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Original article

Effect of iron and zinc chelates on quantitative characteristics and amount of grain nutrients of corn (*Zea mayz* L.) under different irrigation regimes

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Introduction

Maize (*Zea mays* L.) is an annual monocotyledonous plant of the poaceaae family. The corn is C4 and is native to the tropical region. The breadth of its degree of adaptation and adaptation makes it possible to cultivate it in temperate and cold regions. The corn is the third highest cereal after wheat and rice production, but its production is equal to the production volume of each of the world's two grains. The agricultural sector and its systems, with more than 90 percent of the country's water consumption, are the largest water consumer, wasting 80 percent of its traditional irrigation systems. Therefore, by reducing water resources, the reform of consumption patterns is the only way to overcome the depleted crisis. About 70% of the Earth's surface is covered by water, but unfortunately, the water crisis in many countries of the world, including the countries of the dry belt of the earth, such as Iran, is a concern. Iranian soils have difficulty absorbing elements such as iron and zinc due to high pH. Therefore, chelate fertilizers, while retaining the elements for a long time, reduce the possibility of water leaching of these elements into the soil. Chelated fertilizers stabilize the material in the soil and do not eliminate it quickly. So that fluctuations in pH range from high acid to alkaline cannot have a negative effect on them. Zinc is one of the essential nutrients needed for optimal plant growth. It plays an important role in many biochemical reactions within the plant. Therefore, study of agronomic traits and nutrient content of maize in Hamidiyeh region to identify sensitive growth stages of water deficit and to investigate the role of zinc and iron chelate were necessary.

Materials and methods

This research was carried out in 2018-19 in a farm located in Hamidieh with a longitude of 48 degrees and 10 minutes east and 31 degrees and 33 degrees north latitude and 13 meters above sea level. This study was carried out as split split plot in a randomized complete block design with three replications. The treatments included three levels of irrigation regimes: 60, 90 and 120 mm evaporation from class A evaporation pan in the main plots and spraying iron and zinc in three levels (non-spraying, foliar spray of 2 per thousand and 5 per thousand) in the sub plots.

Results

Analysis of variance showed that the effect of different irrigation regimes and foliar application of iron and zinc had significant effect on number of grains per ear, number of grains per row, grain yield, zinc percent, iron percent, protein percentage and biological yield. Iron and zinc foliar application at 5 per

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thousand treatments significantly increased yield, grain yield components, plant height, ear length, leaf area index, Fe and Zn concentration of corn, which was not significantly different from 2 per thousand treatments. Interaction between different irrigation regimes and foliar application of iron and zinc had significant effect on grain number per ear, grain yield and biological yield. The highest grain yield (6400.49 kg.ha-1) was obtained by irrigating 95 mm evaporation from the pan and spraying of iron and zinc at 5 per thousand. According to the results of this study, foliar application of iron and zinc at 5 per thousand in 95 mm evaporation of pan caused to increase quantitative and qualitative characteristics of spring maize in Hamidiyeh region which was economically effective.

Conclusion

Overall, the results of this study indicate that soils in most of the southern parts of the country are low-pH calcareous and low in organic matter and lack of micronutrients such as zinc and iron. Therefore, in order to achieve maximum quantitative yield and nutrient content, cultivation of maize with foliar application of 5 to 1000 micronutrients is recommended in appropriate moisture conditions because soils of Khuzestan province are deficient in micro elements so foliar application the micronutrients in the irrigation conditions were able to compensate for the deficiency of these elements. Although, as expected, the highest grain yield was obtained in the irrigation treatment with micronutrients foliar application, but under conditions of water resources limitation, mild moisture stress, ie 95 mm evaporation from the pan with the foliar application of iron and zinc at a concentration of 5 in a thousand can be recommended.

***Keywords*:** Biological yield, Protein content, Seed yield, Zinc seed

Table 1. Physicochemical properties of the soil at experiment location

Soil depth	Soil texture	Clay	Silt	Sand	pH	EC	P	Z	Fe
cm	Clay	---------- % ----------				dS/m	----------ppm----------		
0-30	loam	42	37	21	7.2	4.8	9.4	0.63	1.9

Table 2. Mean square of traits under irrigation regime and spraying zinc and iron

S.O.V.	Df	No.seed per row	No. seed per ear	1000-seed weight	Seed yield
Irrigation regimes (I)	2	257.32**	8854. 4**	980.43**	60054.1**
spraying zinc and iron (ZI)	3	300.17**	7000.01**	844. 03**	75418.3**
I × ZI	6	158.19**	624.01**	20.42^{ns}	12478**
C.V. (%)	-	*9.01*	*5.54*	*5.1*	*6.44*

Table 2. Continued

S.O.V.	df	Biological yield	Seed protein percent	Seed zinc percent	Seed iron percent
Irrigation regimes (I)	2	80055.2**	6.49*	587.4**	7005.5**
Spraying zinc and iron (ZI)	3	65140**	8.07*	615.63**	7841.04**
(I × ZI)	6	11540.1**	0.08^{ns}	0.74^{ns}	12.73^{ns}
C.V. (%)	-	*4.48*	*13.60*	*11.04*	*14.78*

*, ** and ns are significant at 5% and 1% probability level and non significant, respectively

Table 3. Mean comparison of traits under irrigation regime

Iirrigation regimes	1000-seed weight	Seed protein percent	Seed zinc	Seed iron
	g	%	----------mg/kg----------	
60 (mm)	180.65[a]	6.7[c]	39.52[a]	174.15[a]
95 (mm)	159.20[b]	8.85[b]	34.11[b]	162.22[b]
130 (mm)	140.36[c]	11.02[a]	27.58[c]	151.30[c]

The same letters in each column represent no significant differences between the levels of the agent are examined at a 5% probability level.

Table 4. Mean comparison of traits under spraying zinc and iron

Spraying zinc and iron	1000-seed weight	Seed protein percent	Seed zinc	Seed iron
	g	%	----------mg/kg----------	
No spraying	148.14[b]	7.92 [b]	22.50[b]	134.31[b]
2 per a thousand	162.68[a]	8.43[ab]	38.26[a]	175.08[a]
5 per a thousand	169.41[a]	10.16 [a]	40.45[a]	178.27[a]

The same letters in each column represent no significant differences between the levels of the agent are examined at a 5% probability level.

Table 5. Comparison of the average on studied traits of corn influenced by the interaction of irrigation regime and spraying zinc and iron

Irrigation Regime	Spraying zinc and iron	No.seed per row	Number of kernels	Seed yield	Seed bioligical
		No.	No.	kg/ha	g/m^{-2}
60 (mm) Transpiration	**No spraying**	27[b]	445.76[b]	5000.13[b]	1355.11[b]
	2 per a thousand	31.23[a]	490.33[a]	6410.52[a]	1448.41[a]
	5 per a thousand	32.12[a]	501.43[a]	6480.15[a]	1460.20[a]
95 (mm) Transpiration	**No spraying**	24[c]	408.70[c]	4500.45[c]	1279.19[c]
	2 per a thousand	27.13[b]	433.25[b]	5100.23[b]	1370.41[b]
	5 per a thousand	31.02[a]	483.65[a]	6400.49[a]	1435.02[a]
130 (mm) Transpiration	**No spraying**	19.10[d]	363.13[d]	3900.33[e]	1085.12[e]
	2 per a thousand	20.02[d]	370.10[d]	4000.57[e]	1226.14[d]
	5 per a thousand	22[cd]	405.2[c]	4290.09[d]	1230.27[d]

The same letters in each column represent no significant differences between the levels of the agent are examined at a 5% probability level