University of Birjand

تنش‌های محیطی در علوم زراعی
Environmental Stresses In Crop Sciences
Vol. 14, No. 2, pp. 387-402
Summer 2021
http://dx.doi.org/10.22077/escs.2020.2589.1736

Original article

The effect of superabsorbent and iron and zinc foliar application on antioxidant enzyme activity and yield maize (S.C.704) (*Zea mays* L.) under irrigation regimes

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Received 24September2019; Accepted 4November2019

Extended abstract

Introduction

Maize (*Zea mays* L.) is one of the most important cereal grains that is cultivated in more than 180 million hectares, and its production is over 1000 million tons. The occurrence of water stress causes metabolic disorders in plant cells, such as the increase in the production of active forms of oxygen such as radical superoxide, hydrogen peroxide and radical hydroxyl as one of the major factors in metabolic abnormalities in the cell. Plants against oxidative stress induced, efficient defense system that can destroy or neutralize free radicals. This defense system includes superoxide dismutase, catalase and ascorbate peroxidase. Correct management practices and the application of advanced techniques to maintain moisture storage and increase water holding capacity are effective measures to increase the efficiency of irrigation and thus improve the utilization of water resources. One of the new methods for increasing irrigation efficiency is the use of superabsorbents. Superabsorbent polymers can absorb large amounts of water or aqueous solutions and swell. These water storage tanks, when placed in the soil, absorb irrigation water and rainfall and prevent it from quenching. After the environment is dry, the water inside the polymer is gradually evacuated, and thus the soil for a period of Long and no need to re-irrigate, it's moisturizing, it also increases the impact of plant and nutrients, and, on average, reduces phosphorus losses by 84 percent, reducing nitrogen to 83 percent. Therefore, the purpose of this study was to investigate the effect of iron, zinc, and superabsorbent application of water deficit stress on quantitative yield and corn antioxidant enzymes activity in Shushtar climate.

Materials and methods

This research was carried out in two years between 2016-2017 and 2017-2018 in a farm located in Shushtar with a longitude 48 degrees and 49 minutes east and a latitude 32 degrees and 14 minutes north and a height of 110 meters from the sea level. The experiment was carried out as split split plot in a randomized complete block design with three replications. The main factor was irrigation regime with three levels (irrigation after 30, 40 and 50% field capacity depletion, respectively). Sub-factor was composed of twolevels of polyurethane foam (super-adsorbent, 0 and 200 kg ha^{-1}) and sub-subplots including spraying of nutrients with four levels [control (water), iron spraying, zinc spraying and spraying Iron + zinc].

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Results

Combined analysis of variance showed that the effect of water deficit and superabsorbent stress on grain yield, 1000 grain weight, number of grain per ear, catalase enzyme and supraoxydisodium were significant. In dehydration conditions, grain yield, number of seeds per ear and ascorbate peroxidase decreased, but the activity of catalase and superoxide dismutase enzymes increased. On the other hand interaction of dehydration and superabsorbent stress was significant on grain yield. The highest grain yield (8530.6 kg ha-1) was attributed to irrigation after 40% capacity utilization and application of 200 kg/ha superabsorbent. Spray application of iron and zinc resulted in increased grain yield, number of seeds per ear, catalase and superoxide dismutase.

Conclusion

Overall, the results showed that foliar application of micronutrients and superabsorbent important role in the growth and development of corn plants as well as the fact that the highest values of grain yield and activities of antioxidant enzymes of fertilizer zinc and iron from micro-nutrients are, It can be concluded that using such fertilizers can provide the best conditions for obtaining maximum yield and biochemical traits in corn. On the other hand, iron and zinc micronutrient spraying caused a decrease of 45% damage caused by water deficit stress on grain yield. The superabsorbent effect is also more pronounced in lower moisture content. The application of superabsorbent hydrogels in the soil increased plant yield and saved water consumption, therefore the use of this substance in less water can be effective in increasing the yield and reducing the adverse effects of stress in conditions of water shortage. Therefore, according to the results obtained in irrigation conditions after discharge of 40% of the crop capacity, the application of polyester absorbent and micronutrient application of iron and zinc improved seed yield and biochemical traits of corn.

***Keywords*:** Catalase, Grain yield, Iron, Optimal irrigation, Superabsorbent

Table1. Physicochemical properties of the soil at experiment location

Farming year	Depth of soil	Soil texture	pH	EC	Organic Matter	N	Z	Fe
	cm			dc/m	%	-----------ppm-----------		
2016-17	0-30	Clay-Silty	7.61	3.78	0.32	0.03	0.32	9.8
2017-18	0-30	Clay-Silty	7.22	3.43	0.3	0.02	0.3	9.54

Table 2. Mean square of traits under irrigation regime, superabsorbent and micronutrient

S.O.V	df	Number of kernels	1000-grain weight	Grain yield	Catalase	Superoxide dismutase	Ascorbate peroxidase
Year (Y)	1	1042.6^{ns}	154.73^{ns}	4334^{ns}	0.051^{ns}	13.1^{ns}	4.34^{ns}
Year×Replication	4	315.1	13.05	20.35	0.14	10.02	0.3
Irrigation regime (I)	2	334718**	6470.1**	1970421**	4485**	41400.1**	2574.3**
Y×I	2	900.05^{ns}	25.84^{ns}	6094^{ns}	9.41^{ns}	2.04^{ns}	10.18^{ns}
(Ea)	8	2410.3	305.32	15420	150.23	2641.74	197.74
Super absorbent (S)	1	35788**	9048.2**	246417**	3406.2**	32105.43**	5.65^{ns}
Y×S	1	500.05^{ns}	0.85^{ns}	42^{ns}	0.32^{ns}	0.03^{ns}	1.07^{ns}
I×S	2	5471*	7.82^{ns}	422740**	1098.3**	9540.34*	1.23^{ns}
Y×S×I	2	50.07^{ns}	0.56^{ns}	324^{ns}	0.64^{ns}	0.63^{ns}	0.05^{ns}
Error b	12	2130.94	284.09	14162.1	104.21	2345.5	155.4
Micronutrient (M)	3	23840**	4870.16**	477980**	840.43*	25241.11**	2008.57**
Y×M	3	60.12^{ns}	3.51^{ns}	115^{ns}	0.15^{ns}	1.24^{ns}	0.14^{ns}
S×M	6	2044.51*	20.31^{ns}	390547**	2.31^{ns}	9400.74*	0.77^{ns}
Y×I×M	6	74.1^{ns}	10.5^{ns}	202.1^{ns}	1.02^{ns}	0.19^{ns}	0.35^{ns}
S×M	3	1847.2*	0.04^{ns}	165470**	5.47^{ns}	4.03^{ns}	5.04^{ns}
Y×S×M	3	231^{ns}	32.47^{ns}	738^{ns}	3.81^{ns}	0.2^{ns}	1.18^{ns}
I×S×M	6	85.2^{ns}	9.15^{ns}	340^{ns}	4.75^{ns}	0.05^{ns}	2.84^{ns}
Y×I*S×M	6	101.2^{ns}	11.09^{ns}	783^{ns}	0.51^{ns}	0.23^{ns}	2.09^{ns}
Error c	72	1985.3	250.66	13402	97.39	2200.3	140.03

ns, * and **: Non–significant and significant at 5% and 1% probability levels, respectively

Table 3. Mean comparison of traits under irrigation regime, superabsorbent and micronutrient

Treatment	Number of kernels	1000-grain weight	Grain yield	Catalase	Superoxide dismutase	Ascorbate peroxidase
		g	kg.ha^{-1}	-------------Unit.mg^{1}Protein-------------		
irrigation regime						
30%Field capacity	420.8^{a}	238.29^{a}	8880.8^{a}	67.16^{c}	361.06^{c}	200.4^{a}
40% Field capacity	381.54^{b}	218.38^{b}	6890.4^{b}	90.04^{b}	466.2^{b}	164.34^{b}
50% Field capacity	336.72^{c}	205.64^{c}	5630.9^{c}	123.61^{a}	521.0^{a}	110.12^{c}
Superabsorbent						
Non-application	349.35^{b}	207.08^{b}	6400.3^{b}	109.46^{a}	518.33^{a}	160.64^{a}
200 Kg/ha	410.02^{a}	234.46^{a}	7870.8^{a}	77.74^{b}	380.51^{b}	155.92^{a}
Micronutrient						
Control	327.06^{c}	206.62^{c}	6270.5^{c}	71.85^{c}	393.21^{c}	105.71^{c}
Iron spraying	376.15^{b}	218.45^{b}	7110.3^{b}	90.63^{b}	448.33^{b}	163.68^{b}
Zinc spraying	383.69^{b}	221.31^{b}	7170.1^{b}	92.74^{b}	450.12^{b}	157.90^{b}
Iron and zinc spraying	431.84^{a}	236.70^{a}	8000.3^{a}	119.18^{a}	506.03^{a}	205.83^{a}

Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level.

Table 4. Mean comparison of traits under interaction of irrigation regime × superabsorbent

irrigation regime	Superabsorbent	Grain Yield	Number of kernels	Catalase	Superoxide dismutase
		kg/ha		----------Unit.mg^{1}Protein----------	
Field capacity 30%	**Non-application**	7880.93^{b}	390.09^{b}	72.57^{d}	390.08^{d}
	200 Kg/ha	9100.7^{a}	432.25^{a}	60.09^{e}	350.25^{e}
Field capacity 40%	**Non-application**	5930.22^{c}	351.18^{c}	115.3^{b}	528.41^{a}
	200 Kg/ha	8530.69^{a}	428.08^{a}	90.56^{c}	431.54^{c}
Field capacity 50%	**Non-application**	5380.93^{d}	334.42^{d}	127.82^{a}	542.39^{a}
	200 Kg/ha	5990.05^{c}	342.05^{cd}	95.27^{c}	453.85^{b}

Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level.

Table 5. Mean comparison of traits under interaction of irrigation regime × micronutrient

irrigation regime	Micronutrient	Grain yield	Number of kernels	Superoxidedismutase
		kg/ha		Unit.mg[1]Protein
Field capacity 30%	Lack of spraying	7440.55[c]	378.15[c]	323.6[g]
	Iron spraying	8500.41[b]	395.1[b]	368.25[f]
	Zinc spraying	8610.5[b]	397.25[b]	380.13[f]
	Iron and zinc spraying	9650.81[a]	444.21[a]	405.04[e]
Field capacity 40%	Lack of spraying	5870.40[efg]	361.43[d]	440.79[d]
	Iron spraying	6700.56[d]	376.03[c]	465.52[cd]
	Zinc spraying	6830.23[d]	378.17[c]	480.61[c]
	Iron and zinc spraying	9580.62[a]	442.03[a]	535.2[ab]
Field capacity 50%	Lack of spraying	5100.75[g]	327.19[f]	441.14[d]
	Iron spraying	5600.11[fg]	341.34[e]	500.05[b]
	Zinc spraying	5640.68[fg]	345.22[e]	506.54[b]
	Iron and zinc spraying	6110.42[ef]	370.05[cd]	546.25[a]

Means with similar letters in each column are not significantly different by Duncan's test at 5% probability level

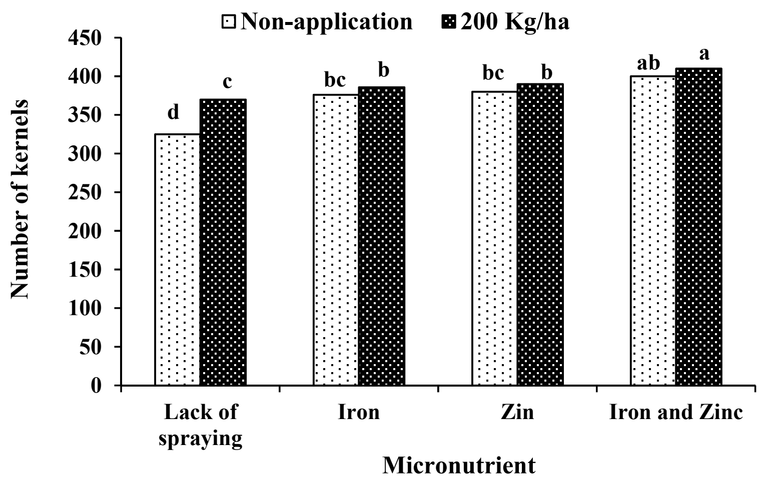

Fig. 1. Interactions effects of superabsorbent and micronutrienton number of kernels

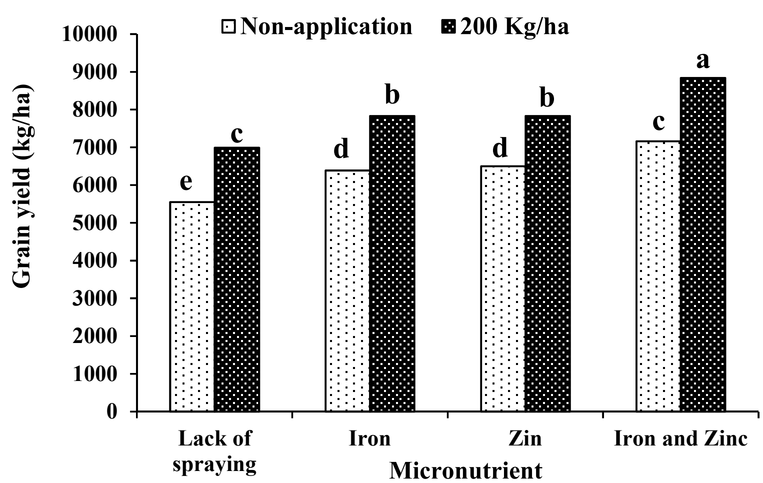

Fig. 2. Interactions effects of superabsorbent and micronutrienton grain yield