J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 3 (4): 483 - 494, 2012

INFLUENCE OF WATER STRESS, PHOSPHORUS AND ZINC APPLICATIONS ON, SEED QUALITY AND SEED YIELD OF SUNFLOWER (*Helianthus annuus L.*)

Hammad, S. A.[1] ; A. Y. Negm [2] ; A. M. El-Ghamry[1] ; M. A. Abou seada[3] and Z. A. Lashin [2]

[1] Soils Department, Faculty of Agriculture, Mansoura Universty.

[2] Soil and Water and Environ. Res. Inst., ARC.

[3] National Research Centre (NRC), Cairo, Egypt.

ABSTRACT

Two field experiments were conducted during 2007 and 2008 summer seasons in the farm of the Faculty of Agriculture, Mansoura University, to evaluate the influence of water stress, phosphorus and zinc fertilization on, seed quality, seed yield and yield components of sunflower crop using a split-split plot design with 3 replicates. The experimental field treatments were 24. The results showed that, water stress significantly decreased seed yield, 100- seed weight, seed oil and protein contents as well as seed contents of N, P, K and Zn. Whereas mineral P combined with phosphorus solubilizing bacteria (PSB) increased them except seed content of Zn which decreased with mineral P application and increased with PSB application. Foliar application of chelated zinc increased the above mentioned parameters except seed content of P.

It could be concluded that for producing a high yield and a good quality of sunflower seeds, it must be considered a suitable program of water stress, bio and mineral fertilization of P and Zn.

INTRODUCTION

Sunflower is the fourth oil grain crop grown world wide by area (Fagundes *et al*., 2007). Sunflower, with a world production of grain and oil of over 28.5×10^6 and 10.5×10^6 Mg, respectively, and grown around 22.6×10^6 ha with a seed yield of 1.3 kg/ha (2003 to 2007 mean), is one of the most common grown oilseed species (FAO-STAT Agriculture, 2009). Sunflower seeds contain a high amount of oil (40 to 50%) which is an important source of polyunsaturated fatty acids (linoleic acid) of potential health benefits (Lopez *et al*., 2000; Leon *et al*., 2003; Monotti, 2004).

Adequate water and nutrient supply are important factors affecting optimal plant growth and successful crop production. Water stress is one of the most limiting factors affecting crop growth, especially in arid and semi-arid regions of the world because it has a vital role in plant growth and development at all growth stages. Identification of the critical plant growth stages and scheduling irrigation according to plant's demand is the key factor for conserving water and improving irrigation efficiency and sustainability of irrigated agriculture (Igbadun 2006 and Ngouajio *et al*. 2007). The fresh and dry weights of sunflower, reduced under water stress. Also, seed yield and 1000 seed weight of sunflower decreased as drought stress increased (Manivannan *et al*., 2007, Chimenti *et al*., 2002 and Erdem *et al*., 2006). Some evidences have indicated that water stress deficit causes considerable decrease in yield and oil content of sunflower (Stone *et al*., 2001). Although a lot of literature is available about water stress effects on sunflower (Tahir and

Mehdi, 2001 and Angadi and Entz, 2002), information regarding the effect of normally irrigated and water deficit environment on seed yield, yield component, seed oil and protein content is scanty.

Phosphorus (P) is an essential plant nutrient required for higher and sustained productivity of oil from sunflower. Its influence on seed yield, oil yield and oil quality has been well established. Therefore, the application of phosphorus has become an essential part of sunflower fertilization program. (Bahl and Toor, 1999 and Zubillaga *et al*., 2002).

Micro-organisms are also involved in a range of process that affect the transformation of soil P and thus an integral part of the soil P cycle (Chen *et al*., 2006). In particular, P-solubilizing micro-organisms (bacteria or fungi) are able to solubilize unavailable soil P and increase the yield of crops (Adesemoye and Kloepper, 2009). P-solubilization ability of micro-organisms is considered to be one of the most important traits associated with plant P nutrition (Chen *et al*., 2006). Several bacterial species, in association with plant rhizosphere, are capable of increasing availability of Phosphorus to plants either by mineralization of organic phosphate or by solubilization of inorganic phosphate by production of acids (Rodriguez and Fraga, 1999). These bacteria are referred to as phosphate solubilizing bacteria (PSB) and have been considered to have potential use as inoculants biofertilizer to improve the plant growth and yield (Vessey, 2003 and Chen *et al*., 2006). Consequently, many researchers have isolated P-solubilizing bacteria from different soil and the inoculations of these bacteria to increase P-availability of plants have been intensively studied (Peix *et al*., 2001 and Chen *et al*., 2006).

Zinc is a cofactor of over 300 enzymes and constituent of many proteins that involved in cell division, nucleic acid metabolism and protein synthesis. Khurana and Chatterjee (2001) reported that the numbers of seeds per head and 1000 seed weight of sunflower were highest when zinc was sufficient. Mirzapour and Khoshgoftar (2006) stated that addition of 20 kg Zn ha^{-1} increased seed production and shoot dry matter yield of sunflower, while plant height and head diameter did not change.

Therefore, the present study aimed to evaluate effects of water stress, P and Zn fertilization on both seed quality and seed yield of sunflower crop.

MATERIALS AND METHODS

Two field experiments were carried out at the farm of the faculty of agriculture, Mansoura University during the summer seasons of 2007 and 2008 using sunflower (*Helianthus annuus L.*) crop. The experiment included 24 treatments as follows : 2 irrigation treatments (at two durations i.e. 15 or 21 days after the planting irrigation, thus, plant received 8 or 6 irrigations including planting irrigation, respectively),six phosphorus treatments including mineral P as super phosphate (15% P_2O_5) and phosphate solubilizing bacteria (PSB) using *Basillus Megaterium* strain were added at planting in 6 combinations (0kg P_2O_5 fed^{-1}, 0kg P_2O_5 fed^{-1} + PSB, 7.5 kg P_2O_5 fed^{-1}, 7.5 kg P_2O_5 fed^{-1} + PSB, 15 kg P_2O_5 fed^{-1} and 15 kg P_2O_5 fed^{-1}+ PSB). Within each combination of P-fertilizer two levels of chelated zinc (0 and 25gm Zn-EDTA fed^{-1}) were applied as foliar application in two doses. The first was added in 200 L water per fed at formation of 8 true leaves and the second was added in 300 L water per fed after two weeks from the first dose. Nitrogen fertilization was added in the form of urea (46%N) to the soil at rate of 75kg fed^{-1} (34.5 Kg N) in two equal portions, after 17 days from planting and 15 days later. Potassium sulphate (48% K_2O) was added with the first dose of nitrogen fertilization at rate of 50 kg fed^{-1} (24 Kg K_2O). At harvest, 100-seed weight and seed yield per feddan were recorded. Seed samples were taken, to determine seed contents of N, P, K and Zn.

N, P and K were determined according to Jackson (1967). While Zn concentration was measured according to Cottenie, (1980). Oil percentage was determined using soxhlet apparatus according to the A.O.A.C.(1975). Oil yield/fed was calculated by multiplying oil percentage by seed yield (i.e. dry seed). Crude protein was calculated by multiplying total nitrogen percentage by 6.25. Protein yield was calculated by multiplying crude protein percentage by seed yield/fed (i.e. dry seed). The significant differences among the mean of various treatments were established by the new least significant differences methods (NLSD) according to Gomez and Gomez (1984).

Some physical and chemical characteristics of the experimental soil are presented in Table (1). The different characteristics were determined according to Jackson, 1967, Piper (1950), Dewis and Freilas, (1970), Black, (1965), Hillel, (1972), Chapman *et al*., (1961), Olsen *et al*., (1954), Lindsay and Norvell (1978) and Cottenie, (1980).

Table (1): Some physical and chemical characteristics of the experimental soil.

Soil properties	2007	2008
Coarse sand (%)	6.65	6.37
Fine sand (%)	5.35	5.43
Silt (%)	35.5	33.0
Clay (%)	52.5	55.2
Texture class	Clay	clay
Saturation percentage (%)	64.31	62.14
F. C. (%)	41.5	38.5
W. P. (%)	18.2	17.39
Real Density (gm cm^{-3})	2.4	2.1
Bulk Density (gm cm^{-3})	1.14	1.17
Porosity (%)	40.2	44.3
pH (soil paste extract)	8.4	8.3
$CaCO_3$ (%)	2.5	2.0
E.C. dS.m^{-1}	0.6	0.4
Ca (meq/L)	0.61	0.51
Mg (meq/L)	0.68	0.55
Na (meq/L)	0.8	0.9
K (meq/L)	0.05	0.03
HCO_3 (meq/L)	0.6	0.4
Cl (meq/L)	0.8	0.7
SO_4 (meq/L)	0.74	0.89
O.M. (%)	2.24	2.36
Available N (ppm)	35	49
Available P (ppm)	14.44	18.96
Available K (ppm)	453.36	462.805
Available Zn (ppm)	1.448	1.55

RESULTS AND DISCUSSION

Effect of water stress, P and Zn application on:
100-seed weight and seed yield

Results in Table 2 and Table 3 show that water stress significantly decreased 100- seed weight and seed yield of sunflower .This might indicate that seed vigor could be reduced by water stress during flowering and latter growth stages. In addition, water stress might reduce photosynthesates available for seed filling. It appear that sunflower yield is very sensitive to water stress imposed by delayed irrigation and/or probably by high transpiration demand during late flowering when flowers with low vigor are pollinating and the growth potential of pollinated ovaries. Alahdadi *et al*., (2011) revealed that water stress significantly decreased seed yield of sunflower. The highest seed yield of 2591kg ha^{-1} was obtained from normal irrigation. Ebrahimi *et al*., (2011) showed that irrigation after 120 mm evaporation significantly reduced 100 seed weight and seed yield.

Table 2: Effect of irrigation, phosphorus and zinc on the 100 seeds weight (g) and seed yield (t/f) of sunflower crop:

Treatments	2007		2008	
	100 Seed weight (g)	Seed yield (t/fed)	100 Seed weight (g)	Seed yield (t/fed)
Ir_1	15.16	0.909	11.23	1.096
Ir_2	12.19	0.701	6.66	0.538
F. test	*	*	*	*
LSD (5%)	0.2931	0.0124	0.1986	0.0089
Zn_0	13.34	0.764	8.73	0.769
Zn_1	13.92	0.846	9.10	0.864
F. test	*	*	*	*
LSD (5%)	0.2931	0.0124	0.1986	0.0089
P_0	12.13	0.60	7.99	0.540
P_0+PSB	12.07	0.833	8.55	0.819
P_1	12.63	0.765	8.40	0.766
P_1+PSB	14.72	0.867	9.14	0.906
P_2	13.97	0.829	9.40	0.862
P_2+PSB	16.16	0.931	9.95	1.007
F. test	*	*	*	*
LSD (5%)	0.5076	0.0215	0.3441	0.0155

Ir_1=Irrigation at 15 day, Ir_2=Irrigation at 21 day, Zn_0=0 g chelated zinc $fed.^{-1}$, Zn_1= 25 g chelated zinc $fed.^{-1}$, P_0=0 Kg P_2O_5 $fed.^{-1}$, P_0+PSB= 0 Kg P_2O_5 $fed.^{-1}$ and phosphate solubilizing bacteria, P_1=7.5 Kg P_2O_5 $fed.^{-1}$, P_1+PSB=7.5 Kg P_2O_5 $fed.^{-1}$ and phosphate solubilizing bacteria, P_2=15 Kg P_2O_5 $fed.^{-1}$, P_2+PSB=15 Kg P_2O_5 $fed.^{-1}$ and phosphate solubilizing bacteria.

On the other hand data in the same Table show that foliar application of chelated zinc increased significantly 100- seed weight and seed yield. Mirzapoura and Khoshgoftar (2006) confirmed these results and stated that addition of 20 kg Zn ha^{-1} significantly increased seed production.

Data also show that 100- seed weight and seed yield were increased with increasing application rate of mineral P and it was greater by addition of phosphate solubilizing bacteria (PSB). The high response of plant to (PSB) inoculation might be due to mobilization of available P by the native soil microflora, or attributed to increasing PSB activity in the rhizosphere following PSB application and consequently by enhanced P solubilization. Seed or soil inoculation with PSB can solubilize fixed soil P and applied phosphates. For these reasons, its enhanced P uptake by the crops following PSB additions has led to an increase in stem and head diameter and thus number of filled grains per head and 1000 seed weight growth ultimately leading to higher seed yield. The work confirmed this result, Ekin (2010)

Table 3:Interactions effect of irrigation, phosphorus and zinc on the 100 seeds weight (g) and seed yield (t/f) of sunflower crop:

Treatments			2007		2008	
			100 Seed weight (g)	Seed yield (t/fed)	100 Seed weight (g)	Seed yield (t/fed)
Ir_1	P_0	Zn_0	11.75	0.56	10.15	0.45
		Zn_1	13.01	0.76	10.50	0.92
	P_0+PSB	Zn_0	12.88	0.86	10.93	1.03
		Zn_1	13.91	0.98	11.33	1.17
	P_1	Zn_0	12.30	0.90	10.69	1.05
		Zn_1	15.26	0.89	10.83	1.06
	P_1+PSB	Zn_0	15.84	0.92	11.03	1.16
		Zn_1	17.65	1.00	11.47	1.21
	P_2	Zn_0	15.89	0.93	11.70	1.18
		Zn_1	16.31	0.97	11.70	1.22
	P_2+PSB	Zn_0	17.57	0.99	11.97	1.34
		Zn_1	18.80	1.15	12.20	1.38
Ir_2	P_0	Zn_0	13.24	0.50	6.97	0.36
		Zn_1	10.43	0.61	5.07	0.44
	P_0+PSB	Zn_0	10.72	0.72	5.23	0.44
		Zn_1	10.79	0.77	6.70	0.64
	P_1	Zn_0	11.25	0.61	5.97	0.49
		Zn_1	11.71	0.66	6.13	0.47
	P_1+PSB	Zn_0	12.40	0.75	6.50	0.59
		Zn_1	13.00	0.79	7.57	0.67
	P_2	Zn_0	12.36	0.67	6.80	0.52
		Zn_1	12.10	0.75	7.40	0.53
	P_2+PSB	Zn_0	13.36	0.76	7.33	0.64
		Zn_1	14.93	0.82	8.33	0.68
LSD(5%)	IrxPxZn		1.0152	0.043	0.6881	0.031

Seed nutrient contents

As shown in Table 4 and Table 5, water stress significantly decreased total contents of N and P in the seeds of sunflower during the two growing seasons. In this regard, Singh *et al*., (2002) found that water stagnation reduced ion uptake especially of N, P, K, Zn.

Table 4: Effect of irrigation, phosphorus and zinc on sunflower seeds N and P contents.

Treatments	2007		2008	
	N %	P %	N %	P %
Ir_1	3.422	0.324	1.970	0.436
Ir_2	2.569	0.304	1.818	0.406
F. test	*	*	*	*
LSD (5%)	0.0290	0.0023	0.0199	0.0007
Zn_0	2.974	0.316	1.854	0.428
Zn_1	3.005	0.312	1.930	0.414
F. test	*	*	*	*
LSD (5%)	0.0290	0.0023	0.0199	0.0007
P_0	2.818	0.302	1.495	0.364
P_0+PSB	2.891	0.310	1.750	0.411
P_1	2.850	0.306	1.825	0.405
P_1+PSB	3.066	0.321	2.012	0.454
P_2	3.066	0.312	2.012	0.424
P_2+PSB	3.233	0.331	2.228	0.462
F. test	*	*	*	*
LSD (5%)	0.0503	0.0040	0.0345	0.0012

Ir_1=Irrigation at 15 day, Ir_2=Irrigation at 21 day, Zn_0=0 g chelated zinc $fed.^{-1}$, Zn_1= 25 g chelated zinc $fed.^{-1}$, P_0=0 Kg P_2O_5 $fed.^{-1}$, P_0+PSB= 0 Kg P_2O_5 $fed.^{-1}$ and phosphate solubilizing bacteria, P_1=7.5 Kg P_2O_5 $fed.^{-1}$, P_1+PSB=7.5 Kg P_2O_5 $fed.^{-1}$ and phosphate solubilizing bacteria, P_2=15 Kg P_2O_5 $fed.^{-1}$, P_2+PSB=15 Kg P_2O_5 $fed.^{-1}$ and phosphate solubilizing bacteria.

Table 5:Interactions effect of irrigation, phosphorus and zinc on sunflower seeds N and P contents.

Treatments			2007		2008	
			N %	P %	N %	P %
Ir_1	P_0	Zn_0	3.10	0.31	1.61	0.40
		Zn_1	3.13	0.31	1.70	0.35
	P_0+PSB	Zn_0	3.30	0.32	1.73	0.42
		Zn_1	3.37	0.32	1.87	0.43
	P_1	Zn_0	3.27	0.32	1.84	0.44
		Zn_1	3.33	0.32	1.89	0.43
	P_1+PSB	Zn_0	3.47	0.33	1.94	0.46
		Zn_1	3.53	0.33	2.22	0.48
	P_2	Zn_0	3.47	0.33	2.12	0.46
		Zn_1	3.57	0.32	1.94	0.43
	P_2+PSB	Zn_0	3.67	0.34	2.22	0.47
		Zn_1	3.77	0.35	2.45	0.46
Ir_2	P_0	Zn_0	2.80	0.31	1.40	0.39
		Zn_1	2.33	0.29	1.31	0.32
	P_0+PSB	Zn_0	2.40	0.30	1.61	0.39
		Zn_1	2.50	0.30	1.80	0.41
	P_1	Zn_0	2.40	0.30	1.75	0.41
		Zn_1	2.40	0.30	1.82	0.34
	P_1+PSB	Zn_0	2.57	0.31	1.87	0.42
		Zn_1	2.70	0.31	2.03	0.46
	P_2	Zn_0	2.63	0.30	2.01	0.43
		Zn_1	2.60	0.30	1.98	0.37
	P_2+PSB	Zn_0	2.67	0.32	2.08	0.44
		Zn_1	2.83	0.31	2.17	0.48
LSD(5%)	IrxPxZn		0.1005	0.008	0.069	0.0024

It was also observed that foliar application of chelated zinc increased total N content and decreased total P content in sunflower seeds. Similarly, Gitte *et al*., (2005) recorded that the application of Zn showed an increase over the control in nitrogen content in dry matter and seed.

Results in the same Table show that the application of mineral P combined with PSB increased seed N and P concentrations. Several studies have reported that seed or soil inoculation with PSB such as *Bacillus spp*. can solubilize fixed soil P and applied phosphates. It is also known that P availability in soils is important for the uptake of N from soils and its utilization in plant and thus better crop growth. Reddy and Khera (1999) illustrated that uptake of N, P, K, S and Zn by sunflower was increased significantly with the increase in phosphorus fertilizer dose.

Results in Table 6 and Table 7 show that water stress significantly decreased K and Zn concentrations in the seeds of sunflower. This could be attributed to the lack of nutrient uptake, since under water stress the films around the soil particles are thin and path length of ion movement increases. Hence movement of potassium and zinc to the roots is reduced. Singh *et al*., (2002) illustrated that water stagnation reduced ion uptake especially of N, P, K, Zn.

Table 6: Effect of irrigation, phosphorus and zinc on sunflower seeds K and Zn contents

Treatments	2007		2008	
	K %	**Zn (ppm)**	**K %**	**Zn (ppm)**
Ir_1	2.044	82.82	1.940	73.38
Ir_2	1.952	57.78	1.831	65.73
F. test	*	*	*	*
LSD (5%)	**0.0242**	**0.8709**	**0.0356**	**1.3543**
Zn_0	1.967	67.29	1.811	65.71
Zn_1	2.026	72.87	1.957	73.19
F. test	*	*	*	*
LSD (5%)	**0.0242**	**0.8709**	**0.0356**	**1.3543**
P_0	1.836	69.68	1.632	74.59
P_0+PSB	1.914	85.49	1.755	88.71
P_1	1.926	62.98	1.770	67.83
P_1+PSB	2.065	76.05	1.999	75.07
P_2	2.061	57.95	1.904	49.16
P_2+PSB	2.166	68.56	2.227	62.07
F. test	*	*	*	**N.S**
LSD (5%)	**0.0419**	**1.5084**	**0.0616**	**--**

Ir_1=Irrigation at 15 day, Ir_2=Irrigation at 21 day, Zn_0=0 g chelated zinc $fed.^{-1}$, Zn_1= 25 g chelated zinc $fed.^{-1}$, P_0=0 Kg P_2O_5 $fed.^{-1}$, P_0+PSB= 0 Kg P_2O_5 $fed.^{-1}$ and phosphate solubilizing bacteria, P_1=7.5 Kg P_2O_5 $fed.^{-1}$, P_1+PSB=7.5 Kg P_2O_5 $fed.^{-1}$ and phosphate solubilizing bacteria, P_2=15 Kg P_2O_5 $fed.^{-1}$, P_2+PSB=15 Kg P_2O_5 $fed.^{-1}$ and phosphate solubilizing bacteria.

On the other hand data in the same Table illustrat that foliar application of chelated zinc increased significantly K and Zn concentrations in the seeds. Gitte *et al*., (2005) recorded that the application of Zn showed an increase over the control in potassium content in plant dry matter and seed.

Table 7:Interactions effect of irrigation, phosphorus and zinc on seeds K and Zn contents

Treatments			2007		2008	
			K %	Zn (ppm)	K %	Zn (ppm)
Ir_1	P_0	Zn_0	1.86	82.01	1.42	71.61
		Zn_1	1.91	87.28	1.73	84.42
	P_0+PSB	Zn_0	1.89	91.53	1.79	86.84
		Zn_1	2.04	95.46	1.92	91.86
	P_1	Zn_0	1.97	79.58	1.73	73.92
		Zn_1	1.97	82.31	1.92	74.98
	P_1+PSB	Zn_0	2.09	84.66	1.95	77.11
		Zn_1	2.12	90.41	2.20	80.22
	P_2	Zn_0	2.06	73.85	1.95	50.12
		Zn_1	2.14	73.79	1.92	58.38
	P_2+PSB	Zn_0	2.16	72.77	2.14	60.18
		Zn_1	2.26	79.93	2.42	70.39
Ir_2	P_0	Zn_0	1.86	57.38	1.67	65.15
		Zn_1	1.74	56.17	1.64	76.21
	P_0+PSB	Zn_0	1.82	67.15	1.57	84.34
		Zn_1	1.91	87.83	1.73	91.82
	P_1	Zn_0	1.86	55.08	1.64	59.78
		Zn_1	1.91	34.96	1.79	62.66
	P_1+PSB	Zn_0	1.97	49.65	1.83	68.66
		Zn_1	2.07	79.51	2.01	74.30
	P_2	Zn_0	1.97	51.52	1.83	40.74
		Zn_1	2.07	32.63	1.92	47.41
	P_2+PSB	Zn_0	2.07	47.30	2.08	52.05
		Zn_1	2.18	74.25	2.27	65.67
LSD(5%)	IrxPxZn		0.0837	3.0169	0.1232	4.6916

The obtained data also show that K concentration in the seeds increased with increasing application rate of mineral P and more increase was detected by addition of PSB, whereas, Zn concentration decreased with increasing application rate of mineral P, however, it was increased by PSB application.

seed oil and protein contents

Results in Table 8 and Table 9 show that water stress significantly decreased seed content of oil and protein of sunflower plants. Apparently water stress decreased seed yield and seed oil content through reduction in photosynthesis and assimilate remobilization and thus oil yield. Alahdadi *et al.*, (2011) revealed that water stress significantly decreased seed oil content in all sunflower hybrids. A decrease of the seed oil content was occurred when water input decreased.

On the other hand data in the same table indicated that foliar application of chelated zinc increased significantly oil and protein contents. Data also show that oil and protein content increased with increasing application rate of mineral P and the increase was enhanced by addition of PSB. Increased seed quality in case of PSB application might be attributed to the production of higher quantities of growth promoting substances and complementary effect of enhanced phosphate availability. Ekin (2010) showed that the PSB application enhanced oil contents and led to oil yield increase of 24.7% over no application. However, when PSB was used in conjunction with P fertilizers, a much greater effect was observed. The important effect of PSB on oil yield was noted at 100 kg P_2O_5 ha^{-1}.

Table 8: Effect of irrigation, phosphorus and zinc on seed oil and protein content.

Treatments	2007		2008	
	Oil %	Protein %	Oil %	Protein %
Ir_1	18.14	21.39	15.62	12.41
Ir_2	15.83	16.05	14.30	11.36
F. test	*	*	*	*
LSD (5%)	**0.2955**	**0.1813**	**0.3008**	**0.1340**
Zn_0	16.62	18.58	14.51	11.62
Zn_1	17.30	18.78	15.38	12.12
F. test	*	*	*	*
LSD (5%)	**0.2955**	**0.1813**	**0.3008**	**0.1340**
P_0	14.90	17.61	12.54	9.34
P_0+PSB	15.83	18.07	14.00	10.93
P_1	15.75	17.81	13.41	11.41
P_1+PSB	17.50	19.16	15.66	12.57
P_2	18.16	19.16	16.16	12.76
P_2+PSB	19.50	20.20	17.75	14.03
F. test	*	*	*	*
LSD (5%)	**0.5119**	**0.3140**	**0.5209**	**0.2322**

Ir_1=Irrigation at 15 day, Ir_2=Irrigation at 21 day, Zn_0=0 g chelated zinc $fed.^{-1}$, Zn_1= 25 g chelated zinc $fed.^{-1}$, P_0=0 Kg P_2O_5 $fed.^{-1}$, P_0+PSB= 0 Kg P_2O_5 $fed.^{-1}$ and phosphate solubilizing bacteria, P_1=7.5 Kg P_2O_5 $fed.^{-1}$, P_1+PSB=7.5 Kg P_2O_5 $fed.^{-1}$ and phosphate solubilizing bacteria, P_2=15 Kg P_2O_5 $fed.^{-1}$, P_2+PSB=15 Kg P_2O_5 $fed.^{-1}$ and phosphate solubilizing bacteria.

Table 9:interactions effect of irrigation, phosphorus and zinc on seed oil and protein content.

Treatments			2007		2008	
			Oil %	Protein %	Oil %	Protein %
Ir_1	P_0	Zn_0	14.00	19.38	11.00	10.06
		Zn_1	16.00	19.58	13.33	10.65
	P_0+PSB	Zn_0	15.67	20.63	14.00	10.79
		Zn_1	18.00	21.04	15.67	11.67
	P_1	Zn_0	16.33	20.42	13.00	11.52
		Zn_1	16.67	20.83	15.00	11.81
	P_1+PSB	Zn_0	17.67	21.67	16.00	12.10
		Zn_1	20.00	22.08	16.67	13.85
	P_2	Zn_0	20.33	21.67	17.00	13.27
		Zn_1	19.67	22.29	17.00	12.83
	P_2+PSB	Zn_0	20.33	22.92	18.33	14.29
		Zn_1	21.67	23.54	19.00	15.31
Ir_2	P_0	Zn_0	16.00	17.50	13.00	8.75
		Zn_1	13.33	14.58	12.33	8.17
	P_0+PSB	Zn_0	14.33	15.00	12.67	10.06
		Zn_1	15.33	15.63	13.67	11.23
	P_1	Zn_0	15.00	15.00	12.67	10.94
		Zn_1	15.00	15.00	13.00	11.38
	P_1+PSB	Zn_0	15.67	16.04	14.67	11.67
		Zn_1	16.67	16.88	15.33	12.69
	P_2	Zn_0	16.00	16.46	14.67	12.54
		Zn_1	16.67	16.25	16.00	12.40
	P_2+PSB	Zn_0	17.33	16.67	16.00	12.98
		Zn_1	18.67	17.71	17.67	13.56
LSD(5%)	**IrxPxZn**		**1.0238**	**0.628**	**1.0419**	**0.4643**

CONCLUSION

It could be concluded that for producing a high yield and a good quality of sunflower seeds, it must be considered a suitable program of water stress, bio and mineral fertilization of P and Zn.

REFERENCES

Adesemoye A.O. and J.W. Kloepper. (2009). Plant-microbes interactions in enhanced fertilizer-use efficiency. Appl. Microbiol. Biotechnol. 85: 1-12.

Alahdadi, I.; H. Oraki and F.P. Khajani. (2011). Effect of water stress on yield and yield components of sunflower hybrids. African Journal of Biotechnology, 10 (34): 6504-6509.

Angadi S.V. and M.H. Entz. (2002). Root system and water use patterns of different height sunflower cultivars. Agron. J., 94: 136-145.

A.O.A.C. (1975). "Official and Tentative Methods of Analysis". Association of official Agric. Chem., Washington, D.C.U.S.A.

Bahl G.S. and G.S. Toor. (1999). Efficiency of P utilization by sunflower grown on residual P fertility. Bioresour. Technol. 67: 97-100.

Black, C.A. (1965). "Methods of Soil Analysis" Part 1 and 2 USA, Madison, Wisconsin.

Chapman, H. D.; F. Paker and Pratt (1961). "Methods of Analysis" part 2 A. S. A. Madison, Wisconsin.

Chen Y.P.; P.D. Rekha; A.B. Arun; F.T. Shen; W.A. Lai and C.C. Young. (2006). Phosphate solubilizing bacteria from subtropical soil and their tricalcium phosphate solubilizing abilities. Appl. Soil Ecol. 34: 33-41.

Chimenti, C.A.; J. Pearson and A.J. Hall. (2002). Osmotic adjustment and yield maintenance under drought in sunflower. Field Crops Res., 75: 235-246.

Cottenie, A. (1980). Soil and plant testing as basis of fertilizer recommendations. F.A.O. Soils Bull., 38/2 FAO, Rome.

Dewis, J. and F. Freilas. (1970). Physical and Chemical Methods of Soil and Water Analysis. Food and Agriculture Organization of the United Nations. Soil Bulletin No. 10.

Ebrahimi, M.; A. Naderi; M.R. Khajehpour and B. Majde Nassirri. (2011). Effects of water stress and zinc fertilizer on yield components, seed and oil yields of a sunflower hybrid, alstar. Middle- East Journal of Scientific Research, 7 (6): 994-1000.

Ekin, Z. (2010). Performance of phosphate solubilizing bacteria for improving growth and yield of sunflower *(Helianthus annuus L.)* in the presence of phosphorus fertilizer. African Journal of Biotechnology, 9 (25): 3794-3800.

Erdem, T., Y. Erdem, A.H. Orta and H. Okursoy, (2006). Use of a crop water stress index for scheduling the irrigation of sunflower *(Helianthus annuus L.)*, Turk. J. Agric. For., 30: 11-20.

Fagundes, J; D. Santiago; G. Mello; A.M. de Belle and N.A. Streck. (2007). Growth, development and delay of leaf senescence in pot grown sunflower *(Helianthus annuus L.)*: sources and rates of nitrogen. Ciencia Rural, 37 (4): 987-993.

FAO-STAT–Food and Agricultural Organization of the United Nations (2009). Statistics Division. ProdSTAT: crops (30 November 2009) based on 2003–2007 data. Available online:http://faostat. fao.org / site / 567 / default. aspxs.

Gitte, A.N.; S.R. Patil and M.A. Tike. (2005). Influence of zinc and boron on biochemical and yield characteristics of sunflower. Indian J. of Plant Physiology, 10(4): 400-403.

Gomez, K. A. and A. A. Gomez. (1984). Statistical procedures for agricultural research. John Wiley and Sons. Inc. New York.

Hillel, D. (1972). Optimizing the soil physical environment toward greater crop yields. Symp Soil Water Physics and Technology.

Igbadun, H.E. (2006). Crop water productivity of an irrigated maize crop in Mkoji sub-catchment of the Great Ruaha River Basin, Tanzania. Agric. Water Manage., 85 (1/2): 141-150.

Jackson, M. L. (1967). "Soil Chemical Analysis". Printic Hall of India New Delhi, 144-197.

Khurana, N. and C. Chatterjee, (2001). Influence of variable zinc on yield, oil content and physiology of sunflower. Soil Sci. Plant Anal., 32 (19 and 20): 3023-3030.

Leon A.J.; F. Andrade and M. Lee. (2003). Genetic analysis of seed-oil concentrations across generations and environments in sunflower (*Helianthus annuus* L.). Crop Sci., 43: 135-140.

Lindsay, W.L. and W.A. Norvell.(1978). Development of a DTPA soil test for zinc, manganese and copper. Soil Sci. Am. J., 42: 421-427.

Lopez P.M.; N. Trapani and V. Sadras. (2000). Genetic improvement of sunflower in Argentina between 1930 and 1995. III. Dry matter partitioning and achene composition. Field Crop Res., 67: 215-221.

Manivannan, P.; C. Abdul Jaleel; B. Sankar; A. Kishorekumar; R. Somasundaram and G.M.A. Lashmanan, (2007). Growth, biochemical modifications and praline metabolism in *Helianthus annuus L.* as induced by drought stress**.** Chem. Eng. And Process. 46 (7): 614-622.

Mirzapour, M.H. and A.H. Khoshgoftar.(2006). Zinc application effects on yield and seed oil content of sunflower grown on saline calcareous soil. J. of Plant Nutrition, 29(10): 1719-1727.

Monotti, M. (2004). Growing non-food sunflower in dry land conditions. Ital. J. Agron., 8: 3-8.

Ngouajio, M.; G. Wang and R. Gold, (2007). Withholding of drip irrigation between transplanting and flowering increases the yield of field-grown tomato under plastic mulch. Agric. Water Manage., 87 (30): 285-291.

Olsen, S.R.; C.V. Cole; F.S. Watanab and L.A. Dean.(1954). Estimilation of available phosphorus in soil by extraction with sodium bicarbonate. U.S. Dept. Agric. Cric. No. 939.

Peix, A.; P.F. Mateos; C.R. Barrueco; E.M. Molina and E. Velazquez. (2001a). Growth promotion of common bean (*Phaseolus vulgaris* L.) by a strain of *Burkholderia cepacia* under growth chamber conditions. Soil Biol. Biochem. 33: 1927-1935.

Piper, C.S. (1950). "Soil and Plant Analysis". Inter. Sci. Publishers Inc. New York.

Reddy, D.D. and M.S. Khera. (1999). Fertilizer, plant density and variety interactions and soil nutrient status under maximum yield research on maize-sunflower system. International J. of Tropical Agric., 17(1/4): 61-68.

Rodriguez H, Fraga R (1999). Phosphate solubilizing bacteria and their role in plant growth promotion. Biotechnol. Adv. 17: 319-339.

Singh, M.P.; D.P. Sharma; S.K. Gupta and N.L. Sharma. (2002). Effect of time and duration of water stagnation on growth, yield and mineral composition of sunflower in a gypsum amended alkali soil. Current Agric., 26(1/2): 23-29.

Stone L.; R.D.E. Goodrum; M.N. Jafar and A.H. Khan. (2001). Rooting front and water depletion depths in grain sorghum and sunflower. Agron. J., 1: 105-111.

Tahir, M.H.N. and S.S. Mehid. (2001). Evaluation of open pollinated sunflower (*Helianthus annuus* L.) populations under water stress and normal conditions. Int. J. Agric. Biol., 3: 236-238.

Vessey, K.J. (2003). Plant growth promoting rhizobacteria as biofertilizers. Plant Soil, 255: 571-586.

Zubillaga, M.M.; J.P. Aristi and R.S. Lavado. (2002). Effect of phosphorus and nitrogen fertilization on sunflower (*Helianthus annuus* L.) nitrogen uptake and yield. J. Argon. Crop Sci. 188: 267-274.

تأثير الاجهاد المائي وإضافة الفوسفور والزنك علي جودة ومحصول بذور عباد الشمس

سامي عبد الحميد حماد[1] – عبد الواحد يوسف نجم [2] – أيمن محمد الغمري[1] - محمد علي طه ابو سعده [3] و زينب عبد الرؤف لاشين [2]

[1] قسم الأراضي – كلية الزراعة – جامعة المنصورة.

[2] معهد بحوث الأراضي والمياه والبيئة – مركز البحوث الزراعية.

[3] المركز القومي للبحوث.

تم إقامة تجربتين حقليتين خلال الموسمين الصيفيين 2007 و2008 في مزرعة كلية الزراعة، جامعة المنصورة. وكان الهدف من الدراسة تقييم اثر الاجهاد المائي واضافة السماد الفوسفاتي المعدني والبكتريا المذيبة للفوسفات والتسميد بالزنك علي جودة ومحصول بذور عباد الشمس باستخدام تصيميم قطع منشقة مرتين ذات 3 مكررات. وكانت معاملات التجربة الحقلية عبارة عن 24 معامله. أشارت النتائج إلي أن الإجهاد المائي أدي إلي نقص كلا من محصول البذور ووزن100 بذرة ومحتوي البذور من الزيت والبروتين وكذلك محتوي البذور من النيتروجين والفوسفور والبوتاسيوم والزنك في حين ان اضافة السماد الفوسفاتي المعدني مع البكتريا المذيبة للفوسفات ادي الي زيادة جميع هذه الصفات ماعدا محتوي البذور من الزنك الذي نقص مع اضافة السماد الفوسفاتي المعدني وزاد مع اضافة البكتريا المذيبة للفوسفات بينما ادت اضافة الزنك المخلبي الي زيادة جميع الصفات المدروسة ماعدا محتوي البذور من الفوسفور.

ويستنتج من الدراسة انه للحصول علي اعلي محصول وأفضل جودة لبذور عباد الشمس فيجب إتباع برنامج مناسب لكل من الإجهاد المائي والأسمدة الفوسفاتية المعدنية والحيوية وإضافة الزنك المخلبي.

قام بتحكيم البحث

أ.د / السيد محمود الحديدى	**كلية الزراعة – جامعة المنصورة**
أ.د / احمد سعيد متولى	**كلية الزراعة – جامعة الزقازيق**