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Responses of some Sunflower Genotypes to Foliar Application of some Antioxidants under Two Irrigation Levels under East of El-Ewinate Conditions

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Abstract:

Two field experiments were conducted at Agricultural Research Station, East of El-Ewinate, Egypt, during 2013 and 2014 seasons, to investigate the response of some sunflower genotypes to foliar application of some antioxidants under two irrigation levels in East of El-Ewinate conditions. The results could be summarized as follows:

- The differences among sunflower genotypes were highly significant for all studied traits except days to 50% flowering and oil % in both seasons. Also, all studied traits except of oil % were significantly affected by water deficit in the both seasons.

- The highest mean values of plant height (181.7 and 183.3 cm), stem diameter (1.10 and 1.12 cm), head diameter (27.17 and 24.73 cm), head yield (67.33 and 66.80 g), 100-seed weight (4.49 and 4.59 g), oil yield fed.$^{-1}$ (464.95 and 441.56 kg) and seed yield fed.$^{-1}$ (1352.0 and 1328.0 kg) were recorded for G_1 (RF_{15} X A_{12}) genotype irrigated by 100% (I_1) and spray with ascorbic acid (AA) in the first and second seasons, respectively. While the lowest mean values of plant height (133.3 and 131.7 cm), stem diameter (0.713 and 0.710 cm), head diameter (15.47 and 15.20 cm), head yield (28.97 and 32.53 g), 100-seed weight (2.94 and 2.87 g), oil yield fed.$^{-1}$ (258.62 and 303.74 kg) and seed yield fed.$^{-1}$ (732.0 and 884.0 kg) were recorded for Sakha-53 genotype irrigated by 75% (I_2) and spray with tap water in the first and second season, respectively.

Keywords: Sunflower, water deficit, antioxidant and El-Ewinate region.

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Introduction:

Production of vegetative oils are still one of major problem in Egypt because of consumption of these oils which are gradually increased due to increase population, limited cultivated area and the competition of the oil crops in the demes agriculture rotation. In Egypt, there is a big shortage in edible vegetable oil for many years due to fluctuations in the production of oil seeds. The local production of oil doesn't exceed 2% of consumption. Presently, over 98% of vegetable oil being consumed has to be imported**.** Increasing oil production depends on enlargement of cultivated area by oil crops.

Sunflower (*Helianthus annuus* L.) is a high yielding oilseed crop and has the potential to bridge up the gap existing between consumption and domestic production of edible oil in Egypt subcontinent. Sunflower is planted to be extended crop in soil under East of El-Ewinate conditions. It is adapted to wide types of soils and climate conditions. This wide adaptability enables sunflower to be grown under the low productive soils, particularly, in the newly reclaimed soils in Egypt. Due to the sunflower ability to tolerate short periods of water deficit the potential exists for it to become an important crop in semi-arid environments and wherever available irrigation water is limited. Sunflower has good potential for drought tolerance because of well developed root system and to withstand temporary wilting. Although sunflower is moderately tolerant to water stress yet its area and production is greatly affected by drought. If drought resistant cultivars are developed, sunflower can be grown successfully in areas where water is a limiting factor.

Salicylic Acid (SA) is considered as a hormone like substance which acting an important role in regulating a number of physiological processes in the plants such as stomata closure, ion uptake and transport, inhibition of ethylene biosynthesis, transpiration, membrane permeability, photosynthesis and growth (Abdel-Wahed *et al*., 2006 and Ashraf *et al*., 2010), nitrate metabolism, flowering and stress tolerance (Hayat *et al*., 2007). Application of SA stimulated tolerance in plants to many biotic and abiotic stresses like salinity, water stress and heat (Khan *et al*., 2010). The SA can have useful or inhibitory effects on plant physiological processes. Salicylic acid is an endogenous growth regulator of phenolic nature, which participates in the regulation of physiological processes in plants, and plays an important role in plant growth and development (Raskin 1992), and abiotic stress tolerance and considerable attention has been focused on the ability of SA to induce protective effect on plants under stress. Also, citric Acid (CA) is an organic compound belonging to the family of carboxylic acids. It presents in practically all plants. It is one of a series of compounds involved in the physiological oxidation of fats, proteins and carbohydrates to CO_2 and water. Abd-Allah *et al*. (2007) found that plant height, yield and its components as well as protein content in common bean, pea and faba bean were increased with application of citric acid. Sheteawi (2007) reported that ascorbic and citric acids appeared to act in a concert which indicates a complete set of antioxidant defense system, rather than protection by a single antioxidant under stressful conditions.

Ascorbic acid (vitamin C) is one of the key products of D-glucose metabolism which synthesized in higher plants. It has been shown to play multiple roles in plant growth and development, such as cell division, cell wall expansion (Pignocchi and Foyer, 2003) and other developmental processes. Ascorbic acid is an excellent antioxidant consists of molecules that can neutralize harmful reactivate oxygen species generated by salt, water, through doing as a co-factor in synthesis of absisic acid. Although, a lot of work has been done on different crops to mitigate the adverse effects of moisture stress by exogenous application of different compatible solutes in the world, little information is available regarding sunflower. So, the present study was carried out to investigate the effect of water stress on the performance of sunflower genotypes and to explore the possibility of improving drought tolerance by foliar application of salicylic, ascorbic and citric acid under East of El-Ewinate conditions.

Materials and Methods:

This investigation was carried out at Agricultural Research Station, East of El-Ewinate, Egypt, during 2013 and 2014 seasons to study the response of some sunflower genotypes to foliar application of antioxidants (Ascorbic, Citric and Salicylic acid) under different water regimes. Before planting, soil samples were taken from the experimental site and analyzed according to the procedure of Jackson (1973). Some physical and chemical properties of the soil are presented in Table (1). In each season, two separate experiments, first one under normal irrigation (I_1=100%) and the second under water deficit (I_2= 75% of potential evapotranspiration, ET_p). Each experiment was laid out in a randomized complete block design using split-plot arrangement with three replicates. Sunflower genotypes G_1 (RF_{15} x A_{12}), G_2 (RF_3 x A_{12}), G_3 (Giza-102) and G_4 (Sakha-53) were arranged in main plots while, the foliar applications of antioxidant as following:

F_0 = the untreated plants (control) were sprayed with tap water and spreading agent.

F_1 = citric acid (CA) application at the level of 150 ppm

F_2 = salicylic acid (SA) application at the level of 150 ppm

F_3 = ascorbic acid (AA) application at the level of 150 ppm, were allocated in sub plots.

Table 1: Some physical and chemical properties of a representative soil samples in the experimental site before sowing (0-30 cm depth) in 2013 and 2014 seasons.

Soil properties		2013*	2014*
Partice size distribution			
Sand	(%)	74.5	73.7
Silt	(%)	18.5	17.9
Clay	(%)	7.0	8.4
Texture grade		Sandy loam	Sandy loam
EC (1:1 extract)	(dS m^{-1})	1.95	1.84
pH (1:1 suspension)		7.59	7.64
Total $CaCO_3$	(%)	8.75	8.63
Ca^+	(ppm)	140.4	141.2
Mg^{++}	(ppm)	18.6	17.9
Na^+	(ppm)	195.2	194.7
K^+	(ppm)	78.4	79.4
Ca^+	(ppm)	177.5	176.8
$NaHCO_3$-extractable P	(ppm)	423.5	427.2
SO_4	(ppm)	343.2	344.6
Organic matter	(%)	0.04	0.043
NaOAC-extractable K	(ppm)	132.80	122.50
Total nitrogen	(%)	0.002	0.002
KCl-extractable N	(ppm)	31.04	29.16

*Each value represents the mean of three replications.

The area of each experimental unit was 10.5 m^2 (3.5 m length x 3 m width) included 5 rows, 60 cm apart and 20 cm between hills. Seeds (seeds 3 $hill^{-1}$) were hand drilled on June 28th and 26th in the 1st and the 2nd seasons, respectively. One plant was left $hill^{-1}$ after thinned (3 weeks from planting). Phosphorous fertilizer was applied during seedbed preparation in the form of calcium superphosphate (15.5% P_2O_5) at the rate of 31 kg P_2O_5 $fed.^{-1}$. Nitrogen fertilizer in the form of ammonium nitrate (33.5% N) at the rate of 90 kg N $fed.^{-1}$ was added in three equal doses at thinning, after one month and one month later. Potassium fertilizer in the form of potassium sulphate (48% K_2O) at the rate of 50 kg K_2O $fed.^{-1}$ was added in two equal doses at thinning and after one month. Sprinkler irrigation system was using under ground water was (every day) followed in table 2.

Table 2: Amount of water and time of application

Day from planting	100% w.h.c		75% w.h.c.	
	Minuets	Amount of water	Minuets	Amount of water
1-30 (30 days)	15	225	12	168.75
31-90 (60 days)	60	1800	45	1350
91-105 (15 days)	30	450	22.5	337.5
Total		2475		1856.25

The preceding crop was wheat in both seasons. SA, AA and CA were applied with a knap sack sprayer. All other cultural practices were carried out as recommended for sunflower production in both seasons.

At maturity, (after 120 days from sowing) random sample of ten guarded plants from each sub plot were taken and the following data were determined: plant height (cm), stem diameter (cm) and head diameter (cm), a bulk sample including all plants in plot was harvested to determine and the seed yield plot^{-1} and then converted into kg fed.$^{-1}$(seed yield plot^{-1}X 400).

- Dates to 50% flowering were determined on the basis of all plants in the sub plot.

- 100- seed weight (g).

- Oil percentage (%): dried mature seeds were ground into very fine powder to determine oil % using Soxhelt apparatus and diethyl ether according to A.O.A.C. (1995). In order to calculate oil yield, the yield was converted to oil yield using the following formulae: Oil yield (kg fed.$^{-1}$) = oil % X seed yield (kg fed.$^{-1}$)/100

Each experiment was subjected to analysis of variance using the MSTAT. C statistical package programme according to Gomez and Gomez (1984), Bartlet test was done, then combined analysis was done to evaluate the irrigation effect and the least significant difference (L.S.D.) at 5% and 1% levels of probability was used to compare the differences among means.

Results and Discution:

A- Effect of genotypes

Data illustrated in Tables 3, 4 and 5 reveal that the differences among the genotypes were highly significant for all studied traits except days to 50% flowering, oil % and oil yield in both seasons. RF_{15} x A_{12} genotype had the highest mean values of plant height (171.91 and 173.04 cm), stem diameter (0.97 and 1.00 cm), head diameter (23.05 and 21.75 cm), head yield (50.16 and 52.20 g), seed yield fed.$^{-1}$ (1116 and 1188 kg) and 100-seed weight (4.01 and 4.10 g) in the first and second seasons, respectively. These differences may be due to the genetics behavior combined with environment factors which was suitable for RF_{15} x A_{12} genotype than other genotype. These results are harmony with those obtained by Ahmad *et al*., (1999), Basha (2000) Allam *et al*., (2003) and Abdel-Motagally and Osman, (2010).

B - Effect of water deficit

The presented data (Tables 3, 4 and 5) show that all studied traits except oil % were significantly affected by water regime in the both seasons. The highest mean values of plant height (166.95 and 167.63 cm), stem diameter (0.93 and 0.98 cm), head diameter (21.78 and 20.49 cm), head yield (52.81 and 57.21 g), seed yield fed.$^{-1}$ (1097 and 1149 kg), 100-seed weight (3.88 and 3.85 g) and oil yield fed.$^{-1}$ (385.41 and 394.86 kg) and the lowest mean values of days to 50% flowering (61.43 and 59.77) were obtained by adding high irrigation level (I_1) in the first and second seasons, respectively.

The lowest mean values of plant height (159.13 and 160.93 cm), stem diameter (0.85 and 0.90 cm), head diameter (19.59 and 20.48 cm), head yield (37.90 and 41.81 g), seed yield fed.$^{-1}$ (905 and 1015 kg), 100-seed weight (3.55 and 3.60 g) and oil yield fed.$^{-1}$ (314.58 and 343.39 kg) and the highest mean values of days to 50% flowering (64.06 and 59.30), were obtained by adding low irrigation level (I_2) in the first and second seasons, respectively.

A common adverse effect of water stress on crop plants is the reduction in fresh and dry biomass production and the reduction of biomass production resulting from water stress has been observed in almost all genotypes of sunflower (Tahir and Mehdi 2001). When plants are exposed to water stress, plant cells protect themselves from the stress of high concentrations of intracellular salts by accumulating a variety of small organic metabolites that are referred to collectively as compatible solutes (Ashraf and Follad 2007). Compatible solutes are small molecules that are very soluble in water and are also uniformly neutral with respect to the perturbation of cellular functions, even when present at high concentrations (Yancey *et al.* 1982). The properties of these solutes allow the maintenance of turgor pressure during water stress.

C - Effect of antioxidant

Data presented in Tables 3, 4 and 5 show that the most studies traits except days to 50% flowering and oil % were significantly affected by foliar application of antioxidant in both seasons. The highest mean values of plant height (171.23 and 172.03 cm), stem diameter (0.99 and 1.01 cm), head diameter (22.42 and 21.53 cm), head yield (50.32 and 55.84 g), seed yield fed.$^{-1}$ (1082 and 1154 kg), 100-seed weight (4.08 and 4.07 g), and oil yield fed.$^{-1}$ (378.17 and 391.97 kg) were obtained by adding F_3 (Ascorbic acid) in the first and second seasons, respectively.

These results may be due to the role of Ascorbic acid (AA) as an important natural additive to improve growth and yield in plants. Ascorbic substances are an important soil component because they constitute a stable fraction of carbon and improve water holding capacity, pH buffering and thermal insulation, stimulate plant growth by the assimilation of major and minor elements, enzyme activation and/or inhibition changes in membrane permeability, protein synthesis which activate the biomass production, regulating endogenous hormone levels and finally it was hypothesized that ascorbic acid increase the photo-chemical efficiency. Also, salicylic acid enhancing some physiological and biochemical aspects (Maity and Bera 2009), or increasing N, P, K and Ca content, activity in antioxidant enzymes and glutathione content (Khan *et al.*, 2010). The simulation effect of salicylic acid on plant growth was confirmed by Abdo *et al.* 2002, El-Shraiy and Hagazi 2009, Nagasubramanian *et al.*, 2007, and Hussain *et al.* (2008). Also, increase yield seems to be the direct result of improved head diameter and 100-seed weight. It may be the result of maintenance of photosynthetic activity owing to AA, SA or CA application. By means of osmotic adjustment, the organelles and cytoplasmic activities take place at about a normal pace and help plants to perform better in terms of growth, photosynthesis and assimilate partitioning to grain filling (Ludlow and Muchow 1990).

D- Effect of interaction

Data presented in Tables 3, 4 and 5 show that the all studied traits except days to 50% flowering and oil% were significantly affected by genotypes X irrigation treatments X foliar application of antioxidant interaction in both seasons. The highest mean values of plant height (181.7 and 183.3 cm), stem diameter (1.100 and 1.117 cm), head diameter (27.17 and 24.73 cm), head yield (67.33 and 66.80 g), seed yield fed.$^{-1}$ (1352 and 1328 kg), 100-seed weight (4.49 and 4.59 g) and oil yield fed.$^{-1}$ (464.95 and 441.56 kg) were recorded for G_1 (RF_{15} X A_{12}) irrigated by 100% (I_1) and spray with F_3 treatment in the first and second seasons, respectively. While, the lowest mean values of plant height (133.3 and 131.7 cm), stem diameter (0.713 and 0.710 cm), head diameter (15.47 and 15.18 cm), head yield (28.97 and 32.53 g), seed yield fed.$^{-1}$ (732 and 884 kg), 100-seed weight (2.94 and 2.87 g) and oil yield fed.$^{-1}$ (258.62 and 303.79 kg) were recorded for G_4 (Sakha-53) irrigated by 75% (I_2) and spray with F_0 (tap water treatment) in the first and second seasons, respectively.

Conclusion:

On the light of the obtained results, it can be concluded from this study that yield and its components of sunflower are reduced under water deficit. Moreover, exogenous antioxidant spring was only advantageous under stress conditions. Antioxidant application can help to reduce the adverse effects of water deficit and may increase the sunflower yield under water-limited environments. Water deficit negatively affected the plant growth of the crop including yield, but foliar application of antioxidant particularly SA, AA and CA appreciably improved these attributes. It could be concluded that under the conditions of this investigation, G_1 (Rf $_{15}$ x A_{12}) hybrid spring performance for studied with foliar application of ascorbic acid under normal irrigation (100%) led to the highest yield and it components of sunflower.

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أستجابه بعض التراكيب الوراثيه لعباد الشمس للرش ببعض مضادات الاكسده تحت مستويين للرى تحت ظروف منطقه شرق العوينات

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الملخص:
أجريت تجربتين حقليتين في مركزالبحوث الزراعية - محطة بحوث شرق العوينات خلال موسمى الزراعة ٢٠١٣ و٢٠١٤ لدراسة أستجابه بعض التراكيب الوراثيه لعباد الشمس للرش ببعض مضادات الاكسده (حمض الاسكوربيك أو حمض السترك أو حمض السلسليك) تحت مستويين للرى والمنزرعة فى الاراضى المستصلحة حديثا فى شرق العوينات حيث صممت تجربتين منفصلتين كل واحده تحت مستوى رى مختلف. واستخدم لذلك تصميم القطاعات كامله العشوائيه بترتيب الالواح المنشقه فى ثلاث مكررات حيث تم وضع التراكيب الوراثية في القطع الرئيسية بينما وضعت معاملات الرش بمضادات الاكسده في القطع الشقيه. وكانت اهم النتائج كما يلى:

- اختلفت التراكيب الوراثية فى كل الصفات المدروسه ماعدا صفه ٥٠% تزهير ونسبه الزيت بالبذره كما تأثرت معنويا كل الصفات المدروسه بنقص الماء ماعدا صفه ٥٠% تزهير فى كلا الموسمين.

- سجلت أعلى متوسطات القيم لطول النبات (١٨١,٧ و ١٨٣,٣ سم) وقطر الساق (١,١٠ و ١,١٢ سم) وقطر القرص (٢٧,١٧و ٢٤,٧٣ سم) ومحصول القرص (٦٧,٣٣ و ٦٦,٨ جم) ووزن ١٠٠ بذره (٤,٤٩ و ٤,٥٩ جم) ومحصول الزيت للفدان (٤٦٤,٩٥ و ٤٤١,٥٦ كجم) ومحصول البذور للفدان(١٣٥٢ و ١٣٢٨ كجم) من التركيب الوراثى (RF_{15} X A_{12}) مع الرى العادى (١٠٠%) والمعامل بحمض الاسكوربك بينما تم الحصول على اقل القيم من التركيب الوراثى (سخا ٥٣) المروى ب ٧٥% والغير المعامل بأى من مضادات الاكسده.