Original Research Article

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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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 Annum 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 ZnSO4@ 10 kg ha⁻¹ + Foliar spray of FeSO4@ 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 ZnSO4 @ 10 kg ha⁻¹ + Foliar spray of FeSO4@ 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 ZnSO4 @ 10 kg ha⁻¹ + Foliar spray of FeSO4@ 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 percent 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, chlorotic 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°15' North, longitude of 77°21' 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 5 cm 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\(_2\)O\(_5\), K\(_2\)O, 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 sunflower was 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\(^{-1}\) (2,268 kg 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 of 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
(T₈): RDF + FYM @ 8 t ha⁻¹ + ZnSO₄@ 10 kg ha⁻¹ + foliar spray of FeSO₄@ 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 (T₈): RDF + FYM @ 8 t ha⁻¹ + ZnSO₄@ 10 kg ha⁻¹ + foliar spray of FeSO₄@ 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 (T₈): RDF + FYM @ 8 t ha⁻¹ + ZnSO₄@ 10 kg ha⁻¹ + foliar spray of FeSO₄@ 0.5 % recorded (937 kg ha⁻¹) which is due to the higher seed yield and oil content produced in the treatment (T₈). Lowest oil yield recorded in the control treatment. The above result is in agreed with the findings of Saedid (2007).

Highest dry matter accumulation was recorded in the treatment (T₈): RDF + FYM @ 8 t ha⁻¹ + ZnSO₄@ 10 kg ha⁻¹ + foliar spray of FeSO₄@ 0.5 % recorded (106.8 g plant⁻¹) and it was on par with the treatment of T₉: T₉ + foliar spray of ZnSO₄@ 0.5 % (100.6 g plant⁻¹), T₇: T₇ + foliar spray of ZnSO₄@ 0.5 % (102.1 g plant⁻¹) and T₃: T₃ + ZnSO₄ 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 ZnSO₄ 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 Harshnam Singh and Robin Graham (2001).

Significantly highest gross returns (Rs.84,680 ha⁻¹), net returns (Rs.58,453 ha⁻¹) and B:C ratio (3.23) were recorded with application of T₈: T₃ + Foliar spray of FeSO₄ 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 (T₈): RDF + FYM @ 8 t ha⁻¹ + ZnSO₄@ 10 kg ha⁻¹ + foliar spray of FeSO₄@ 0.5 % recorded (189.2 cm) at harvest. It was on par with (T₉), (T₇), (T₁₀) and (T₃) 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 ZnSO₄ 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.

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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 |
| T1: RDF (No FYM)                                     | 13.3  | 37.4  | 32.1  | 82.8  | 158.4      |
| T2: RDF + FYM @ 8 tonnes ha\(^{-1}\)                 | 15.0  | 38.5  | 35.3  | 88.8  | 171.5      |
| T3: T2 + ZnSO\(_4\) @10 kg ha\(^{-1}\) soil application | 16.2  | 42.4  | 40.7  | 99.3  | 181.2      |
| T4: T2 + FeSO\(_4\) @10 kg ha\(^{-1}\) soil application | 15.1  | 39.6  | 36.1  | 90.8  | 172.6      |
| T5: T2 + Foliar spray of ZnSO\(_4\) @ 0.5 %           | 15.2  | 40.5  | 38.6  | 94.3  | 176.5      |
| T6: T2 + Foliar spray of FeSO\(_4\) @ 0.5 %           | 15.0  | 40.3  | 36.7  | 92.0  | 174.2      |
| T7: T3 + Foliar spray of ZnSO\(_4\) @ 0.5 %           | 16.3  | 43.2  | 42.6  | 102.1 | 183.6      |
| T8: T3 + Foliar spray of FeSO\(_4\) @ 0.5 %           | 17.0  | 45.3  | 44.5  | 106.8 | 189.2      |
| T9: T4 + Foliar spray of ZnSO\(_4\) @ 0.5 %           | 15.8  | 42.9  | 41.9  | 100.6 | 185.2      |
| T10: T4 + 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   |
|------------------------------------|---------------------------------------|---------------------------------|-------------------------------|-------|
| T₁ – RDF                           | 21,180                                | 56,720                          | 34,410                        | 2.68  |
| T₂ – RDF + FYM @ 8 tonnes ha\(^{-1}\) | 25,180                                | 73,560                          | 48,380                        | 2.92  |
| T₃ – T₂ + ZnSO₄ @ 10 kg ha\(^{-1}\) soil application | 25,690                                | 79,440                          | 53,750                        | 3.09  |
| T₄ – T₂ + FeSO₄ @ 10 kg ha\(^{-1}\) soil application | 25,330                                | 70,880                          | 45,550                        | 2.80  |
| T₅ – T₂ + Foliar spray of ZnSO₄ @ 0.5 % | 25,805                                | 75,960                          | 50,155                        | 2.94  |
| T₆ – T₂ + Foliar spray of FeSO₄ @ 0.5 % | 25,717                                | 72,200                          | 46,483                        | 2.81  |
| T₇ – T₃ + Foliar spray of ZnSO₄ @ 0.5 % | 25,715                                | 80,520                          | 54,805                        | 3.13  |
| T₈ – T₃ + Foliar spray of FeSO₄ @ 0.5 % | 26,227                                | 84,680                          | 58,453                        | 3.23  |
| T₉ – T₄ + Foliar spray of ZnSO₄ @ 0.5 % | 25,955                                | 83,320                          | 57,365                        | 3.21  |
| T₁₀ – T₄ + Foliar spray of FeSO₄ @ 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 T8: RDF + FYM @ 8 t ha⁻¹ + ZnSO₄@ 10 kg ha⁻¹+ foliar spray of FeSO₄@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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