

INTERACTION BETWEEN WATER STRESS IN LATE STAGE OF GROWTH AND FOLIAR APPLICATION OF ZINC ON YIELD OF DIFFERENT WHEAT GENOTYPES

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Abstract

To investigate the effect of water stress and foliar application of zinc and its interaction on water use efficiency, split factorial design study was conducted in Isfahan 2012/2013. Water stress treatments in this experiment were established at three water stress levels (no water stress, water stress at grain filling stage, and water stress at flowering stage) in the main plots. Plants were exposed to three zinc levels (0, 2.5, and 5 mg l⁻¹ as ZnSO₄·7H₂O) and wheat genotypes including Mahdavi, Shiraz and Pishtaz were leading in the sub plots. The results showed that the difference between water stress treatments on grain yield, biological yield and weight thousand seeds were significant. The increasing zinc sulphate up to 2.5 mg l⁻¹ in the water stress at grain filling stage increased grain yield up to 12 percent. Grain yield response to foliar application of Zn in Pishtaz genotype was higher than Shiraz and Mahdavi genotypes. Grain yield in water stress treatment at flowering stage decreased 13 percent compared to no water stress treatment, whereas less than two rounds irrigation done and water use efficiency significantly increased.

Keywords: zinc, stress, cultivar, wheat

INTRODUCTION

Drought is one of the most important restricting factors in the production of agricultural crops in the arid and semi-arid regions of the world. Iran with the average atmospheric precipitation of 240 mm per year will be classified in this group. When the stress occurs and duration of continuation, frequency of drought occurrence, intrinsic characteristics of the soil, soil nutritional elements, rain changes and fluctuations, whole of them have a great effect of it and shows that why tolerant genotypes reactions to the drought, in one year is good, but in the next year is less than our expectance (Ebrahimi Mollabashi et al., 2007).

Plant appropriate nutrition in raising the plants' tolerance level against the various stresses has a great significant effect and zinc is one of the 7 essential and low consumption elements in the plant nutrition. The shortage of zinc as the third nutritional matter after N and P in most of soils especially calcareous soils can restrict the growth of cereals. Shortage of this element in the soil not only causes the plant yield to be reduced, but via reduction of this element concentration in the nutritional materials, including the wheat grain, causes its absorption in human and animals to be reduced that this causes the different diseases to occur and finally the community health to come down (Khan et al., 2008).

The status of water is effective of the uptake and exploitation from the nutritional elements. If the nutritional elements shortage causes to restrict the root growth, uptake of the nutritional elements and water will be restricted, in particular if the intensive water stress exists (Tariq et al., 2014). Use of zinc fertilizer, will rise the use of water both in the suitable conditions of irrigation and low-irrigation conditions. Wheat in most of the world regions and in the final stages of growth often during the grain filling will face with the water shortage that this lead to the restriction in the grain yield (Moore et al., 2014).

The goal of performing this research is to investigate simultaneously the effects of supplying the zinc nutritional element and cutting the irrigation off in the final stages of growth on the grain yield, biologic yield, harvest index and possibility of enriching the wheat grain with the zinc element in the desired condition and drought periods

MATERIALS AND METHODS

These experiments were performed in two agricultural seasons during the years 2011-2012 in the agricultural research station of Kabootar Abad located at 24 km from the east of Isfahan, Iran. Long term average of rain and annual temperature of region respectively 112 mm and 15.8°C and total precipitation in 2011 and 2012 respectively were 107.8 and 166.7 mm.

This selected soil for experiment is silt-loam with the capability of electrical conductivity of 3.2 mm/cm, acidity of 7.5 and having the 77% organic matter and zinc about 0.5 mg/kg. To assess the effect of water shortage and use of zinc on three cultivars of wheat titles as Mahdavi, Shirazi and Pishtaz, an experiment was done in the form of split factorial to the framework of complete random basic block design with three replications. The treatments related to the water shortage in the form of cutting the irrigation off in different stages of wheat growth and in three levels were applied as following:

W₁: Complete irrigation to the end of wheat bush growth (the irrigation was done when the emptying the soil from moisture in depth of 30-60 cm reached to the 40 percent).

W₂: Complete irrigation to the starting stage of wheat fertility (pollination stage) stage 1- 10.5, fixed scale and cutting the irrigation off from this time to the harvest time.

W₃: Full irrigation to the milky stage of wheat grain (stage 10.5 -5 fix scale) and cutting the irrigation off from this time to the harvesting time. Use of zinc in this experiment as the foliar application was done and these treatments include three levels as follows:

Z₁: Not using the of zinc

Z₂: Use of 2.5 mg/kg of zinc in the stage of tillering

Z₃: Use of 5 mg/kg of zinc in the stage of tillering

In this research, main plots include three different humidity diets of low irrigation and 9 sub plots included the interactions of three different genotypes of wheat and three different concentrations of zinc

Each experimental plot includes 8 rows of plants in length of 3 meters that distance of lines was considered as 20 cm and seed density about 400 grains per M². In this experiment in the main plots, treatments related to the irrigation levels and in the sub plots, treatments related to the use of zinc were applied on the mentioned cultivars.

Physical and chemical properties of soil in the performing place of experiment are according to the some explanation of tables 1 and 2. For statistically analyzing the data in the form of combined analysis was used of "Mstatc" and for drawing the graphs was used of "Excel" and for comparing the average of data was used of Duncan method.

Table 1. Chemical properties of soil

Depth (cm)	Saturated mud PH	Electrical Conductivity (ds.m ⁻¹)	Organic Carbon (%)	P Absorption mg.kg ⁻¹	K Absorption mg.kg ⁻¹	Zinc Absorption mg.kg ⁻¹
0-30	7.5	3.2	0.77	11.6	230	0.5

Table 2. Physical properties of different layers of soil

Soil depth (cm)	Soil Texture (%)			Soil Texture Class	Bulk density (g/cm ³)
	Sand	Silt	Clay		
0-30	32	58	10	Silty-Loam	1.47
30-60	30	46	22	Clay-Loam	1.46
60-90	25	35	40	Loam	1.42

RESULTS

Results obtained from the combined analysis of variance related to the two years of experiment show that cutting the irrigation off on the amount of dry matter, grain yield, harvest index and water use efficiency in the wheat cultivars was effective. Minimum amount of dry matter, grain yield and harvest index and maximum water use efficiency by the effect of cutting off the water treatment in the stage of pollination was acquired (Table 3).

Table 3. Comparing the grain average yield, biological yield, harvest index, zinc in the grain and water use efficiency in the different treatments

Treatments	Grain yield (Kg/Ha)	Biological yield (Kg/Ha)	Harvest index (%)	Water use efficiency (Kg/M ³)	Zinc in the Grain (Mg/Kg)
W1	a 8385	a 21626	39 a	b 0.96	32.4 a
W2	c 5786	b 17015	34 b	1.22 a	32.5a
W3	b 6579	18197 b	36 ab	a 1.18	32.6 a
Z1	b 6559	ab 18773	b 35	b 1.11	b 25
Z2	a 7409	a 19807	a 38	a 1.25	a 35
Z3	b 6781	b 18258	a 37	b 1.13	a 38
V1	a 7224	a 19592	b 37	a 1.19	33 a
V2	b 6723	ab 19051	a 35	b 1.14	30 a
V3	b 6803	b 18195	a 38	b 1.17	34 a

Zinc efficiency on all the traits became very significant (Table 3) and results showed that concentration of 2.5 mg/kg for zinc, in comparison with other concentrations had a more effect in the increase of average in all the traits (Table 3).

Also, the results related to the comparison of averages showed that in conditions without stress by increase of the zinc in the level of 2.5 mg/Kg, water use efficiency was increased compared to the other concentration. Such that water use efficiency in conditions without stress by consumption of zinc in level of 2.5 mg/Kg was 53 %, but in the concentration of zero was 42 % and this shows that we have an increase about 26 % here.

Of course, in terms of water stress and in the pollination stage and use of 2.5 mg/kg zinc, the water use efficiency showed a great and significant increase from itself (Table 4).

Table 4. Comparing the average effect of water stress and application of zinc on the grain yield, biological yield and harvest index and zinc in the grain at two years

	Grain yield (Kg/Ha)	Biological yield (Kg/Ha)	Harvest index (%)	Water use efficiency (Kg/M ³)	Zinc in the Grain (Mg/Kg)
W1	Z1 c 7286	bc 19981	37 bc	f 0.8	26 bc
	Z2 a 9279	a 23994	39 ab	1.07 d	33 ab
	Z3 b 8590	b 20903	42 a	e 0.98	37 a
W2	Z1 e 5707	de 17720	d 32	b 1.31	bc 26
	Z2 d 6313	cde 17830	bc 36	a 1.46	a 34
	Z3 e 5339	e 16147	cd 34	c 1.23	a 39
W3	Z1 d 6637	bcd 17273	bc 35	c 1.23	23 c
	Z2 d 6686	de 17596	abc 38	c 1.22	38 a
	Z3 d 6414	de 17723	bc 36	c 1.18	36 a

According to the results of combined analysis of variance (The two-year-old) in Table 3, there is a significant difference between cultivars and Mahdavi cultivar in comparison with Shiraz and Pishtaz showed superiority from itself.

Also, interaction of water stress and cultivars (W*V) on the grain yield was significant (Table 3). Results showed that in conditions without having the water stress, all cultivars especially Mahdavi have a great and significant yield (Figure1).

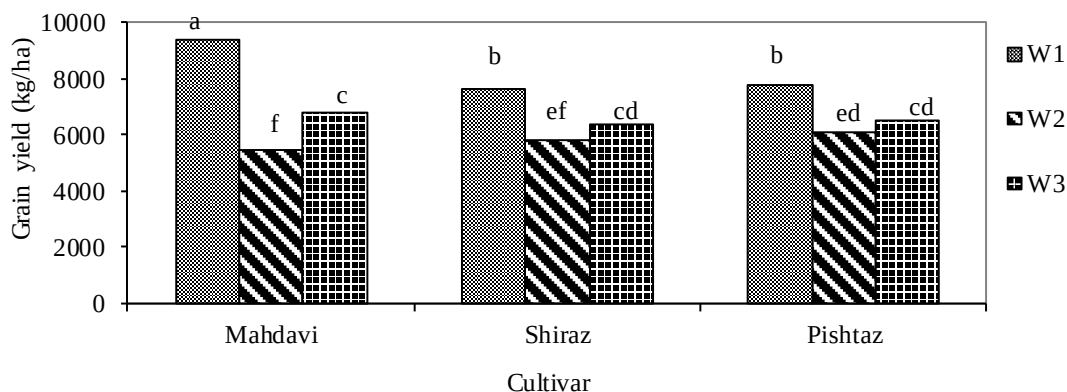


Figure1. Interaction between the drought stress and cultivar on the grain yield

The interaction between water stress and zinc (W*Z) become significant in most of the traits (Table 3). Results showed that the grain yield in 2.5 mg/kg of zinc in the different levels of water stress specially when there is not any water stress was increased, such that the grain yield in comparison with zero concentration reached to the amount of 9279 kg per hectare (27%).

Results showed that in all levels of water stress, an increase in the concentration of the foliar application of zinc had the positive effect on the amount of grain zinc (Table 4).

DISCUSSION

By cutting off the water in the phase of pollination, in other word, by reducing the 4 stages of irrigation or reducing the 50 % from the consumed water compared to the improved irrigation, the grain yield 31% was reduced, but the water use efficiency has been increased about 37% and this indicates that the plant growth after pollination has not been increased and regarding to this that the wheat growth is limited, then this issue is rational (Tariq and et al., 2014).

Grain yield in the concentration of 2.5 mg/kg for zinc is 7409 kg per hectare that compared to the control was more about 13 %. Moore *et al.*, 2014 have acknowledged that proper usage of zinc has the significant effects on the total dry matter and yield of wheat cultivars.

Zinc shortage in crops will reduce both plant growth and final yield, because zinc element in a wide range of physiological and biological processes can be effective (Sajedi and Rejali 2011) and its shortage causes the plant significantly to be damaged. (Chaker Alhoseini et al., 2009).

Movahhedi et al., (2009) showed that in high concentration of zinc in the soil, in addition to the growth of root and shoots in plant, the concentration of zinc in the grain significantly was increased.

Cakmak et al., (2009) has reported that appearance of genetic potential related to some of wheat cultivars and dry matter accumulation, if any proper nutritional resources will be there, is possible. Although, grain yield showed a reduction by increase of the water stress in all cultivars, but it was considered that Pishtaz cultivar showed a maximum yield of grain in amount of 6107 kg per hectare by cutting off the irrigation in the stage of pollination (figure 1). Pishtaz cultivar as a resistant cultivar due to having a proper genetic potential has a higher yield than Mahdavi cultivar in the stressful conditions.

Researchers consider that the foliar application of zinc are effective in conditions of drought and salinity stress on the yield and yield components (Sakaro et al., 2007) and (Movahhedi et al., 2009). Biological yield by use of 2.5 mg/kg zinc in conditions of full irrigation significantly was increased (Table 3). This issue is come from where the zinc utilization causes to the better water uptake from soil to the plant and causes the dry matter to be increased. Zinc application causes the root and shoots to be increased in the wheat (Cakmak, 2009). Khan et al., (2008) have reported that nutrition of zinc in the regions with shortage associated with the drought stress can has a significant role in improving the plant state and amount of zinc storage in the grain.

CONCLUSION

Effect of water stress and Zn sulphate application on growth and grain yield of *Pishtaz* genotype was different from *Shiraz* and *Mahdavi* genotypes. So that *Pishtaz* genotype was more efficient in use of water and Zn sulphate and could produce a better product. Although superior of *Mahdavi* genotype in period of no stress was considerable than other genotypes. Overall results showed that due to weather conditions and limited water in Isfahan region in late spring can be applying optimal crop operation on the amount of irrigation water saving. Also effects of water stress at grain filling stage are reduced by selecting the appropriate cultivars with potential nutritional resources.

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