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The Relationship between Intermittent Irrigation and Foliar Application of Zinc on yield components of Sweet Corn Varieties

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Abstract: In order to evaluate growth indices of two hybrids of sweet corn, Chase and Challenger under deficit irrigation and foliar application of zinc compounds, an experiment was carried out as the split plot factorial in the form of randomized complete block design with three replications in the experimental field of Faculty of Agriculture, Islamic Azad University of Arak in 2014 and 2015. Different levels of irrigation pattern included the conventional furrow irrigation (I_1), fixed every other furrow irrigation (I_2) and alternate every other furrow irrigation (I_3) in the main plots and different levels of foliar application of zinc in the sub plots as lack of foliar application of zinc (control, foliar application of water), use of Drop zinc sulfate $\left(\frac{2}{1000} lit.ha^{-1}\left(zn_2\right)\right)$, use of Fast zinc sulfate $\left(\frac{2}{1000} lit.ha^{-1}\left(zn_3\right)\right)$ and two hybrids of sweet and super sweet corn. Drought stress in alternate irrigation caused the significance decrease of yield components ,Chlorophil and carothenoid content so that the highest parameters was observed in the control irrigation treatment against every furrow irrigation treatment, but there was no significant difference between alternative irrigation and control.The results showed that the interactive effect of treatments on the parameters was significant at 1% probability level .

***Keyword**: Intermittent Irrigation, Zinc, Sweet Corn*

INTRODUCTION

Corn (Zea mays L.) is the world's third most important cereal after wheat and rice grown primarily for grain and secondarily for fodder (Adiloglu *et al.,* 2006).Sweet corn is used as a fresh or processed vegetable.Sweet corn contains higher kernel protein, oil,starch, sugar contents and many other nutrients than the other maize types(Ahmadi *et al.,* 2013). Sweet corn is favorable for fresh consumption because of its delicious taste,delicate crust and soft and sugary texture compared to other corn varieties. The human body needs nutritious food to stay healthy(Alizadeh *et al.,* 2007). Drought is one of the factors,which threatens the agricultural products in most parts of the world . Shortage of water, on the other hand, is an important limiting factor in crop production. Using every other furrow irrigation is an ideal strategy to reduce irrigation water used. Every other furrow irrigation may reduce the volume of water used up to 50 percent and induce a decrease in growth and yield due to the water stress caused by the smaller amount of applied irrigation in same irrigation frequency (Ashraf *et al.,* 2009; Ayad *et al.,* 2010). Among

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fertilizers, zinc sulfate fertilizer plays a more important role in adjusting stomata and ionic balance in plant system to decrease stresses caused by water shortage; therefore,under water shortage conditions,consumption of fertilizers should be balanced and optimized and special attentions should be taken to the consumption of zinc sulfate fertilizers (Basetti *et al.,* 2003; Benjamin *et al.,* 2007). However, it should be noted that soils of Iran, which are categorized under the calcareous soils,due to drought stress, salinity, being calcareous, highly acidity, having low contents of organic materials,continuing drought, and continuing unbalanced consumption of fertilizers, iron and zinc contents are too low(Alizadeh *et al.,* 2007).Therefore, the plants which grow in such soils are mainly suffered from shortage of iron and zinc and shortage indications are observed in them (Emam *et al.,* 2005).The yield components of tropical maize varieties differ considerably (Benjamin *et al.,* 2007). Yield components can be modified to some extent by crop management and environmental factors. Tadayoun (2009) found that Zn fertilization had varying effects on the ear number per plant,ear length, and kernel weight of inbred lines. Compared with small grain cereals, the kernel weight of maize is relatively flexible; artificially reduced seed set caused increases in kernel weight from 0 to 25%,depending on the genotype (Rafie *et al.,* 2003). It is assumed that prolific and semi-prolific maize varieties adjust better to environmental stresses and have greater stability of performance across environments (Salarmandi *et al.,* 2004). The aim of our study was,therefore, to determine the interactive effects of irrigiation patterns and Zn fertilizer rate on the grain yield and yield components of sweet corn in Iran.

MATERIALS AND METHODS

This test was conducted in agricultural years of 2014 and 2015 in split plot factoriel style in completely randomized block design in three replicates in the Azad University research field of Arak (34°40′ N 58°25′ E and height of 1150 m). The soil of experimental plot was loam, *p*H 7.70,EC 1.20 dSm-1, organic carbon 1.50%,available nitrogen 0.02%, phosphorus 0.6% and potassium 0.2%.Experiment treatments including irrigiation patterns were carried out at three levels of conventional furrow irrigation (I_1), fixed every other furrow irrigation (I_2) and alternate every other furrow irrigation (I_3). Subplots were considered with three levels of without zinc spray(control)(zn_1), drop zinc spray $\left(\frac{\bullet}{\bullet\bullet\bullet\bullet} lit/ha\right)$ (zn_2)and fast zinc spray $\left(\frac{\bullet}{\bullet\bullet\bullet\bullet} lit/ha\right)$ (zn_3)and Chase(v_1) and Challenger (v_2) as sweetcorn varieties. Generally, there were 36 subsidiary plots with the surface area of 20 m2 (5meters NS and 4 meters WE) which were divided into two rows. Planting was performed on 26 May as dry planting with the density of 7.5 plants per square meter.According to the results obtained from the soil analysis, the required fertilizer was added to the farmland. To do so, 150 kg of urea, 150 kg of super phosphate and 100 kg of potassium soleplate per hectare were added to the soil. Each plot was harvested at maturity for yield and yield components and leaf area index , dry matter were measured each 15 days to calculate Leaf Area Index (LAI),Crop Growth Rate (CGR), Net Assimilation Rate (NAR), Relative Growth Rate (RGR) and Harvest Index (HI) according to below equations:

$$\text{Chlorophyll a} = 12/7(663)\ \text{-}2/69(645) \times \frac{\text{v}}{1000} \times w \quad (1)$$

$$\text{Chlorophyll b} = 22/9(645)\ \text{-}4/69(663) \times \frac{\text{v}}{1000} \times w \quad (2)$$

$$Charothenoid = 100(\text{A470}) + 3/27(\text{mg chl a}) - 104\frac{(\text{mg chl b})}{227} \quad (3)$$

$$HI = \frac{Ye}{Yb} \times 100 \quad (4)$$

Comparisons of average related to the drought stress and spray were carried out through Duncan experiment.

RESULTS AND DISCUSSION

Yield components

The results of Table 2 show that, because of the similarity of temperature and precipitation in the region of two years testing, the year was not significant on none of the yield and physiological indices.also None of phenological and physiological parameters were not significant affected by the interaction of the experimental treatments.Both drought and without Zn supply reduced the number of grains per ear, number of grains per row, weight of thousand grains and biological yield. In examining the interactive effect of treatments it was observed that the maximum Plant height belonged to $I_3ZN_3V_2$ treatment (alternate irrigation, fast zinc and Challenger hybrid) by 129.02 cm and the lowest belonged to $I_2Zn_2V_2$ treatment (furrow irrigation, without zinc and Challenger hybrid) by 73.93 cm that were significantly different at 1% level. These findings are in agreement with Emam *et al*. (2004) and taddayon (2009) who investigated the effect of drought stress on corn .The mean comparison of the effects of treatments showed that from the full irrigation treatment to every furrow irrigiation treatment, the Plant height dramatically dropped by 19.04% which would result in the reduction of chlorophyll in leaf and photosynthesis. In examining the interactive effects of irrigation pattern and zinc, Challenger hybrid at different irrigation patterns had higher Plant height than Chase hybrid (118.222 Vs. 107.556), Its Plant height was 10.28% more than the other one. This finding was in agreement with the results of Chaker et al (2004). In examining the interactive effects of the treatments, the foliar application of fast zinc by 21.36% increase of Plant height in comparison with the control treatment and was significantly different from drop zinc and control treatment at 1% level. The results are matches with results of Chaker *et al*. (2004) and payero *et al*. (2009).The grain number in row and ear and biological yield were significantly affected by the irrigation patterns × Zn rate interaction (*Table 2*). Under drought, Zn supply increased number of grains per ear and biological yield about 12.12 and 10.73 %, respectively, than without Zn (*Table 2*). Also the number of grains per ear increased with Zn application regard to the water regime, and the differences between the supply and without supply Zn treatments were generally significant (*Table 2)*. Under drought, Zn supply was similar other mineral supply and weight of thousand grains is significantly affected by Zn supply (*Table 2*), also under full irrigation, all of yield components were significantly affected by zn supply except number of row per ear which Which seems to be a genetic trait and Which seems to be a genetic trait and not dependent on environmental conditions (*Table 2*). The 1000 grain weight of drought stressed plants was considerably lower than that of wellwatered plants; the average reductions due to drought were 17% (*Table 1*).Thus, every furrow irrigiation treatment formation a decrease in 1000 grain weight and, to a lesser extent, a decrease in number of grains per ear contributed to lower grain yields due to water shortage. In studies with US maize, it was also found that grain number was the yield component most affected by furrow irrigiation water deficit

Table 1
Meteorological data of Arak field research during the growing season in 2014

Climatic Factor	*May*	*Jun.*	*Jul.*	*Aug.*	*Sep.*	*Oct.*
Precipitation (mm)	9.3	0	0	0	0	1.1
Mean temperature (°C)	20.3	26.	31.1	29.7	24	19
Mean max. temp. (°C)	28.9	36.3	40.6	39.1	34.6	28.6
Mean min. temp. (°C)	11.3	15.6 9	20.2	19.5	12.7	9.9
RH (%)	40	22	20	22	23	28

Table 1(a)
Soil physical and chemical characteristics

	percent%			*ppm*							*percent%*	*Soil texture*		
E.C	*pH*	*SP*	*O.C*	*N*	*P*	*K*	*Fe*	*Zn*	*Mn*	*Cu*	*sand*	*silt*	*clay*	*loam*
1.20	7.70	31.00	1.50	0.15	25.60	400.00	2.98	4.16	6.72	1.04	41.0	35.0	22.4	

Table 2
Analysis of variance effects of irrigiation patterns and Zn fertilizer on Sweetcorn genotypes

	Mean square									
sov	*HI*	*Plant height*	*Thousand seed weight*	*Seed per row*	*Row per ear*	*Seed yield*	*Biolog-ical yield*	*Chloro-phila*	*Chloro-philb*	*caroth-enoid*
Year	5234.22$^{n.s}$	22.44^{ns}	11.22$^{n.s}$	9.98$^{n.s}$	0.21$^{n.s}$	111.9$^{n.s}$	71.5$^{n.s}$	0.031^{ns}	2.003^{ns}	0.003^{ns}
Rep(year)	5893.1$^{n.s}$	36.22^{ns}	564.018$^{n.s}$	10.119$^{n.s}$	3.464$^{n.s}$	380011.9$^{n.s}$	1057895.54$^{n.s}$	0.001^{ns}	0.003^{ns}	0.0006^{ns}
Irrigiation	155.378**	463.31**	206.623**	0.021**	0.51$^{n.s}$	118511132**	61366764.12**	0.23**	0.0339**	.0220*
Y*I	4293.1$^{n.s}$	23.34^{ns}	10.78$^{n.s}$	8/87$^{n.s}$	0.44$^{n.s}$	139.9$^{n.s}$	61.25$^{n.s}$	0.0421^{ns}	12.003^{ns}	0.0016^{ns}
Error	2.580	6.19	10.095	10.241	5.56	7254542	16481188.45	0.0004	0.0002	0.0008
Zn	112.234**	2004.2**	4318.694**	0.018**	0.41$^{n.s}$	21435611**	1374624.42**	0.06**	0.0068**	0.0048*
Y* Zn	4294.12$^{n.s}$	2.224^{ns}	8.41$^{n.s}$	9/94$^{n.s}$	0.36$^{n.s}$	211.6$^{n.s}$	68.75$^{n.s}$	0.0015^{ns}	8.043^{n}	^{s}0.012^{ns}
I*Zn	111.363**	842.56**	541.074**	0.131**	0.36$^{n.s}$	1245145**	1105687.25**	0.0003**	0.0055**	0.0015**
Y* I*Zn	6313.21$^{n.s}$	3.841^{ns}	7.22$^{n.s}$	22.10$^{n.s}$	0.25$^{n.s}$	133.4$^{n.s}$	44.35$^{n.s}$	0.0012^{ns}	9.003^{ns}	0.36^{ns}
Variety	216.001**	156**	401.434**	0.063**	0.221$^{n.s}$	755412**	1303000.4**	0.306**	0.0538**	0.0095**
Y*V	6123.26$^{n.s}$	3.258^{ns}	6.77$^{n.s}$	23/9$^{n.s}$	0.26$^{n.s}$	432.3$^{n.s}$	14.05$^{n.s}$	0.0212^{ns}	10.023^{ns}	0.16^{ns}
I*V	124.464**	60.39**	71.401**	0.022**	0.228$^{n.s}$	723314.24**	1212629.74**	0.0412*	0.0116*	0.0019***
Y* I*V	8294.12$^{n.s}$	2.365^{ns}	7.54$^{n.s}$	9/87$^{n.s}$	0.33$^{n.s}$	233.4$^{n.s}$	18.75$^{n.s}$	0.021^{ns}	13.003^{ns}	0.0204^{ns}
Zn*V	120.036**	436.77**	508.346**	0.111**	0.531$^{n.s}$	7254425**	3566311.25**	0.0073**	0.0219**	0.0016**
Y* Zn*V	4014.18$^{n.s}$	2.145^{ns}	6.24$^{n.s}$	9/64$^{n.s}$	0.37$^{n.s}$	22.4$^{n.s}$	24.25$^{n.s}$	0.0030^{ns}	11.123^{ns}	0.226^{ns}
*I*Zn*V	136.077**	559.11**	486.483**	0.086**	0.428$^{n.s}$	2514562**	1576346.56**	0.0210**	0.0021**	0.0018*
Y*I*Zn*V	52354.12$^{n.s}$	2.123^{ns}	7.55$^{n.s}$	9/88$^{n.s}$	0.33$^{n.s}$	33.3$^{n.s}$	21.15$^{n.s}$	0.0112^{ns}	10.043^{ns}	0.1146^{ns}
Error	1.302	1.137	1.655	0.003	5.251	145987	208015.98	0.0020	0.0003	0.0003
Cv (%)	11.09	8.94	8.41	5.57	6.39	6.39	14.11	6.12	4.67	7.12

* and**: significant at the 5% and 1% levels, respectively, ns: non –significant

treatment	*Plant height (Cm)*	*Thousand seed weight (gr)*	*Seed per row*	*Row per ear*	*Seed yield (kg/ ha)*	*Biological yield (gr/m^2)*	*HI (%)*	*Chloro-phil a (gr/ gfw)*	*Chloro-phil b (gr/ gfw)*	*caroth-enoid (gr/ gfw)*
Year 1	175/80^{a}	300/25^{a}	23/52^{a}	13/01^{a}	8120/25^{a}	2359^{a}	48/21^{a}	0/821^{a}	0/412^{a}	0/301^{a}
Year 2	170/54^{a}	305/27^{a}	24/02^{a}	12/93^{a}	8000/14^{a}	2289^{a}	50/22^{a}	0/756^{a}	0/402^{a}	0/298^{a}
I_1	117/056^{a}	318/950a	24/278^{a}	13/066^{a}	7760/556^{a}	2535^{a}	50/633^{a}	0/895^{a}	0/477^{a}	0/319^{a}
I_2	98/333^{b}	313/467b	21/333^{b}	13/05^{a}	6824/833^{b}	1933^{b}	46/893^{b}	0/679^{b}	0/412^{b}	0/275^{b}
I_3	115/278^{a}	318/428a	24/022^{a}	13/037^{a}	7379/722^{a}	2441^{a}	52/688^{a}	0/887^{a}	0/476^{a}	0/309^{a}
Zn_1	100/944^{c}	305/494^{c}	^{c}24/078	13/01^{a}	7332/722^{c}	1591^{c}	50/008^{b}	0/595^{c}	0/377^{c}	0/219^{c}
Zn_2	113/444^{b}	305/850^{b}	23/90^{b}	13/003^{a}	7736/389^{b}	2411^{b}	50/003^{b}	0/679^{b}	0/412^{b}	0/275^{b}
Zn_3	124/278^{a}	332/50^{a}	23/833^{a}	13/021^{a}	8300/000^{a}	2584^{a}	50/203^{a}	0/887^{a}	0/476^{a}	0/309^{a}
V_1	107/556^{b}	286/77^{b}	21/889^{c}	12/98^{a}	7294/185^{b}	2234^{b}	42/067^{b}	0/779^{b}	0/412^{b}	0/285^{b}
V_2	118/222^{a}	314/452^{a}	23/852^{a}	12/96^{a}	7785/222^{a}	2451^{a}	50/075^{a}	0/891^{a}	0/476^{a}	0/311^{a}
I_1Zn_1	98/667^{d}	307/766^{c}	23/333^{b}	13/021^{a}	7186/167^{f}	2431^{c}	50/477^{d}	0/895^{a}	0/477^{a}	0/319^{a}
I_1Zn_2	114/50^{b}	^{c}309/333	23/21^{c}	^{a}13/01	7305/833^{d}	2314^{d}	50/728^{d}	0/865^{a}	0/412^{b}	0/310^{a}
I_1Zn_3	126/00^{a}	318/85^{a}	23/50^{b}	13/07^{a}	8789/667^{a}	2145^{d}	50/693^{d}	0/841^{b}	0/476^{a}	0/309^{a}
I_2Zn_1	106/77^{c}	^{e}299/303	23/50^{a}	^{a}13/05	7229/167^{e}	1532^{f}	47/103^{e}	0/645^{d}	0/377^{c}	0/219^{c}

(contd... Table 2b)

treatment	*Plant height (Cm)*	*Thousand seed weight (gr)*	*Seed per row*	*Row per ear*	*Seed yield (kg/ha)*	*Biological yield (gr/m^2)*	*HI (%)*	*Chloro-phil a (gr/gfw)*	*Chloro-phil b (gr/gfw)*	*caroth-enoid (gr/gfw)*
I_2Zn_2	98/667 ^{d}	299/10 ^{a}	23/20 ^{c}	13/05 ^{a}	7208/500 ^{e}	1451 ^{f}	46/548 ^{f}	0/683 ^{c}	0/312 ^{e}	0/225 ^{d}
I_2Zn_3	116/667 ^{b}	^{c} 302/267	23/50 ^{b}	^{a} 13/017	7248/833 ^{e}	1601 ^{e}	47/027 ^{e}	0/70 ^{bc}	0/326 ^{d}	0/229 ^{d}
I_3Zn_1	127/50 ^{a}	309/863 ^{b}	24 ^{ab}	13/02 ^{a}	7582/833 ^{c}	2412 ^{c}	52/443 ^{c}	0/875 ^{a}	0/412 ^{b}	0/305 ^{b}
I_3Zn_2	97/167 ^{d}	^{b} 309/217	22/50 ^{d}	13/04 ^{a}	8694/833 ^{b}	2542 ^{b}	52/732 ^{b}	0/872 ^{a}	0/476 ^{a}	0/311 ^{a}
I_3Zn_3	127/167 ^{a}	336/383 ^{a}	22/50 ^{d}	13/06 ^{a}	8861/500 ^{a}	2651 ^{a}	52/888 ^{a}	0/888 ^{a}	0/476 ^{a}	0/306 ^{a}
I_1V_1	107/778 ^{b}	314/411 ^{a}	24/02 ^{a}	^{a} 13/057	7801/667 ^{c}	2541	50/569 ^{c}	0/865 ^{a}	0/412 ^{b}	0/319 ^{a}
I_1V_2	120/333 ^{a}	^{d} 309/489	24/15 ^{a}	13/066 ^{a}	7719/444 ^{d}	2351 ^{b}	50/697 ^{c}	0/841 ^{b}	0/416 ^{a}	0/315 ^{a}
I_2V_1	104/111 ^{c}	312/556 ^{c}	24/167 ^{a}	13/05 ^{a}	7211/222 ^{e}	1532 ^{e}	47/071 ^{e}	0/645 ^{d}	0/377 ^{c}	0/229 ^{b}
I_2V_2	110/556 ^{b}	^{b} 314/378	24/01 ^{a}	13/037 ^{a}	7246/444 ^{e}	1425 ^{e}	46/714 ^{e}	0/683 ^{c}	0/312 ^{e}	0/225 ^{b}
I_3V_1	110/778 ^{b}	317/367 ^{b}	23/90 ^{b}	13/01 ^{a}	8369/667 ^{b}	2345 ^{b}	52/562 ^{b}	0/872 ^{a}	0/326 ^{d}	0/311 ^{a}
I_3V_2	123/778 ^{a}	^{a} 319/489	23/98 ^{b}	13/003 ^{a}	8389/778 ^{a}	2531 ^{a}	52/813 ^{a}	0/888 ^{a}	0/421 ^{a}	0/216 ^{c}
Zn_1V_1	100/00 ^{d}	301/444 ^{e}	24/03 ^{b}	13/021 ^{a}	7339/000 ^{e}	2001 ^{d}	49/964 ^{d}	0/675 ^{d}	0/321 ^{c}	0/219 ^{c}
Zn_1V_2	121/889 ^{d}	^{b} 309/544	^{a} 24/556	12/98 ^{a}	7326/444 ^{f}	2012 ^{d}	50/051 ^{c}	0/651 ^{d}	0/316 ^{c}	0/315 ^{a}
Zn_2V_1	100/111 ^{e}	304/256 ^{d}	23/667 ^{c}	12/96 ^{a}	7699/000 ^{d}	2514 ^{b}	49/990 ^{d}	0/755 ^{c}	0/377 ^{c}	0/229 ^{b}
Zn_2V_2	106/778 ^{e}	^{c} 307/444	^{c} 23/333	13/021 ^{a}	7773/778	2154 ^{c}	50/016 ^{c}	0/793 ^{c}	0/312 ^{e}	0/225 ^{b}
Zn_3V_1	122/556 ^{d}	^{a} 338/633	24/04 ^{a}	^{a} 13/01	8344/556 ^{b}	2564 ^{a}	50/248 ^{b}	0/882 ^{a}	0/426 ^{a}	0/311 ^{a}
Zn_3V_2	126/00 ^{a}	326/367 ^{a}	^{b} 23/67	13/07 ^{a}	8355/444 ^{a}	2598 ^{a}	50/158 ^{a}	0/898 ^{a}	0/429 ^{a}	0/316 ^{a}

(Bassetti *et al.,* 2003). The effects of drought on 1000 grain weight were more distinct in our study than in that of benjamin *et al.* (2007), which was also conducted on Farm Suwan in the dry season. The mean comparison of the effects of treatments showed that from the full irrigation treatment to every furrow irrigiation treatment, the Thousand seed weight dramatically dropped by 21.34% which would result in lack of appropriate sink and source. In examining the interactive effects of irrigation pattern and zinc, Challenger hybrid at different irrigation patterns had higher Thousand seed weight than Chase hybrid (314.452 Vs. 286.77), it is 9.7% more than the other one. This finding was in agreement with the results of Paolo et al (2011) and Debake et al (2004). In examining the interactive effects of the treatments, the foliar application of fast zinc by 18.16% increase of Thousand seed weight in comparison with the control treatment and was significantly different from drop zinc and control treatment at 1% level. The results are matches with results of Majidian *et al*. (2002). Ayad *et al*. (2010)were investigated effects of water stress on yield and yield components and found that water deficit stress during vegetative period until grain filling reduce the product because of the effect of fertility ears. Eck (1986) reported that the adverse effect of drought stress on the grain number was compensated for by an increase in 1000 grain weight. Low 1000 grain weight due to drought stress, as found in our experiments, may indicate that the plants were unable to fully meet the demand of the growing grain.Majidian *et al*. (2002) reported that early drought stress probably reduced the capacity of assimilate production and.or storage during grain filling. The capacity of maize grains to store assimilates is a function of the number of endosperm cells and starch granules established during the first 10–14 days after pollination (Balanos *et al*. , 2005). Thus,reduced assimilate production due to a small green leaf area, reduced capacity to store assimilates due to short internodes, or high levels of endogenous abscisic acid (cakir *et al*., 2004) during the abovementioned critical period may have limited the 1000 grain weight in our study.According to the results, the Biological yield of evey furrow irrigiation was 32% lower than that of well-watered maize in control condition (*Table 2*). The biological yield reductions are well within the range of yield decreases due to water deficit (Ayad *et al*,2010). that were significantly different at 1% level. Similar effects were found in previous studies (Panley *et al.*, 2006). In the present study, Zn supply resulted in maximum biological yield under full irrigation, whereas without Zn resulted in minimum biological yield under every furrow irrigiation treatment. The results of analyzing data variance showed the interaction between drought stress and zinc spraying on seed yield to be significant at 1% probability level (*Table 3*). The highest biological yield was related to the application of zinc in the full irrigation conditions $I_3ZN_3V_2$ treatment (alternate irrigation, fast zinc and Challenger hybrid) by 2698 gr.m^2 and its lowest value was related to the lack of application of zinc in $I_2Zn_2V_2$ treatment (furrow irrigation, without zinc and Challenger hybrid) by 1254 gr.m^2 that were significantly different at 1% level(*Table 3*). In examining the interactive effects of irrigation pattern and zinc, Challenger hybrid at different irrigation patterns had higher biological yield than Chase hybrid (2451 Vs. 2234), it is 10.73% more than the other one. This finding was in agreement with the results of Perry et al (2011) and Payero et al (2009).

Chlorophyll and Carotenoid

The ANOVA results showed that the effect of irrigation pattern at 1% level and the effects of foliar application of zinc and the effects of different genotypes and their interactive effects on Chlorophyll a were significant at 1% probability level. The comparison of varieties showed that Challenger had the highest chlorophyll a (0.889 gr.grfw)compared to chase hybrid(0.779 gr.grfw) during full irrigation,alternative and furrow irrigiation condition by 14.37% .In examining the interactive effect of treatments it was observed that the maximum Chlorophyll a belonged to $I_1ZN_3V_2$ treatment (control irrigation, fast zinc and Challenger hybrid) by 0.995 gr.grfw and the lowest belonged to $I_2Zn_2V_1$ treatment (furrow irrigation, Drop zinc and Chase hybrid) by 0.598 gr.grfw that were significantly different at 1% level. These findings are in agreement with Friedrick *et al*. (2012) and Ghatavi (2012) who investigated the effect of drought stress on corn. The mean comparison of the effects of treatments showed that as the stress increased from the full irrigation treatment to furrow irrigation treatment, Chlorophyll a dramatically dropped by 28.47% which would result in the reduction of LAI by 31.81% and reduction in CGR too. In examining the interactive effects of irrigation pattern and zinc, Challenger hybrid at different irrigation patterns had MORE STABILITY ABOUT Chlorophyll a than Chase hybrid which Its Chlorophyll a was 14.21% more than the other one. This finding was in agreement with the results of Benjamin et al., (2007). In examining the interactive effects of the treatments, the foliar application of fast zinc with 22.18% increase of Chlorophyll a in comparison with the control treatment was effective in the increase of Chlorophyll a and was significantly different from drop zinc and control treatment at 1% level. zn application for sweet corn by Yazdani *et al*. (2006) has led to the increase of Chlorophyll a in agreement with our results. kaman *et al*. (2011) reported that Drought stress can be substantially reduced Chlorophyll a of the corn And thereby reduce plant biomass. Our result is in agreement with Shao et al. (2004) and Khayatnezhad et al., (2011) who stated that chlorophyll could stops in severe water shortages. The comparison of varieties showed that Challenger had the highest chlorophyll b (0.476 gr.grfw)compared to chase hybrid(0.412 gr.grfw) during full irrigation,alternative and furrow irrigiation condition by 15.53% . Khayatnezhad et al. (2011) reported similar results. In examining the interactive effect of treatments it was observed that the maximum Chlorophyll a belonged to $I_3ZN_3V_2$ treatment (alternate irrigation, fast zinc and Challenger hybrid) by 0.491 gr.grfw and the lowest belonged to $I_2Zn_2V_1$ treatment (furrow irrigation, Drop zinc and Chase hybrid) by 0.301 gr.grfw that were significantly different at 1% level. These findings are in agreement with Niyani khamsi *et al*. (2006) and Ghatavi (2012) who investigated the effect of drought stress on corn. The mean comparison of the effects of treatments

Table 3
Mean comparisons interaction effects of irrigiation patterns, Zn fertilizer and Sweetcorn genotypes

treatment	*Plant height (Cm)*	*Thousand seed weight (g)*	*Seed per row*	*Row per ear*	*Seed yield (kg. ha^{-1})*	*Biological yield (kg. ha^{-1})*	*HI (%)*	*Chloro-phil a*	*Chloro-phil b*	*caroth-enoid*
$I_1Zn_1V_1$	75.00^{h}	^{a} 296.700	24^{b}	13.066^{a}	7181.000^{i}	2564^{a}	50.487^{c}	0.895^{a}	0.477^{c}	0.299^{c}
$I_1Zn_1V_2$	122.333^{a}	318.833^{a}	^{a} 24	13.05^{a}	7221.333^{i}	2456^{b}	50.467^{c}	0.865^{g}	0.478^{c}	0.301^{c}
$I_1Zn_2V_1$	119.25^{b}	^{a} 308.033	24^{b}	13.037^{a}	7322.000^{e}	2351^{c}	50.560^{c}	0.941^{b}	0.476^{c}	0.309^{cd}
$I_1Zn_2V_2$	110.78^{c}	310.433^{a}	^{ab} 26	13.01^{a}	7289.667^{f}	2354^{c}	50.897^{c}	0.945^{b}	0.465^{d}	0.308^{cd}
$I_1Zn_3V_1$	129.333^{a}	^{a} 338.200	^{a} 24	13.003^{a}	8832.000^{a}	2145^{d}	50.660^{d}	0.983^{a}	0.491^{a}	0.312^{a}
$I_1Zn_3V_2$	128.667^{a}	299.200^{de}	^{c} 23	13.021^{a}	8647.333^{b}	2541^{a}	50.727^{c}	0.995^{a}	0.498^{a}	0.311^{a}
$I_2Zn_1V_1$	73.93^{h}	^{f} 298.400	24^{a}	12.98^{a}	6118.333^{i}	1254^{h}	47.167^{e}	0.675^{h}	0.301^{jk}	0.215^{h}
$I_2Zn_1V_2$	106.333^{bc}	299.667^{f}	^{a} 25	12.96^{a}	7240.000^{f}	1542^{e}	47.040^{g}	0.622^{i}	0.322^{i}	0.212^{i}
$I_2Zn_2V_1$	92.333^{g}	^{hi} 297.300	22de	13.021^{a}	7163.000^{i}	1652^{e}	46.710^{f}	0.598^{a}	0.341^{g}	0.213^{g}
$I_2Zn_2V_2$	105.25^{e}	300.900^{g}	^{a} 24	^{a} 13.01	7254.000^{g}	1325^{g}	46.387^{h}	0.674^{h}	0.324^{i}	0.212^{i}
$I_2Zn_3V_1$	113.44^{cd}	^{a} 341.967	24^{a}	13.07^{a}	7252.333	1542^{f}	47.337^{e}	0.611^{i}	0.311^{j}	0.209^{j}
$I_2Zn_3V_2$	120.333^{b}	342.567^{a}	^{b} 24	^{a} 13.05	7295.333^{h}	1664^{f}	46.717^{f}	0.567^{jk}	0.311^{j}	0.211^{j}
$I_3Zn_1V_1$	118.22^{c}	^{a} 309.233	24^{bc}	13.05^{a}	7647.667^{c}	2564^{a}	52.240^{b}	0.879^{a}	0.441^{f}	0.293^{ef}
$I_3Zn_1V_2$	127.54^{a}	310.133^{c}	^{d} 23	^{a} 13.017	7518.000^{d}	2145^{d}	52.647^{b}	0.815^{a}	0.443^{f}	0.294^{ef}
$I_3Zn_2V_1$	89.33^{g}	^{e} 307.433	22^{e}	13.02^{a}	8612.000^{b}	2451^{b}	52.700^{a}	0.876^{e}	0.445^{f}	0.292^{ef}
$I_3Zn_2V_2$	105.333^{ef}	311^{b}	^{e} 22	13.04^{a}	8777.667^{a}	2543^{a}	52.763^{a}	0.845^{f}	0.455^{de}	0.289^{de}
$I_3Zn_3V_1$	125.333^{b}	^{a} 335.433	24^{a}	13.06^{a}	8849.333^{a}	2365^{c}	52.747^{a}	0.987^{a}	0.488^{b}	0.298^{b}
$I_3Zn_3V_2$	129.02^{a}	339.333^{a}	^{a} 25	^{a} 13.057	8873.667^{a}	2698^{a}	53.030^{a}	0.991^{a}	0.491^{a}	0.299^{a}

common letters in each column are not significantly different for each treatment.

showed that as the stress increased from the full irrigation treatment to furrow irrigation treatment, Chlorophyll b dramatically dropped by 32.31% which would result in the reduction of Chlorophyll a and reduction in LAI too. In examining the interactive effects of irrigation pattern and zinc, Challenger hybrid at different irrigation patterns had more stability about Chlorophyll b than Chase hybrid which Its Chlorophyll a was 12.32 % more than the other one. This finding was in agreement with the results of Moison et al., (2006). In examining the interactive effects of the treatments, the foliar application of fast zinc with 24.18% increase of Chlorophyll b in comparison with the control treatment was effective in the increase of Chlorophyll b and was significantly different from drop zinc and control treatment at 1% level. zn application for sweet corn by Yazdani *et al*. (2006) has led to the increase of Chlorophyll b in agreement with our results.Niyani khamsi *et al*. (2006) reported that Drought stress can be substantially reduced Chlorophyll b of the corn And thereby reduce plant biomass. Our result is in agreement with Shao et al. (2004) and Khayatnezhad et al., (2011) who stated that chlorophyll could stops in severe water shortages. In examining the interactive effect of treatments it was observed that the maximum Carotenoid belonged to $I_1ZN_3V_2$ treatment (full irrigation, fast zinc and Challenger hybrid) by 0.313 mg.g^{-1} and the lowest belonged to $I_2Zn_2V_1$ treatment (furrow irrigation,Drop zinc and Chase hybrid) by 0.210 mg.g^{-1} that were significantly different at 1% level by 49.04%. These findings are in agreement with Salardini *et al*. (2004) and Sanders (2014).The mean comparison of the effects of treatments showed that as the stress increased from the full irrigation treatment to alternate irrigation treatment, the Carotenoid dramatically dropped by 36.38% which would result in the reduction of chlorophyll in leaf by 31.81%. In examining the interactive effects of irrigation pattern and zinc, Challenger hybrid at different irrigation patterns had higher leaf area index than Chase hybrid 0.311 Vs. 0.285), Its Carotenoid was 9.12% more than the other one. This finding was in agreement with the results of Rakers (2013), Rahnama (2006) and Payero (2009). In examining the interactive effects of the treatments, the foliar application of fast zinc with 21.12% increase of Carotenoid in comparison with the control treatment. Loongenecker *et al*. (2009) and Layer *et al*. (2003) reported that drought stress is the most important parameter in decrease of Carotenoid and was significantly different from mineral application and control treatment at 1% level.

CONCLUSION

Generally, the results of the research indicated that the drought stress allied in irrigation treatments as alternate irrigation reduced plant height, thousand seed weight, yield and yield components and Chlorophyll and Carotenoids.. The highest reduction in yield components was related to the stress resulting from every furrow irrigiation pattern, but the application of alternative irrigation pattern, due to successive double-sided irrigation of the roots led to more effective absorption of irrigating water and consequently reduced the effects of drought stress. However, in all cases the alternative irrigation treatment could compensate for the water deficit of crops and made the control treatment not be different from alternate irrigation treatment. According to the results of the research it can be said that at the reproductive stage which is the most sensitive stage of maize to drought stress, the irrigation must be done in accordance to the plant need to achieve the maximum yield. In addition, with regard to the slight decrease of performance in alternative irrigation pattern, in case of water restriction which is quite evident nowadays in almost all arid and semiarid areas of Iran, it is possible to allocate the best amount of irrigating water to the plant by using this irrigation pattern at vegetative and reproductive stages and achieve a suitable yield. The review of the interactive effect of irrigation patterns indicated that under drought conditions and without stress, Challenger hybrid which is one of the hybrids of super sweet corn and which has recently entered into Iran and Markazi Province had a good stable yield (grain yield). Therefore, with regard to its short growth period as the second planting after the harvest of crops such as fall wheat and barley, Challenger hybrid can be cultivated in the area because its drop is less than Chase hybrid in case of applying stress. Meanwhile, Chase hybrid also has a fairly good yield as a hybrid of sweet corn. Foliar application of zing has a significant effect on yield and yield components and physiological parameters of corn, so that we witnessed 11.65% of the increase of grain yield in fast zinc treatment than the control treatment without foliar application of zinc which could result from the stimulation of grain metabolism and consequently the prevention of damage to proteins, chlorophyll, nucleic acids and enzymes which cause the growth of plant chlorophyll and its higher storage in grains. According to the results of the research, in case of water restriction, the alternate irrigation pattern can be applied because the decrease of yield in such conditions was insignificant in comparison to the normal irrigation particularly in Challenger hybrid. Moreover, the foliar application of zinc, particularly zinc sulfate with fast zinc composition leads to the stable yield in stress conditions which can be proposed to the farmers in Markazi Province and Arak.

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