EFFECT OF SEED SOAKING IN SOME BIOREGULATORS AND FOLIAR APPLICATIONS OF PHOSPHORUS, POTASSIUM AND ZINC ON SUNFLOWER PLANTS GROWTH AND YEILD IN CALCAREOUS-SALINE SOIL

Journal

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ABSTRACT

Field experiments were carried out during 2003 and 2004 seasons to investigate the role of some bioregulators and mineral nutrients in adapting and improving sunflower (*Helianthus annuus* L.) plants cv. Vidoc under calcareous and salinity stress conditions. Bioregulators; paclobutrazol (PP_{333}) at 10 ppm, salicylic acid (SA) at 10 ppm and thidiazuron (TDZ) at 5 ppm were applied as seed soaking for 4 hours before sowing. Mineral nutrients; phosphorous as H_3PO_4 0.5%, potassium as KCl 2.0% and Zinc as $ZnSO_4$ 0.01% were foliar sprayed (5 and 6 weeks after sowing). Two samples were taken at 50 days after sowing and at harvesting time (90 days after sowing).

Application of P showed significant increase in the mean values of plant height. Potassium treatment showed significant increase in shoot fresh and dry weights. In respect to bioregulators, PP_{333} showed significant increase in shoot fresh and dry weights in both seasons. Salicylic acid and TDZ increased Stem diameter and shoot fresh and dry weights. Application of TDZ reduced Plant height.

All mineral nutrients and bioregulators treatments increased number of seeds/ head, seeds weight/ head and seeds yield. Foliar applications of K and Zn decreased Na concentration and increased K, Ca and P concentrations as well as K/Na ratio. Application of P showed an increase in Ca and P concentrations. Trace elements; Zn, Mn and Fe were significantly increased by K and Zn applications. Seed soaking in SA and TDZ significantly decreased Na concentrations and increased K, K /Na, Mg and P concentrations. All mineral nutrients applications significantly increased oil percentage and yield.

Regarding mineral nutrients and bioregulators interactions, best results were obtained by K+TDZ and Zn+SA treatments, which recorded the maximum values of shoot fresh and dry weights, yield and its Components and unsaturated/saturated fatty acids ratio. Also, the best results of mineral elements concentrations in terms of the lowest values of Na and the highest values of K, K /Na, Mg, Zn, Mn and Fe. The effects of mineral nutrients, bioregulators and their interactions on sunflower growth and productivity under calcareous and salinity stress were discussed.

Key Words: Sunflower, *Helianthus annuus*, Paclobutrazol, Salicylic acid, Thidiazuron, Phosphorous, Potassium, Zinc, Growth, Yield, Oil quality, Mineral elements, Fatty acids.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) represents one of the main oil crops of the world. Being a thermo insensitive, grown in all seasons and producing oil resistant to rancidity and characterized by higher percent of unsaturated fatty acids (El-Baz, 1995).

In Egypt, there is a gap between production and consumption of plant oils. Increasing the cultivated areas of sunflower should be done in the reclaimed lands due to the limited areas of the Nile valley and the competition of the main crops.

Thus, the Experimental farm at Maryout Research station devoted to Desert Research Center was undertaken for the present investigation. This farm is characterized as highly calcareous soil (31.7 % $CaCO_3$), slightly saline (EC 2986 ppm), mildly alkaline (pH 7.9) and loamy in texture. Irrigation water is slightly saline (EC 2950.4 ppm salts). The presence of $CaCO_3$ directly or indirectly affecting the chemistry and availability of Nitrogen (N), Phosphorous (P), potassium (K), magnesium (Mg) , Iron (Fe), Manganese (Mn) and Zinc (Zn), (Obreza *et al.*, 1993).

On the other hand, salinity had deleterious effects on plant growth, development and even seed germination, particularly seed characteristic of sunflower, mainly oil content. Also, salinity influences nutrient uptake. Where salt concentration is low to moderate, the first visual symptom is often a thin stem and stunted growth (Weiss, 2000). Under these circumstances, potassium, phosphorus and zinc play an important role in improving the plant growth and subsequently the yield of oil crops. Sakr *et al.* (1990) reported that, application of P as monocalcium phosphate gave the highest dry matter yield in barley and sunflower plants under calcareous soil. Moreover, Harmati (1993) stated that P_2O_5 and K applications increased achene and oil yield of sunflower plants. Badawy (1990) investigated the effect of P on the growth and yield of soybean plants. He found that P (48 kg P_2O_5/ fed) treatment increased shoot dry weight and seed yield of soybean plants under calcareous soil (34% $CaCO_3$). Salama (1987) showed that, K fertilizer (200 kg/ h) increased achene and oil yields of sunflower plants on calcareous sandy soil.

Application of microelements either as soil application or foliar spray provided the best treatments which improved growth and yield of sunflower plants (Hegazy, 2004). In this respect, dry matter amount of maize plant increased with increasing Zn doses applied to each pot as $ZnSO_4.7H_2O$ in sandy calcareous and clay calcareous soils (Adiloglu, 2006). Foliar application of Zn (at 60 ppm Zn applied twice; 75 and 85 days after planting) increased seed yield h^{-1} , seed index and seed oil content of Egyptian cotton grown under clay loam soil. Even this effect was extended to improve oil quality (Sawan *et al,* 2006).

Salinity stress not only impact nutrition status of sunflower plant but endogenous cytokinins as well. Meanwhile, a decrease in cytokinins (CK) concentration in xylem exudates was found to be proportional to the concentration of NaCl in root medium of sunflower plants. This decrease was generally accompanied by an accumulation of growth inhibitor in the shoot (Pawan *et al.*, 1997).

In consequence, salinity stress can reduce CK export from the root to the shoot. Therefore, the possible involvement of exogenously applied CKs in response to adverse environmental conditions has been suggested by Brault and Maldiney (1999). Also, Becket and Van Staden (1992) suggested that the synthetic thidiazuron (TDZ) is more likely to be a commercially viable way of reducing the effects of stresses compared with other synthetic cytokinins. It is water soluble and is 10^4 times more effective than zeatin in the soya callus bioassay.

So, phytohormones regulate growth and development by up or down regulating gene expression in plants; their external application may serve as some kind of a gene substitution. However, in exploring how to counteract adverse environmental constrains, the synthetic phytohormones (bio- regulators) proved to be more value than natural plant hormones (Stark, 1993).

Plant growth retardants such as paclobutrazol (PP_{333}) and cycocel (CCC) are synthetic bioregulators. They have been shown to improve plant growth under different stress conditions (Shen *et al.*, 1996). Also, the natural plant hormone, salicylic acid (SA) as classified by Raskin (1992) was shown to be an important signal molecule in plant defense (Shah, 2003) and improve plant growth under stress conditions when used as seed soaking treatment (Afzal *et al.*, 2005).

The present study tended to improve growth and oil production of sunflower plants grown under calcareous soil and salinity stresses using bioregulators [Paclobutrazol (PP_{333}), thidiazuron (TDZ) and salicylic acid (SA)]as presowing seed soaking and application of mineral nutrients (P, K and Zn) as foliar spray or their combinations.

MATERIALS AND METHODS

Field experiment was conducted in Maryout Station, Desert Research Center during the seasons of 2003 and 2004. The soil of experimental station is characteristic as highly calcareous, slightly saline soil, mildly alkaline and clay loamy in texture (Table 1-a, b). Irrigation water used was slightly saline as described in Table (1c).

Sunflower seeds were obtained from Oil Crop Research Institute, Agriculture Research Center in Giza, Egypt. Seeds were sown in June 1^{st} in both seasons. Bioregulators, 10 ppm PP_{333}, 10 ppm SA and 5 ppm TDZ were applied as seed soaking for 4 hours before sowing. Control seeds were soaked in distilled water. Two foliar applications with one week interval of phosphorous as H_3PO_4 0.5%, potassium as KCl 2.0% and Zinc as $ZnSO_4$ 0.01% were started at 5weeks after sowing. Distilled water was used as control. Tween 20 was used as wetting agent at 0.05%.

Table (1); (a) Mechanical and (b) chemical properties of the experimental farm soil and (c) chemical analysis of irrigation water at Maryout Research station.

a) Mechanical analysis

Depth (cm)	Saturation Percentage (%)	Coarse Sand (%)	Fine Sand (%)	Silt (%)	Clay (%)	Textural Class
0-28	41.50	2.06	53.01	21.67	23.26	**Sandy Clay loam**
28-80	43.5	0.74	44.73	24.10	30.43	**Clay loam**
80-110	47.5	0.40	41.10	34.53	34.53	**Clay loam**

b) Chemical analysis

Depth (cm)	pH	EC (dSm^{-1})	Organic Matter (%)	$CaCO_3$ (%)	Cations (meq/L)				Anions (meq/L)			
					Na^+	K^+	Ca^{++}	Mg^{++}	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}
0-28	7.8	4.30	1.13	31.70	23.90	0.70	8.85	6.32	-	4.37	16.67	17.27
28-80	7.9	3.60	0.28	31.70	21.70	0.80	5.95	3.01	-	1.77	15.50	14.00
80-110	7.9	6.10	-	39.30	34.80	0.60	9.42	6.44	-	1.04	22.50	27.72

c) Chemical analysis of irrigation water

PH	EC (DSM^{-1})	SOLUBLE CATIONS (MEQ/L)				SOLUBLE ANIONS (MEQ/L)			
		NA^+	K^+	CA^{++}	MG^{++}	CO_3^{--}	HCO_3^-	CL^-	SO_4^{--}
8.1	4.610	580	27	201	164	-	179.8	783	1050

Treatments were arranged in split plot design with three replicates. Each replicate was divided into four main plots represent mineral nutrition treatments; P, K , Zn and their control and main plot in turn was divided into four sub plots represent bioregulators treatments; TDZ , SA , PP_{333} and their control. The experimental unit area (sub plot) was 9 m^2 (3 x 3 m) with 30 cm apart rows and plants spacing 30 cm. The number of treatments reached 16 treatments as follows:

1. Control
2. TDZ
3. SA
4. PP_{333}
5. P
6. P + TDZ
7. P + SA
8. P + PP_{333}
9. K
10. K + TDZ
11. K+ SA
12. K+ PP_{333}
13. Zn
14. Zn + TDZ
15. Zn + SA
16. Zn+ PP_{333}

Recommended fertilization for this type of soil was applied according to Desert Research Center leaflet (table, 2).

Table (2): Applied fertilization of the experiment

Fertilizer	Rate	Timing
Organic fertilizer	20 m^3/fed	**During manegment**
$Ca(H_2PO_4)_2$	45Kg P_2O_5/fed	**Before sowing**
NH_4NO_3	30-50 Kg N/fed 3 times; at 2 weeks, 4 weeks and 6 weeks after sowing	**After sowing**
K_2SO_4	50Kg K_2O/ fed 3 times with N application	**After sowing**
Microelements	300 L/fed (3 times at 4,6and 8 weeks after sowing)	**After sowing**

Two samples were taken. First sample was taken at 50 days after sowing and the following growth parameters were recorded; plant height, stem diameter on the 10^{th} node from the top, leaves number, plant fresh and dry weights. Chemical analysis was conducted in leaves on the $7\text{-}8^{th}$ nodes from the top for determination of some elements (Na, K, Ca, Mg, P, Zn, Mn and Fe).

The second sample was taken at harvesting time (90 days after sowing) to determine yield components including, head diameter, seeds number/head, seeds weight/ head, 100 seeds weight and the seeds yield (ton/ fed).

Chemical analysis in seeds was conducted to determine fatty acids and oil percentage. Furthermore, identification of different fatty acids under different treatment conditions was also analyzed.

Chemical analysis

1. Mineral concentrations

Plant leaves were oven dried at 75° C for 48 h. The dried materials were ground into fine powder and kept for mineral analysis. Plant materials were exposed to acid digestion using the wet ashing procedure as described by Johanson and Ulrich (1959) to determine Na, K and Ca concentration by flame photometer according to the method of Brown and Lilleland (1964) using Jenway PFP7 flame photometer model.

On the other hand, Mg, Zn, Mn and Fe were estimated using atomic absorption spectrophotometer Pye unicium Sp 1900.

Phosphorus (P) was determined according to Murphy and Riley (1962).

2. Determination of oil percentage

Oil content of seeds extracted using hexane and soxhlet apparatus according to A.O.A.C. (2000).

3. Determination of Fatty acids

3.1. Lipid extraction

The method of A.O.A.C. (2000) was conducted for lipid extraction from sample (3-5g seeds) using chloroform /methanol (2:1, v/v) and soxhlet apparatus to extract the lipids. The associated non-lipids were removed by washing lipid extract three times with CH_3OH: H_2O (1:1v/v). The lipids in chloroform were dried over anhydrous sodium sulfate, and then the solvent was removed by heating at 60 °C under vacuum. Separation and methylation with diazomethane of fatty acids were performed according to Vogel (1975).

A set of standard fatty acids of lauric (12:0), myristic (14:0), palmetic (16:0), stearic (18:0), oleic (18:1), linoleic (18:2) with a stated purity of 99% by GLC was purchased from Nu-check Prop.

3.2. Identification and determination of fatty acids by gas liquid chromatograph (GLC)

The method described by Farag et al (1986) was applied for determination of fatty acids by GLC. The methyl esters of fatty acids of the samples and standard materials were analyzed with a Pye Unicam Series 304 gas chromatograph equipped with dual flame inoization detector and dual channel recorder. The separation of fatty acid methyl esters was conducted using a coiled glass column (1.5 m x 4 mm) packed with Diatomite (100- 120 mesh) and coated with 10 % polyethylene glycol adipate (PEGA) . The column oven temperature was programmed at 8 °C/min from 70 °C to 190 °C, then isothermally at 190 °C for 25 min with nitrogen at 30 ml/min.

Separation Conditions Of Fatty acids

Instrument: Gas Liquid Chromatography/		Injector	250 °C
Pye Unicam Pro-GC		Detector	300 °C
Column: SP- 2300-Fatty acids		Gases flow rate:	
Dimensions: 1.5x 4mm		N_2	30 ml/min.
Temperature Programming		H_2	33 ml/min.
Initial temp.	70 °C	Air	330 ml/min.
Rate	8 °C/min	Chart speed:	0.4 cm/min.
Final temp.	190 °C		
		Final time.	35 C/min

Statistical analysis

The data from all experiments were subjected to statistical analysis of variance and calculated means were separated by Duncan's (1955) multiple range test at 0.05 level, using MSTAT computer statistical software according to Russel (1991).

RESULTS AND DISCUSSION

1. Growth parameters

1.1. Effect of mineral nutrients

The effect of foliar application of P, K and Zn nutrients on growth parameters of sunflower plants was presented in Table (3). Application of P showed significant increase in plant height and stem diameter during the two successive seasons. These results may be due to the essential role of P in cell division and development of meristematic tissues (Russell, 1973). Meanwhile, P treatment did not significantly affect shoot fresh and dry weights in both seasons. Such response was noticed by El- Baisary *et al.* (1981) on cowpea plants grown under calcareous soil.

The maximum mean values of stem diameter (2.20 cm), shoot fresh weight (932.31 g/ plant) and shoot dry weight (105.99 g/plant) was achieved by K compared to untreated plants which recorded 1.81 cm, 683.06 g and 75.83 g respectively in 2003. The same trend was noticed in the second season. This finding is in harmony with that obtained by Aboul- Magd (1999) on tomato plants. The interpretation for this promotive effect of K on sunflower growth is that, K increases the photosynthetic rates, CO_2 assimilation (Sangakkara *et al.*, 2000) and has an important role in the translocation of photosynthates from source to sink (Cakmak *et al.*, 1994). Furthermore, K plays an important role in the osmotic adjustment for plant under saline conditions to maintain the selectivity and integrity of cell membrane (Satti and Lopez, 1994).

Plants treated with Zn showed a significant increase in the previously mentioned growth parameters in both seasons. These results are in confirmation with those obtained by Kishk *et al.* (1985); Cakmak *et al.* (1989) and Adiloglu (2006). These results could be attributed to the role of Zn in the biosynthesis of tryptophan and its conversion to the growth promoter phytohormone; IAA (Cakmak *et al.,* 1989 and Peter, 2001). Mineral nutrients did not significantly affect leaves number in the two seasons.

1.2. Effect of bioregulators

It is clear from Table (4) that soaking sunflower seeds in PP_{333} showed significant increase in shoot fresh and dry weights in both seasons, recording 715.69, 774.63 g fresh weight and 76.54, 93.50 g dry weight compared with control plants (587.38, 670.28 g fresh weight and 66.76, 86.26 g dry weight) in 2003 and 2004 seasons respectively. This increase in fresh weight could be due to the role of PP_{333} in decreasing the rate of water loss caused by stress (Wang and Lin, 1992). Concerning the increment in dry weight, this effect probably referred to the improving nutrient uptake from soil by PP_{333}

application (Kuchenbuch and Jung, 1988) and subsequent improve in plant growth.

Application of PP_{333} decreased plant height. This decrement was significant in season 2003. The same trend was noticed by Rademacher (2000). He concluded that plant growth retardants decreased shoot growth of sorghum in terms of plant height and internodes elongation without any changes in numbers of internodes. Growth retardants considered as anti-gibberellins and reduce plant height by inhibiting GA_3 production which responsible for the cell elongation (Barrett, 2001). Meanwhile, insignificant effects were detected by PP_{333} on stem diameter or leaves number.

Seed soaking in SA significantly depressed plant height and number of leaves of sunflower plants in the first seasons. This depression was insignificant in the second season. Stem diameter, shoot fresh and dry weights were significantly increased during the two seasons.

Many investigators declared the effect of SA as a natural hormone on enhancing growth parameters. Seed soaking with SA at 10 and 20 ppm stimulated fresh and dry weights of mungbean (Zaghlool, 2002), and maize (Aydin *et al*, 2005). Salicylic acid regulates the response of plant to the environmental stresses and could be used as growth regulator to improve plant growth under stress conditions (Aydin *et al.*, 2005 and Afzal *et al.*, 2005). It plays an important role in plant response to abiotic stress by increasing the level of cell division within the apical meristem of seedling roots (Sakhabutdinova *et al.*, 2003). Horváth *et al.*, (2007) found that, preliminary treatment of plants with low concentrations of SA showed acclimatization-like effect, causing enhanced tolerance toward most kinds of abiotic stress.

Table (3): Effect of foliar applications with mineral nutrients on some growth parameters of sunflower plants at 50 days after planting during the seasons of 2003 and 2004.

Minerals	2003					2004				
	Plant height (cm)	Stem Diameter (cm)	Shoot Fresh weight (g)	Shoot Dry weight (g)	No.of leaves / plant	Plant height (cm)	Stem Diameter (cm)	Shoot Fresh weight (g)	Shoot Dry weight (g)	No.of leaves / plant
cont	122.63 b	1.81 d	683.06 c	75.83 c	22.58 a	124.45 c	2.06 c	742.35 b	92.77 b	22.75 a
P	129.04 a	1.93 c	663.88 c	72.74 c	22.75 a	133.29 a	2.25 b	742.97 b	93.36 b	22.75 a
K	125.83 ab	2.20 a	932.31 a	105.99 a	23.9 a	130.54 b	2.54 a	914.59 a	112.59 a	23.17 a
Zn	127.17 a	2.04 b	794.88 b	87.56 b	23.50 a	133.36 a	2.43 ab	885.63 a	109.86 a	23.33 a

Table (4): Effect of seed soaking with bioregulators on some growth parameters of sunflower plants at 50 days after planting during the seasons of 2003 and 2004.

Bioregulators	2003					2004				
	Plant height (cm)	Stem Diameter (cm)	Shoot Fresh weight (g)	Shoot Dry weight (g)	No.of leaves / plant	Plant height (cm)	Stem Diameter (cm)	Shoot Fresh weight (g)	Shoot Dry weight (g)	No.of leaves / plant
cont	131.63 a	1.87 c	587.38 d	66.76 d	23.42 ab	135.82 a	2.15 c	670.28 c	86.28 c	23.25 a
PP_{333}	126.88 b	1.86 c	715.69 c	76.54 c	22.92 bc	133.78 a	2.11 c	774.63 b	93.50 b	22.83 a
SA	128.33 b	2.07 b	841.19 b	93.75 b	22.58 c	134.53 a	2.44 b	929.39 a	114.75 a	22.50 a
TDZ	117.83 c	2.17 a	929.88 a	105.06 a	23.83 a	117.53 b	2.58 a	911.23 a	114.05 a	23.42 a

It is obvious from data in Table (4) that stem diameter, shoots fresh and dry weights were significantly increased by TDZ treatment in both seasons. This promotive effect of TDZ could be attributed to two factors; first, the role of TDZ as a synthetic cytokinin in enhancing plant growth in terms of, cell division chlorophyll biosynthesis. Second, the role of TDZ in reducing the harmful influences of stress upon plants. The later role could be explained by the role of TDZ in reducing ABA levels (Ji and Wang, 1988,) promoting the synthesis of endogenous cytokinins (Thomas and Katterman, 1986) or inhibiting cytokinin oxidase (Beckett and Van Staden, 1992). On contrary, plant height showed a significant reduction in both seasons. This reduction in plant height was also recorded on tomato seedlings treated with TDZ (Aboul- Magd, 1999). Insignificant increase was noticed in leaves number in both seasons.

However, plants treated with TDZ recorded the maximum mean values of stem diameter (2.17 cm), shoot fresh weights (929.88 g) and dry weights (105.06 g) as compared to control pants which recorded 1.87 cm, 587.38 and 66.76 g respectively in season 2003.

1.3. Effect of mineral nutrients, bioregulators and their interactions

Approximately all treatments significantly increased plants height during the seasons of 2003 and 2004 (Table 5) except TDZ treatment and its combination with P or K which gave insignificant reduction. Application of Zn + TDZ and P+SA showed insignificant stimulating effect in the two seasons. The maximum values were obtained from P treatment (144.17cm) followed by P+PP_{333} (135.50 cm) then Zn (132.67 cm) comparing with control plants (120.67cm) in the first season. An increase in stem diameter was noticed by all treatments. This effect was insignificant with P, PP_{333} and their combinations as well as Zn treatment. The superiority was due to K+TDZ and Zn+SA in both seasons.

Regarding the effect of the interactions between mineral nutrients and bioregulators on shoot fresh and dry weight during the seasons of 2003 and 2004, a significant increase was obtained by all treatments except P application which gave insignificant increase in shoot fresh and dry weights in the 1st season. Moreover, K+TDZ treatment showed the maximum significant values recording (1399.00

g fresh weight and 162.75 g dry weight) followed by Zn+SA which recorded 928 g fresh weight and 101.05 g dry weight comparing with control plants which recorded 378.00 g fresh weight and 47.85 g dry weight in the 1st season. The same trend was achieved in the 2nd season with the exception that, the difference between the two applications was not significant in case of fresh weight.

It is obvious that, K and TDZ treatments acted synergistically. So combination treatment (K+TDZ) showed significant increase in fresh and dry weights as compared with the individual application of K or TDZ.

Application of K, K+TDZ and Zn+SA showed the best results for enhancing leaves number recording 26.00, 26.00 and 24.67 leaves /plant, respectively comparing with control plants which recorded 21.00 leaves/plant in season 2003. In the season of 2004, the values were 25, 24.33, 24.33 leaves/plant compared to control plants (21.67 leaves/plant).

It is obvious from Table (5) that the highest values of stem diameter during the two seasons could be achieved by descending orders of K+TDZ, Zn+SA and K treatments.

Table (5): Effect of mineral nutrients / bioregulator interactions on some growth parameters of sunflower plants at 50 days after planting during the seasons of 2003 and 2004

		2003					2004				
Minerals	Bioregulators	Plant height (cm)	Stem Diameter (cm)	Shoot Fresh weight (g)	Shoot Dry weight (g)	No.of leaves / plant	Plant height (cm)	Stem Diameter (cm)	Shoot Fresh weight (g)	Shoot Dry weight (g)	No.of leaves / plant
cont	cont	120.67 gh	1.65 h	378.00 g	47.85 f	21.00 fg	120.93 g	1.83 g	430.50 j	58.70 h	21.67 de
	PP_{333}	125.67 d-g	1.67 h	750.75 c-e	78.90 de	22.33 d-f	129.93 de	1.85 g	808.03 fg	96.90 ef	22.00 c-e
	SA	129.17 b-e	1.88 e-g	799.50 b-d	85.00 cd	23.67 b-d	136.43 cd	2.21 d-f	852.37 d-f	104.77 de	23.67 a-d
	TDZ	115.00 h	2.02 de	804.00 b-d	91.55 bc	23.33 b-d	110.50 h	2.34 cd	878.50 de	110.70 cd	23.67 a-d
P	cont	144.17 a	1.81 f-h	438.00 g	51.70 f	22.67 c-e	148.17 a	2.06 e-g	561.00 i	75.10g	22.33 b-d
	PP_{333}	135.50 b	1.69 h	736.25 c-e	76.40 de	24.00 bc	146.67 ab	1.95 g	754.70 gh	93.93 f	24.00 a-c
	SA	120.83 gh	2.11 cd	807.75 b-d	93.15 bc	21.33 e-g	121.67 g	2.48 bc	903.93 cd	111.97 cd	22.00 c-e
	TDZ	115.67 h	2.11 cd	673.50 d-f	69.70 e	23.00 cd	116.67 gh	2.51 bc	752.23 gh	92.43 f	22.67 b-d
K	cont	129.00 c-f	2.22 bc	912.00 b	97.15 b	26.00 a	133.00 de	2.68 ab	984.90 ab	118.50 c	25.00 a
	PP333	122.67 fg	2.11 cd	588.75 f	68.25 e	23.00 cd	129.00 ef	2.38 cd	695.63 h	78.90 g	23.33 a-d
	SA	132.33 bc	2.01de	829.50 bc	95.80 b	20.667 g	140.17bc	2.31 cd	943.60bc	114.87 c	20.00 e
	TDZ	119.33gh	2.44 a	1399.00 a	162.75 a	26.00 a	120.00 g	2.81 a	1034.23 a	138.10 a	24.33 ab
Zn	cont	132.67 bc	1.78 gh	621.50 ef	70.35 e	24.00 bc	141.17 bc	2.03 fg	704.70 h	92.80 f	24.00 a-c
	PP_{333}	123.67 e-g	1.99 d-f	787.00b-d	82.60 cd	22.33 d-f	129.50 ef	2.28 c-e	840.17 ef	104.27 de	22.00 c-e
	SA	131.00 b-d	2.29 ab	928.00 d	101.05 b	24.67 ab	139.83 c	2.78 a	1017.67 a	127.40 b	24.33 a-b
	TDZ	121.33 gh	2.12 b-d	843.00 bc	96.25 b	23.00 cd	122.93 fg	2.66 ab	979.97 ab	114.97 c	23.00 a-d

2. Yield and yield component

2.1. Effect of mineral nutrients

Data in Table (6) showed that, all foliar applications of mineral nutrients increased head diameter, number of seeds/ head, seeds weight/ head, 100 seeds weight and seeds yield during the seasons of 2003 and 2004 with the exception of P treatment, which insignificantly decreased head diameter in the 1st season, but increased other yield parameters. The positive effect of P upon oilseed crops was mentioned by, Cheema *et al.* (2001) and Sawan *et al.* (2006).

Phosphorus has a key role in reactions in which energy is involved. The biosynthesis of fats, oils and related molecules requires a correspondingly large investment of metabolic energy (Taiz and Zeiger, 1998). This explains the enhancement in oil seeds production by P application.

Concerning the effect of K application, it is obvious from data in Table (6) that K significantly enhanced all yield parameters in both seasons except head diameter which showed insignificant increase in the first season. These results confirmed the findings of Salama (1987) and Mekki *et al.* (1999) on sunflower plants.

However, K is required as cofactor for many enzymes involved in respiration and photosynthesis. Thus, an enhancement in carbon fixation and energy production would gain by K application which positively affect oil seed yield.

Plants applied with Zn showed significant increase in head diameter, number of seeds, seeds weight/ head, 100 seeds weight and seeds yield during the seasons of 2003 and 2004. These results were in agreement with Hegazy (2004) on sunflower and Sawan *et al.* (2006) on seeds yield of Egyptian cotton.

The superiority was due to foliar application with Zn in all the studied yield parameters recording 21.25 and 26.46 cm head diameter, 1219.00 and 1404.00 seeds/ head, 115.76 and 113.22 g seeds / head, 9.30 and 8.83 g/100 seeds and 1678.50 and 1641.67 kg seeds / fed during the seasons of 2003 and 2004 respectively. Bid *et al.* (1993) pointed out that application of $ZnSO_4$ significantly increased yield of *solanum melongena* in calcareous soils. Insignificant differences were noticed between Zn and K treatments with seeds number in both seasons and 100 seeds weight in the 1st season as well as, seeds weight/ head and seeds yield in the 2nd season.

2.2. Effect of bioregulators

As shown in Table (7), it is obvious that seed soaking in all bioregulators significantly enhanced seeds number/head, seeds weight/ head, 100 seeds weight and seeds yield in both seasons with the exception that, the increment in head diameter of plants treated with PP_{333}, didn't reach the 5% level of significance in both seasons. Seed soaking in SA gave the highest mean values for seed number/head as well as seeds weight/ head and seeds yield which recorded 1201.83 seeds/ head, 107.83 g seeds/head and 1563.55 kg/fed in the 1^{st} season comparing with control plants (876.83 seeds/ head, 78.08 g seeds/head and 1132.15 kg/fed). On the other hand, TDZ surpassed all treatment in head diameter and 100 seeds weight recording 21.21 cm and 8.92 g respectively in the 1^{st} season comparing with control plants (18.79 cm and 7.73 g).

However, insignificant differences were noticed between SA and TDZ treatments regarding seeds number and 100 seeds weight. The enhancing effects of growth retardants on seeds yield were obtained on barley by Khafagi *et al* (1984) and on garden pea by Bisen et al (1999) who mentioned that, seeds soaking treatment in CCC increased yield as compared with foliar spray. The positive response of TDZ could be due to the increase in cytokinin activity by inhibiting cytokinin oxidase. Consequently, the plant could avoid the harmful surrounding conditions in the early stage of growth which supposed to be the most sensitive stage to stress. The improvement of plant growth either by TDZ or SA reflected latter on plant yield.

Table (6): Effect of foliar applications with mineral nutrients on yield and yield components of sunflower plants at 90 days after planting during the of 2003 and 2004.

Minerals	2003 Head diameter (cm)	2003 No.of seeds /head	2003 Seeds weight /head(g)	2003 100 Seeds weight (g)	2003 Seeds yield (Kg/fed)	2004 Head diameter (cm)	2004 No.of seeds /head	2004 Seeds weight /head(g)	2004 100 Seeds weight (g)	2004 Seeds yield (Kg/fed)
cont	19.00 bc	867.75 c	66.01 d	7.17 b	957.08 d	21.88 c	1010.92 c	65.50 c	6.10 d	949.52 c
P	18.88 c	1017.92 b	86.24 c	7.89 b	1250.46 c	22.29 bc	1203.58 b	90.22 b	6.30 c	1308.29 b
K	20.04 b	1191.25 a	107.91 b	9.20 a	1564.72 b	23.54 b	1381.75 a	106.64 a	8.27 b	1546.89 a
Zn	21.25 a	1219.00 a	115.76 a	9.30 a	1678.50 a	26.46 a	1404.00 a	113.22 a	8.83 a	1641.67 a

Table (7): Effect of seed soaking with bioregulators on yield and yield components of sunflower plants at 90 days after planting during the seasons of 2003 and 2004.

Bioregulators	2003 Head diameter (cm)	2003 No.of seeds /head	2003 Seeds weight /head(g)	2003 100 Seeds weight (g)	2003 Seeds yield (Kg/fed)	2004 Head diameter (cm)	2004 No.of seeds /head	2004 Seeds weight /head(g)	2004 100 Seeds weight (g)	2004 Seeds yield (Kg/fed)
cont	18.79 c	876.83 c	78.08 d	7.73 c	1132.15 d	22.13 c	1011.50 c	80.33 d	6.61 c	1164.63 d
PP_{333}	19.21 bc	1037.50 b	91.07 c	8.21 b	1320.53 c	22.29 c	1249.75 b	90.36 c	7.38 b	1310.26 c
SA	19.96 b	1201.83 a	107.83 a	8.71 a	1563.55 a	23.92 b	1382.17 a	104.81 a	7.93 a	1520.34 a
TDZ	21.21 a	1179.75 a	98.93 b	8.92 a	1434.53 b	25.83 a	1356.83 a	100.08 b	8.20 a	1451.14 b

2.3. Effect of mineral nutrients, bioregulators and their interactions

Results presented in Table (8) showed the effect of mineral nutrition and bioregulators interactions. Seeds number/head, seeds weight/head and seeds yield were significantly increased by individual treatments and their interactions during the two seasons with an exception that the increment in seeds yield of plants treated with PP_{333} was insignificant in 2003 season. Concerning head diameter, an increment was noticed by all treatments, comparing with control plants, except P application which insignificantly decreased head diameter in both seasons. Moreover, the values of head diameter of plants applied with PP_{333} and K didn't reach the level of significance in the two seasons. Insignificant increase in 100 seeds weight was obtained by TDZ, P and its interaction with PP_{333}. Other treatments significantly increased 100 seeds weight except PP_{333} which insignificantly decreased it. Yield and yield components reached the highest values of seeds number, seeds weight/head and seeds yield by the application of Zn+SA recording 1447.00 and 1550.67 seeds no. /head, 129.85 and 125.62 g seeds/ head and 1882.78 and 1821.54 kg/ fed during the seasons of 2003 and 2004 respectively comparing with control plants which recorded 672.67 and 677.67 seeds no./ head, 51.30 and 52.97 g seed/ head and 743.80 and 767.20 kg/ fed, followed by K+TDZ treatment. Anyhow, insignificant differences were found between the two applications. Heads diameter and 100 seeds weight achieved their maximum values by K+TDZ and Zn+SA treatments. These results were in agreement with Aboul- Magd (1999) who found that application of KCl with TDZ significantly increased the fruits yield /fed of tomato irrigated with saline water.

3. Chemical analysis

3.1. Mineral elements

3.1.1. Effect of mineral nutrients

Data presented in Table (9) showed that foliar applications of K and Zn significantly decreased Na content and increased K, K/Na, Ca and P with an exception that the increment of Ca concentration in plants treated with Zn didn't reach the 5% level of significance during the two seasons. These results were in agreement with Wu *et al.* (1999) who revealed that K and trace elements application increased P concentration in soybean.

Table (8): Effect of mineral nutrients / bioregulator interactions on yield and yield components of sunflower plants at 90 days after planting during tl seasons of 2003 and 2004.

Minerals	Bioregulators	2003 Head diameter (cm)	2003 No.of seeds / head	2003 Seeds weight (g/head)	2003 100 Seeds weight (g)	2003 Seeds yield (Kg/fed)	2004 Head diameter (cm)	2004 No.of seeds / head	2004 Seeds weight (g/head)	2004 100 Seeds weight (g)	2004 Seeds yield (Kg/fed)
cont	cont	17.83 gh	672.67 j	51.30 j	7.07 h	743.80 j	20.17 i	677.67 l	52.97 i	5.67 i	767.20 i
	PP_{333}	18.33 f-h	879.67 h	63.15 i	6.87 h	915.68 ij	20.67 g-i	1074.00 j	62.15 h	5.62 i	901.18 h
	SA	19.67 d-f	944.00 gh	84.61 fg	7.64 fg	1226.80 fg	22.50 ef	1121.00 ij	82.45 fg	6.86 f-h	1195.48 fg
	TDZ	20.17 c-e	974.67 fg	64.97 i	7.12 gh	942.02 hi	24.17 cd	1171.00 hi	64.43 h	6.23 hi	934.24 h
P	cont	17.00 h	767.67 i	67.07 hi	7.26 gh	972.47 hi	20.00 i	859.67 k	76.57 g	6.26 hi	1110.27 g
	PP_{333}	18.67 e-g	979.67 fg	76.63 gh	7.33 gh	1111.14 gh	21.83 fg	1178.00 hi	82.37 fg	6.72 gh	1194.41 fg
	SA	18.33 f-h	1245.67 b	105.80 de	8.27 de	1534.05c-e	21.67 f-h	1483.00 bc	102.55 cd	7.03 e-g	1486.93 cd
	TDZ	21.50 a-c	1078.67 de	95.46 ef	8.73 cd	1384.17 ef	25.67 b	1293.67 f	99.41 de	7.71 de	1441.54 de
K	cont	18.33f-h	1058.00 d-f	89.91 f	7.94 ef	1303.65 f	20.33 hi	1282.67 fg	91.04 ef	6.90 f-h	1320.13 ef
	PP_{333}	19.50 d-f	1113.67 cd	107.24 cd	9.10 bc	1554.93 c-e	22.17 ef	1349.33 ef	103.38 cd	7.94 d	1499.01 cd
	SA	19.67 d-f	1170.67 bc	111.07 cd	9.38 b	1610.57b-d	23.50 de	1374.00 e	108.61 bc	8.32 cd	1577.41 bc
	TDZ	22.67 a	1422.67 a	123.43 ab	10.40 a	1789.74 ab	28.17 a	1521.00 ab	123.52 a	9.92 a	1790.99 a
Zn	cont	22.00 ab	1009.00 e-g	104.05 de	8.68 cd	1508.68 de	28.00 a	1226.00 gh	100.75 cd	7.61 d-f	1460.93 cd
	PP_{333}	20.33 cd	1177.00 bc	117.27 bc	9.54 b	1700.37 bc	24.50 b-d	1397.67 de	113.55 b	9.24 ab	1646.43 b
	SA	22.17 a	1447.00 a	129.85 a	9.56 b	1882.78 a	28.00 a	1550.67 a	125.62 a	9.51 ab	1821.54 a
	TDZ	20.50 b-d	1243.00 b	111.87 cd	9.43 b	1622.17 b-d	25.33 bc	1441.67 cd	112.95 b	8.95 bc	1637.78 b

Table (9): Effect of foliar applications with mineral nutrients on mineral element concentrations in leaves (7,8) of sunflow 50 days after planting during the seasons of 2003 and 2004.

Minerals	Na (mg/g dw)	K (mg/g dw)	Ca (mg/g dw)	K/Na ratio	Mg (mg/g dw)	P (mg/100g dw)	Zn (mg/100g dw)	Mn (mg/100g dw)	Fe (mg/100g dw)
					2003				
cont	18.43 a	44.40 c	79.20 c	2.45 b	3.48 a	0.28 d	1.16 c	5.08 c	89.50 b
P	18.11 a	44.99 bc	83.86 a	2.50 b	3.56 a	0.48 a	1.24 b	4.81 c	76.34 c
K	16.11 b	47.08 a	82.94 b	3.02 a	3.73 a	0.40 b	1.55 a	7.10 b	119.62 a
Zn	16.36 b	46.92 ab	81.30 bc	2.93 a	3.78 a	0.36 c	1.54 a	7.98 a	121.76 a
					2004				
cont	15.79 a	46.50 b	66.59 c	3.02 c	3.50 b	0.217 d	0.608 b	5.433 b	92.487 b
P	16.19 a	45.49 b	72.61 a	2.86 d	3.47 b	0.446 a	0.658 b	5.295 b	82.903 c
K	13.94 b	54.58 a	69.20 b	4.08 a	3.62 a	0.394 b	1.081 a	5.948 ab	108.948 a
Zn	14.42 b	52.19 a	67.49 c	3.72 b	3.63 a	0.333 c	1.060 a	6.183 a	115.428 a

Insignificant increments in Mg concentration were noticed by all treatments in the season of 2003; this effect was significant by K and Zn applications in season 2004. Also, an increase in Mg concentration of Sudan grass plants was mentioned by Kishk *et al.* (1985) as a result of Zn application under calcareous soil (30%$CaCO_3$) with salinity.

Application of P showed an increase in Ca and P concentrations but did not significantly affect Na, K and Mg concentrations. These effects were noticed in both seasons.

Trace elements; Zn, Mn and Fe were significantly increased by K and Zn applications in both seasons, while application of P insignificantly reduced Mn in both seasons and showed significant reduction in Fe concentration in both seasons as well as significant increase in Zn in the 1st one. Many investigators achieved similar results. Sakr *et al.* (1990) and Hegazy (2004) mentioned that, P application decreased Mn and Fe concentrations and increased the concentration and uptake of Zn in sunflower plants grown under calcareous soil.

The highest values recorded for K and K/ Na (47.08 mg/g dry weight and 3.02) were achieved by K foliar application in the season of 2003 followed by Zn treatment. Moreover P treatment gave the maximum mean values of Ca and P concentration recording (88.86

mg/ g dry weight and 0.48 mg/ 100 g dry weight) followed by K then Zn treatments. On the other hand, the lowest mean values of Na concentration (16.11 and 13.94 mg/g dry weight) comparing with the control plants (18.43 and 15.79 mg/g dry weigh) were gained by K treatment in the seasons of 2003 and 2004 respectively. This finding was in harmony with Ozoris *et al.* (1985) who reported that the concentration of K^{+} and Mg^{+2} in sorghum plants were increased by application of Zn under calcareous soil and saline conditions. The role of K in the osmotic adjustment of plants under saline conditions and consequently its importance of being required to the selectivity and integrity of cell membrane was explained by (Satti and Lopez, 1994).

The highest concentration of Zn (1.55 mg/100 g dry weight) was observed by K treatment followed by Zn treatment .Meanwhile, Zn application gave the maximum values of Mn and Fe (7.98 and 121.76 mg/100 g dry weight) respectively in the season of 2003 followed by K foliar application. The same trend was true in 2004 season. Regarding foliar application of Zn, Liu *et al.* (1992) reported that Zn, Mn and Fe concentrations and uptake were increased in sorghum and rape plants.

3.1.2. Effect of bioregulators

Presoaking treatments of SA and TDZ significantly decreased Na concentrations (Table, 10). Seed soaking in PP_{333} significantly decreased P concentration in both seasons. Concerning the effect of SA and TDZ on other elements, significant increase in K, K /Na, Ca, Mg and P concentrations was noticed in both seasons. The highest mean values were observed by SA application on K concentration (47.25 mg/g dry weight), Ca (89.31 mg/g dry weight), K/Na ratio (3.00) and Mg (3.83 mg/g dry weight) followed by TDZ treatment with insignificant differences in season 2003. Improving minerals uptake by SA and TDZ treatments was mentioned by Stark (1993) and Iqbal and Ashraf (2005) who mentioned that cytokinins modified the uptake and distribution of Na and K which improved the osmotic adjustment and stabilized the leaf turgor of cotton plants grown under salinity stress. Aydin *et al.* (2005) reported that salicylic acid pretreatment as seed soaking increased K, Mg and P and reduced the accumulation of Na^{+} under either salt or drought stress conditions. These results suggest the possibility of SA to be used as a potential growth regulator to improve plant resistance to salinity stress.

Application of SA and TDZ showed significant increase in Zn, Mn and Fe. Meanwhile, PP_{333} enhanced Mn and Fe concentrations but the significant effect was achieved with Mn in the 1st season and with Fe in the 2nd one. This promotion in Zn, Mn and Fe obtained by SA and TDZ was in agreement with Aydin *et al.* (2005). Whereas, PP_{333} results were confirmed with Yelenosky (1995) who mentioned that, PP_{333} showed higher concentration of Fe and Mn.

The promotion of growth and yield was concomitant with lower Na^{+} content as well as higher K content and K/Na ratio which achieved by SA and TDZ treatments in the successive seasons.

Table (10): Effect of seed soaking with bioregulators on mineral elements concentrations of sunflower plants at 50 days after planting during the seasons of 2003 and 2004.

Bioregulators	Na (mg/g dw)	K (mg/g dw)	Ca (mg/g dw)	K/Na ratio	Mg (mg/g dw)	P (mg/100g dw)	Zn (mg/100g dw)	Mn (mg/100g dw)	Fe (mg/100g dw)
					2003				
cont	18.44 a	44.66 b	80.45 c	2.51 b	3.43 c	0.34 c	1.16 c	5.07 c	82.20 c
PP_{333}	18.27 a	44.57 b	78.90 c	2.46 b	3.59 bc	0.28 d	1.18 c	5.82 b	87.87 c
SA	15.95 b	47.25 a	89.31 a	3.00 a	3.83 a	0.43 b	1.65 a	7.27 a	127.95 a
TDZ	16.35 b	46.91 a	83.63 b	2.93 a	3.70 ab	0.46 a	1.49 b	6.83 a	109.21 b
					2004				
cont	16.43 a	46.06 b	67.16 c	2.94 b	3.46 b	0.30 c	0.60 b	5.28 b	79.54 d
PP_{333}	15.95 a	46.33 b	68.06 c	2.96 b	3.47 b	0.22 d	0.59 b	5.69 ab	93.57 c
SA	13.87 b	53.20 a	71.13 a	3.88 a	3.68 a	0.40 b	1.14 a	6.09 a	121.87 a
TDZ	14.10 b	53.17 a	69.54 b	3.90 a	3.61 a	0.47 a	1.09 a	5.80 a	104.79 b

3.1.3. Effect of mineral nutrients, bioregulators and their interactions

As shown in Tables (11,12), application of mineral nutrients, bioregulators and their interactions showed an inhibitory effect on Na content which recorded higher values in control plants grown under calcareous saline soil in the two seasons . The reverse was true by other determined elements with the following exceptions; PP_{333} insignificantly inhibited P concentration in both seasons. Individual application of SA decreased Ca content in the 2nd seasons. Application of Zn+SA as well as K+TDZ gave the best results in terms of the lowest values of Na (14.43 and 14.43mg/g dry weight) and the highest values of K (49.51 and 49.17mg/g dry weight), K/Na (3.46 and 3.45mg/g dry weight), Mg (4.06 and 3.87mg/g dry weight), Zn (1.79and 1.83mg/100g dry weight), Mn (10.73and 9.00mg/100g dry weight) and Fe (204.75and 143.83mg/100g dry weight) in the 1st season respectively. Application of P + SA gave the maximum values of Ca concentration.

These results could be attributed to the role of K in the osmotic adjustment and maintaining the selectivity and integrity of cell membrane (Satti and Lopez, 1994).

Adyin *et al.* (2005) reported that SA has a diminishing effect on Na concentration and has a promotive effect on K, Mg, P, Zn, Mn and Fe content.

3.2. Oil percentage and oil yield

3.2.1. Effect of mineral nutrients

Data in Table (13) clearly demonstrate that, all mineral applications significantly increased oil % and yield in both seasons with exception of K in the first season where insignificant increase in oil % was recorded. Application of Zn recorded the highest mean values of oil % (39.77, 39.94%) and oil yield (668.13 and 656.52 Kg/fed) comparing with control plants which recorded 34.31, 34.76 oil% and 324.95, 326.24 Kg/fed oil yield in both seasons respectively.

3.2.2. Effect of bioregulators

As shown in Table (14), seed soaking in bioregulators induced reduction in oil%. This effect was significant by PP_{333} and SA in both seasons and by TDZ in the second season. On contrary an increase was noticed in oil yield. This effect was significant by SA and TDZ in both seasons.

Table (11): Effect of mineral nutrients / bioregulator interactions on mineral elements concentrations of sunflower plants at 50 days after planting during the season of 2003 .

Minerals	Bioregulators	2003								
		Na (mg/g dw)	K (mg/g dw)	Ca (mg/g dw)	K/Na ratio	Mg (mg/g dw)	P (mg/100g dw)	Zn (mg/100g dw)	Mn (mg/100g dw)	Fe (mg/100g dw)
cont	cont	21.80 a	41.48 f	59.99 i	1.90 g	2.85 e	0.23 h	0.63 g	3.20 i	57.29 h
	PP_{333}	17.63 c-e	44.82 de	87.26 c	2.55 d-f	3.65 b-d	0.20 h	1.08 f	4.73 gh	93.00 de
	SA	17.31 c-f	45.49 cd	67.27 h	2.63 c-e	3.71 a-d	0.33 ef	1.50 b-d	5.80 e-g	94.75 de
	TDZ	16.99 c-f	45.83 cd	102.27 b	2.70c-e	3.72 a-d	0.37 de	1.45 c-e	6.60 d-f	112.96 c
P	cont	19.23 bc	44.16 de	73.63 fg	2.30 e-g	3.41 d	0.41 d	1.13 f	4.13 hi	63.33 gh
	PP_{333}	17.63 c-e	44.49 de	77.72 ef	2.53 d-f	3.64 b-d	0.39 d	1.22 ef	5.60 fg	84.38 d-f
	SA	16.67 d-g	46.83 bc	118.63 a	2.82 b-d	3.73 a-d	0.55 a	1.68 a-d	5.60 fg	95.58 d
	TDZ	18.91 b-d	44.49 de	85.45 cd	2.35 e-g	3.49 cd	0.55 a	0.95 f	3.93 hi	62.08 gh
K	cont	14.43 g	48.51 ab	104.09 b	3.38 a	3.75 a-d	0.47 bc	1.70 a-c	7.73 b-d	134.33 b
	PP_{333}	20.19 ab	43.49 e	69.50 gh	2.15 fg	3.46 d	0.25 gh	1.03 f	4.73 gh	83.58 ef
	SA	15.39 e-g	47.17 bc	84.54 cd	3.08 a-c	3.83 a-c	0.37 ge	1.65 a-d	6.93 c-e	116.71 c
	TDZ	14.43 g	49.17 a	73.63 fg	3.45 a	3.87 ab	0.50 ab	1.83 a	9.00 b	143.83 b
Zn	cont	18.32 b-d	44.49 de	84.09 cd	2.46 d-f	3.70 a-d	0.25 gh	1.19 ef	5.20 gh	73.83 fg
	PP_{333}	17.63 c-e	45.49cd	81.13 de	2.59 d-f	3.64 b-d	0.28 fg	1.42 de	8.20 bc	90.50 de
	SA	14.43 g	49.51 a	86.81 c	3.46 a	4.06 a	0.48 b	1.79 a	10.73 a	204.75 a
	TDZ	15.07 fg	48.17 ab	73.18 fg	3.23 ab	3.74 a-d	0.42 cd	1.75 ab	7.80 b-d	117.96 c

Table (12): Effect of mineral nutrients / bioregulator interactions on mineral elements concentrations of sunflower plants at 50 days after planting during the season of 2004 .

Minerals	Bioregulators	Na (mg/g dw)	K (mg/g dw)	Ca (mg/g dw)	K/Na ratio	Mg (mg/g dw)	P (mg/100g dw)	Zn (mg/100g dw)	Mn (mg/100g dw)	Fe (mg/100g dw)
		2004								
cont	cont	18.59 a	40.14 g	55.91 h	2.16 j	3.22 e	0.19 g	0.10 i	4.37 d	55.20 i
	PP333	15.39 b-e	48.17 de	77.27 c	3.18 e-h	3.54 bc	0.18 g	0.54 gh	5.47 bc	102.63 de
	SA	15.07 b-e	48.50 de	50.91 i	3.25 e-h	3.62 ab	0.23 e-g	0.90 de	5.98 ab	103.94 d
	TDZ	14.19 c-f	49.17 de	82.27 b	3.49 d-g	3.64 ab	0.26 d-f	0.89 de	5.93 ab	108.17 cd
P	cont	18.27 a	42.15 fg	60.91 g	2.31 ij	3.31de	0.29 d	0.49 gh	4.97 cd	62.75 i
	PP333	16.03 a-d	46.50 ef	68.63 e	2.91 f-i	3.52 bc	0.28 de	0.63 fg	5.65 bc	90.43 fg
	SA	13.78 d-f	49.17 de	85.90 a	3.57 d-f	3.65 ab	0.60 a	1.09 bc	5.72 bc	105.87 cd
	TDZ	16.67 a-c	44.16 e-g	75.00 c	2.66 h-j	3.42 cd	0.62 a	0.43 h	4.85 cd	72.57 h
K	cont	12.82 ef	57.78 bc	82.72 b	4.51 bc	3.69 ab	0.52 b	1.18 b	6.14 ab	112.33 c
	PP333	17.31 ab	42.49 fg	58.18 h	2.46 ij	3.32 de	0.20 g	0.43 h	5.40 bc	85.00 g
	SA	13.78 d-f	53.22 cd	72.27 d	3.87 c-e	3.72 a	0.27 d-f	0.97 cd	6.00 ab	109.18 cd
	TDZ	11.86 f	64.53 a	63.63 f	5.49 a	3.74 a	0.59 a	1.75 a	6.25 ab	128.29 b
Zn	cont	16.03 a-d	44.16 e-g	69.09 e	2.79 g-j	3.61 ab	0.20 g	0.63 fg	5.64 bc	87.88 fg
	PP333	15.07 b-e	48.18 de	68.18 e	3.28 d-h	3.52 bc	0.22 fg	0.74 ef	6.24 ab	95.22 ef
	SA	12.82 ef	61.91 ab	75.45 c	4.83 ab	3.74 a	0.52 b	1.60 a	6.65 a	168.49 a
	TDZ	13.78 d-f	54.53 c	57.27 h	3.97 cd	3.66 ab	0.40 c	1.28 b	6.20 ab	110.13 cd

Table (13): Effect of foliar applications with mineral nutrients on oil % and oil yeild (Kg/fed) of sunflower plants at 90 days after planting during the seasons of 2003 and 2004.

Minerals	2003 % Oil	2003 Oil yield (Kg/fed)	2004 % Oil	2004 Oil yield (Kg/fed)
cont	34.31 b	324.95 d	34.76 d	326.24 d
P	39.14 a	486.35 c	38.93 b	507.22 c
K	35.13 b	549.33 b	35.79 c	554.12 b
Zn	39.77 a	668.13 a	39.94 a	656.52 a

Table(14): Effect of seed soaking with bioregulators on oil% and oil yeild (Kg/fed) of sunflowe plants at 90 days after planting during the seasons of 2003 and 2004.

Bioregulators	2003 % Oil	2003 Oil yield (Kg/fed)	2004 % Oil	2004 Oil yield (Kg/fed)
cont	38.68 a	435.62 b	39.39 a	458.61 b
PP333	35.38 b	466.09 b	35.90 c	470.58 b
SA	36.39 b	574.82 a	36.83 bc	566.12 a
TDZ	37.91 a	552.24 a	37.29 b	548.78 a

3.2.3. Effect of mineral nutrients, bioregulators and their interactions on oil % and oil yield

Data in Table (15) showed that oil percentage of sunflower seeds cv. Vidoc under the experimental conditions is 35.50 and 36.40% in 2003 and 2004 respectively.

The maximum values of oil % were due to foliar application of P (45.41%) followed by Zn+TDZ and P+SA then Zn+SA or PP_{333} comparing with untreated plants in both seasons. The lowest values of oil % comparing with control plants were recorded by SA and K+PP_{333}. It could be seen that, Zn acted synergistically with bioregulators as its combination with PP_{333}, SA and TDZ showed higher values compared with individual applications of Zn.

Oil yield was significantly increased by application of the studied treatments with the exception of TDZ in the two seasons. The superiority was due to Zn+SA followed by Zn+TDZ then K+TDZ which recorded 745.02, 708.75and 702.70% in the first season respectively.

Table (15): Effect of mineral nutrients / bioregulator interactions on oil% and oil yeild (Kg/fed) of sunflower plants at 90 days after planting during the seasons of 2003 and 2004.

		2003		2004	
Minerals	Bioregulators	% Oil	Oil yield (Kg/fed)	% Oil	Oil yield (Kg/fed)
cont	cont	35.50 e-g	264.02 j	36.40 e-g	278.50 h
	PP_{333}	36.58 ef	335.21 hi	37.60 de	339.00 g
	SA	30.67 h	375.87 hi	30.75 j	367.40 fg
	TDZ	34.48 fg	324.69 ij	34.27 gh	320.04 gh
P	cont	45.38 a	441.20 fg	45.32 a	502.40 cd
	PP_{333}	35.50 e-g	394.21 gh	34.52 gh	413.39 ef
	SA	41.50 bc	636.95 c	42.38 b	630.72 b
	TDZ	34.17 g	473.05 f	33.48 hi	482.36 d
K	cont	37.25 de	485.24 ef	38.67 c-e	510.47 cd
	PP_{333}	30.12 h	468.18 f	31.10 ij	466.11 de
	SA	33.83 g	541.44 de	34.65 f-h	546.44 c
	TDZ	39.33 cd	702.47 ab	38.72 c-e	693.45 a
Zn	cont	36.59 ef	552.02 d	37.18 d-f	543.08 c
	PP_{333}	39.3 cd	666.74 bc	40.33 bc	663.82 ab
	SA	39.57 c	745.02 a	39.52 cd	719.92 a
	TDZ	43.64 ab	708.75 ab	42.72 b	699.26 a

The promotive effects of spraying plants with P and Zn in increasing oil % were achieved also by Sawan et al. (2006) on cotton plants. This may be attributed to the requirement of P for production of high quality seeds, since it involved in energy transfer reactions; energy is trapped in photosynthesis in form of ATP and NADP. This energy is then used in photosynthetic fixation of CO_2 and the synthesis of lipids and other essential organic compounds (Taiz and Zeiger, 1998). These results were found to be agreeing with those obtained by Rajendran and Veeraputhiran (2001) on sunflower.

3.3. Effect of mineral nutrients, bioregulators and their interactions on fatty acids composition.

As shown in Table (16), the most 4 common fatty acids in sunflower oil are the saturated fatty acids; palmitic (16:0) and stearic (18:0) and the unsaturated fatty acids; oleic (18:1) and linoleic (18:2). Also, low percentage of lauric and myristic acids were observed in sunflower oil comparing with other fatty acids.

Myristic acid was not detected by K+TDZ application, while the rest of treatments increased it. Lauric acid showed a variable trend. Concerning palmitic acid %, an increment was observed by foliar applications of P, K and Zn. The highest values of palmitic acid were due to TDZ followed by K then K+SA and Zn respectively. Stearic acid was depressed by all treatments except K, P+SA and P+TDZ.

Considering total saturated fatty acids %, an enhancement was showed by application of TDZ, P, P+PP_{333}, K and K+ PP_{333} or SA. Oleic acid was increased by all treatments. Results of linoleic acid % showed an opposite trend to those of oleic acid %. The effect of treatments on oleic/linoleic ratio showed the same trend of oleic acid %. All the studied applications, except P+PP_{333}, enhanced unsaturated fatty acids % (oleic % + linoleic %). In addition, unsaturated/saturated fatty acids ratio was reduced by TDZ, P, K, P+ PP333 and K+SA. This ratio was enhanced by other treatments. The highest values of unsaturated/saturated fatty acids ratio were obtained by Zn+SA and K+TDZ treatments. The marked increase in oleic acid %(65.63 %) noticed by TDZ was in agreement with that obtained by Ahmed *et al.* (1988).

Table (16): Effect of mineral nutrients (as foliar application) and bioregulators (as seed soaking) and their combinations on fatty acids (%) of sunflower seeds at 90 days after planting.

Minerals	Bioregulators	lauric (C12:0)	myristic (C14:0)	palmetic(C16:0)	stearic(C18:0)	oleic(C18:1)	linoleic(C18:2)	Saturated fatty acids	Unsaturated fatty acids	unsat / sat ratio	oleic / lenoleic
cont	cont	0.21	0.08	4.60	4.00	44.89	43.34	8.89	88.23	9.92	1.04
	PP_{333}	0.09	0.20	4.51	3.46	48.98	40.52	8.26	89.50	10.83	1.21
	SA	0.26	0.20	4.10	3.40	59.43	31.35	7.96	90.78	11.41	1.90
	TDZ	0.10	0.24	5.83	3.00	65.63	24.20	9.16	89.83	9.80	2.71
P	cont	0.35	0.45	4.82	3.92	64.07	24.84	9.55	88.91	9.31	2.58
	PP_{333}	0.20	0.66	4.95	3.30	55.17	33.00	9.11	88.17	9.68	1.67
	SA	0.05	0.16	4.13	4.12	60.45	28.94	8.47	89.39	10.56	2.09
	TDZ	0.02	0.64	3.60	4.60	64.78	24.34	8.86	89.12	10.06	2.66
K	cont	0.00	0.15	5.64	4.26	60.04	29.14	10.05	89.18	8.87	2.06
	PP_{333}	0.00	0.97	4.50	3.50	53.04	36.00	8.97	89.04	9.93	1.47
	SA	1.19	2.76	5.45	3.80	49.93	39.00	13.20	88.93	6.74	1.28
	TDZ	0.00	0.00	4.04	3.12	61.03	28.82	7.16	89.85	12.55	2.12
Zn	cont	0.00	0.09	5.10	2.90	69.97	18.27	8.09	88.24	10.91	3.83
	PP_{333}	0.22	0.21	4.06	3.36	65.18	25.63	7.85	90.81	11.57	2.54
	SA	0.00	0.36	4.50	2.45	70.61	22.05	7.31	92.66	12.68	3.20
	TDZ	0.33	0.39	4.04	3.76	60.64	29.54	8.52	90.18	10.59	2.05

The higher % of oleic acid, unsaturated fatty acids, unsaturated/ saturated fatty acids ratio and oleic/linoleic ratio are mostly indicators for stress tolerance (Salama, 1987; Badawy, 1990; and Flagella, 2004). Oil quality plays a necessary role. High oil quality could be achieved by increasing the ratio of unsaturated/saturated fatty acids. So, Zn+SA and K+TDZ treatments gave the best results in this concern.

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تأثير نقع البذور فى بعض منظمات النمو والرش الورقى بالفوسفور والبوتاسيوم والزنك على النمو والمحصول فى نباتات عباد الشمس في الأرض الكلسية الملحية

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أجريت التجارب الحقلية فى محطة بحوث مريوط التابعة لمركز بحوث الصحراء على نبات عباد الشمس صنف فيدوك خلال موسمى 2004،2003.

تم نقع البذور قبل الزراعة لمدة أربع ساعات فى محاليل منظمات النمو التالية:

الباكلوبترازول بتركيز 10 جزء فى المليون و حامض الساليسيليك بتركيز 10 جزء فى المليون و الثيديازيورون بتركيز 5 جزء فى المليون.

تم رش النباتات بعد 5و6 أسابيع من الزراعة بمحاليل العناصر التالية:

حمض الفسفوريك بتركيز 0,5 % و كلوريد البوتاسيوم بتركيز 2 % و كبريتات الزنك بتركيز 0,01 %.

تم أخذ عينتين: الأولى عند عمر 50 يوم بعد الزراعة والثانية عند الحصاد(90 يوم). تم أخذ قياسات النمو وعمل تحليلات كيميائية لتقدير العناصر فى العينة الأولى وتقدير قياسات المحصول ومكوناته ونسبة ومحصول الزيت و الحماض الدهنية وذلك فى العينة الثانية.

كانت أهم النتائج ما يلى:

أدى رش النباتات بالفسفور الى زيادة معنوية فى طول النباتات وكذلك أظهرت المعاملة بالبوتاسيوم زيادة معنوية فى كل من الوزن الغض و الجاف للمجموع الخضرى .

فيما يتعلق بنقع البذور فى منظمات النمو أشارت النتائج الى حدوث زيادة معنوية فى كل من الوزن الغض و الجاف للمجموع الخضرى فى النباتات التى نقعت بذورها الباكلوبترازول بينما أدت معاملات النقع فى كل من حمض الساليسيليك و كذلك الثيديازيورون الى زيادة معنوية فى قطر الساق و الوزن الغض و الجاف للمجموع الخضرى وقد لوحظ تأثير سلبى للمعاملة بالثيديازيورون على طول النبات.

أوضحت كل معاملات الرش بالعناصر وكذلك النقع فى منظمات النمو زيادة فى عدد البذور ووزن البذور/ قرص ووزن المحصول.

أدت معاملات رش النباتات بالبوتاسيوم و الزنك الى نقص فى تركيزات الصوديوم وزيادة فى تركيزات كل من البوتاسيوم و الكالسيوم و الفوسفور .

أما بالنسبة الى العناصر الصغرى ، الزنك و المنجنيز و الحديد فقد أدى الرش بكل من البوتاسيوم والزنك الى زيادة معنوية فى تلك العناصر .

لوحظ نقص معنوى فى تركيز الصوديوم وزيادة فى تركيز البوتاسيوم و كذلك نسبة البوتاسيوم / الصوديوم و الماغنسيوم و الفسفور.

أوضحت النتائج أن كل معاملات الرش بالعناصر أدت الى زيادة معنوية فى النسبة المئوية لزيت بذرة عباد الشمس وكذلك محصول الزيت .

وعموما فقد أشارت نتائج التفاعل بين معاملات الرش بالعناصر و النقع فى منظمات النمو الى أن أفضل النتائج تم الحصول عليها من معاملتى البوتاسيوم + الثيديازيورون وكذلك الزنك + حمض الساليسيليك والتى أعطت أعلى قيم للوزن الغض و الجاف للمجموع الخضرى بالأضافة لأعلى محصول ومكوناته و كذلك أعلى نسبة من الأحماض الدهنية غير المشبعة / المشبعة .

كذلك أعطت هاتان المعاملتان أفضل نتائج فى تركيزات العناصر فى صورة أقل تركيزات من الصوديوم و أعلى تركيزات من البوتاسيوم و نسبة البوتاسيوم / الصوديوم و الماغنسيوم والزنك والحديد و المنجنيز .