www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(11): 1805-1809

www.thepharmajournal.com
Received: 02-09-2021
Accepted: 05-10-2021

P Lata Achary
M. Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Umesha C
Assistant Professor, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj Uttar Pradesh, India

Corresponding Author:
P Lata Achary
M. Sc. Scholar, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India

Effect of Sulphur and Zinc levels on growth and yield of safflower (*Carthamus tinctorius* L.)

P Lata Achary and Umesha C

DOI: https://doi.org/10.22271/tpi.2021.v10.i11z.9139

Abstract
A field experiment was conducted during *Rabi* season 2020 at Crop Research Farm, Department of Agronomy, SHUATS, Allahabad (U.P) to determine the Effect of Sulphur and Zinc levels on growth and yield of spineless safflower. The experiment was laid out in Randomized Block Design, with nine treatments which consisted of *viz*., T1: Sulphur 0 kg/ha+ Zinc 0 kg/ha, T2: Sulphur 0 kg/ha + Zinc 15 kg/ha, T3: Sulphur 0 kg/ha + Zinc 30 kg/ha, T4: Sulphur 30 kg/ha + Zinc 0 kg/ha, T5: Sulphur 30 kg/ha + Zinc 15 kg/ha, T6: Sulphur 30 kg/ha + Zinc 30 kg/ha, T7: Sulphur 45 kg/ha + Zinc 0 kg/ha, T8: Sulphur 45 kg/ha + Zinc 15 kg/ha, T9: Sulphur 45 kg/ha + Zinc 30 kg/ha which were replicated thrice. The results revealed that treatment combination of Sulphur 45 kg/ha + Zinc 30 kg/ha had shown significant increase in growth parameters *viz*., plant height (101.71cm), number of branches (22.37), plant dry weight (42.62 g), and yield attributes *viz*., heads per plant (21.33), seeds per head (22.67), Test weight (56.67 g), seed yield (1522.7 kg/ha) and stover yield (5888.24 kg/ha) and harvest index (25.86 %). Therefore it's concluded that combination of Sulphur 45kg/ha + Zinc 30 kg/ha recorded significantly higher value in all the parameters as compared to other treatment combination.

Keywords: Sulphur, Zinc, Seed Yield, B:C ratio

Introduction
Safflower (*Carthamus tinctorius* L.) is an oilseed crop which belongs to the Asteraceae family, mostly cultivated on black soils known as vertisols in India under residual moisture conditions. India ranks first in area (41 %) and production (29 %) of safflower grown across the world. In India, Safflower is grown on 1.5 lakh/ha with the production of 1.09 lakh tonnes with an average productivity of 726 kg/ha. In India, the crop is largely grown in Maharashtra, Karnataka, Gujarat, and Andhra Pradesh. Indian yield levels are very low compared to world productivity (820 kg/ha). In Telangana, safflower is grown in an area of 35,000 acres with production of about 8,000 tonnes and productivity of about 345 kg/ha (Vyavasaya Panchangam, 2015-16) [21]. The major reasons for low productivity of safflower are its cultivation under rainfed condition and poor crop nutrition.

Safflower is cultivated for cooking oil and dye from flowers. The seeds contain 24- 36 % of oil which is flavourless, colourless, nutritionally similar to sunflower oil and 11- 24 % protein. Oil is rich in poly unsaturated fatty acids like linoleic fatty acids (73- 79 %), oleic fatty acids (13-21 %), palmitic fatty acids (3-6 %), stearic fatty acids (1-4 %) which plays an important role in reducing the blood cholesterol, hence recommended for heart patients. Safflower oil is also used in the industrial sector as a drying oil that is used in the manufacturing of paints, varnishes and linoleum tile. Oil is used to prepare 'Roghan' which is used to preserve leather and also production of waterproof cloth. Safflower petals are used for colouring and flavouring food products, used in medicines and making of dyes like orange red (carthamin) and yellow (carthamidin) dyes.

Zinc deficiency is the most common widespread micronutrients deficiency. The Zinc plays very important role in plant metabolism by influencing the activities of hydrogenase and carbonic anhydrase, stabilization of ribosomal fractions and synthesis of cytochrome. Plant enzymes activated by Zinc are involved in carbohydrate metabolism, maintenance of the integrity of cellular membranes, protein synthesis, regulation of auxin synthesis and pollen formation. Zinc deficiency can be found in every part of the world and almost all crops respond positively to application of Zinc. Zinc (Zn) is known to have an important role either as a metal component of enzymes or as a functional, structural, or regulatory cofactor of a large number of enzymes. Zinc seems to affect the capacity for water uptake and transport in plants and also reduce the adverse effects of short periods of heat and salt stress. Its deficiency results in the development of abnormalities in plants which become visible as deficiency symptom such as stunted growth, chlorosis and smaller leaves, spikelet sterility. Micronutrient Zinc deficiency can also adversely affect the quality of harvested products. This will weaken the stalk or stem reducing the yield of the crop. Safflower crop consumes on an average 43.2 kg N, 21.8 kg P2O5, 36.6 kg K2O and 12.6 kg Sulphur to produce a tonne of seed (Hegde, 1998) [9].

In Vertisol, deficiency of secondary nutrients is widespread and is one of the reasons for low productivity of safflower. Sulphur has become one of the major limiting nutrients for oilseeds in recent years due to its widespread deficiency (Hegde and Murthy, 2005) [10]. On an average, oilseed crops absorb as much Sulphur. Sulphur is considered as quality nutrient as its application not only influences crop yield but also improves crop quality owing to its influence on protein metabolism, oil synthesis and formation of amino acids (Krishnamoorthy, 1989) [12]. It is a constituent of three amino acids viz. Methionine (21% Sulphur), Cysteine (26% Sulphur) and Cystine (27% Sulphur). Soils deficient in Sulphur cannot provide adequate Sulphur to meet crop demand resulting in Sulphur deficient crops and sub-optimal yields. Sulphur use was also reported to be very remunerative in many crop sequences involving oilseeds (Sudhakarababu and Hegde, 2003) [18].

Materials and Method

The experiment was carried out during winter season of 2020-2021 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The Crop Research Farm is situated at 25o 39’ 42’’N latitude, 81o67’56” E longitude and at an altitude of 98 m above sea level, this city is situated on the right side of the river Yamuna and by the opposite side of Prayagraj city. Experiment was conducted during *Rabi* season 2020-2021.The soil of experiment site was sandy loam, neutral in soil reaction (pH 7.4), available nitrogen (225 kg/ha), available Sulphur (19.45 kg/ha) and available potassium (92.00 kg/ha). Treatment combinations are Sulphur 0 kg/ha + Zinc 0 kg/ha, Sulphur 0 kg/ha + Zinc 15 kg/ha, Sulphur 0 kg/ha + Zinc 30kg/ha, Sulphur 30 kg/ha + Zinc 0 kg/ha, Sulphur 30 kg/ha + Zinc 15 kg/ha, Sulphur 30 kg/ha + 30 Zinc kg/ha, Sulphur 45 kg/ha + Zinc 0 kg/ha, Sulphur 45 kg/ha + Zinc 15 kg/ha and Sulphur 45 kg/ha + Zinc 30kg/ha. These were replicated thrice in Randomized Block Design. The recommended dose of fertilizer is 40:40:20 kg/ha NPK.

Results and Discussions Growth parameters

The growth parameters like plant height, number of branches per plant and dry weight were significantly affected by application of Sulphur and Zinc levels at different stages.

Plant height (cm)

Growth attributes in Table No.1 revealed that safflower crop fertilized with 45 kg/ha Sulphur + 30 kg/ha Zinc significantly resulted maximum plant height (53.15 cm, 81.21 cm, 92.01 cm and 101.71 cm) from 40 DAS, 60 DAS, 80 DAS up to harvest.

Better growth and development of safflower plants successively till the maturity of crop was due to increase in cell multiplication, cell elongation and cell expansion throughout the entire period by the application of higher levels of Sulphur doses. Multiple roles of Sulphur in protein and carbohydrate metabolism of plants by activating several enzymes which participate in dark reaction of photosynthesis hence increasing the plant height. The crop receiving higher dose of Sulphur might have been helped in terms of vigorous root growth, formation of chlorophyll, resulting in higher photosynthesis (Ravi *et al.*, 2010) [14].

Number of branches per plant

Number of branches per plant were tabulated during various stages of plant growth and there was significant increase in number of branches (9.75, 15.31, 20.06, 22.37) per plant by the application of 45 kg/ha Sulphur + 30 kg/ha Zinc during different intervals from 40 DAS, 60 DAS, 80 DAS up to harvest. Sulphur 45 kg/ha + Zinc 15 kg/ha and Sulphur 30 kg/ha + Zinc 30 kg/ha were statistically at par with 45 kg/ha Sulphur + 30 kg/ha Zinc.

Number of branches per plant increased successively till the maturity of crop due to increase in cell multiplication, cell elongation and cell expansion throughout the entire period of crop. This might be ascribed to adequate supply of Sulphur that resulted in higher production of photosynthates and their translocation to sink, which ultimately increased the plant growth and growth attributes (Satish *et al.*, 2011) [17]. These results agree with the findings of Baviskar *et al.*, (2005) [2].

Plant dry weight (g)

Plant dry weight (g) were recorded at various growth stages during plant growth. Significant increase in dry weight (7.54 g, 18.16 g, 40.21 g and 42.62 g) was observed with the application of Sulphur 45 kg/ha + Zinc 30 kg/ha, at 40DAS, 60DAS, 80DAS, and at harvest, and was superior over all the treatments. However, treatment combination of Sulphur 45 kg/ha + Zinc 15 kg/ha and Sulphur 30 kg/ha + Zinc 30 kg/ha (41.89 and 41.29 g/plant) were statistically at par with Sulphur 45 kg/ha + Zinc 30 kg/ha.

Application of Sulphur significantly increased the Nitrogen uptake, stimulated the photosynthetic activity and synthesis of chloroplast protein which might have resulted in higher dry matter production. Similarly, better Sulphur nutrition to plants resulted in more height and number of branches and other growth parameters, which resulted in higher dry matter production (Harendra Kumar and Yadav, 2007) [8]. These results are in line with findings of Baviskar *et al.*, (2005) [2], Venkatesh *et al.*, (2002) [19] and Babhulkar *et al.*, (2000) [1]

Table 1: Effect of Sulphur and Zinc levels on Plant height (cm) and Number of branches of Safflower.

Treatments	Plant height (cm)				Number of branches per plant			
	40 DAS	60 DAS	80 DAS	At harvest	40 DAS	60 DAS	80 DAS	At harvest
Sulphur 0 kg/ha + Zinc 0 kg/ha	32.21	68.16	83.05	92.53	7.01	8.71	13.31	16.02
Sulphur 0 kg/ha + Zinc 15 kg/ha	34.14	69.33	84.63	93.94	7.04	9.03	14.06	16.74
Sulphur 0 kg/ha + Zinc 30 kg/ha	40.75	73.82	88.14	96.25	7.32	9.33	15.32	17.38
Sulphur 30 kg/ha + Zinc 0 kg/ha	40.02	71.71	85.54	96.06	7.74	10.34	16.31	18.79
Sulphur 30 kg/ha + Zinc 15 kg/ha	44.33	78.42	89.85	99.02	7.71	12.71	17.76	20.76
Sulphur 30 kg/ha + Zinc 30 kg/ha	46.64	78.54	91.03	99.32	8.31	13.02	18.38	21.03
Sulphur 45 kg/ha + Zinc 0 kg/ha	42.42	76.12	88.84	98.31	7.32	12.36	16.02	19.72
Sulphur 45 kg/ha + Zinc 15 kg/ha	52.21	79.56	91.22	100.42	8.35	13.37	19.09	21.31
Sulphur 45 kg/ha + Zinc 30 kg/ha	53.15	81.21	92.01	101.71	9.75	15.31	20.06	22.37
SEm(±)	2.575	1.837	1.488	1.359	0.640	0.608	0.822	1.008
CD(P=0.05)	7.72	5.51	4.46	4.08	1.92	1.82	2.46	3.02

Table 2: Effect of Sulphur and Zinc levels on Dry weight (g) of Safflower.

Treatments	Dry weight (g)			
	40 DAS	60 DAS	80 DAS	At harvest
Sulphur 0 kg/ha + Zinc 0 kg/ha	6.17	12.10	34.41	38.21
Sulphur 0 kg/ha + Zinc 15 kg/ha	6.26	12.32	35.49	38.37
Sulphur 0 kg/ha + Zinc 30 kg/ha	6.90	13.41	36.47	39.06
Sulphur 30 kg/ha + Zinc 0 kg/ha	6.27	13.25	37.20	39.10
Sulphur 30 kg/ha + Zinc 15 kg/ha	7.03	16.09	38.16	41.20
Sulphur 30 kg/ha + Zinc 30 kg/ha	7.06	16.33	39.19	41.29
Sulphur 45 kg/ha + Zinc 0 kg/ha	7.05	15.45	37.59	40.08
Sulphur 45 kg/ha + Zinc 15 kg/ha	7.25	17.29	39.24	41.89
Sulphur 45 kg/ha + Zinc 30 kg/ha	7.54	18.16	40.21	42.62
SEm(±)	0.231	0.241	0.366	0.474
CD(P=0.05)	0.70	0.72	1.10	1.42

Yield and Yield attributes

The yield and yield parameters like number of heads per plant, number of seeds per head, seed yield, stover yield were significantly affected by application of Sulphur and Zinc levels. Whereas test weight and harvest index were found to be non-significant.

Number of Heads per Plant

Highest number of heads per plant (21.33) was recorded with the Application of Sulphur 45kg/ha + Zinc 30 kg/ha and was significantly higher among all the treatments and statistically at par with Sulphur 45 kg/ha + Zinc 15 kg/ha and least number of heads per plant (15.15) was recorded with the application Sulphur 0 kg/ha + Zinc 0 kg/ha.

This might be because of better growth of plant due to availability of Sulphur leading to increased number of heads per plant as seed yield is directly related to the growth and yield attributes. Increase in number of capsules per plant with each increase in the levels of Sulphur was also reported by Baviskar *et al.,* (2005) [2]. These results agree with the findings of Venkatesh *et al.,* (2002) [19], Dashora and Sharma (2006) [3].

Number of seeds per head

Maximum number of seeds per head (22.6) was recorded with the application of Sulphur 45 kg/ha + Zinc 30 kg/ha and was significantly higher among all the treatments and statistically at par with Sulphur 45 kg/ha + Zinc 15 kg/ha and minimum seeds per head (17.15) was recorded with the application of Sulphur 0 kg/ha + Zinc 0 kg/ha.

Application of Sulphur increased the plant growth by increasing the assimilating surface area. The higher photosynthates assimilation helped in net export of carbon to sink and thus increased the number of seeds/head (Verma *et al.,* (2012) [20] also found similar observations in safflower.

Test Weight (g)

Maximum test weight (56.67 g) was recorded with the application of Sulphur 45 kg/ha + Zinc 30 kg/ha and no significant difference was observed among the treatments and least test weight (46.67 g) was recorded with the application of Sulphur 0 kg/ha + Zinc 0 kg/ha.

Higher weight of capitulum per plant might be due to higher yield components that are directly responsible for higher seed yield determined by physiological characters both during vegetative and reproductive phase of the crop (Ravi *et al.,* 2010) [14]. These results agree with the findings of Venkatesh *et al.,* (2002) [19].

Seed Yield (kg/ha)

Seed yield differed significantly among the levels of Sulphur and Zinc. Application of Treatment Sulphur 45 kg/ha + Zinc 30 kg/ha) recorded significantly highest seed yield of (1522.70 kg/ha) among all other treatments. The lowest seed yield (989.41 kg/ha) was observed with the application of Sulphur 0 kg/ha + Zinc 0 kg/ha. Seed yield is the function of several yield attributing characters viz., number of heads per plant, number of seeds per head.

The favorable effect of Sulphur fertilization on yield components and finally on yield might be due to balanced nutritional environment, efficient and greater partitioning of metabolites and adequate translocation of nutrients towards reproductive site. The increase in yield might be due to more accumulation of amino acids and amide substances and their translocation to the reproductive organs which influenced growth and yield due to application of Sulphur (Dongarkar, 2005) [5]. The results are in conformity with the findings of Patel *et al.,* (2002) [13].

Stalk yield (kg/ha)

Maximum Stalk yield (5888.24 kg/ha) was recorded with the application of Sulphur 45 kg/ha + Zinc 30 kg/ha and was significantly higher among all the treatments and statistically at par with Sulphur 45 kg/ha + Zinc 15 kg/ha and lowest stalk yield (4536.69 INR/ha) was recorded with the application of Sulphur 0 kg/ha + Zinc 0 kg/ha.

Increase in vegetative growth of plants by Sulphur levels was ultimately responsible for such increase in stalk yield (Dubey *et al.,* 1999) [6]. This was owing to a significant increase in growth and yield attributes with increasing rate of Sulphur application (Santosh Kumar *et al.*, 2009) [16] and Jat and Mehra (2007) [11] also reported an increase in the seed and stalk yield with increasing level of Sulphur.

Harvest Index (%)

Maximum harvest index (25.86 %) was recorded with the application of Sulphur 45 kg/ha + Zinc 30 kg/ha and was significantly higher among all the treatments and statistically at par with Sulphur 45 kg/ha + Zinc 15 kg/ha and lowest harvest index (21.80 %) was recorded with the application of Sulphur 0 kg/ha + Zinc 0 kg/ha.

Table 3: Effect of Sulphur and Zinc levels on yield and yield components of Safflower.

Treatments	Number of Heads/Plant	Number of Seeds/ heads	Test Weight (1000) seeds(g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index %
Sulphur 0 kg/ha + Zinc 0 kg/ha	15.15	17.15	46.67	989.01	4536.69	21.80
Sulphur 0 kg/ha + Zinc 15 kg/ha	15.33	17.89	48.83	1077.20	4868.06	21.98
Sulphur 0 kg/ha + Zinc 30 kg/ha	16.67	18.69	49.17	1155.02	4559.13	22.83
Sulphur 30 kg/ha + Zinc 0 kg/ha	16.56	17.33	51.15	1102.03	4902.13	22.48
Sulphur 30 kg/ha + Zinc 15 kg/ha	17.33	18.67	48.83	1332.0	5523.63	24.12
Sulphur 30 kg/ha + Zinc 30 kg/ha	17.89	19.13	55.27	1360.02	5541.97	24.54
Sulphur 45 kg/ha + Zinc 0 kg/ha	17.25	18.33	51.0	1234.0	5208.94	23.69
Sulphur 45 kg/ha + Zinc 15 kg/ha	18.59	20.33	55.67	1432.02	5781.16	24.77
Sulphur 45 kg/ha + Zinc 30 kg/ha	21.33	22.67	56.67	1522.70	5888.24	25.86
SEm(±)	1.04	0.83	0.57	24.01	59.78	0.33
CD(P=0.05)	3.10	2.45	-	71.99	179.23	0.98

Conclusion

From the above experiment it is concluded that sowing of Safflower with the application of Sulphur 45 kg/ha along with Zinc 30 kg/ha has been found to be more productive and remunerative.

Acknowledgement

I express gratitude to my advisor Dr. Umesha C, Department of Agronomy for constant support and guidance. I am indebted to Prof. (Dr.) Joy Dawson, Department of Agronomy and all the faculty members of SHUATS for inspiration.

References

1. Babhulkar PS, Dineshkar, Badole WP, Balpande SS. Effect of Sulphur and Zinc on yield, quality and nutrient uptake by safflower in vertisol. Journal of Indian Society of Soil Science 2000;48(3):541-543
2. Baviskar PK, Varsha VT, Jagdale RB, Sarika VS, Bhatia NH. Effect of levels of Sulphur and its sources on Sulphur uptake, growth and yield of safflower. Journal of Soils and Crops 2005;15(2):466-469.
3. Dashora P, Sharma RP. Effect of sowing date, irrigation and sulphur nutrition on yield attributes, yield and oil content of safflower. Crop Research 2006;31(1):56-57.
4. Debanath S, Basu AK. Effect of Sulphur on seed yield and oil content in safflower. Journal of Crop and Weed 2013;9(2):113-114.
5. Dongarkar KP, Pawar WS, Khawale VS, Khutate NG, Gudadhe NN. Effect of nitrogen and Sulphur on growth and yield of mustard (*Brassica juncea* L.). Journal of Soils and Crops 2005;15(1):163-167.
6. Dubey SD, Shukla P, Chandra R. Effect of nitrogen and sulphur on their content and uptake in linseed. Journal of Oilseeds Research 1999;16(1):43-47.
7. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research, John Wiley and Sons, Singaporer, 1984.
8. Harendra Kumar, Yadav DS. Effect of phosphorus and Sulphur levels on growth, yield and quality of Indian mustard (*Brassica juncea*) cultivars. Indian Journal of Agronomy 2007;52(2):154-157.
9. Hegde DM. Integrated nutrient management for production sustainability of oilseeds.A review. Journal of Oilseeds Research 1998;15(1):1-17. Hyderabad. 118.
10. Hegde DM, Murthy IYLN. Management of secondary nutrients: Achievements and challenges. Indian Journal of Fertilizers 2005;1(9):93-100 and 105- 110.
11. Jat JR, Mehra RK. Effect of Sulphur and Zinc on yield, macronutrient content in and uptake by mustard on Haplustepts. Journal of the Indian Society of Soil Science 2007;55(2):190-195.
12. Krishnamoorthy SK. Sulphur fertilization for yield and quality of crops. Proc. National Seminar on sulphur in agriculture held at UAS, Bangalore, 1989, 22-25.
13. Patel PT, Patel GG, Patel GA, Sonani VV, Patel HB. Effect of sources and levels of Sulphur on seed and oil yield of safflower (*Carthamus tinctorius* L.). Journal of Oilseeds Research 2002;19(1):76-78.
14. Ravi S, Channal HT, Shailendra Kumar. Response of sulphur and micronutrients (Zn and Fe) on yield and available nutrients of safflower (*Carthamus tinctorius* L.). An Asian Journal of Soil Science 2010;5(2):402-405.
15. Ravi S, Channal HT, Hebsur NS, Patil BN, Dharmatti PR. Effect of Sulphur, Zinc and iron nutrition on growth, yield, nutrient uptake and quality of safflower (*Carthamus tinctorius* L.). Karnataka Journal of Agricultural Science 2008;21(3):382-385.
16. Santosh Kumar, Verma SK, Singh TK, Shyambeer Singh. Effect of nitrogen and Sulphur on growth, yield and nutrient uptake by Indian mustard (*Brassica juncea*) under rainfed condition. Indian Journal of Agricultural Science 2009;79(8):648-650.
17. Satish Kumar, Tewari SK, Singh SS. Effect of sources and levels of Sulphur and spacing on the growth, yield

and quality of spring sunflower (*Helianthus annuus* L.). Indian Journal of Agronomy 2011;56(3):242-246.

18. Sudhakarababu SN, Hegde DM. Annual report.Directorate of oilseeds research. Sudhir Singh Bhadauria. (1999). Yield and quality of safflower as affected by N and P application. Journal of Oilseeds Research 2003;16(1):139-140.
19. Venkatesh MS, Hebsur NS, Satyanarayana T. Evaluation of Sulphur carriers for safflower in vertisol of North Karnataka. Karnataka Journal of Agricultural Science. 2002;15(2):284-287.
20. Verma AK, Shrivastava GK, Tripathi VK, Kolhe SS. Response of safflower (*Carthamus tinctorius* L.) to Sulphur fertilization in alfisols of Chhattisgarh Plains. Journal of Oilseeds Research 2012;29(3):244-245
21. Vyavasaya Panchangam. Published by Agricultural Information & Communication Centre, PJTSAU, 2015-16pp, 109-112.