J. Plant Production, Mansoura Univ., Vol. 9 (3): 273 - 279, 2018

Effect of Skipping Irrigation at Different Growth Stages and Zinc Foliar Application on Yield and Water Productivity of Sunflower

Rania F. El Mantawy[1]and Dalia A. El-Hag[2]
[1]Crop Physiology Res. Dep. - Field Crops Research Institute- Agric. Res. Center,Egypt.
[2] Agro. Dep. – Fac. of Agric. – Kafr el-sheikh University, Egypt.

ABSTRACT

An experiment was conducted at the Experimental Farm of Sakha Agricultural Research Station 31° 07\\ N and 30° 57\\, Kafr El-Sheikh, Egypt, during 2015 and 2016 seasons to study the effect of skipping one irrigation at different growth stages and foliar application of zinc on quantitative and qualitative characteristics of sunflower cultivar Sakha 53.A split plot design with four replications was used. The main plots were devoted to water treatments *i.e.* I_1= without skipping (control four irrigation during season), I_2= skipping one irrigation during vegetative stage, I_3=skipping one irrigation during flowering stage, I_4= skipping one irrigation during grain filling stage. Sub plot treatments were devoted to foliar application with zinc sulfate , *i.e.* Zn_o= water application, Zn_1= 0.5% and Zn_2= 1% concentration. The results showed that flowering stage was the most sensitive to water deficit stress and skipping irrigation at this stage caused marked decrease in chlorophyll content in leaves, relative water content (RWC %), seed oil %, seed yield and its components, while increased proline content and seed protein % in the two growing seasons. Zinc spraying had significant effect on all attributes in this research. In general, application of Zn could be used as a good tool to increase yield of sunflower under drought stress.Also, the highest mean values for seasonal amount of water applied and water productivity were recorded under traditional irrigation. From this study we can be concluded that it is possible to gain high seed yield with less quantities of applied water when the irrigation skipping happens at vegetative stage with application of 1% zinc sulfate .

Keywords: sunflower, water stress, zinc sulfate, yield, water relations.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the most important oil seed crops containing high quantity of edible oil ranging from 35-48%, high percentage of poly unsaturated fatty acids (60%) including oleic acid (16.0%) and linoleic acid (72.5%), which control cholesterol (LDL) in human blood and about 20-27% protein (Patra *et al.* 2013 and Amirian *et al.* 2013). Sunflower is the most susceptible to soil water deficiency at flowering stage, and seed filling, whereas at the start and end of the growing period the sensitivity is not so evident (Stone *et al.,* 1996 and Erdem *et al.,* 2002).

Water is the most important element in whole life depends, it is involves in most physiological and biochemical processes in plants, (Farias *et al.,* 2007). Also, Flagela *et al.,* (2002) found that, flowering and seed filling periods in sunflower showed the highest sensitivity to drought stress and gave the lowest values in number of seeds, seed weight and oil quality. Drought affected leaves exhibit large reduction in leaf relative water content (Rauf and Sadaqat, 2008). In the same trend (Ebrahimi *et al.,* 2014) showed that, water stress reduced chlorophyll a and b, chlorophyll a/b, total chlorophyll, but increased proline content of leaves. Skipping irrigation is a way for increasing water use efficiency (WUE) for higher yields per unit of irrigation water applied (English *et al.,* 1990; English and Raja, 1996).

Among micronutrient elements, zinc plays an important role in stomata regulation and ion balance in plants to reduce the harmful effects of drought. (Babaeian *et al.,* 2010). Zinc application stimulated the enzymes involved in reactive oxygen species detoxification and increased leaf dry weight and accumulation of proline in sunflower under salt stress conditions (Ebrahimian and Bybordi, 2011). Also,(Zafar *et al.,* 2014) found that foliar application of zinc reduces the harmful effects of drought stress in sunflower.

The goal of this study was designed to examine the effect of foliar spraying with Zn for improving growth, yield and some water relations of sunflower under water deficit conditions.

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Farm of Sakha Agricultural Research Station (31° 07\\ N and 30° 57\\) during the two successive growing summer seasons 2015 and 2016 to study the effect of skipping one irrigation during different growth stages and zinc foliar applications on quantitative and qualitative characteristics of sunflower Sakha 53cultivar. The seeds was planted in 23th of June in the two seasons. The experimental design was split plot design with four replicates. The main plots were assigned to irrigation treatments which consisted of four irrigation treatments, *i.e.* I_1= irrigation as recommended (control four irrigation), I_2= skipping one irrigation during vegetative growth stage, I_3=skipping one irrigation during flowering stage, I_4= skipping one irrigation during seed filling stage. Sub plot units included zinc treatments which consisted of three foliar applications with zinc, *i.e.* Zn_o= without zinc application (spraying with water), Zn_1= 0.5% and Zn_2= 1% of zinc sulfate . Foliar application was done two times (two weeks before and two weeks after flowering).

The plot area was 12 m^2 (3 m width and 4 m length). Each plot, contained 5 rows and the distance between two hills were 20 cm. In each plot, two rows were devoted for planting growth sampling, and anther three rows used for determining seed yield and its components. The plants were thinned to secure one plant per hill after 21 days from sowing. Other cultural practices for growing sunflower were done as recommended. The experimental field was fertilized with 100kg/P_2O_5 in the form of superphosphate fertilizer (15.5% P_2O_5) during soil preparation .Soil samples were randomly taken from the experimental area at a depth of 0 to 30 cm.The soil mechanical and chemical analysis were determined according to Piper (1950)as presented in Table (1).

Table 1. Mechanical and chemical analysis of soil at the experimental sites during 2015 and 2016 seasons.

Determination	2015	2016
Mechanical analysis:		
Sand %	18.78	15.99
Silt %	20.52	24.12
Clay %	60.74	59.89
Field capacity %	40.03	40.11
Wilting point	21.71	21.75
Balk density (g/cm^3)	1.14	1.14
Chemical analysis:		
pH	8.06	8.15
E.C. mm hos/cm	2.93	2.96
Organic matter (O.M) %	1.75	1.82
Available N ppm	18.58	18.72
Available P ppm	6.74	6.52
Available K ppm	270.25	272.36

Weather data from planting to harvest were collected from Sakha Meteorological Station, Egypt (Table 2).

Table 2. Means of some meteorological data for Kafr El-Sheikh area during the two growing seasons (2015 and 2016).

Month	T(C°) Max.	Min.	Mean	R.H.%	WS m/sec.at 2m height	Pan Evap. mm/day
			2015			
June	32.1	20.3	26.2	46	3.12	8.23
July	38.2	28.3	33.2	48	2.85	7.45
Aug.	39.9	29.2	34.5	45	2.47	8.12
Sep.	38.6	26.5	32.5	44	2.74	7.15
			2016			
June	33.6	26.3	29.95	47	3.24	8.62
July	33.7	26.1	29.9	49	3.01	7.92
Aug.	33.6	26	29.8	48	2.58	8.45
Sep.	32.6	24.3	28.45	46	2.65	7.75

Source: Meteorological station at Sakha Agricultural Research Station (31° 07\\N Latitude and 3° 57\\Elongitude) with an elevation of about 6 meters above sea level.

Studied characteristics:

1. Proline content

Proline content of leaves was determined according to a modification of the method of Bates *et al.*(1973).Its absorbance was measured at 520 nm in a spectrophotometer. The content of proline was calculated from a standard curve in mg.g^{-1} FW.

2. Measurement of leaf relative water content (RWC %):

Leaf relative water content, was carried out according to the method of Weatherly (1950) and its modification by Barrs and Weatherly (1962) with following the considerations given by El-Sharkawy and Salama (1973). Leaf discs, were punched from the center of the leaf. Fresh weight (FW) was taken and floated for 4 hours in distilled water and weighted again to obtain turgid weight (TW). For dry weight (DW) determination, the discs were oven dried at 85ºC for a constant weight. Relative water content was calculated according to the following equation:

RWC (%) = (FW-DW) / (TW-DW) x 100

3. Photosynthetic pigments content in leaves: (chlorophyll a, chlorophyll b and total chlorophylls), which were homogenized in N-N-dimethyl formamid and determination using the spectrophotometric method according to the equation mentioned by Moran (1982).

Chl. a= 12.7(O.D) 664-2.79(O.D)647

Chl. b =20.7(O.D)647-4.62(O.D)664

Total chlorophyll = 7.04 (O.D)664 + 20.27 (O.D)647

Yield and its components:

At maturity, five guarded plants were taken randomly from inner ridges and characters were recorded *i.e.* Plant height (cm), stem diameter (cm) and head diameter (cm).

- To calculate the average 100-seed weight (g), five samples were randomly taken from the each plot and mean of weight was recorded.
- Seed yield kg fed^{-1}: heads of bagged plants from inner ridges of each plot were harvested and left two weeks until fully air dried and seed weight was used to estimate seed yield kgfed^{-1}.
- Seed oil percentage (%): was determined according to A.O.A.C.(1995)using soxhlet apparatus using petroleum ether as a solvent.
- Seed protein %: was determined according to A.O.A.C.(1995)and calculated by multiplying the N by the converting factor 6.25 (Hymowitz *et al.,*1972).

A. Water relations:

D.1. Determination of seasonal water applied:

The irrigation water applied was measured with a flow meter installed in the water delivery unit of the irrigation pump.

Seasonal water applied was calculated as described by **Giriappa (1983)**

$$W_a = IW + ER + S$$

Where:

- IW is the irrigation applied.
- ER is the effective rainfall.
- S is the contribution of the ground water table to crop water use (neglected) because it wasn't high (about 120 cm).

D.2. Assessment of irrigation water productivity:

The irrigation water productivity (IWP, kg m^{-3}) was estimated as:

$$IWP = \frac{Y_a}{I}$$

Where,

- Ya is *the* actual yield achieved for the various treatments (Kg fed^{-1}).

I is the amount of applied irrigation water (m^3 fed.$^{-1}$**).**

Statistical Analysis

The obtained data were statistically analyzed and comparison among means were performed by computer programming methods (statgraphics,v.4.2 software),as described by Snedecor and Cochran (1982). Treatment means were compared by Duncan's multiple range test (Duncan's,1955).

RESULTS AND DISCUSSION

Effect on Proline content:

Table (3) shows that, significant effect of water stress in proline content. I_3 irrigation treatment gave the highest proline content during the both seasons. as well as conserving N element produced from protein degradation during water stress . Proline accumulation helps the plant to retains low water potentials and allows additional water to be taken up from the environment, thus decrease the harmful effect of water shortages within the plant (Kumar *et al.,* 2003).

Table 3. Effect of irrigation and foliar application with zinc on proline content and (RWC%) during the two growing seasons 2015 and 2016.

Treatments	Proline(mg g^{-1} fresh wt.)		RWC (%)	
	2015	2016	2015	2016
Irrigation				
I_1	0.0009 d	0.011 d	66.93a	66.03 a
I_2	0.025 c	0.027 c	64.49b	63.60 b
I_3	0.033 a	0.035 a	62.55d	61.82 d
I_4	0.029 b	0.030 b	63.48c	62.73 c
F-test	*	*	*	*
Zinc sulfate				
Zn_0	0.021 c	0.023 c	63.02c	62.06 c
Zn_1	0.024 b	0.025 b	64.50b	63.50 b
Zn_2	0.026 a	0.028 a	65.57a	65.07 a
F-test	*	*	**	**
Interaction(I x Zn)	N.S.	N.S.	*	N.S.

***,** significant at 5% and 1% level of probability, respectively. Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test.**

Concerning, spraying zinc sulfate at the high level (1%) significantly increased the amount of proline content (0.026& 0.028) in 2015 and 2016 season, respectively. These results are in agreement with (Babaeian *et al.,*2011) who found that, application of zinc increase proline content and thus decrease the harmful effects of drought.

Effect on leaf relative water content (RWC %):

Results in Table (3) showed that, Abundance available soil moisture at I_1 irrigation (without stress) treatment resulted in substantial increase in RWC% in both seasons. Irrigation treatment of I_3 decreased RWC% compared to I_1,I_2 and I_4 treatments. These results are in harmony with (Anjum *et al.,* 2011) who reported that, leaf relative water content is an important tool of plant water status and is used as a useful index for dehydration tolerance .

Foliar application of zinc sulfate had a significant effect on relative water content. Plants sprayed with Zn_2 treatment significantly exceeded Zn_0 and Zn_1treatments (Table 3).

Effect on chlorophyll content:

Water deficit stress caused significant decrease in chlorophyll content(Chl. a, Chl. b and total Chl.) during the two seasons (Table 4). The highest values were observed with plants irrigated at all growth stages (control treatment). Interrupt irrigation during flowering stage recorded the lowest chlorophyll content during the two studied seasons. These results maybe due to water stress reduced photosynthetic capacity and lead to an increase in reactive oxygen species (ROS) which cause oxidative damage to DNA, lipid and proteins and thus decrease in chlorophyll content Ebrahimi *et al.,* (2014).

Foliar application of zinc at the rate of 1 % partially decreased the adverse effects of water stress on photosynthesis. In this concern, Ved *et al.,* (2002) and (Cakmak, 2000) stated that foliar applied zinc stimulates photosynthesis and improves chlorophyll content in plants.

Table 4. Effect of irrigation and foliar application of zinc treatments on chlorophyll content during the two growing seasons 2015 and 2016.

Treatment	Chl.a (mg/dm^2)		Chl.b (mg/dm^2)		Total Chl. (mg/dm^2)	
	2015	2016	2015	2016	2015	2016
Irrigation treatments						
I_1	2.933 a	2.837 a	1.956 a	1.983 a	4.891a	4.749 a
I_2	2.648 b	2.584 b	1.777 b	1.696 b	4.450 b	4.348 b
I_3	2.284 d	2.235 d	1.609 c	1.568 d	3.942 d	3.830c
I_4	2.346 c	2.311 c	1.718 b	1.662 c	4.031c	3.964c
F-test	*	*	**	*	*	*
Zinc sulfate treatments						
Zn_0	2.316 c	2.289 c	1.619 c	1.576 c	4.081 c	4.049 c
Zn_1	2.534 b	2.450 b	1.768 b	1.666 b	4.261 b	4.136 b
Zn_2	2.809 a	2.737 a	1.909 a	1.865 a	4.643 a	4.470 a
F-test	*	*	*	*	*	*
Interaction(IxZ)	**	**	NS	*	NS	NS

***,** significant at 5% and 1% level of probability, respectively. Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test.**

Yield and its Components

Data in Table (5) clearly showed that plant height was significantly affected by irrigation withholding water at different growth stages. The tallest plants were obtained with traditional irrigation (189.2 cm), while the shortest plants were obtained with plants interrupted water during the flowering stage (177.1cm). These results may be due to water stress decrease water potential of stem cell to a lower level needed for cell elongation and thus, shorter internodes and stem height. Shahri *et al.,* (2012).

In the same trend, both stem and head diameters were significantly affected by applied water stress. The thickest stems and biggest heads were observed with plants irrigated at all growth stages. Our findings showed that irrigation withholding at flowering stage had the lowest values of both stem and head diameters in the two growing seasons. Water deficit stress could be attributed to decrease in photosynthesis process and assimilate transportation to stems as an important sink in sunflower Zafar *et al.,*(2014).

Table 5. Effect of irrigation and foliar application of zinc treatments on yield components during the two growing seasons 2015 and 2016.

Treatment	Plant height(Cm)		Stem diameter (Cm)		Head diameter (Cm)	
	2015	2016	2015	2016	2015	2016
Irrigation						
I_1	189.2 a	187.8 a	2.80 a	2.70 a	17.79 a	17.53 a
I_2	184.2 b	182.0 b	2.55 b	2.45 b	16.46 b	16.31 b
I_3	177.1 d	174.7 d	2.14 d	2.06 c	15.35 d	15.15 c
I_4	179.0 c	177.0 c	2.31 c	2.08 c	15.83 c	15.68 bc
F-test	*	**	**	*	**	**
Zinc sulfate						
Zn_0	177.1 c	174.8 c	2.18 c	2.09 c	14.83 c	14.73 c
Zn_1	181.8 b	180.0 b	2.46 b	2.30 b	16.54 b	16.28 b
Zn_2	188.3 a	186.3 a	2.71 a	2.57 a	17.69 a	17.49 a
F-test	**	*	**	**	*	**
Interaction(IxZ)	NS	*	NS	NS	**	*

***,** significant at 5% and 1% level of probability, respectively. Mean values designed by the same letter in each column are not significant according to Duncan'sMultiple Range Test.**

Zinc sulfate foliar application exerted significant effect on plant height ,stem and head diameters (Table 5). Spraying treatment with 1% concentration reported the highest values of both stem and head diameters during the two growing seasons. In this concern, Hussein and Alva (2014) stated that, zinc application lead to activation of many enzymes in plants and is involved in the biosynthesis of growth substances, such as auxin which produces more plant cells which result in increased growth parameters.

Effect on seed yield:

Results in Table (6) showed that water stress caused significant decrease in 100-seed weight. High 100-seed weight was obtained from I_1 (complete irrigation) which was due to the presence of adequate soil moisture during flowering, seed formation and seed filling stages.On the other hand, the minimum weight of seeds were recorded when irrigation water was interrupt at the flowering stage which was the most sensitive stage to water stress as seen in the results the yield reduction during the flowering stage was (11.08&8.04 %) in the first and second season, respectively. These results are in agreement with Roshdi *et al.,* (2006) who conducted that, under water deficit conditions, plants do not absorb enough water and hence, the seeds are more or less unfilled. Similar results were obtained by Shahri *et al.,* (2012), Babaeain *et al.,* (2010) and Vazin (2012)

Table 6. Effect of irrigation and foliar application of zinc treatments on yield and yield reduction during the two growing seasons 2015 and 2016.

Treatments	100 -seed weight (g)		Seed yield (kg/fed.)		Yield Reduction(%)	
	2015	2016	2015	2016	2015	2016
Irrigation						
I_1	6.87 a	6.71a	1884.63 a	1869.95 a	---	---
I_2	6.47 b	6.37 b	1822.22 b	1786.66 b	-3.312	-4.454
I_3	5.98 d	5.85 d	1675.79 d	1636.4 d	-11.081	-12.490
I_4	6.14 c	5.97 c	1775.68 c	1719.52 c	-5.940	-8.045
F-test	*	**	**	**	--	--
Zinc sulfate						
Zn_0	6.07 c	5.90 c	1711.27 c	1625.31 c	---	---
Zn_1	6.37 b	6.24 b	1787.40 b	1761.40 b	4.449	8.373
Zn_2	6.67 a	6.53 a	1870.07 a	1752.47 a	9.940	6.163
F-test	*	*	**	**	-	-
Interaction (IxZ)	NS	*	**	**	-	-

***,** significant at 5% and 1% level of probability, respectively. Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test.**

Concerning, Zinc foliar application lead to increase 100-seed weight of sunflower compared to the control (Zn_0).The highest value of 100-seed weight was observed with application of 1% Zn (6.67 and 6.53g) during the first and the second season, respectively. In this concern, Ved *et al.,* (2002) stated that foliar spraying of zinc improves photosynthesis, growth parameters, seed protein and yield. The positive effect of zinc sulfate spraying on seed yield has been also reported by Flagela *et al.,* (2002) who found that flowering and seed filling stages in sunflower showed the highest sensitivity to water stress and gave the lowest values of seed weight and oil content .

Concerning the effect of interaction between irrigation treatments and zinc sulfate spraying Fig.(1 and 2) showed that full irrigation with Zinc sulfate spraying at 1% recorded the highest seed yield in 2015 and 2016 seasons followed by withholding irrigation at vegetative stage with foliar spraying of 1% zinc sulfate during the two seasons.These results are in agreement with (Saeed *et al.* 2015)who found that, full irrigation enhanced highest head diameter, 1000-achene weight, achene yield and biological yield. Also, Hatami (2017) showed that, sunflower yield decreased under increasing drought stress, but zinc application improved yield by showing increase evaluation for diameter and number of seeds per head.

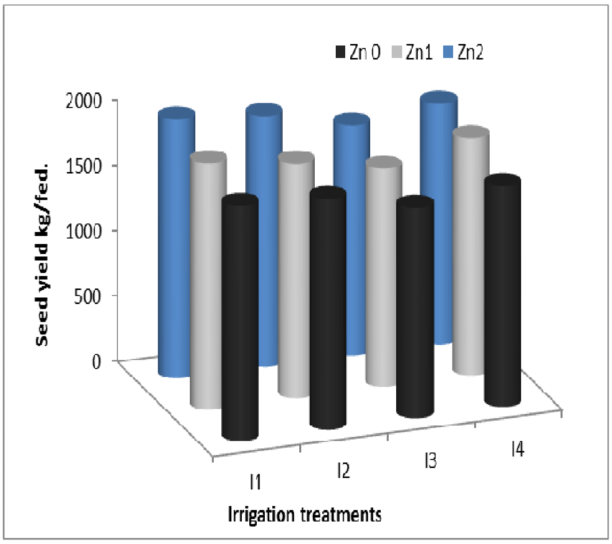

Fig. 1. Effect of interaction between irrigation treatments and zinc Sulfate spraying on seed yield during 2015 season.

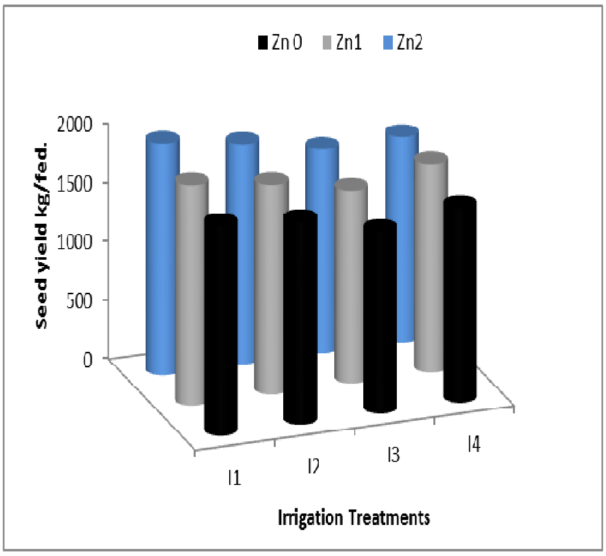

Fig. 2. Effect of interaction between irrigation treatments and zinc Sulfate spraying on seed yield during 2016 season.

Effect on seed protein content:

Based on the obtained results, it seems that water stress significantly affected in protein % . The higher values of seed protein content was observed under water stress than the complete irrigation. This result is consistent with other findings (Jiang and Huang 2002). Also, Heidari and Karami (2013) reported increase in protein content of sunflower under a moisture stressed condition. The reason for increasing the protein percentage by drought stress is osmo-regulation and water absorption phenomena (Cellier *et al.,* 1998). Similar to our results, Esmaeilian *et al.,* (2012) found that in sunflower, with increasing drought stress, oil content significantly decreased but protein percentage increased.

Table 7. Effect of irrigation and foliar application of zinc treatments on seed protein and seed oil % during the two growing seasons 2015 and 2016.

Treatments	Seed Protein %		Seed oil %	
	2015	2016	2015	2016
Irrigation				
I_1	16.11 d	16.32 c	47.35 a	47.14 a
I_2	16.37 c	16.52 b	45.79 b	45.67 b
I_3	16.59 a	16.73 a	44.64 d	44.53 d
I_4	16.47 b	16.62 b	45.05 c	44.99 c
F-test	**	**	*	**
Zinc sulfate				
Zn_0	15.60 c	15.77 c	44.97 c	44.87 c
Zn_1	16.57 b	16.78 b	45.72 b	45.58 b
Zn_2	16.99 a	17.09 a	46.44 a	46.30 a
F-test	**	*	**	**
Interaction (IxZn)	NS	NS	**	**

*,** significant at 5% and 1% level of probability, respectively. Mean values designed by the same letter in each column are not significant according to Duncan'sMultiple Range Test.

Zn_2 treatments significantly increased the percentage of protein(16.99 %) in the first season and (17.09 %) in the second season(Table 7).The results were supported by Darwish *et al.,*(2005) who found that, foliar spraying with zinc had significant effect on chemical constituents including protein content, NPK% as well as oil%. Increasing zinc concentration from 0.5% to 1% significantly increased the characteristics of chemical constituents.

Effect on seed oil Percentage

The results in Table (7) revealed that oil percentage is significantly affected by water shortage during the two studied seasons. The highest oil % was recorded with complete irrigation while, the lowest ones recorded withholding water at the flowering stage. Rauf *et al.,* (2012) reported that the oil percentage of sunflower is higher under non-stressed conditions (optimum irrigation) whereas water stress causes a decrease in oil percentage. Kassab *et al.,* (2012) revealed that the oil percentage of sunflower declined under drought stress. Also, Khajae-Pour (2004) found that water stress disrupts seed filling and decreases the synthesis of nutrients and these result in increasing the ratio of hull tokernel and decreasing seed oil content and oil yield. Also, Ali *et al.,* (2009) indicated that by increasing drought stress, the oil percentage and the oil yield of sunflower decreased significantly. Soleimanzadeh *et al.,* (2010) investigated the response of sunflower to drought stress and reported that the oil yield decreased significantly by drought stress. They attributed the oil yield decrease under drought stress to the reduction in seed yield.

In comparison to the control values which spraying zinc sulfate at the higher concentration (1%) caused significant increase in oil % at the two growing seasons. The effect of zinc application on oil yield has been reported by other studies (Tabatabaei *et al.,* 2012; Afkari, 2010; Jabbari *et al.,* 2008).

Water applied , irrigation water productivity and water saving:

Table (8) shows the average water applied ,irrigation water productivity and water saving as affected by water stress and zinc sulfate spraying. The results indicated that plants have significant change on seed yield and eventually on irrigation water productivity. The treatment withholding irrigation at flowering or seed filling stage of the life cycle of sunflower had a better crop irrigation water productivity (IWP). This indicates that the efficiency of individual crop in these treatments are to convert water transpired (or used) to grain. In other words, the results indicated that IWP is an important physiological characteristic that is related to the ability of crop to cope with water stress (Ebrahimi *et al.,* 2014).

Table 8. Average water applied (Wa m^{-3} fed.) , irrigation water productivity(IWP kgm^{-3}) and water saving (WS %) as affected by irrigation treatments and foliar application of zinc during the two growing seasons 2015 and 2016.

Irrigation treatments	Zinc sulfate	Wa (m^3 fed^{-1})		Mean	IWP(kg m^{-3})		Mean	WS (%)		Mean
		2015	2016		2015	2016		2016	2016	
	Zn_0	2614	2722	2668	0.687	0.654	0.670			0.701
I_1	Zn_1	2642	2731	2686.5	0.713	0.689	0.701	1.071	0.331	1.093
	Zn_2	2651	2743	2697	0.745	0.716	0.730	1.415	0.771	0.897
Mean		2635.67	2732.00	2683.83	0.714	0.686	0.701	1.243	0.551	-25.48
	Zn_0	1954	2022	1988	0.900	0.850	0.875	-25.24	-25.716	-25.84
I_2	Zn_1	1961	2033	1997	0.914	0.874	0.893	-26.05	-25.643	-25.88
	Zn_2	1968	2045	2006.5	0.948	0.912	0.929	-26.12	-25.643	-25.73
Mean		1961.00	2033.33	1997.17	0.921	0.879	0.900	-25.81	-25.66	-26.92
	Zn_0	1900	2000	1950	0.846	0.772	0.808	-27.31	-26.525	-26.94
I_3	Zn_1	1912	2014	1963	0.870	0.812	0.841	-27.63	-26.254	-26.96
	Zn_2	1922	2018	1970	0.914	0.857	0.885	-27.49	-26.431	-26.94
Mean		1911.33	2010.67	1961	0.880	0.814	0.845	-27.48	-26.40	-26.50
	Zn_0	1911	2011	1961.00	0.881	0.820	0.850	-6.89	-26.120	-26.33
I_4	Zn_1	1915	2044	1979.5	0.945	0.864	0.904	-27.51	-25.156	-26.32
	Zn_2	1922	2053	1987.5	0.954	0.849	0.901	-27.49	-25.155	-26.32
Mean		1916.00	2036.0	1976.00	0.927	0.844	0.886	-27.30	-25.47	-26.39

CONCLUSION

The recent results clearly showed that, flowering stage was the most sensitive to water shortage .Thus, in case of limited irrigation, reduced irrigation water during the flowering period should be avoided. Additionally, results cleared that the application of zinc sulfate at the rate of 1 % reduce the harmful effect of water stress on the growth and yield of sunflower plant.

REFERENCES

Afkari, B. A. (2010). Effect of water limitation on grain yield of sunflower (*Helianthus annuus* L.) cultivars.J. Food Agric. and Env., 8: 98-101.

Ali, Q.; Ashraf M. and Anwar F. (2009).Physico-chemical attributes of seed oil from drought stressed sunflower (*Helianthus annuus* L.) plants. *Grasas Aceites*, 60: 475-481.

A.O.A.C. (1995):Official Methods of Analysis 16th Ed, A.O.A.C Benjamin ranklin Station, Washington, D.C, U.S.A. pp 490 – 510.

Amirian, Sh.;Golparvar A.R.; and Nassiri, B. (2013). Character association, regression andpath analysis in sunflower (*Helianthus annuus* L.) hybrids. Tech. J. Eng. App. Sci. 3(24): 3640-3643.

Anjum, S.A.;Xie, X.; Wang, L.; Saleem, M.F.; Man, C. and Lei, W. (2011). Morphological,physiological and biochemical responses of plants to drought stress. African J. Agric.Res. 6, 2026-2032.

Babaeian, M;Heidari, M. and Ghanbari, A. (2010). Effect of water stress and foliar micronutrient application on physiological characteristics and nutrient uptake in sunflower (*Helianthus annuus* L.). Iranian J. Crop Sci. 12(4), 311-391.

Babaeian,M.; Tavassoli,A.; Ghanbari,A.; Esmaeilian,Y. and Fahimifard,M. (2011).Effects of foliar micronutrient application on osmotic adjustments, grain yield and yield components in sunflower (Alstar cultivar) under water stress at threestages. African J. Agri. Res. Vol. 6(5): 1204-1208.

Barrs,H.D. and Weatherly, P.E. C. (1962): Are-examination of relative turgidity technique for estimating water deficits in leaves. Aust. J. Bio. Sci., 15:413-428.

Bates L.S.; Waldren,R.P. and Teare,I.D. (1973).Rapid determination of free proline for water stress studies, Plant and soil, 39: 205-208.

Cakmak, I.,(2000). Possible roles of zinc in protecting plant cells from damage by reactive oxygen species. New Phytol. J., 146: 185-205.

Cellier, F.;Conejero, G.;Breitler, G. C.andCasse, F. (1998). Molecular and physiological responses to water deficit in drought- tolerant and drought sensitive lines of sunflower. Plant Phys., 116: 319-328.

Darwish, D.S.; El-G. El-Gharreib; M.A. El-Hawary and O.A. Rafft (2005).Effect of some macro and micronutrients application on peanut production in a saline soil in El-Faiyum Governorate. Egypt. J.Appl. Sci., 17: 17-32.

Duncan,D.B.(1955). Multiple range and multiple F.test Biometrics,11:1-24.

Ebrahimian, E. and Bybordi, A. (2011). Exogenous selenium and zinc increase antioxidant enzyme activity and alleviate salt stress in leaves of sunflower. J. Food Agric. Env.9 (1), 422-427.

Ebrahimi,M. ; Khajehpour,M.R.;Naderi,A. and Nassiri, B.M.(2014)Physiological responses of sunflower to water stressunder different levels of zinc fertilizer. Inter. J. Plant Prod. 8 (4):83-504.

El-Sharkawy, H.M. and Salama, F.M. (1973): Response of olive and almond orchards to partial irrigation under dry farming practices in semi arid regions. Π-Plant soil water relations in olive during the growing season. Plant and Soil, 41:13-32.

English M.J.;Musich, J.T.;Murty, V.V.N. (1990). Deficit irrigation. In: G.J., Hoffman, T.A., Howell and K.H.,Soloman (Eds.). Management of Farm Irrigation Systems. ASAE, St. Joseph, MI.

English, M., and Raja, S.N. (1996). Perspectives on deficit irrigation. Agric. Water Manag., 32: 1-14.

Erdem, T.; L. Delibas and A.H. Orta (2002). Water use characteristics of sunflower (*Helianthus annuus* L.) under deficit irrigation. Pakistan J. Bio. Sci., 7: 766-769.

Esmaeilian Y.;Sirousmehr A. R.;Asghripour M. R., and Amiri E. (2012). Comparison of sole and combined nutrient application on yield and biochemical composition of sunflower under water stress. International J. Appl. Sci. and Techn., 3: 214-220.

Flagella, Z.T.;Rotunno,R. and Dicuro,A. (2002). Changes in seed yield and oil fatty acid composition of sunflower (*Helianthus annuus* L.) hybrid in relation to the sowing date and the water regime. Eur. J. Agron., 7: 221-230.

Farias, J. R. B;Nepomuceno, A. L. and Neumaier, N. (2007).Ecofisiologia da soja. Londrina: EMBRAPA - CNPSo, 9 p. (EMBRAPA-CNPSo. Circular técnica, 48).

Giriappa, S (1983): Water use efficiency in agriculture. Oxford-IBH Publishing Co, New Delhi.

Hatami, H.(2017). The effect of zinc and humic acid application on yield and yield components of sunflower in drought stress. J. Adv. Agric. Techn. 4(1):36-39.

Heidari M., and Karami V. (2013). Effects of different mycorrhiza species on grain yield, nutrient uptake and oil content of sunflower under water stress. Journal of the Saudi Soc. Agric. Sci., 13: 9-13.

Hussein, M.M. and A. K. Alva (2014).Effects of Zinc and Ascorbic Acid Application on the Growth and Photosynthetic Pigments of Millet Plants Grown under Different Salinity. Agric. Sci. 5 :1253-1260

Hymowitz, T. F.; Collins, P. and Walker, W. M.(1972):Relationship between the content of oil,protein and sugar in soybean seed. Agronomy J. 64: 613 – 616.

Jabbari, H.;Akbari, G. A.;Daneshian, J.;Allahdadi, I., and Shahbazian, N. (2008). Effect of limited irrigation on phonologic and morphologic traits of sunflower hybrids. Abstracts Book of 5th Inter. Crop Sci. Congress and Exhibition,: 215.

Jiang Y. and Huang B., (2002):Protein alterations in tall fescue in response to drought stress and abscisic acid. Crop Sci., No.42, : 202-207.

Kassab, O. M.; Abo Ellil, A. A. and Abo El-Kheir, M. S. A. (2012). Water use efficiency and productivity of two sunflower cultivars as influenced by three rates of drip irrigation water. J. Appl. Sci. Res., 7: 3524-3529.

Khajae-Pour M. R. (2004).Industrial Crops.Esfahan Industrial University Jahad-Daneshgahi Press,422 p.

Kumar, A.; Tamogami, G.; Iwahashi, S.; Prasad, H.; Agrawal, V. and Transient, R. (2003).Regulation of jasmonic acid inducible rice MAP kinase gene (OSBWMK1) by diverse biotic and abiotic stresses. Plant Physiol. Biochem., 41: 355-361.

Moran, R. (1982):Formula determination of chlorophylls pigments extracted with N-N dimethyl-frmamide. Plant Physiol., 69: 1376 – 1381.

Patra, P.;Pati, B.K.;Ghosh, G.K.; Mura, S.S. andSaha, A. (2013). Effect of biofertilizers and sulphur on growth, yield, and oil content of hybrid sunflower (*Helianthus annuus* L.) In a typical lateritic soil. Open Access Scientific Reports 2: art.603.

Piper, C.S.(1950).Soil and plant analysis. Interscience Pumlisher. Inc. New York , USA.

Rauf, S. and Sadaqat, H.A. (2008). Identification of physiological traits and genotypes combined to high achene yield in sunflower (*Helianthus annuus* L.) under contrasting water regimes. Aust. J. Crop Sci. 1, 23-30.

Rauf A.;Maqsood M.; Ahmad A., and Gondal A. S. (2012).Yield and oil content of sunflower (*Helianthus annuus* L.) as influenced by spacing and reduced irrigation condition. Sci. J. Crop Prod., 1: 41-45.

Roshdi,M.;Sharifabad,H.;Karimi,M.;Nourmohammadi,GH . and Darvish,F. (2006). A Survey on the impact of water deficiency over the yield of sunflower seed cultivar and its components. J. Agri. Sci. 12(1): 109-121.

Saeed,U.; Sher,A.; Hussain,S.; Khan, A.; Asif,A.; Jincai,L.and Shakoor,A.(2015).Impact of foliar application of zinc on growth and yield of sunflower under different irrigation conditions. Academia J. Agric. Sci. Res. 3(9):219-225.

Shahri, Z.B.; Zamani, G.R. and Sayyari-Zahan, M.H. (2012). Effect of drought Stress and Zinc Sulfate on the yield and some physiological characteristics of Sunflower (*Helianthus. Annuus* L.)Adv.in Environ. Biol.,6 (2): 518-525.

Snedecor, G.W. and Cochran W.G.(1982).Statistical Methods 6th addition , Iowa state college press .Ams .Iowa, U.S.A.

Soleimanzadeh H.;Habibi D.;Ardakani M. R.;Paknejad F. and Rejali F. (2010). Response of sunflower (*Helianthus annuus*L.) to drought stress under different potassium levels. World Appl. Sci. J. (WASJ), 4: 443-448.

Stone, I.R.; A.J. Schlegel;R.E.Gwin and A.H. Khan(1996). Response of corn, grain sorghum and sunflower to irrigation in the high Plants of Kansas. Agric. Water Manag., 30: 251-259.

Tabatabaei S. A.;Rafiee V.;Shakeri E. and Salmani M.(2012). Responses of sunflower (*Helianthus annuus* L.) to deficit irrigation at different growth stages. Inter. J. Agric. Res. and Review (IJARR), 5:624-629.

Vazin(2012).Effect of zinc sulfate on characteristics of corn in drought stress. Cercetări Agronomiceîn MoldovaVol. XLV , No. 3 :151-159.

Ved R.;Misra, S.K. and Upadhyay R.M.(2002). Effects of sulphur zinc and biofertilizers on the quality characteristics of mungbean. Ind. J. Pulses Res. 2:139-141.

Weatherly, P.E. (1950): Studies on the water relations of the cotton plants. I. The field measurement of water deficits in leaves. New Phytol., 49:81-97.

Zafar,S. ; M. Nasri ; H.R. Moghadam and H. Zahedi (2014). Effect of zinc and sulfur foliar applications on physiological characteristics of sunflower (*Helianthus annuus* L.) under water deficit stress. Inter. J. Bio Sci., 5 (12):87-96.

تاثير منع الرى فى بعض مراحل النمو مع الرش الورقى بالزنك على المحصول وانتاجية المياه لزهرة الشمس

رانيا فاروق المنطاوى[١] وداليا عبدربه الحاج[٢]

[١]قسم بحوث فسيولوجيا المحاصيل – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – مصر.

[٢] قسم المحاصيل – كلية الزراعة – جامعة كفر الشيخ- مصر

أقيمت تجربة حقلية بمزرعة محطة البحوث الزراعية بسخا- كفرالشيخ- خلال موسمين ٢٠١٦/٢٠١٥م لدراسة تأثير الرش الورقى بكبريتات الزنك على محصول وانتاجية المياه لنبات زهرة الشمس تحت ظروف الاجهاد المائى . وكان التصميم الاحصائى المستخدم هو القطع المنشقة مرة واحدة حيث وضعت معاملات الرى فى القطع الرئيسية وهى الرى بالمعدل الموصى به (أربع ريات) ، منع ريه فى مرحله النمو الخضرى ، منع ريه فى مرحلة التزهير ، منع ريه فى مرحلة امتلاء البذور بينما وضعت معاملات الرش الورقى بكبريتات الزنك فى القطع الشقية وهى بدون زنك (الرش بالماء) ، الرش بمعدل ٠.٥ % ، الرش بمعدل ١%.وقدرت الصفات الآتية محتوى الأوراق من صبغات الكلوروفيل والمحتوى المائى النسبي للاوراق ومحتوى الاوراق من البرولين وعند الحصاد تم تقدير المحصول ومكوناته وكذلك نسبة البروتين والزيت فى البذور كذلك تم حساب كمية المياه المضافه ونسبة المياه الموفره وكذلك كفاءة استخدام المياه. وقد بينت النتائج أن أعلى كميه للمياه المضافه قد سجلت مع الرى التقليدى كما أوضحت النتائج أن مرحلة التزهير كانت أكثر المراحل حساسية لنقص المياه لذلك فى حالة نقص المياه يجب تجنب منع الرى خلال هذة الفترة. ومن خلال هذة الدراسه يمكن التوصيه بأنه تحت ظروف نقص المياه يمكن زراعة زهرة الشمس مع اسقاط ريه فى مرحلة النمو الخضرى والرش الورقى بكبريتات الزنك بمعدل ١% لتعويض الاثر الضار للاجهاد المائى.