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Effect of Micronutrients on Productivity of Safflower *(Carthamus tinctorius* L.) Under Rainfed Conditions

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ABSTRACT

A field experiment was conducted under rainfed conditions in vertisols to study the effect of micronutrients (Fe and Zn) on the productivity of safflower during *rabi* 2004-05 and 2005-06 at Agriculture Research Station, Annigeri, Karnataka. The experiment was laid out in randomized block design with three replications and eleven treatment combinations (Three levels of ZnSO4 @ 10, 20, 30 and 40 kg ha^{-1} along with RDF, three levels of FeSo4 @ 10, 20 and 30 kg ha^{-1} along with RDF three levels of elemental sulphur @ 1.7, 3.4 and 5.1 kg ha^{-1} along with RDF, RDF+FYM @ 5t ha^{-1} and RDF alone 40-40-20 kg NPK ha^{-1}). Safflower responded significantly to the iron and zinc nutrients. The safflower seed yield was significantly higher (2478 kg ha^{-1}) with application of ZnSO4 @ 20 kg ha^{-1} along with RDF which was 7.1 and 19.2 % higher over RDF+FYM and RDF alone, respectively. The same treatment recorded significantly higher oil yield (709 kg ha^{-1}), gross returns (Rs.32,222 ha^{-1}), net returns (Rs. 25,340 ha^{-1}) and B:C ratio (4.68). The maximum additional yield (297 kg ha^{-1}) was obtained with same treatment compared to RDF+ 3.4 kg ha^{-1} elemental sulphur.

Key words : Safflower, Micronutrients, Productivity, Oil yield, Vertilsols

Safflower is one of the important *rabi* oil seed crops mostly grown under rainfed/ residual soil moisture condition. The safflower oil which is rich in polyunsaturated fatty acids, is considered useful and safe for heart patients.

India has about 68% of the world acreage of safflower accounting for 60% of the total production. The area under safflower is significantly reduced from 7.9 lakh hectares in 1993-94 to 3.5 lakh hectares during 2002-03. Similarly its productivity is drastically reduced from 733 kg ha^{-1} to 450 kg ha^{-1} compared to other countries (Anon, 2006). Among the different factors responsible for low yield of safflower, inadequate and imbalance use of chemical fertilizers plays an important role. Apart from major nutrients (NPK), some of secondary and micro nutrients also to be applied in proper proportion along with NPK to enhance the productivity of safflower. The importance of sulphur is well emphasized in oil seed crops due to its role in biosynthesis of oil (Tisdale *et al.,* 1985). Response of safflower to sulphur application in India was reported by Abbas *et al.,* (1995). Due to the paucity of information on response of safflower to zinc and iron , the present investigation was under taken.

MATERIAL AND METHODS

A field experiment was conducted at Agriculture Research Station, Annigeri, Karnataka during *Rabi* seasons of 2004-05 and 2005-06 under rainfed conditions. The soil is vertisol deficient in available sulphur (4.3 ppm), iron (4.5 ppm) and zinc (0.5 ppm). The soil is medium in available N (255 kg ha^{-1}), low in available P (9.4 kg ha^{-1}) and high in K (510 kg ha^{-1}) with pH of 8.1. The experiment was laid out in randomised complete block design with three replications comprising eleven treatment combinations. The gross and net plot sizes were 4.5 m x 5.0 m and 2.70 m x 4.0 m, respectively. The FYM @ 5 t ha^{-1} was applied at 15 days advance of sowing. The seeds of safflower cv. A-1 were treated with thiram @ 2g kg^{-1} seeds against wilt disease and sown on 10th October 2004 and 16th October 2005 at 45 cm x 20 cm spacing. The sulphur, iron and zinc containing fertilizers along with RDF (40-40-20 kg NPK ha^{-1}) were applied as per the treatments at sowing. In the present study, elemental sulphur was used to isolate the effect of sulphur in iron sulphate and zinc sulphate so that the effect of iron and zinc alone on safflower could be studied. The quantity of elemental sulphur was worked out based on S content in $FeSO_4$ and $ZnSO_4$. The crop was thinned at 30 DAS to retain one seedling per hill. The total rainfall of 740.9 mm during 2004 and 931.6 mm during 2005 was received. The crop was sprayed with monocrotphos @ 1ml l^{-1} against aphids and Heliothis. The crop was harvested on 11th March 2005 and 16th March 2006. At harvest, five plants were randomly selected in each treatments for recording growth and yield parameters. Then the seed yield was recorded as kg net $plot^{-1}$ and expressed in kg $hectare^{-1}$. The economics was

Table 1. Effect of micronutrients on growth and yield components of safflower.

[Pooled over two years]

Treatments	Plant height (cm)	Branches $plant^{-1}$	Capitula $plant^{-1}$	Seeds $capitulum^{-1}$	100-Seed weight (g)
RDF+ZnSO4 @10 kg ha^{-1}	73.7	11.0	25.3	29.4	6.08
RDF+ZnSO4 @20 kg ha^{-1}	73.3	11.4	28.2	36.7	6.10
RDF+ZnSO4 @30 kg ha^{-1}	70.7	10.5	25.2	30.8	6.11
RDF+FeSO4 @10 kg ha^{-1}	71.2	10.2	24.7	28.5	6.09
RDF+FeSO4 @20 kg ha^{-1}	72.0	9.8	23.5	27.4	6.11
RDF+FeSO4 @30 kg ha^{-1}	72.5	10.7	26.5	31.8	6.03
Elemental sulphur @ 1.7 kg ha^{-1}	69.7	10.5	22.7	26.8	6.0
Elemental sulphur @ 3.4 kg ha^{-1}	71.7	10.5	25.8	31.2	6.10
Elemental sulphur @ 5.1 kg ha^{-1}	74.2	10.8	26.5	31.3	6.13
RDF + FYM @ 5 t ha^{-1}	71.5	10.5	24.3	30.3	6.12
RDF (40-40-20 kg NPK ha^{-1})	69.7	10.7	21.8	28.9	5.95
S.Em+	0.9	0.7	0.8	1.5	0.07
C.D.(5%)	2.6	NS	2.3	4.3	NS

calculated based on the prevailing market prices. The safflower oil was estimated by Minispec 20 pi NMR spectrophotometer. Since, the trend of results during both the years was same, the pooled data of two years were statistically analysed for interpretation.

RESULTS AND DISCUSSION

The pooled data indicated the significant effect of treatments on plant height, capitula $plant^{-1}$, seeds $capitulum^{-1}$, seed yield, economics, oil content, oil yield and harvest index (Tables 1 & 2).

The pooled data indicated that application of RDF along with $ZnSO_4$ @ 10 kg ha^{-1} recorded significantly higher plant height (73.7 cm) compared to other treatments except RDF+ $ZnSO_4$ @ 20 kg ha^{-1} (73.3 cm), RDF+ $FeSO_4$ @ 20 kg ha^{-1} (72.0 cm), RDF+FeSO4 @ 30 kg ha^{-1} (72.5 cm), RDF+ Elemental sulphur @ 3.4 kg ha^{-1} and also RDF + FYM @ 5 t ha^{-1} with which it was on par. The capitula $plant^{-1}$ (28.2) and seeds $capitulum^{-1}$ (36.7) were significantly higher with RDF+ $ZnSO_4$ @ 20 kg ha^{-1} compared to others and was on par with RDF+ $ZnSO_4$ @ 30 kg ha^{-1} (26.5 and 31.8, respectively). However, the branches $plant^{-1}$ and 100-seed weight did not differ significantly due to different treatments (Table 1). Application of RDF with $ZnSO_4$ @ 20 kg ha^{-1} produced significantly higher safflower seed yield of 2478 kg ha^{-1} compared to others and was on par with RDF+ $ZnSO_4$ @ 30kg ha^{-1} (2383 kg ha^{-1}), RDF+ $FeSO_4$ @ 20 kg ha^{-1} (2258 kg ha^{-1}) and RDF+ $ZnSO_4$ @ 30 kg ha^{-1} (2253 kg ha^{-1}). The higher seed yield was mainly attributed to higher capitula $plant^{-1}$ and seeds $capitulum^{-1}$. The maximum additional yield of 297 kg ha^{-1} was obtained due to application of zinc in the form of $ZnSO_4$ @ 20 kg ha^{-1} along with RDF (Table 2). The higher safflower yield due to application of zinc and iron was reported by Babhulkar *et al.* (2000) and Shekharagouda *et al.* (1997), respectively. The same treatment recorded significantly higher harvest index (25.9%). The oil content due to application of $ZnSO_4$ and $FeSO_4$ with RDF was on par but significantly higher over RDF+FYM and RDF. The higher oil content may be ascribed to sulphur content in Zn and Fe micronutrients. The oil yield was significantly higher with RDF+ $ZnSO_4$@ 20 kg ha^{-1} (709 kg ha^{-1}) compared to others except RDF+ $ZnSO_4$ @ 30 kg ha^{-1} (686 kg ha^{-1}) with which it was on par. This was mainly due to higher seed yield (Shekharagouda *et al.*, 1997).

Significantly higher gross returns (Rs.32,222 ha^{-1}), net returns (Rs.25,340 ha^{-1}) and B:C ratio (4.68) were realized with the application of RDF along with $ZnSO_4$ @ 20 kg ha^{-1} compared to others except RDF+$ZnSO_4$ @10 kg ha^{-1}, RDF+$ZnSO_4$ @30 kg ha^{-1}, RDF+$FeSO_4$ @30 kg ha^{-1}, Elemental sulphur @ 5.1

Table 2. Effect of micronutrients on seed yield, oil content and economics of safflower.

[Pooled over two years]

Treatments	Seed Yield ($kg\ ha^{-1}$)	Additional yield (kg)	Gross returns ($Rs\ ha^{-1}$)	Net returns ($Rs\ ha^{-1}$)	B : C ratio	Oil content (%)	Oil yield ($kg\ ha^{-1}$)	Harvest index (%)
RDF+ZnSO4 @10 kg ha^{-1}	2231	193	30304	23621	4.54	28.4	634	24.7
RDF+ZnSO4 @20 kg ha^{-1}	2478	297	32222	25340	4.68	28.6	709	25.9
RDF+ZnSO4 @30 kg ha^{-1}	2383	53	30979	24036	4.46	28.8	686	22.9
RDF+FeSO4 @10 kg ha^{-1}	2213	175	28773	21962	4.22	28.2	624	24.5
RDF+FeSO4 @20 kg ha^{-1}	2258	77	26749	20077	4.01	28.7	648	22.8
RDF+FeSO4 @30 kg ha^{-1}	2253	23	29288	22503	4.32	28.3	638	24.2
Elemental sulphur @ 1.7 kg ha^{-1}	2038	-	26495	19736	3.92	28.2	575	21.9
Elemental sulphur @ 3.4 kg ha^{-1}	2181	-	28354	21399	4.08	28.4	619	23.6
Elemental sulphur @ 5.1 kg ha^{-1}	2230	-	30298	23210	4.27	28.9	644	25.7
RDF + FYM @ 5 t ha^{-1}	2301	-	29920	22235	3.89	27.9	642	24.7
RDF (40-40-20 kg NPK ha^{-1})	2001	-	26094	19334	3.86	27.2	546	22.9
S.Em+	81	-	1048	1048	-	0.4	14	1.0
C.D.(5%)	242	-	3149	3149	-	1.2	43	2.8

Market price of safflower - Rs. 1300 q^{-1}

kg ha^{-1} and RDF + FYM @ 5 t ha^{-1} with which it was on par. The additional net returns realized due to application of $ZnSO_4$ @ 20 kg ha^{-1} with RDF were 3,105 and Rs. 6,006 ha^{-1} over RDF+FYM @5t ha^{-1} and RDF alone, respectively (Table 2). The significant response to $ZnSO_4$ and $FeSO_4$ was due to deficient status of Zn and Fe in the soil.

Thus, it may be concluded that $ZnSO_4$ @ 20 kg ha^{-1} along with RDF was found to be optimum to get maximum safflower seed yield, oil yield and higher net returns under rainfed conditions in vertisols.

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