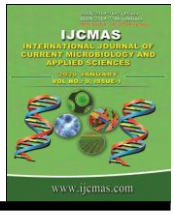
Int.J.Curr.Microbiol.App.Sci (2020) *9*(1): 928-937

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 9 Number 1 (2020)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2020.901.104

Effect of Soil and Foliar Applications of Zinc and Iron on Yield and Economics of Sunflower (*Helianthus annus* L.) Under Irrigation

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Keywords

Sunflower, Zinc, Iron, Yield and Economics

Article Info

Accepted:
15 December 2019
Available Online:
20 January 2020

A B S T R A C T

In order to find out the response of soil and foliar application of zinc and iron fertilization on Sunflower (*Helianthus Annus* L.) yield and economics. A field experiment was conducted during the *kharif* 2012at Agricultural College Farm, Raichur, the results revealed that, yield and yield components of sunflower were influenced favourably by soil application of $ZnSO_4$@ 10 kg ha^{-1} + Foliar spray of $FeSO_4$@ 0.5 % along with RDF and FYM @ 8 t ha^{-1} recorded significantly highest grain yield (2,268 kg ha^{-1}), oil yield (937 ha^{-1}), oil content (41.3%) and test weight (5.47 g). The growth parameters of sunflower were also influenced favourably with soil application of $ZnSO_4$ @ 10 kg ha^{-1} + Foliar spray of $FeSO_4$@ 0.5 % along with RDF and FYM @ 8 t ha^{-1}, dry matter production (106.8 g $plant^{-1}$) and plant height (189.2 cm), over other treatment combinations. The highest net returns of Rs.58, 453ha^{-1} and B: C (3.46) was recorded in soil application of $ZnSO_4$ @ 10 kg ha^{-1} + Foliar spray of $FeSO_4$@ 0.5 % along with RDF and FYM @ 8 t ha^{-1} to RDF (2.68).

Introduction

Sunflower (*Helianthus annus* L.) is an important oilseed crop in the world and ranks third next only to groundnut and soybean in crop production. In India, sunflower has recently established as a potential oilseed crop of economic importance. In India, sunflower is grown in an area of 0.72 million hectares with an annual production of 0.50 million tonnes. Presently, Karnataka is the leading state in the country contributing 53.19 and 38.61 per cent of total area and production respectively. It is the second important oilseed crop after groundnut in the state having an area of 0.38 million hectares with production of 0.19 million tonnes. However, productivity (503 kg ha^{-1}) is lesser than the national average of 692 kg ha^{-1} (Anon., 2012).

Generally, black soils are deficient in micronutrients particularly zinc and iron. Deficiency of these two micronutrients causes an extensive problem in crop production. Zinc is one of the first micronutrients recognized as essential for plants. It is a micronutrient most commonly limiting crop yields in Indian soils.

Works done by All India Co-ordinate Scheme on micronutrients in soils and plants have shown that 47 percent of Indian soils are deficient in zinc (Katyal and Rattan, 1993), while as indicated by Takkar and Walker (1996), among all the micronutrients, zinc deficiency is wide spread in Indian soils and nearly 50 percent of the Indian soils and 78 per cent of Karnataka soils were found to be deficient in zinc. Katyal (1985) reported that the deficiency of zinc in South Indian soils is most commonly seen in soil order of Vertisols and Alfisols. Shivaprasad *et al.*, (1996) indicated that zinc is the most limiting nutrient to crop growth throughout the Karnataka state.

Zinc is transported to plant root surface through diffusion. Zinc deficient sunflower plants are stunted in growth and pale green in colour, chloratic spots are seen at base of leaves near margin. It is necessary for production of chlorophyll and carbohydrates. Zinc is not translocated within the plant, so symptoms first appear on the younger leaves.

Khurana and Chatterjee (2001) found that zinc fertilization had a positive effect on sunflower and increased its seed yield, growth parameters and also reported elevate concentration of seed oil by application of zinc. Similarly, iron plays an important role in the synthesis of chlorophyll and also helps in the absorption of other nutrients. As a constituent of chlorophyll, it regulates respiration, photosynthesis, reduction of nitrates and sulphates.

Materials and Methods

The field experiment on "Response of sunflower (*Helianthus annus* L.) to zinc and iron fertilization under irrigation"was conducted during the *kharif* 2012 at Agricultural college farm, Raichur, situated on the latitude of $16^{0}15^{1}$North, longitude of $77^{0}21^{1}$ East and at an elevation of 389 meters above mean sea level and is located in North Eastern Dry Zone of Karnataka. The experiment was laid out in RCBD. The soil of the experimental site was medium black and clay loam in texture with the available nitrogen (268.00 kg ha^{-1}), phosphorus (26.50 kg ha^{-1}), potassium (239.00 kg ha^{-1}) and organic carbon content (6.20 g kg^{-1}).

Certified seeds of RSFH-130 were used for investigation. Duration of the crop is (90- 100 days) with the plant height of 158-189 cm.

Recommended dose of fertilizers (NPK) and zinc and iron were applied as per the treatment details. Nitrogen, phosphorus and potassium were applied in the form of urea, diammonium phosphate (DAP) and muriate of potash (MOP), respectively. Zinc and iron were applied in the form of $ZnSO_4$ and $FeSO_4$ @ 10 kg ha^{-1} as soil application according to the treatment detail as band placement. All these nutrients were applied 5cm away from the seed line and 5 cm deep in to soil. Basal dose of fertilizer (half of nitrogen and full dose of phosphorus and potassium) was applied at the time of planting and remaining half of nitrogen was applied at 30 DAS. Foliar spray of zinc and iron were sprayed in the form of zinc sulphate and ferrous sulphate @ 0.5 % at evening hours of 35 days and 55 days DAS according to the treatment details.

Five plants per plot were selected randomly in the net plot area and tagged for observations at critical stages (30, 60 DAS and at harvest) for recording growth and yield parameters.

Treatment details of experiment

T_1: Recommended Doses of Fertilizers (90:90:60 kg N, P_2O_5, K_2O, ha^{-1})
T_2: RDF + FYM at the rate of the rate of 8 tonnes ha^{-1}
T_3: T_2 + $ZnSO_4$at the rate of 10 kg ha^{-1} soil application
T_4: T_2 + $FeSO_4$at the rate of 10 kg ha^{-1} soil application
T_5: T_2 + Foliar spray of $ZnSO_4$ at the rate of 0.5 percent
T_6: T_2 + Foliar spray of $FeSO_4$ at the rate of 0.5 percent
T_7: T_3 + Foliar spray of $ZnSO_4$ at the rate of 0.5 percent
T_8: T_3 + Foliar spray of $FeSO_4$ at the rate of 0.5 percent
T_9: T_4 + Foliar spray of $ZnSO_4$ at the rate of 0.5 percent
T_{10}: T_4 + Foliar spray of $FeSO_4$ at the rate of 0.5 percent

Note: Recommended dose of fertilizer (NPK Only) was common for all the treatments.
Foliar spray of $ZnSO_4$ and $FeSO_4$ @ 0.5% at 35 and 55 DAS.

Results and Discussion

In the present study, the soil application of $ZnSO_4$ @ 10 kg ha^{-1} + Foliar spray of $FeSO_4$@ 0.5 % along with RDF and FYM @ 8 t ha^{-1} exerted significant influence on the grain and oil yield of sunflower. The highest grain and oil yield of sunflowerwas obtained with application nutrient by soil application of $ZnSO_4$ @ 10 kg ha^{-1} + Foliar spray of $FeSO_4$@ 0.5 % along with RDF and FYM @ 8 t ha^{-1} (2,268kg ha^{-1} and 937 kg ha^{-1} respectively) it was on par with T_7, T_3 and T_9, these treatments were significantly superior over Control (Table 1 & Fig 1). An increase in seed yield due to increase in yield components especially seed weight and higher seed setting. This is due to balanced supply plant nutrients through application of RDF, FYM along with soil application of $ZnSO_4$@ 10 kg $ha^{-1}$and iron foliar @ 0.5%, all these treatment applications attained healthy & vigorous growth of crop, more seed setting and increased seed weight. Specially zinc and iron fertilization involved in increased synthesis of enzymes like auxine biosynthesis, IAA production and protein synthesis which helps in promoting vegetative growth. It was due to the zinc helps to helps in starch synthesis and protein biosynthesis. These results are in accordance with those obtained by Guggari *et al.,* (1995), Mirzapour and Khoshgoftar (2006) and Ramulu *et al.,* (2011).

Higher test weight of (5.47 g), was obtained with application of (T_8): RDF + FYM @ 8 t ha^{-1} + $ZnSO_4$@ 10 kg ha^{-1}+ foliar spray of $FeSO_4$@ 0.5 % recorded, over other treatments, was due to supplement of zinc fertilization and iron foliar spray micronutrients because zinc helps to proper functioning of many enzyme systems, synthesis of nucleic acid and normal crop development and growth. It seems that with increased starch accumulation in seed. Increased 100-grain weight noticed in treatments and the results are in agreement with the findings of Muzzammil Hussain Siddiqui *et al.,* (2009) and Selvi *et al.,* (2008) in sunflower. The increased test weight is due to the synthesis of indole acetic acid and protein metabolism which is governed by the zinc and iron fertilization. This might be due to balanced supply of these nutrients helped in increased rate of photosynthesis along with active absorption of various nutrients and translocation of photosynthates to the site of storage organ. The present findings are in consonance with that of Mukhtar *et al.,* (2009).

Highest oil content and highest oil yield (Fig. 3) recorded with application of application of

(T_8): RDF + FYM @ 8 t ha^{-1} + $ZnSO_4$@ 10 kg ha^{-1}+ foliar spray of $FeSO_4$@ 0.5 % (41.3 %) oil content and 937 kg ha^{-1}oil yield. The result oil content was found to be non-significant statistically. However, higher oil content were recorded in (T_8):RDF + FYM @ 8 t ha^{-1} + $ZnSO_4$@ 10 kg ha^{-1}+ foliar spray of $FeSO_4$@ 0.5 % recorded highest oil content of (41.3 %). This might be due to zinc and iron sulphate fertilization. That leads to proper functioning of many enzymes, involved in the formation of glucosides, glucosinolates and sulphydril-linkage, activation of enzymes which aids in biochemical reaction within the plant which helps in Bio-synthesis of oil. This might have resulted in higher oil content compared to control. However, there is no significant difference in the oil content statistically, but recorded highest oil yield in the treatment (T_8):RDF + FYM @ 8 t ha^{-1} + $ZnSO_4$@ 10 kg ha^{-1}+ foliar spray of $FeSO_4$@ 0.5 % recorded (937 kg ha^{-1}) which is due to the higher seed yield and oil content produced in the treatment (T_8). Lowest oil yield recorded in the control treatment. The above result is in agreed with the findings of Saeidi (2007).

Highest dry matter accumulation was recorded in the treatment (T_8): RDF + FYM @ 8 t ha^{-1} + $ZnSO_4$@ 10 kg ha^{-1}+ foliar spray of $FeSO_4$@ 0.5 % recorded (106.8 $gplant^{-1}$) and it was on par with the treatment of T_9: T_4 + Foliar spray of $ZnSO_4$@ 0.5 %(100.6 g $plant^{-1}$), T_7: T_3 + Foliar spray of $ZnSO_4$@ 0.5 %(102.1 g $plant^{-1}$) andT_3: T_2 + $ZnSO_4$ at 10 kg ha^{-1} soil application(99.3 g $plant^{-1}$) and significantly superior over other treatments. Balanced supply plant nutrients through soil application of $ZnSO_4$ along with FYM, RDF and iron foliar all these treatments specially zinc and iron tend to increased synthesis of enzymes like auxine biosynthesis, IAA production and protein synthesis which helps in promoting vegetative growth. Increased in dry matter productions in the treatments were attributed to higher photosynthetic capacity of plants, which depends upon number of leaves, plant height, and dry matter accumulation in plants. Similar results were reported by Meena *et al.,* (2006) and Harsharn Singh and Robin Graham (2001).

Significantly highest gross returns (Rs.84,680 ha^{-1}), net returns (Rs.58,453ha^{-1}) and B:C ratio (3.23) were recorded with application of T_8: T_3 + Foliar spray of $FeSO_4$ at the rate of 0.5 percent and compared to RDF and all other treatments. This was attributed to the lower cost of cultivation compared to other treatments, which involved in higher costs. Highest seed yield is also a factor that influences the economics. The results are in conformity with the findings of Arjun Sharma *et al.,* (2007).

A significantly higher plant height registered with the treatment (T_8): RDF + FYM @ 8 t ha^{-1} + $ZnSO_4$@ 10 kg ha^{-1}+ foliar spray of $FeSO_4$@ 0.5 % recorded (189.2 cm) at harvest. It was on par with (T_9), (T_7), (T_{10}) and (T_3)over control was due to enhancement of auxine biosynthesis and synergistic relationship between zinc and nitrogen which leads to vigorous growth, and higher photosynthesis, a balanced supply plant nutrients through soil application of $ZnSO_4$along with FYM, RDF and iron foliar all these treatments specially zinc tend to increased synthesis of enzymes like auxine biosynthesis, IAA production which helps in promoting plant growth. The results of this investigation are consonance with the findings of Aravinda Kumar *et al.,* (2010) and Patil *et al.,* (2006) and significantly increasing plant height due to the improvement in availability of native soil nutrients and synchronized uptake of nutrients. Similar results were reported by Umbarkar *et al.,* (2010), who also opinion that the increased availability of the nutrients especially nitrogen, which is associated with protoplasm synthesis and vigorous vegetative growth.

Table.1 Effect of zinc and iron fertilization on test weight, seed yield, oil content and oil yield of sunflower

Treatments	Test weight (g)	Seed yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
T_1: RDF (No FYM)	4.33	1418	38.2	**542**
T_2: RDF + FYM @ 8 tonnesha^{-1}	4.53	1839	39.3	**723**
T_3: T_2 + $ZnSO_4$ @10 kg ha^{-1} soil application	4.88	2086	40.2	**839**
T_4:T_2 + $FeSO_4$ @10 kg ha^{-1}soil application	4.57	1852	39.2	**726**
T_5:T_2 + Foliar spray of $ZnSO_4$ @ 0.5 %	4.84	1918	39.3	**754**
T_6:T_2 + Foliar spray of $FeSO_4$ @ 0.5 %	4.57	1840	39.6	**729**
T_7:T_3 + Foliar spray of $ZnSO_4$ @ 0.5 %	5.20	2132	40.8	**870**
T_8:T_3 + Foliar spray of $FeSO_4$ @ 0.5 %	5.47	2268	41.3	**937**
T_9: T_4 + Foliar spray of $ZnSO_4$ @ 0.5 %	5.08	1993	39.2	**781**
T_{10}:T_4 + Foliar spray of $FeSO_4$ @ 0.5 %	4.83	1902	39.4	**749**
S.Em. ±	0.21	95.31	1.03	**36.05**
C.D. at 5%	**0.60**	**278.20**	**NS**	**113.0**

NOTE:
Recommended dose of fertilizer (RDF) 90:90:60 kg NPK ha^{-1}
Foliar spray of $ZnSO_4$ and $FeSO_4$ @ 0.5% at 35 and 55 DAS

Table.2 Effect of zinc and iron fertilization on dry matter accumulation and plant height at harvest in sunflower

Treatments	Dry matter accumulation (g plant $^{-1}$)				Plant height (cm)
	Leaf	Stem	Head	Total	At harvest
T_1: RDF (No FYM)	13.3	37.4	32.1	82.8	158.4
T_2: RDF + FYM @ 8 tonnes ha^{-1}	15.0	38.5	35.3	88.8	171.5
T_3: T_2 + $ZnSO_4$ @10 kg ha^{-1} soil application	16.2	42.4	40.7	99.3	181.2
T_4:T_2 + $FeSO_4$ @10 kg ha^{-1}soil application	15.1	39.6	36.1	90.8	172.6
T_5:T_2 + Foliar spray of $ZnSO_4$ @ 0.5 %	15.2	40.5	38.6	94.3	176.5
T_6:T_2 + Foliar spray of $FeSO_4$ @ 0.5 %	15.0	40.3	36.7	92.0	174.2
T_7:T_3 + Foliar spray of $ZnSO_4$ @ 0.5 %	16.3	43.2	42.6	102.1	183.6
T_8:T_3 + Foliar spray of $FeSO_4$ @ 0.5 %	17.0	45.3	44.5	106.8	189.2
T_9: T_4 + Foliar spray of $ZnSO_4$ @ 0.5 %	15.8	42.9	41.9	100.6	185.2
T_{10}:T_4 + Foliar spray of $FeSO_4$ @ 0.5 %	15.5	41.2	39.5	96.2	182.1
S.Em. ±	0.52	1.21	1.27	2.81	5.11
C.D. at 5%	1.52	3.54	3.72	8.21	14.21

NOTE:
Recommended dose of fertilizer (RDF) 90:90:60 kg NPK ha^{-1}
Foliar spray of $ZnSO_4$ and $FeSO_4$ @ 0.5% at 35 and 55 DAS

Table.3 Effect of Zinc and Iron fertilization on economics of sunflower cultivation

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs.ha^{-1})	Net returns (Rs. ha^{-1})	B:C
T_1 – RDF	21,180	56,720	34,410	2.68
T_2 – RDF + FYM @ 8 tonnes ha^{-1}	25,180	73,560	48,380	2.92
T_3 – T_2 + $ZnSO_4$ @10 kg ha^{-1} soil application	25,690	79,440	53,750	3.09
T_4 – T_2 + $FeSO_4$ @10 kg ha^{-1}soil application	25,330	70,880	45,550	2.80
T_5 – T_2 + Foliar spray of $ZnSO_4$ @ 0.5 %	25,805	75,960	50,155	2.94
T_6 – T_2 + Foliar spray of $FeSO_4$ @ 0.5 %	25,717	72,200	46,483	2.81
T_7 – T_3 + Foliar spray of $ZnSO_4$ @ 0.5 %	25,715	80,520	54,805	3.13
T_8 – T_3 + Foliar spray of $FeSO_4$ @ 0.5 %	26,227	84,680	58,453	3.23
T_9 – T_4 + Foliar spray of $ZnSO_4$ @ 0.5 %	25,955	83,320	57,365	3.21
T_{10} – T_4 + Foliar spray of $FeSO_4$ @ 0.5 %	25,867	79,720	53,853	3.08

RDF: Recommended dose of fertilizer 90:90:60 kg NPK ha^{-1}
Foliar spray of $ZnSO_4$ and $FeSO_4$ @ 0.5% at 35 and 55 DAS

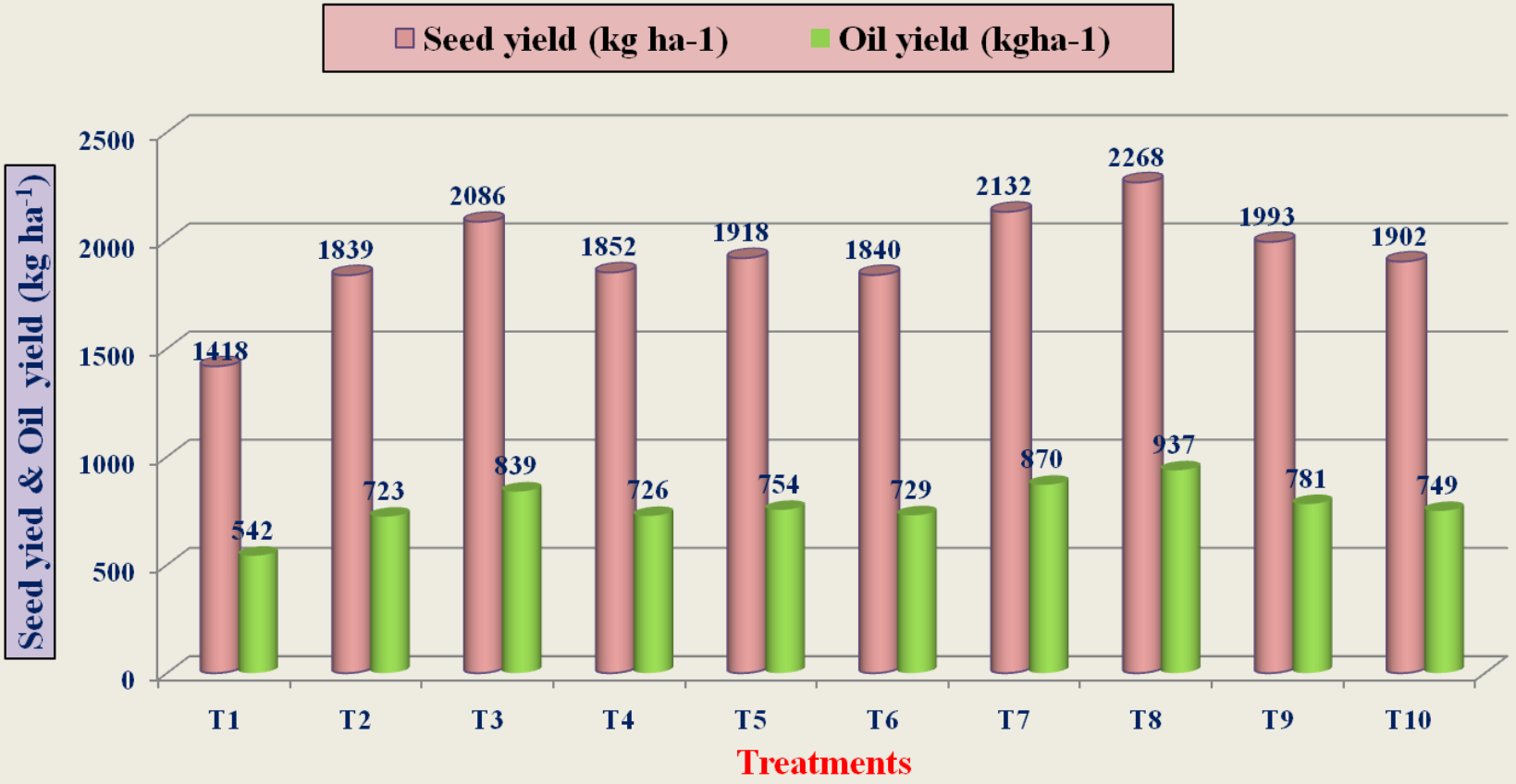

Fig.1. Effect of zinc and iron fertilization on seed yield and oil yield (kg ha^{-1}) of sunflower

From this study it can be concluded that to get higher grain yield and net returns it is advocated to follow T_8:RDF + FYM @ 8 t ha^{-1} + $ZnSO_4$@ 10 kg ha^{-1}+ foliar spray of $FeSO_4$@per cent, because soil application of zinc is better way to correct the zinc deficiency in soil and crop than the foliar spray. But iron foliar spray observed better because easy absorption by the leaves and effective absorption. However, combined application of these two nutrients along with FYM and RDF had significantly better yield and returns. Because proper growth and development of plant for a balanced supply of nutrients for proper growth and yield.

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How to cite this article:

Raghavendra, M. A. Bellakki, B.V, Shreenivas and Satyanarayana Rao. 2020. Effect of Soil and Foliar Applications of Zinc and Iron on Yield and Economics of Sunflower (*Helianthus annus* L.) Under Irrigation. *Int.J.Curr.Microbiol.App.Sci.* 9(01): 928-937.
doi: https://doi.org/10.20546/ijcmas.2020.901.104