



## Assess Foliar Application of Iron and Zinc Fertilizers on Quantitative and Qualitative Traits of Sunflower in Warm and Dry Climate Condition (Southwest of Iran, Ahvaz Region)

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### RESEARCH ARTICLE

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### ABSTRACT

**BACKGROUND:** Nutrients play a very important role in chemical, biochemical, physiological, metabolic, geochemical, biogeochemical, and enzymatic processes.

**OBJECTIVES:** Current research was done to evaluate the effect of foliar application of Micronutrients (Iron and Zinc) on crop production of Sunflower.

**METHODS:** This study was conducted in Ahvaz city (southwest of Iran) via a Factorial experiment based on randomized complete block design with three replications during 2022. The first factor included foliar application of Iron fertilizer (Zero or control, 0.003 and 0.005 concentration) and second factor consisted foliar application of Zinc fertilizer (Zero or control, 0.002 and 0.004 concentration).

**RESULT:** According to the result of analysis of variance, the effect of different levels of Iron and Zinc fertilizer on all studied traits were significant, but the interaction effect of treatments on 1000-grain weight, oil content and oil yield was not significant. Evaluation of the mean comparison result of different levels of Iron fertilizer revealed that the maximum amount of 1000-grain weight (65.27 gr), oil content (41.11%) and oil yield (116.87 gr.m<sup>-2</sup>) belonged to 0.005 L.ha<sup>-1</sup> and the lowest ones were control. Also, comparing different levels of foliar application of Zinc showed that the maximum and the minimum amount of 1000-grain weight, oil content and oil yield belonged to 0.004 L.ha<sup>-1</sup> and control treatments. Evaluation of the mean comparison result of the interaction effect of treatments indicated that the maximum number of grain per head (620.31), grain yield (298.6 gr.m<sup>-2</sup>), protein content (19.3%) and protein yield (57.62 gr.m<sup>-2</sup>) was noted for 0.005 L.ha<sup>-1</sup> foliar application of Iron and 0.004 L.ha<sup>-1</sup> foliar application of Zinc and the lowest ones belonged to control treatment.

**CONCLUSION:** Finally, according to the result of current research, application of 0.005 L.ha<sup>-1</sup> foliar application of Iron and 0.004 L.ha<sup>-1</sup> foliar application of Zinc had the highest amount of studied traits and it can be advised to producers in the studied region.

**KEYWORDS:** *Crop production, Nutrition, Oil, Protein, Seed yield.*

## 1. BACKGROUND

Agricultural soils in Iran suffer from severe deficiencies of micronutrients, especially Iron and Zinc, due to reasons such as calcareous soils, none carbonate irrigation water, low organic matter in agricultural soils, drought stress and excessive use of phosphate fertilizers (Rahimizadeh *et al.*, 2012). In agriculture, Zinc deficiency is common and widespread. This phenomenon arises due to the intense uptake of usable Zinc from the root penetration zone in the soil and, in some cases, due to the beneficial effect of soil organic matter in Zinc absorption by plants and surface erosion leading to Zinc deficiency. Additionally, in calcareous and alkaline soils, Zinc deficiency occurs due to the high soil acidity (Koochaki and Sarmandian, 1994). It appears that while foliar Zn spraying is more effective than soil N or Zn application to enrich wheat grains with Zn, the grain Zn bioavailability is influenced more by cultivar selection (Xia *et al.*, 2018). The results of the research of Al-Murshidi and Halool Jassim (2023) showed that the superiority of Nano-Zinc at the level of 300 ppm on the flag leaf area and the number of grains in the spike, as the highest averages, while Zinc sulfate at the level of 200 ppm outperformed in the trait of plant height, as it recorded the highest average, as well as the superiority of Zinc Sulphate at the level of 300 ppm in the trait of spike length, number of branches, and grain yield, which recorded the highest averages. Iron is an essential but in short supply element in most plants. Its role in nitrogen fixation and the activity of some enzymes such

as catalase, peroxidase, and cytochrome oxidase is well established (Ruiz *et al.*, 2000). Nouraein *et al.* (2019) studied the effects of micronutrients on Sunflower crop production and stated that the highest number of seeds per head, thousand-seed weight, oil percentage, seed yield, harvest index, and head diameter were attributed to the combined application of Iron and Zinc. Lotha and Dawson (2021) studied the effects of micronutrients on Sunflower stated that the traits of plant height, head diameter, seed yield, harvest index and biological yield were obtained in the foliar application of Iron, Zinc and Boron, and the lowest amount of these traits were obtained in the treatment without foliar application of micronutrients.

## 2. OBJECTIVES

Current research was done to evaluate effect of foliar application of Microelements (Iron and Zinc) on crop production of Sunflower.

## 3. MATERIALS AND METHODS

### 3.1. Field and Treatments Information

This research was conducted in Ahvaz City at longitude 48°40'E and latitude 31°20' N in Khuzestan province (Southwest of Iran) via a Factorial experiment based on randomized complete block design with three replications during 2022. The first factor included foliar application of Iron fertilizer (Zero or control, 0.003 and 0.005 concentration) and second factor consisted foliar application of Zinc fertilizer (Zero or control, 0.002 and 0.004 concentration). The experiment consisted of 27 plots. For

the experiment, the distance between rows to rows was 75 cm with six rows per treatment. The size of each plot was 6×5 m<sup>2</sup>. The distance between plots was

two unplanted rows and the distance between blocks was 1.5 meters. Soil properties of studied field was listed in table (1).

**Table 1.** Physical and chemical properties of studied field

Soil depth (cm)	Soil texture	SP (%)	EC (ds.m <sup>-1</sup> )	OC (%)	pH	P (ppm)	K (ppm)
0-15	Clay loam	47	3.89	0.77	7.2	9.1	190
15-30	Clay loam	45	3.71	0.64	7.1	8.8	178

### 3.2. Farm Management

Tillage and land preparation operations included irrigation before land preparation, one deep plowing and two disking, leveling, creating ridges and furrow, and plotting. The amount of phosphorus fertilizer was calculated and used based on 100 kg of phosphorus (P<sub>2</sub>O<sub>5</sub>) per hectare from triple superphosphate. All phosphorus fertilizer was distributed uniformly at the same time as final leveling. Nitrogen fertilizer from Urea source was applied at a rate of 200 kg.ha<sup>-1</sup>, half of which was spread in the field with a disk before planting and the other half was distributed at the 8-leaf stage. The seed used was the Shams hybrid. The Shams hybrid, with an average yield of 3.5 tons per hectare, was identified as a superior and stable hybrid due to its equal yield to imported hybrids, lower height, early maturity, and more suitable head shape. Due to its desirable agronomic characteristics, this hybrid was introduced in January 2016 as a new Sunflower cultivar for spring cultivation in temperate and cold regions and summer cultivation in temperate regions (Ghafari, 2019). Seed sowing was done manually. The first irrigation was done one day after sowing. Foliar application of Iron and Zinc

fertilizers in the mentioned amounts was carried out three times during the plant growth season at the 12-14 leaf stage, inflorescence emergence, and the beginning of pollination. The prepared solutions were sprayed in all plots was sprayed at early morning. Weed control was carried out by hand weeding, and effective pesticides and sprayers were used to combat possible pests and diseases.

### 3.3. Measured Traits

When 90% of heads turned yellowish-brown and the seeds moisture content was 20% (physiological maturity), the final harvest was carried out from an area equivalent to 2 square meters from lines three, four, and five. To calculate the number of seeds per head at the final harvest, 5 head were randomly selected and after separating the seeds from each head, seeds were counted using a seed counter and the average number of seeds per head was obtained. In order to determine grain yield, an area equivalent to two square meters was harvested and after separating the grains, the grain yield was weighed (Amini and Rushdi, 2013). To determine the percentage of grain protein, the percentage of grain nitrogen was first measured by Kjeldahl

method, which includes digestion, distillation and titration. To measure the seed nitrogen content and straw nitrogen content the Kjeldahl method was used. So, to calculate the seed protein content the following formula was used (Bremner *et al.*, 1983): **Equ.1.** Seed protein content (%) = Nitrogen percentage  $\times$  5.8. Prussic acid was determined according to the AOAC (1990) methods. Grain protein yield was also obtained by multiplying the protein percentage by grain yield. Oil content determined by Near Infrared Spectroscopy (Sato, 2002). Oil yield calculated by multiplying grain yield by oil content.

#### 3.4. Statistical Analysis

Analysis of variance and mean comparisons were done via SAS (Ver.9) software and Duncan multiple range test at 5% probability level.

## 4. RESULT AND DISCUSSION

### 4.1. 1000-grain weight

Result of analysis of variance revealed effect of foliar application of Iron and Zinc on 1000-grain weight was significant at 1% probability level, but interaction effect of treatments was not significant (Table 2). As for Duncan classification made with respect to different level of foliar application of Iron maximum and minimum amount of 1000-grain weight belonged to 0.005 L.ha<sup>-1</sup> (65.27 gr) and control (56.03 gr) (Table 3). Compare different level of foliar application of Zinc showed that the maximum and the minimum amount of 1000-grain weight belonged to 0.004 L.ha<sup>-1</sup> (68.51 gr) and control (50.71 gr) treatments (Table 3). If the micronutri-

ents (Iron and Zinc) are provided in sufficient quantities, the Sunflower can through increase vegetative growth and production of photosynthetic assimilates send a greater amount of carbohydrates to the seeds and increasing the seed weight (Al-Doori, 2019). Rahimi *et al.* (2003) reported consumption of micronutrients can activate and synthesize enzymes, thereby increasing the rate of photosynthesis. Increased photosynthesis also causes a greater amount of assimilates to the seeds, resulting in an increase seed weight. Kumar *et al.* (2010) reported use of micronutrients in Sunflower cultivation has a significant effect on stem height, head diameter, number of seeds per head, seed weight, seed oil percentage, number of leaves and crop production.

### 4.2. Number of grain per head

According result of analysis of variance effect of foliar application of Iron, Zinc and interaction effect of treatments on number of grain per head was significant at 1% probability level (Table 2). Evaluation mean comparison result of interaction effect of treatments indicated maximum number of grain per head (620.31) was noted for 0.005 L.ha<sup>-1</sup> foliar application of Iron and 0.004 L.ha<sup>-1</sup> foliar application of Zinc and lowest one (536.1) belonged to control treatment (Table 4). The results of Putran (2020) indicated a positive effect of microelements (Zinc and Iron) on Sunflower growth, yield, and its components, especially the number of seeds in the head, which was consistent with the results of this study.

**Table 2.** Result analysis of variance of measured traits

S.O.V	df	1000-grain weight	No. grain per head	Grain yield	Protein content	Protein yield	Oil content	Oil yield
Replication	2	5.67 <sup>ns</sup>	724.1 <sup>ns</sup>	741.3 <sup>ns</sup>	0.02 <sup>ns</sup>	19.3 <sup>ns</sup>	2.15 <sup>ns</sup>	32.1 <sup>ns</sup>
Foliar application of Iron fertilizer (I)	2	1821.42 <sup>**</sup>	82361.5 <sup>**</sup>	66428.5 <sup>**</sup>	58.1 <sup>*</sup>	21347.7 <sup>**</sup>	351.33 <sup>**</sup>	8206.4 <sup>**</sup>
Foliar application of Zinc fertilizer (Z)	2	1505.3 <sup>**</sup>	65039.1 <sup>**</sup>	95433.4 <sup>**</sup>	89.37 <sup>**</sup>	1681.05 <sup>**</sup>	199.2 <sup>**</sup>	5271.5 <sup>**</sup>
I × Z	4	7.16 <sup>ns</sup>	24387.8 <sup>**</sup>	22147.01 <sup>**</sup>	71.56 <sup>**</sup>	1433.3 <sup>**</sup>	0.05 <sup>ns</sup>	30.1 <sup>ns</sup>
Error	16	31.49	1721.32	1184.27	6.88	35.9	9.24	151.3
CV (%)		9.21	7.02	13.68	14.43	13	7.63	12.18

<sup>ns</sup>, <sup>\*</sup> and <sup>\*\*</sup>: no significant, significant at 5% and 1% of probability level, respectively.

In studies by researchers, foliar spraying with micronutrients such as Iron and Zinc increases nitrogen absorption, yield components, including the number of grains per head, due to its positive effect on leaf area index and better absorption of some elements such as nitrogen (Baniabbass *et al.*, 2012).

#### 4.3. Grain yield

According result of analysis of variance effect of foliar application of Iron, Zinc and interaction effect of treatments on grain yield was significant at 1% probability level (Table 2). Evaluation mean comparison result of interaction effect of treatments indicated maximum grain yield (298.6 gr.m<sup>-2</sup>) was noted for 0.005 L.ha<sup>-1</sup> foliar application of Iron and 0.004 L.ha<sup>-1</sup> foliar application of Zinc and lowest one (222.9 gr.m<sup>-2</sup>) belonged to control treatment (Table 4). Increased yield in Sunflower can be due to an increase in any of the yield components. The number of seeds per head and seed weight in Sunflower are among the most important traits that affect seed yield, and an increase or de-

crease in any of them can increase or decrease seed yield (Dindoost Eslam *et al.*, 2008). The results of Lotha and Dawson (2021) confirm that the highest grain yield trait was obtained in the foliar application of Iron, Zinc, and boron, and the lowest of this trait was obtained in the treatment without foliar application of micronutrients. By increasing the absorption capacity of macronutrients, micronutrients can store more photosynthetic materials in seeds and, by reducing the number of empty seeds, increase seed yield (Amini and Rushdi, 2013).

#### 4.4. Protein content

Result of analysis of variance revealed effect of foliar application of Iron, Zinc and interaction effect of treatments on protein content was significant at 5%, 1% probability level, respectively (Table 2). Evaluation mean comparison result of interaction effect of treatments indicated maximum protein content (19.3%) was noted for 0.005 L.ha<sup>-1</sup> foliar application of Iron and 0.004 L.ha<sup>-1</sup> foliar application of

Zinc and lowest one (17.2%) belonged to control treatment (Table 4). Caliskan *et al.* (2008) revealed application of 400 gr.ha<sup>-1</sup> Fe-EDTA along with 80 kg.ha<sup>-1</sup> nitrogen had the best soybean yield. They emphasized application of coated nitrogen fertilizer along with Fe-EDTA as starter increased early plant growth. Janmohammadi *et al.* (2018) reported

application of Iron and Zinc fertilizers along with manure had good results on pea yield. Like this maximum sweet corn seed yield obtained when enriched vermin compost with Iron sulfate and Zinc sulfate along with foliar application of Zinc and Iron sulfate applied 20 to 40 days after planting (Arabhanvi and Hulihalli, 2018).

**Table 3.** Mean comparison different level of foliar application of Iron and Zinc fertilizer on studied traits

Treatment	1000-grain weight (gr)	Oil content (%)	Oil yield (gr.m <sup>-2</sup> )
<b>Foliar application of Iron</b>			
None spray or control	56.03b	38.05b	81.84c
0.003 L.ha <sup>-1</sup>	61.34ab	40.22ab	104.25b
0.005 L.ha <sup>-1</sup>	65.27a	41.11a	116.87a
<b>Foliar application of Zinc</b>			
None spray or control	50.71b	37.24b	76.18c
0.002 L.ha <sup>-1</sup>	63.44ab	39.85ab	104.99b
0.004 L.ha <sup>-1</sup>	68.51a	40.76a	118.33a

\*Mean which have at least once common letter are not significant different at the 5% level using (DMRT).

#### 4.5. Protein yield

According result of analysis of variance effect of foliar application of Iron, Zinc and interaction effect of treatments on protein yield was significant at 1% probability level (Table 2). Evaluation mean comparison result of interaction effect of treatments indicated maximum protein yield (57.62 gr.m<sup>-2</sup>) was noted for 0.005 L.ha<sup>-1</sup> foliar application of Iron and 0.004 L.ha<sup>-1</sup> foliar application of Zinc and lowest one (38.33 gr.m<sup>-2</sup>) belonged to control treatment (Table 4). The results of research by Khalafi *et al.* (1401) showed that use microelements (Iron and Zinc) significantly increased grain protein. They reported that these elements play a role in the structure of enzymes involved in the synthesis of

amino acids, which are the basis of protein synthesis. Therefore, the consumption of these elements increased the amount of grain protein, which was consisted with the results of this study. The researchers concluded that Zinc and Iron deficiency may prevent the activity of a number of antioxidant enzymes, which in turn causes oxidative damage to protein molecules, chlorophyll, and nucleic acids, so led to reduces crop protein production (Daniel and Triboi, 2008).

#### 4.6. Oil content

Result of analysis of variance revealed effect of foliar application of Iron and Zinc on oil content was significant at 1% probability level, but interaction

effect of treatments was not significant (Table 2). As for Duncan classification made with respect to different level of foliar application of Iron maximum and minimum amount of oil content belonged to 0.005 L.ha<sup>-1</sup> (41.11%) and control (38.05%) (Table 3). Compare different level of foliar application of Zinc showed that the maximum and the minimum amount of oil content belonged to 0.004 L.ha<sup>-1</sup> (40.76%) and control (37.24%) treatments (Table 3). Roshdi *et al.* (2008) based on their two-year research stated that inoculation of

seed with Nitroxin plus 50% of urea required the most positive effect in increasing seed and oil yield and the use of biological fertilizers can improve the characteristics of the oil seed be useful. Research by Babulkar *et al.* (2010) found that the effect of micronutrients significantly increased the percentage of protein and oil content. These results indicate that the application of micronutrients can have a significant impact on increasing quantitative and qualitative yield.

**Table 4.** Interaction effect of treatments on studied traits

Foliar application of Iron	Foliar application of Zinc	No. Grain per head	Grain yield (gr.m <sup>-2</sup> )	Protein content (%)	Protein yield (gr.m <sup>-2</sup> )
None spray or control	None spray or control	536.1e	222.9f	17.2e	38.33d
	0.002 L.ha <sup>-1</sup>	575.1d	231.6e	17.5d	40.53cd
	0.004 L.ha <sup>-1</sup>	582cd	232.18e	17.8cd	41.33cd
0.003 L.ha <sup>-1</sup>	None spray or control	590.4c	240.05de	18c	43.2c
	0.002 L.ha <sup>-1</sup>	601.4b	248.2d	18.4bc	45.66bc
	0.004 L.ha <sup>-1</sup>	606.23ab	261.4c	18.8c	49.14b
0.005 L.ha <sup>-1</sup>	None spray or control	596.5bc	254.1cd	18.1c	45.99bc
	0.002 L.ha <sup>-1</sup>	609.1ab	275.11b	19ab	52.27ab
	0.004 L.ha <sup>-1</sup>	620.31a	298.6a	19.3a	57.62a

\*Mean which have at least once common letter are not significant different at the 5% level using (DMRT).

#### 4.7. Oil yield

According to result of analysis of variance effect of foliar application of Iron and Zinc on oil yield was significant at 1% probability level, but interaction effect of treatments was not significant (Table 2). Evaluation mean comparison result revealed in different level of foliar application of Iron the maximum oil yield (116.87 gr.m<sup>-2</sup>) was noted for 0.005 L.ha<sup>-1</sup> and minimum of that (81.84 gr.m<sup>-2</sup>) belonged to control treatment (Table

3). Between different level of foliar application of Zinc the maximum oil yield (118.33 gr.m<sup>-2</sup>) was observed in 0.004 L.ha<sup>-1</sup> and the lowest one (76.18 gr.m<sup>-2</sup>) was found in control treatment (Table 3). The results of experiments by Kumar *et al.* (2010) showed that the use of micronutrients in Sunflower cultivation has a significant effect on oil percentage, which was similar to the results of this study. Also in the experiment of Rahimizadeh *et al.* (2010), the highest

oil yield was obtained in fertilizer treatments containing Zinc and Iron, which was consistent with the results of this study.

## 5. CONCLUSION

Finally according result of current research application 0.005 L.ha<sup>-1</sup> foliar application of Iron and 0.004 L.ha<sup>-1</sup> foliar application of Zinc had the highest amount of studied traits and it can be advice to producers in studied region.

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## FOOTNOTES

**AUTHORS' CONTRIBUTION:** All authors are equally involved.

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