

Original Research Article

Response of Iron and Boron on uptake of nutrients and soil nutrient status after harvest of Safflower Crop (*Carthamus tinctorius* L.) in Kalyan Karnataka, India

Abstract

Micronutrients are required by the plants in small quantities, but they are very important for plant to compete life cycle with this the present experiment was conducted at Agricultural Research Station, Hagari, Ballari, Karnataka to evaluate the response of iron and boron on uptake of nutrients and soil nutrient status after harvest of safflower during two consecutive years 2020-21. The experiment consisted of seven treatments, includes T₁: Absolute control, T₂: RDF (40:40:12.5 kg NPK +30 kg Sulphur +15 kg ZnSO₄ ha⁻¹), T₃: RDF + 15 kg FeSO₄ha⁻¹, T₄: RDF + 1.0 kg Boron ha⁻¹, T₅: RDF + 15 kg FeSO₄ ha⁻¹+ 1.0 kg Boron ha⁻¹, T₆: RDF + 20 kg FeSO₄ ha⁻¹, T₇: RDF + 1.5 kg Boron ha⁻¹ and T₈: RDF + 20 kg FeSO₄ ha⁻¹ +1.5 kg Boron ha⁻¹ which replicated thrice in randomized complete block design. The results of the experiment revealed that the combined application of iron and boron *i.e.* 100% recommended dose of fertilizer (RDF) along with 20 kg iron per ha and 1.5 kg boron per ha (T₈) recorded significantly higher uptake of N. P. K. Fe and B by safflower crop. The higher availability of soil nutrients N, K were recorded in control and P, Fe and B were in T₈:RDF + 20 kg FeSO₄ ha⁻¹+1.5 kg Boron ha⁻¹ treatments.

Keywords: Available nutrient status, boron, iron, uptake of nutrients, 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]. “Safflower (*Carthamus tinctorius* L.), an oilseed crop is a member of the family compositae. It can safely be grown during the post rainy season as a potential Rabi crop in rainfed areas. India ranks first in area (41%) and production (29%) of the safflower grown across the world” [2]. “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” [3 and 4]. “The cold pressed oil is golden yellow and is largely used for cooking purposes” [5, 6 and 7]. “The unsaturated fatty acids of safflower lower these

rum cholesterols” [8]. “Oil consumption has been increased due to increasing population and capitation consumption recently” [9]. “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” [10]. In Karnataka, it is cultivated in an area of 1293 thousand ha and production of 805.8 thousand tones, with an average yield of 623 kg ha⁻¹[11], which was low as compared to state average (758 Kg ha⁻¹). The importance of oil crops such as safflower has increased in recent years, as this plant successfully acclimatizes to rain-fed conditions and is highly drought resistant due to its extended root system enabling access to water down to 2-3 m in the soil [12]. “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” [13 and 14]. “Whereas boron is considered as one of the necessary elements for the growth of plants, it participates in the physiological process of pollination, fertilization and plant fruit setting” [15]. Safflower is one of the important oil seed crops being grown in *Rabi* in this region. It is aimed to analyse and assess the soil properties of the selected soils under safflower cultivation to understand the possible reasons. The nature and availability of Fe and B in red and black soils is different due to the basic difference in soil properties. The information on Fe and B fertilization on uptake and available nutrients by safflower is meagre so this present study was undertaken to study effect of application of iron and boron on uptake and available nutrient status after harvest 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 (2020-2021). 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 land was ploughed after application of recommended dose of FYM with mould board plough and cultivator was passed twice to get good tilth. Later the land was converted into required sized plots and levelling was ensured within each plot. The experiment consists of eight treatments replicated thrice in randomized complete block design. The treatments such as T₁: consists of absolute control; T₂: recommended dose of fertilizers (40:40:12.5 kg NPK +30 kg Sulphur +15 kg ZnSO₄ ha⁻¹); T₃: RDF + 15 kg FeSO₄ ha⁻¹, T₄: RDF + 1.0 kg Boron ha⁻¹, T₅:

RDF + 15 kg FeSO₄ ha⁻¹ + 1.0 kg Boron ha⁻¹, T₆: RDF + 20 kg FeSO₄ ha⁻¹, T₇: RDF + 1.5 kg Boron ha⁻¹ and T₈: RDF + 20 kg FeSO₄ha⁻¹ +1.5 kg Boron ha⁻¹. The recommended dose of fertilizers (40:40:12.5 kg NPK + 30 kg sulphur +15 kg ZnSO₄ ha⁻¹) were applied to the safflower crop in the treatments except in the absolute control. Nitrogen was applied in the form of urea; phosphorus was supplied in the form of DAP whereas potassium was through MAP. The secondary nutrient sulphur was applied in the form of elemental sulphur. Zinc was applied in the form of ZnSO₄, Iron in the form of FeSO₄ and boron in the form of borax; these micronutrients were applied as basal application. FYM @ 5 t ha⁻¹ is applied for all treatments except absolute control one month prior to sowing.

Before start of the experiment, initial soil sample (0-15 cm) depth was drawn and analyzed for various soil physico-chemical properties. 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. The post-harvest soil samples at depth of 0-15cm were drawn by treatment wise and analyzed for chemical properties by adopting standard analytical procedures as mentioned in the Table1.

Table 1: Different soil properties and methods employed for analysis

Sl. No.	Soil property	Methods followed
1	pH (1:2.5)	Potentiometry (Jackson, 1973) [16]
2	EC(1:2.5) (dS/m)	Conductometry (Jackson, 1973) [16]
3	OC (%)	Wet oxidation method (Jackson, 1973) [16]
4	Available N (kg/ha)	Alkaline permanganate method (Subbiah and Asija, 1956) [17]
5	Available P ₂ O ₅ (kg/ha)	Bray's method (Jackson 1973) [16]
6	Available K ₂ O (kg/ha)	Neutral 1N NH ₄ OH extractant & flame photometry method (Page,1982) [18]
7	Available. Fe (ppm)	DTPA extraction, AAS method (Lindsay and Norwell, 1978) [19]

8	Available. B (ppm)	Hot water extraction method and colorimetry using Azomethane-H reagent with continuous flow analyzer (John <i>et al.</i> , 1975) [20]
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Analysis of plant samples: Plant samples were randomly collected from labelled plants in each treatment, cleaned with water, air dried and then dried in hot-air oven at 60 °C for 18 hours. The samples were then powdered and stored in polythene bags. These samples were analyzed for nitrogen, phosphorus, potassium, iron and boron content.

Estimation of nitrogen in plant samples: Nitrogen was determined by Kjeldahl distillation method. Plant sample (1 g) was digested in digestion flasks using sulphuric acid and digestion mixture. After complete digestion, the digested material was distilled in alkaline medium and the liberated ammonia was trapped in four percent boric acid solution containing mixed indicator. The trapped ammonia was titrated against standard sulphuric acid by Piper, (1966) [21].

Estimation of phosphorus and potassium: Powdered leaf samples (1 gram) were treated with 10 ml of concentrated HNO₃ and kept overnight for pre digestion. The samples were then digested with 10 ml of the di-acid mixture (HNO₃ and HClO₄ in 9:4 ratio) until a snow white residue was left. Phosphorus content in the di-acid digested extract was estimated by Vanado-molybdo-phosphoric yellow colour method in nitric acid medium and the colour intensity was measured at 420 nm wave length [21]. Potassium in the plant sample was estimated by atomizing the diluted di-acid extract to a flame photometer [21].

Estimation of micronutrients (Iron and Boron): After making suitable dilution of di-acid extract, the samples were fed to the atomic absorption spectrophotometer using appropriate hollow cathode lamps to estimate the Fe content in the plant samples. Boron concentration in di-acid digested sample of plant was estimated by Azomethine-H reagent method using continuous flow analyzer [18].

Uptake of Nutrients

Nutrient uptake for the major nutrients was calculated by using formula.

$$\text{Nutrient concentration (\%)} \times \text{Biomass (kg ha}^{-1}\text{)}$$

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (ppm)} \times \text{Biomass (kg ha}^{-1}\text{)}}{100}$$

100

Nutrient uptake for the micronutrients iron and boron were calculated by using following formula.

$$\text{Nutrient uptake (g ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (ppm)} \times \text{Biomass (kg ha}^{-1}\text{)}}{1000}$$

1000

Statistical analysis: The observations recorded in these studies were analysed statistically for test of significance following the Fisher's method of analysis of variance (ANOVA) as outlined by [22]. The level of significance on 'F' test was tested a five percent. The results have been discussed based on critical difference at $P=0.05$. Wherever the treatment differences were found non-significant, it is denoted as 'NS'.

Results and discussion

Uptake of nutrients

The results pertaining to uptake of nutrient and soil available nutrient status are presented in Table 2, 3 and 4. The results of the two years' investigation revealed that levels of iron, boron and their combination treatments had significant effect on total uptake of nutrients. The results of pooled analysis showed that among the different treatments, the treatment (T_8) which consists of recommended dose of nutrients (40:40:12.5 kg NPK +30 kg Sulphur +15 kg $ZnSO_4$ ha⁻¹) along with 20 kg $FeSO_4$ ha⁻¹ and 1.5 kg Boron ha⁻¹ recorded significantly higher uptake of nitrogen (84.52 kg ha⁻¹), phosphorus (8.56 kg ha⁻¹) and potassium (65.55 kg ha⁻¹). Similarly, uptake of micronutrients such as iron (1349.6 g ha⁻¹) and boron (222.3 g ha⁻¹) compared to control (T_1) and recommended dose of fertiliser treatment (T_2). It is on par with the treatments T_5 : RDF+15 kg $FeSO_4$ ha⁻¹+1.0 kg Boron ha⁻¹, T_6 : RDF + 20 kg $FeSO_4$ ha⁻¹ and T_7 : RDF + 1.5 kg Boron ha⁻¹. The higher uptake of nutrients by safflower might be due to application of balanced dose of NPK and FYM along with $FeSO_4$ and Borax enhances rate of mineralization in the soil. The application of iron sulphate and borax were responsible for higher availability in the soil which intern utilised by safflower. Fe and B 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 uptake of nutrients in plant [23 & 24]. These results are agreement with [25] who observed the synergistic effect of iron with phosphorus which enhanced higher dry matter production and yield ultimately resulted in higher nutrient uptake. The similar results are reported by [26] in cotton. The use of micronutrients has a profound effect on the growth and development of plants as they are essential for plant growth since they increase the absorption and uptake of NPK and also trigger the defence mechanism of plants and ultimately enhance plant growth [27].

Soil nutrient status

The results pertaining to soil chemical properties revealed that the effect of iron and boron on soil P^H , EC and OC were found statistical non-significant. However higher EC (0.88 dsm^{-1}) and OC (0.57%) were recorded in treatment T_8 : RDF + $20 \text{ kg FeSO}_4 \text{ ha}^{-1}$ + $1.5 \text{ kg Boron ha}^{-1}$. The results on effect of combination of iron and boron on primary nutrients available status were found statistically significant. Among the different treatments, lower available nutrients such as nitrogen (232.5 kg ha^{-1}) and potassium (382.1 kg ha^{-1}) were recorded in treatment (T_8) which consists of recommended dose of nutrients ($40:40:12.5 \text{ kg NPK} + 30 \text{ kg Sulphur} + 15 \text{ kg ZnSO}_4 \text{ ha}^{-1}$) along with $20 \text{ kg FeSO}_4 \text{ ha}^{-1}$ and $1.5 \text{ kg Boron ha}^{-1}$. The reason behind lower nutrient in this treatment might be due to higher uptake of these nutrients by safflower during its growth and development. The higher uptake of nutrients by plants and its further translocation to various plant parts including fruit, besides being subjected to other losses [28]. Interestingly, the higher available phosphorus in the soil after harvest of safflower was recorded in Treatment T_2 : RDF ($40:40:12.5 \text{ kg NPK} + 30 \text{ kg Sulphur} + 15 \text{ kg ZnSO}_4 \text{ ha}^{-1}$) and lower phosphorus was recorded in T_8 : RDF + $20 \text{ kg FeSO}_4 \text{ ha}^{-1}$ + $1.5 \text{ kg Boron ha}^{-1}$. This might be due to application of iron triggers the availability of phosphorous. The iron status in soil (2.40 ppm) was found high in the treatment T_6 : RDF + $20 \text{ kg FeSO}_4 \text{ ha}^{-1}$ after harvest of safflower. This might be due to higher application of iron in the form of iron sulphate ($20 \text{ kg FeSO}_4 \text{ ha}^{-1}$). Whereas the micronutrient boron (0.62 ppm) was found high in the treatment T_7 : RDF + 1.5

Table 2: Effect of iron and boron nutrition on total nutrient uptake

Treatments details	N Uptake (kg/ha)			P Uptake (kg/ha)			K Uptake (kg/ha)			Fe Uptake (g/ha)			B Uptake (g/ha)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T₁	42.25	43.46	42.86	2.21	2.53	2.37	26.83	27.51	27.17	523.2	549.3	536.3	85.6	88.7	87.2
T₂	58.25	60.39	59.32	3.54	3.81	3.68	38.26	39.43	38.85	985.6	993.5	989.6	165.6	170.3	168.0
T₃	63.42	66.21	64.82	4.89	4.95	4.92	45.61	46.81	46.21	1083.5	1104.3	1093.9	173.8	175.4	174.6
T₄	60.25	62.41	61.33	4.73	4.77	4.75	42.93	43.89	43.41	993.6	1026.1	1009.9	166.4	171.1	168.8
T₅	76.41	77.23	76.82	7.15	7.36	7.26	59.24	61.10	60.17	1213.2	1263.2	1238.2	201.9	203.8	202.9
T₆	74.51	75.63	75.07	6.76	6.97	6.87	51.25	52.83	52.04	1129.8	1183.5	1156.7	192.5	195.7	194.1
T₇	72.23	74.12	73.18	6.12	6.33	6.23	48.65	50.41	49.53	1085.7	1121.0	1103.4	185.8	188.3	187.1
T₈	83.43	85.61	84.52	8.43	8.69	8.56	64.37	66.73	65.55	1325.9	1373.3	1349.6	219.2	225.4	222.3
Mean	66.34	68.13	67.24	5.48	5.68	5.58	47.14	48.59	47.87	1042.6	1076.8	1059.7	173.9	177.3	175.6
S.E._±	2.59	2.80	2.70	0.49	0.51	0.50	2.00	3.10	2.55	38.70	44.44	41.57	8.84	9.43	9.14
C.D.(P=0.05)	7.85	8.51	8.18	1.48	1.54	1.51	6.07	9.41	7.74	117.38	134.81	126.10	26.82	28.71	27.77

Table 4: Effect of iron and boron nutrition on available nutrient status in soils after harvest of safflower crop

Treatments details	N Available (kg/ha)			P ₂ O ₅ Available (kg/ha)			K ₂ O Available (kg/ha)			Fe Available (ppm)			B Available (ppm)		
	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled	2020	2021	Pooled
T₁	273.8	279.3	276.6	28.8	30.5	29.7	412.7	417.8	415.3	1.85	1.89	1.87	0.43	0.44	0.44
T₂	255.8	259.5	257.7	38.5	40.9	39.7	405.2	407.3	406.3	1.76	1.80	1.78	0.45	0.47	0.46
T₃	250.6	256.7	253.7	37.1	39.8	38.5	397.9	400.4	399.2	2.25	2.33	2.29	0.41	0.42	0.42
T₄	253.8	259.3	256.6	37.3	40.6	39.0	400.6	405.6	403.1	1.79	1.84	1.82	0.56	0.59	0.58
T₅	238.6	243.7	241.2	34.9	36.8	35.9	384.3	390.7	387.5	2.15	2.19	2.17	0.53	0.56	0.55
T₆	240.5	246.8	243.7	35.2	37.6	36.4	392.3	396.5	394.4	2.36	2.43	2.40	0.40	0.43	0.42
T₇	242.8	243.9	243.4	35.9	38.1	37.0	394.9	399.5	397.2	1.68	1.72	1.70	0.61	0.62	0.62
T₈	230.6	234.3	232.5	33.6	35.8	34.7	379.1	385.1	382.1	2.23	2.29	2.26	0.59	0.60	0.60
Mean	248.3	252.9	250.6	35.2	37.5	36.4	395.9	400.4	398.2	2.01	2.06	2.04	0.50	0.52	0.51
S.E.±	3.16	3.00	3.08	1.03	1.14	1.09	4.17	5.07	4.62	0.04	0.05	0.05	0.01	0.02	0.02
C.D.(P=0.05)	9.58	9.11	9.35	3.12	3.44	3.28	12.65	15.37	14.01	0.13	0.15	0.14	0.04	0.05	0.05

kg Boron ha⁻¹ after harvest of safflower. The reason behind higher boron nutrient status in soil might be due to higher application of boron (1.5 kg Boron ha⁻¹) through borax fertiliser. The work related to effect of iron and boron on soil nutrient status after harvest of safflower is very recent and couldn't find relevant literature.

Conclusions

The combined application of iron and boron along with recommended dose of fertiliser recorded significantly uptake of nutrients compared to absolute control and recommended dose of fertiliser treatment as these nutrients are deficient in the soil. Whereas soil nutrient status in terms of nitrogen and potassium lower status was recorded in treatment (T₈) and phosphorus was found high in treatment (T₂). The micronutrient such as iron and boron recorded high in the treatments where higher dose of respective micro nutrient was added to the soil. Conclusively, the treatment which received combination of recommended dose of fertilizer along with 20 kg iron per ha and 1.5 kg boron per ha recorded significantly higher uptake of nutrients by safflower which intern showed lower primary nutrient status in soil.

References

1. 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.
2. KHADTARE, S. V., SHINDE, S. K., PAWAR, A. B., MURUMKAR, D. R., AIWALE, H. N., AKASHE, V. B., & TAGAD, L. N. (2018). Yield and water productivity of safflower (*Carthamus tinctorius* L.) as influenced under drip irrigation in scarcity zone of western Maharashtra. *Multilogic in Science*, 8, 228-232.
3. 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.
4. 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.
5. XYLIA, P.; CHRYSARGYRIS, A.; SHAHWAR, D.; AHMED, Z.F.R.; TZORTZAKIS, N (2022). Application of Rosemary and Eucalyptus Essential Oils on the Preservation of Cucumber Fruit. *Horticulturae*, 8, 774. <https://doi.org/10.3390/horticulturae8090774>

6. TAHA, E.M.A. AND AHMED, Z.F.R. (2018). Fruit characteristics and olive oil quality in response to some environmental factors. *Acta Hortic.* 1216, 19-26
DOI: 10.17660/ActaHortic.2018.1216.3
7. TAHA, E., ABD-ELKARIM, N., & AHMED, Z. (2019). Date seed oil as a potential natural additive to improve oxidative stability of edible vegetable oils. *Egyptian Journal of Food Science*, 47(1), 105-113.
8. AHMED, Z. F., TAHA, E., & ABD-ELKARIM, N. A. (2019). Floral Behaviour, Fruit Characteristics and Oil Quality of Some Olive Cultivars. *Egyptian Journal of Horticulture*, 46(1), 155-168.
9. RAKESH, M., SINGH, R., & SINGH, E. (2021). Influence of nitrogen and foliar spray of iron on yield and economics of safflower (*Carthamus tinctorius* L.).
10. RAI, S. K., CHARAK, D., & BHARAT, R. (2016). Scenario of oilseed crops across the globe. *Plant Archives*, 16(1), 125-132.
11. 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.
12. BAGHERI H., SAM-DALIRI M. (2011). Effect of water stress on agronomic traits of spring safflower cultivars (*Carthamus tinctorius*). *Austra. J. Basic and Applied Sci.* 5 (12): 2621-2624.
13. AHMED, Z. F., KAUR, N., & HASSAN, F. E. (2022). Ornamental Date Palm and Sidr Trees: Fruit Elements Composition and Concerns Regarding Consumption. *International Journal of Fruit Science*, 22(1), 17-34.
14. 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.
15. AL-JUHEISHY, W. K. (2020). Effect of Boron on some Industrial Crops: A REVIEW. *Mesopotamia Journal of Agriculture*, 48(4), 134-145.
16. JACKSON, M. L., (1973). Soil chemical analysis, Prentice-Hall of India Pvt. Ltd, New Delhi, pp-498.

17. SUBBAIAH, B. AND ASIJA, C. L., (1956) A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci.*, 25: 270-280.
18. PAGE, A. L., MILLER, R. H. AND KEENEY, D. R., (1982). Method of Soil Analysis. Part-2, *Soil Science Society of America, Inc, Publis., Madison, Wisconsin, USA.*
19. LINDSAY, W. L. AND NORWELL, W. A., (1978). Development of DTPA soil test for Zinc, iron, manganese and copper. *Soil Sci. Soc. American J.*, 42: 421-428.
20. JOHN, M. K., CHUAH, S. H. AND NEUSELD, J. H., (1975). Analysis of micro and macro nutrients in soil and plant. *Anal. Letter*, 8: 559.
21. PIPER, C.S., (1966). Soil and plant Analysis, Academic press, New York, p. 367.
22. COCHRAN, W. G. AND COX, G. M., (1965). Experimental designs. 7(3): 203.
23. 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.
24. 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.
25. RAVI S, CHANNAL HT, HEBSUR NS, PATIL BN, DHARMATTI P. (2008). Effect of sulphur, zinc and iron nutrition on growth, yield, nutrient uptake and quality of Safflower. Karnataka, *J. Agric. Sci.* 21(3):382-385.
26. MAHATMA N, 2007, Effect of sulphur and micronutrients (iron and zinc) on yield and quality of cotton in Vertisol. (2007). M.Sc. (Ag.) Thesis, *University of Agricultural Sciences, Dharwad, Karnataka (India).*
27. ANUPRITA, H., S.R. JADHAV, R.D. DALAL AND P. RAJESHWARI. (2005). Effect of micronutrients on growth and flower production of Gerbera under poly house conditions, *Adv. Pl. Sci.*, 18(11): 755-758.
28. SATHYA, S., MAHENDRAN, P.P. AND ARULMOZHISELVAN, K. (2013). Availability of nutrients as influenced by boron application in Boron deficient soil of typic haplustalf, *Agri. Sci. Digest*, 33 (4), 317-320.