and control. Elemental sulphur proved to be more effective, resulting in taller plants, more branches, greater chlorophyll content, and higher yields. The results underscore the importance of addressing sulphur and micronutrient deficiencies prevalent in Indian soils to optimize safflower productivity. These findings suggest that implementing balanced fertilization strategies that include appropriate sulphur supplementation can significantly boost safflower yield and oil quality, contributing to sustainable agricultural practices in sulphur-deficient regions.

ABBREVIATIONS

RDF: - Recommended Dose of Fertilizers

RBD: - Randomized Block Design

N:P: K: - Nitrogen, Phosphorous, Potassium
kg/ha: - kilogramme per hectare

CONFLICT OF INTERESTS

None.

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REFERENCES

- Baviskar PK, Varsha VT, Jagdale RB, Sarika VS, Bhatia NH. Effect of levels of sulfur and its sources on S uptake, growth, and yield of safflower. *Journal of Soils and Crops*. 2005;15(2):466-469
- Fornasari, C. H., Secco, D., Santos, R. F., da Silva, T. R. B., Lenz, N. B. G., Tokura, L. K., ... & Gurgacz, F. (2017). Efficiency of the use of solvents in vegetable oil extraction at oleaginous crops. *Renewable and Sustainable Energy Reviews*, 80, 121-124.
- Gomashe, S. S., Ingle, K. P., Sarap, Y. A., Chand, D., & Rajkumar, S. (2021). Safflower (*Carthamus tinctorius* L.): An underutilized crop with potential medicinal values. *Annals of Phytomedicine*, 10(1), 242-248.
- Gudadhe, N. N., Mankar, P. S., Khawale, V. S., & Dongarkar, K. P. (2005). Effect of biofertilizers on growth and yield of mustard (*Brassica juncea* L.).
- Narayana, B. B., Umesha, C., Kiran, P. S., & Sekhar, M. (2020). Effect of nitrogen and sulphur levels on growth, yield and economics of spineless safflower (*Carthamus tinctorius* L.). *Journal of Pharmacognosy and Phytochemistry*, 9(6), 1093-1095.
- Panse VG, Sukhatme PV. (1995). Statistical methods for agricultural workers. New Delhi: Indian Council of Agricultural Research.
- Paslawar, A. N., Mali, D. V., Deshmukh, S. D. J., & Kandalkar, A. B. (2012). Response of Sulphur Nutrient on Seed and Oil Yield of Safflower under Rainfed Condition. *PKV Res. J*, 36, 49.
- Patel, U. K., Anurag, B. S., & Kumar, R. (2022). Response of nitrogen and Sulphur levels on growth and yield of safflower (*Carthamus tinctorius* L.).
- Ravi, S., Channal, H. T., & Kumar, G. S. (2010). Response of sulphur and micronutrients (Zn and Fe) on yield and available nutrients of safflower (*Carthamus tinctorius* L.).
- Ravi S, Channal HT, Ananda. Response of sulphur, zinc and iron nutrition on yield components and economics of safflower (*Carthamus tinctorius* L.). *An Asian Journal of Soil Science*. 2008;3(1):21-23.
- Ravikumar PV, Umesha C, Anandamai D, Raju SG. Effect of sulphur and phosphorus levels on growth attributes and economics of safflower (*Carthamus tinctorius* L.). *The Pharma Innovation Journal*. 2021;10(12): 1595-159.
- Salve, D., Bhavsar, M. S., Ghagare, R. B., & Shinde, S. N. (2018). Effect of potassium and sulphur on nutrient uptake, yield and quality of safflower in Vertisol. *International Journal of Current Microbiology and Applied Sciences*, 7(1), 1116-1123.
- Sanghavi, E., Ekale, J. V., & Kulkarni, M. V. (2022). A study on technological gap among safflower growers. *Plant ArchiveS*, 22(2), 110-112
- Shekhawat, K., & Shivay, Y. S. (2008). Effect of nitrogen sources, sulphur and boron levels on productivity, nutrient uptake and quality of sunflower (*Helianthus annuus*). *Indian Journal of Agronomy*, 53(2), 129-134.
- Singh, R., Sanodiya, L. K., Kumar, R., & Singh, S. (2024). Influence of Phosphorus and Sulphur Levels on Economics and Yield of Safflower (*Carthamus tinctorius* L.) under the Eastern Zone of UP, India. *Journal of Experimental Agriculture International*, 46(5), 760-767.
- Singh RK, Singh AK. Effect of nitrogen, phosphorus, and sulfur fertilization on productivity, nutrient-use efficiency, and economics of safflower (*Carthamus tinctorius*) under late-sown condition. *Indian Journal of Agronomy*. 2013;58(4): 583-587.
- Tulasi, J., Ahamed, M. L., Murthy, J. S. V. S., & Rani, Y. A. (2014). Multivariate analysis in upland cotton (*Gossypium hirsutum* L).
- Vikaspedia <https://vikaspedia.in/agriculture/crop-production/package-of-practices/oilseeds/safflower-1> assessed on 26-09-2024
- Withan F. H., Blaydes, D. F. and Devlin, R. M. (1971). Experiments in Plant Physiology. pp 55-58. Van Nostrand Reinhold Co., New York.
- Waterborg, J. H. (2009). The Lowry method for protein quantitation. *The protein protocols handbook*, 7-10.
- Yashpal, N. S., Singh, N., Chaudhary, R., Yadav, S., Singh, R., Vasudev, S., & Yadava, D. K. (2020) Genetic Improvement of Oil Quality Using Molecular Techniques in *Brassica Juncea*. In *Brassica improvement*. Springer Nature, Switzerland. P110-111.