Response of micronutrients (Iron and Boron) on Growth, Yield and quality of Safflower Crop (*Carthamus tinctorius* L.) in Kalyan Karnataka

Abstract

The present experiment was carried at agricultural research station, Hagari, Ballari, Karnataka to evaluate the response of iron and boron on growth, yield and quality of safflower during 2020-22 two consecutive years. The experiment consists of seven treatments replicated thrice in randomized complete block design. The results from the experiment revelled that combined application of iron and boron *i.e*. the treatment which received recommended dose of fertilizer (RDF) along with 20 kg iron per ha and 1.5 kg boron per ha recorded significantly higher plant height (117.0 cm), number of leaves per plant (94.3), number of primary branches per plant (14.1), number of secondary branches per plant (21.3), total dry matter production (2878 kg), number of capsules per plant (36.9), seed weight per head (0.94), thousand seed weight (68.5 g), and seed yield (15.96 q). The quality parameters such as protein (15.5 %) and oil content (28.8 %) were significantly enhanced in same treatment (T_8).

Keywords: Iron, boron, growth, yield, quality and safflower

Introduction

Safflower (*Carthamus tinctorius* L.) (kusum, kusumbha, kardi) has been under cultivation in India for its brilliantly coloured florets and the orange red dye (*carthamin*) extracted from them and seed [1]. The seed contains 24-36% oil and it is good as sunflower oil having enough amount of linolic acid (78%), which is very useful for reducing blood cholesterol content [2]. The cold pressed oil is golden yellow and is largely used for cooking purposes [3]. The unsaturated fatty acids of safflower lower these rum cholesterols. Oil consumption has been increased due to increasing population and capitation consumption recently [4].

India has the larger coverage but lower yield among the major safflower producing countries. Maharashtra and Karnataka are major safflower growing States, which contribute more than 90% of India's production [5]. In Karnataka, it is cultivated in an area of 1293 thousand ha and production of 805.8 thousand tones, safflower is produced with an average yield of 623 kg ha^{-1}[6] Since, the yields are low as compared to state average (758 Kg ha^{-1}),

Safflower is one of the important oil seed crops being grown in *rabi* in this region [7]. The micro nutrients such as iron and boron play vital role in enhancing yield and quality of safflower. Among which, iron is necessary for the biosynthesis of chlorophyll and cytochrome, besides the function of iron in the metabolism of chloroplast RNA, leading to increase in the biosynthesis materials and it acts as cofactor for approximately 140 enzymes that catalyse unique biochemical reactions [8]. Whereas boron is considered one of the necessary elements for the growth of plants, it participates in the physiological process of pollination, fertilization and plant fruit setting [9]. By looking at the importance of iron and boron on growth, yield quality and also the information on Fe and B fertilization on yield, uptake and quality of safflower is meagre with this the present study was undertaken to study effect of application of iron and boron on growth, yield and quality of safflower under rainfed condition in Kalyan Karnataka, India.

Material and methods

The experiment was conducted at agricultural research station, Hagari, Ballari, Karnataka. during two consecutive years (2020-2022). The test crop was safflower grown under *Rabi* conditions with spacing of 60 x 30 cm. The net plot size 2.4 X 3.2m for the experiment. The experiment consists of 8 treatments replicated thrice in randomized complete block design. Land is prepared and levelled based on crop requirement. The recommended dose of fertilizers (40:40:12.5 kg NPK +30 kg sulphur +15 kg $ZnSO_4$ ha^{-1}) were applied to the safflower crop in the treatments expect in the absolute control. The treatments were imposed based on the details as listed in the Table 1.

<u>Treatments</u>:

T_1: Absolute control

T_2: RDF (40:40:12.5 kg NPK +30 kg Sulphur +15 kg $ZnSO_4ha^{-1}$)

T_3: RDF + 15 kg $FeSO_4ha^{-1}$

T_4: RDF + 1.0 kg Boron ha^{-1}

T_5: RDF + 15 kg $FeSO_4ha^{-1}$+ 1.0 kg Boron ha^{-1}

T_6: RDF + 20 kg $FeSO_4ha^{-1}$

T_7: RDF + 1.5 kg Boron ha^{-1}

T_8: RDF + 20 kg $FeSO_4ha^{-1}$ +1.5 kg Boron ha^{-1}

(**Note:** FYM @ 5 t ha^{-1} is applied for all treatments except absolute control)

Growth parameters such as plant height (cm), number of leaves /plant, primary branches, secondary branches and dry matter production (kg/ha) were recorded from the 5 labelled different plants. Similarly, yield parameters, such as number of capsules /plant, seed weight/ head (g), thousand seed weight (g), thousand seed weight (g), thousand seed weight (g) and seed yield (q/ha) were recorded. The quality parameters such as protein content (%), protein yield (kg ha^{-1}), oil content (%) and oil yield (kg ha^{-1}) were analyzed by using standard analytical procedures. The oil content in seeds was estimated by Nuclear Magnetic Resonance (NMR) Spectrophotometer. The oil content was expressed in percentage [10]. The nitrogen content was estimated by modified kjeldahl's method. The protein content was calculated by multiplying the per cent nitrogen with a factor 6.25 [11]. Before start of the experiment, initial soil sample was drawn and analyzed for various soil physico-chemical properties. The details of initial soil properties of experimental site are listed in Table 1. The initial soil was having alkaline soil reaction (8.37) with medium electrical conductivity (0.79 dSm^{-1}) and medium soil organic carbon status (0.53%). The available nutrients such as nitrogen (276 kg ha^{-1}) phosphorus (32 kg ha^{-1}) and potassium (426 kg ha^{-1}) were medium in status. The micro nutrients such as iron (1.96 ppm) and boron (0.50 ppm) were low in fertility status

Table1: Initial soil properties of experimental site:

Sl. No	**Parameters**	**Values**
		2020-21
1	pH	8.37
2	EC(dSm^{-1})	0.79
3	Organic carbon (%)	0.53
4	Available Nitrogen(kg/ha)	276
5	AvailableP_2O_5 (kg/ha)	32.0
6	Available K_2O (kg/ha)	426
7	Available Fe (ppm)	1.96
8	Available B (ppm)	0.50

Results

The results pertaining to growth, yield and quality are presented in Table 2, 3& 4. The results of the two years investigation revealed that levels of iron, boron and their combination treatments had significant influence on plant height, number of leaves per plant, number of primary branches per plant, number of secondary branches per plant, total dry matter production, number of capsules per plant, seed weight per head, thousand seed weight and seed yield of safflower crop.

At harvest, among the iron and boron levels, application of 20 kg $FeSO_4$ ha^{-1} recorded the plant height (102.8 cm), number of leaves per plant (85.4), number of primary branches per plant (11.5), number of secondary branches per plant (17.7), total dry matter production (2550 kg). number of capsules per plant (33.6), seed weight per head (0.85 g), thousand seed weight (59.8 g), seed yield (14.61 q) and quality parameters such as protein content (14.5 %), protein yield (227.0kg ha^{-1}), oil content (28.4 %) and oil yield (443.7 kg ha^{-1}). and it was significantly superior over recommend dose of fertilizer (RDF) and control. But on par with 15 kg $FeSO_4$ ha^{-1},1.5 kg Boron ha^{-1} and 1.0 kg Boron ha^{-1}.

Combination (RDF) with levels of iron and boron (Micronutrient) had profound influence on growth and yield parameters. The treatments receiving T_8: RDF + 20 kg iron per ha + 1.5 kg boron per ha recorded the highest plant height (117.0 cm), number of leaves per plant (94.3), number of primary branches per plant (14.1), number of secondary branches per plant (21.3), total dry matter production(2878 kg), number of capsules per plant (36.9), seed weight per head (0.94), thousand seed weight (68.5 g), and seed yield (15.96 q), and it was significantly superior over T_6: RDF + 20 kg $FeSO_4ha^{-1}$ (14.61 q), T_7: RDF + 1.5 kg Boron ha^{-1} (14.12 q), T_3: RDF + 15 kg $FeSO_4ha^{-1}$(14.23 q), T_4: RDF + 1.0 kg Boron ha^{-1}(13.99 q), T_2: RDF (13.93 q) and T_1: control (7.19 q), but it on par with T_5: RDF + 15 kg $FeSO_4$ ha^{-1}+1.0 kg Boron ha^{-1}(15.65 q). Among the different treatments, the treatment which received recommended dose of fertilizer along with 20 kg iron per ha and 1.5 kg boron per ha recorded significantly higher protein content (15.5 %), protein yield (247.5 kg ha^{-1}), oil content (28.8 %) and oil yield (458.9 kg ha^{-1}).

Discussion

Yield is a function of complex inter-relationships of its components, which was determined from the growth in vegetative phase and its subsequent reflection in reproductive phase of the plant [12]. The results showed that application of combination of iron and boron

Table 2: Response of iron and boron nutrition on growth parameters of safflower crop in Kalyan Karnataka

Treatments details	Plant height (cm)			Number of leaves /plant			Primary Branches/ plant			Secondary Branches/ plant			Dry matter production(kg/ha)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T_1	65.2	66.8	**66.0**	45.6	46.8	**46.2**	5.1	5.8	**5.5**	9.3	9.8	**9.6**	1856	1895	**1876**
T_2	82.6	85.7	**84.2**	72.8	75.4	**74.1**	8.7	8.9	**8.8**	13.5	13.9	**13.7**	2254	2289	**2272**
T_3	96.2	98.9	**97.6**	81.5	83.1	**82.3**	9.6	9.9	**9.8**	15.6	16.1	**15.9**	2389	2415	**2402**
T_4	85.5	87.6	**86.6**	76.6	77.9	**77.3**	8.9	9.3	**9.1**	14.2	14.8	**14.5**	2298	2331	**2315**
T_5	106.6	109.1	**107.9**	89.5	91.3	**90.4**	12.8	13.1	**13.0**	19.1	19.9	**19.5**	2626	2696	**2661**
T_6	101.2	104.4	**102.8**	84.2	86.5	**85.4**	11.1	11.8	**11.5**	17.5	17.9	**17.7**	2502	2597	**2550**
T_7	98.5	99.8	**99.2**	80.9	82.9	**81.9**	10.1	10.5	**10.3**	15.8	16.3	**16.1**	2426	2487	**2457**
T_8	115.3	118.7	**117.0**	93.2	95.3	**94.3**	13.9	14.2	**14.1**	20.9	21.6	**21.3**	2857	2899	**2878**
Mean	93.89	96.38	**95.1**	78.04	79.30	**78.7**	10.03	10.44	**10.24**	15.74	16.29	**16.02**	2401	2451	**2426**
S.E.±	4.58	4.38	**4.5**	2.77	2.82	**2.8**	0.42	0.43	**0.43**	0.67	0.71	**0.69**	80.24	86.30	**83.3**
C.D.(P=0.05)	13.89	13.46	**13.7**	8.41	8.55	**8.5**	1.27	1.29	**1.28**	2.04	2.15	**2.10**	243.4	261.8	**253.6**

Note: FYM @ 5 t ha^{-1} is applied for all treatments except absolute control

Table 3: Response of iron and boron nutrition on yield parameters of safflower crop in Kalyan Karnataka

Treatments details	Number of capsules /plant			Seed weight/ head (g)			Thousand Seed weight(g)			Seed yield (q/ha)		
	2020	**2021**	**Pooled**	**2020**	**2021**	**Pooled**	**2020**	**2021**	**Pooled**	**2020**	**2021**	**Pooled**
T_1	19.5	19.8	**19.7**	0.63	0.66	**0.65**	44.5	44.7	**44.60**	7.09	7.29	**7.19**
T_2	26.3	26.9	**26.6**	0.69	0.73	**0.71**	52.3	52.9	**52.60**	13.78	14.08	**13.93**
T_3	28.9	29.5	**29.2**	0.78	0.81	**0.80**	56.9	57.4	**57.15**	14.05	14.41	**14.23**
T_4	27.2	28.1	**27.7**	0.73	0.77	**0.75**	53.7	54.3	**54.00**	13.81	14.17	**13.99**
T_5	34.5	35.1	**34.8**	0.89	0.94	**0.92**	60.2	61.0	**60.60**	15.28	16.02	**15.65**
T_6	33.3	33.9	**33.6**	0.83	0.87	**0.85**	59.3	60.3	**59.80**	14.53	14.69	**14.61**
T_7	31.1	32.1	**31.6**	0.79	0.81	**0.80**	55.6	56.3	**55.95**	14.06	14.18	**14.12**
T_8	36.5	37.3	**36.9**	0.93	0.95	**0.94**	67.9	69.1	**68.50**	15.57	16.35	**15.96**
Mean	29.7	30.3	**30.0**	0.78	0.82	**0.80**	56.30	57.0	**56.65**	13.52	13.90	**13.71**
S.E.±	0.87	1.01	**0.94**	0.03	0.05	**0.04**	2.57	2.66	**2.62**	0.34	0.54	**0.42**
C.D.(P=0.05)	2.65	3.06	**2.90**	0.09	0.14	**0.12**	7.80	8.06	**7.93**	1.02	1.63	**1.27**

Table 4: Response of iron and boron nutrition on quality parameters of safflower crop in Kalyan Karnataka

Treatments	Protein content	Protein yield	Oil content	Oil yield

	(%)			(kg/ha)			(%)			(kg/ha)		
	2020	**2021**	**Pooled**	**2020**	**2021**	**Pooled**	**2020**	**2021**	**Pooled**	**2020**	**2021**	**Pooled**
T_1	11.6	11.9	**11.8**	82	87	**84.5**	25.1	25.3	**25.2**	178.0	184.4	**181.2**
T_2	12.5	12.8	**12.7**	172	180	**176.0**	26.6	26.8	**26.7**	366.5	377.3	**371.9**
T_3	13.3	13.8	**13.6**	187	199	**193.0**	27.4	27.9	**27.7**	385.0	402.0	**393.5**
T_4	13.1	13.5	**13.3**	181	191	**186.0**	27.1	27.4	**27.3**	374.3	388.3	**381.3**
T_5	14.2	14.8	**14.5**	217	237	**227.0**	28.2	28.5	**28.4**	430.9	456.6	**443.7**
T_6	13.9	14.1	**14.0**	202	207	**204.5**	27.8	28.0	**27.9**	403.9	411.3	**407.6**
T_7	13.4	14.0	**13.7**	188	199	**193.5**	27.6	27.8	**27.7**	388.1	394.2	**391.1**
T_8	15.4	15.6	**15.5**	240	255	**247.5**	28.6	28.9	**28.8**	445.3	472.5	**458.9**
Mean	13.43	13.83	**13.63**	183.63	194.38	**189.01**	27.30	27.58	**27.44**	371.5	385.8	**378.6**
S.E.±	0.47	0.45	**0.46**	8.77	5.64	**7.21**	0.48	0.55	**0.52**	10.57	12.14	**11.35**
C.D.(P=0.05)	1.43	1.36	**1.40**	26.60	17.10	**21.85**	**1.44**	**1.67**	**1.56**	32.06	36.82	**34.44**

significantly influenced growth, yield and quality of safflower might be due to Fe and Bare play vital role in physiological processes such as chlorophyll content, water and nutrients absorption, nucleic acids, IAA, cell division and cell elongation which in turn effect on plant growth, therefore reflected positive effect on increasing the number of leaves per plant [13& 14]. Fe has a structural role in chlorophyll, energy transfer within the plant and enters in root cells and B is necessary in the formation of plant cells, sugar transportation, IAA, formation and germination [15]. Similarly, some of the authors reported that iron enhance the carbohydrates production on photosynthesis for that reason in the end grain of the material can be stored and Can be stated that the use of iron may increase the yield [16]. The current data might be due to the role of Fe as cofactor for different defence enzyme e.g: superoxide dismutase and catalase, these enzymes play significant role against various a biotic stress especially high salinity and drought stress [17]. Iron is credited with a definite role in the synthesis of chlorophyll molecule [18] Boron has metabolic role in biochemical reactions and protects plant cell from stressors [19]. Boron regulates metabolism involved in translocation of carbohydrates, cell wall development and RNA synthesis. The increase in growth, yield and quality parameters are mainly due to the combined application of micronutrients such as iron and boron through soil application with their key role of in physiological and metabolic process.

Conclusions

Micronutrients are required by plants in small quantities, but they are very important for plant to compete complete life cycle. The combined application of iron and boron along with recommended dose of fertiliser recorded significantly higher growth, yield and quality parameters compared to absolute control and recommended dose of fertiliser treatment as these nutrients are deficient in the soil.

References

NEELIMA, S., PRABHAKAR, K., & RAMANAMMA, K. V. (2021). Genetic variability, heritability, association and divergence studies in safflower (*Carthamus tinctorius* L.) genotypes. *Indian Society of Oilseeds Research, 38*, 265-269.

OLALEYE, O. O., EKE, M. O., & AONDO, T. O. (2018). Extraction, physicochemical and phytochemical characterization of oil from sesame seed. *Asian Food Science Journal*, *1*(4), 1-12.

GALAVI, M., RAMROUDI, M., & TAVASSOLI, A. (2012). Effect of micronutrients foliar application on yield and seed oil content of safflower (*Carthamus tinctorius*). *African Journal of Agricultural Research*, *7*(3), 482-486.

RAKESH, M., SINGH, R., & SINGH, E. (2021). Influence of nitrogen and foliar spray of iron on yield and economics of safflower (*Carthamus tinctorius* L.).

RAI, S. K., CHARAK, D., & BHARAT, R. (2016). Scenario of oilseed crops across the globe. *Plant Archives*, *16*(1), 125-132.

KUMARA, K., RAO, K. N., VEERESH, H., GADDI, A. K., & CHANNABASAVANNA, A. S. (2020). Response of safflower to foliar application of micronutrient mixture. *International Research Journal of Pure and Applied Chemistry*, *21*(2), 26-33.

REDDY, B. N., & SURESH, G. (2009). Crop diversification with oilseed crops for-maximizing productivity, profitability and resource conservation. *Indian Journal of Agronomy*, *54*(2), 206-214.

TAHA, M. H., SHALABY, E. A., & SHANAN, N. T. (2013). Improving safflower (*Carthamus tinctorius* L.) growth and biological activities under saline water irrigation by using iron and zinc foliar applications. *Journal of Plant Production*, *4*(8), 1219-1234.

AL-JUHEISHY, W. K. (2020). EFFECT OF BORON ON SOME INDUSTRIAL CROPS: A REVIEW. *Mesopotamia Journal of Agriculture*, *48*(4), 134-145.

ANONYMOUS, 1975, Official Methods of Analysis (12th Ed.), William Storwertzled, A.O.A.C. Publications, Washington, D.C., pp.506- 508.

TAI, Y.P AND YOUNG, G.P., 1974, Variation in protein percentage in different properties of peanut cotyledons. Crop Sci., 14:222- 229

JAGADALA, K., BHOL, R., & SAHOO, J. P. (2020). Effect of boron on growth and yield parameters of sunflower in acid soil. *Journal of Pharmacognosy and Phytochemistry*, *9*(4), 215-218.

EL-FOULY MM, MOBARAK ZM, SALAMA ZA. 2011. Micronutrients (Fe, Mn, Zn) foliar spray for increasing salinity tolerance in wheat (*Triticum aestivum* L). Afr. J. Plant Sci. 5 (5): 314-322.

MASOUD BAMERI, ROOHOLLA ABDOLSHAHI, GHASEM MOHAMMADI-NEJAD, KHATOON YOUSEFI AND SAYED MASOUD TABATABAIE. 2012. Effect of

different microelement treatment on wheat (*Triticum aestivum* L.) growth and yield, Intl. Res. J. Appl. Basic. Sci., 3 (1): 219-223.

RAWASHDEH, H. M., & SALA, F. (2013). The effect of foliar application of iron and boron on early growth parameters of wheat (*Triticum aestivum* L.). *Research Journal of Agricultural Science*, *45*(1).

GHAVAMİ, S., MOGHADASİ, M. S., & OMİDİTABRİZİ, A. (2015). Evaluatıon Of Use Fe And Zn Mıcronutrıents Applıcatıon On Quantıtatıve And Qualıtatıve Traıts Of Safflower (*Carthamus Tinctorius* L.). *Cumhuriyet Üniversitesi Fen Edebiyat Fakültesi Fen Bilimleri Dergisi*, *36*(3), 636-640.

PARINAZ KOHNAWARD, JALAL JALILIAN, ALIREZA PIRZAD. 2012. Effect of foliar application of Micro-nutrients on yield and yield components of safflower under conventional and ecological cropping systems. Intl. Res. J. Appl. Basic. Sci., 3 (7): 1460-1469.

SOHEILI-MOVAHHED, S., KHOMARI, S., SHEIKHZADEH, P., & ALIZADEH, B. (2019). Improvement in seed quantity and quality of spring safflower through foliar application of boron and zinc under end-season drought stress. *Journal of Plant Nutrition*, *42*(8), 942-953.

PANDEY, S. N., AND SINHA, B. K., 2006, Plant Physiology, 4th edition Vikas Publication House, Nodia; pp 130-135.