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Effect of Humic Acid Application on Growth and Productivity of Sunflower Under Saline Soil Conditions

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ABSTRACT

A field experiment was conducted at El-bostan Farm, Faculty of Agriculture, Damanhur University in the two successive summer seasons of 2018 and 2019. The aim of this study was to investigate the effect of humic acid application on sunflower (*Helianthus annuus* L.) growth, yield & its components and some chemical constituents grown under saline soil conditions. The experiment was laid out in a split plot design in four replicates. The main plots were occupied by three sunflower genotypes Sakha 53, Giza 102 and Line 120. While subplots contained four treatments of humic acid (HA) i.e.; without HA (control), HA soil application, foliar HA spray and a combination of both foliar spray and soil addition of HA. The results showed that, different genotypes did not perform similarly under salinity stress conditions. Line 120 had the highest leaf area/plant, head diameter, seed yield/ plant and seed yield/ha. With regard to humic acid application, it caused improvement for most growth, physiological parameters, yield and its components compared to control. Obtained results also, showed that humic acid application as both soil and foliar spray on Line 120 and Sakha 53 led to obtain the highest values of most studied parameters in the two growing seasons. Finally, it could be concluded that humic acid application can ameliorate negative effects of salinity on sunflower.

Keywords: Sunflower, Salinity, Humic acid, Proline, Relative water content, Yield, Seed quality.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an important source of oil and proteins necessary for development of healthy humans (Radic *et al*., 2009). It could be grown in a great range of climatic condition and soils. It plays a main role in the cultivation of the new reclaimed lands, which suffering salinity, high temperatures and drought effects (Keshta *et al*., 2008).

Many environmental stresses as high temperatures, high winds, soil salinity and drought have affected the production of agricultural crops. Soil salinity is one of the most harmful environmental stresses, which causes high reductions in crop quality and productivity (Yamaguchi and Blumwald, 2005 and Shahbaz and Ashraf, 2013).

Salt stressed soils led to decrease seed germination, growth, and yield production (Paul, 2012). Decreasing in plant growth under salinity could be due to ion toxicity as a result of salt stress which caused increase growth inhibitors and decreased growth promoters, leading to stomatal closure, ionic imbalance, accumulation of toxic ions and then reduction of growth (Rady *et al.*, 2013 and Semida and Rady, 2014). Thus, salinity effects are the results of interactions between physiological, morphological and biochemical processes (Singh *et al*., 2001 and Akbarimoghaddam *et al*., 2011).

Soil salinity mostly causes primary and secondary plant responses. In primary effects, salinity causes soil accumulation of salt for over long time in soil and underground water by a natural biological process. Secondary effects causes salinity stress due to change in the balance between applied water and plants used water. Salts have been known to be a problem for so many years decade in those areas where less rainfall and salt move down through plant root (Duane *et al*., 2008).

Technological and natural ways have been studied in recent years to alleviate the adverse effect of salt stress in agricultural products (Walker and Bernal, 2008).

Humic acids are main soil component that can increase nutrient supply and has positive effects on biological, chemical, and physical properties of the soils (Ullah *et al*., 2018).

Humic substances as the major component of soil organic matter could be used as a growth factor to enhance plant growth, photosynthesis rate, chlorophyll content, micronutrient uptake and improve stress tolerance (Pan *et al*., 2009 and Khaled and Fawy, 2011). Humic acid also improve plant growth due to the increasing photosynthesis, cell membrane permeability and NPK uptake (Gulser *et al.*, 2010 and Pizzeghello *et al*., 2013). Therefore, humic substances are important for saline soils as they help plants to cob drought and salinity (Salman *et al.*, 2005).

The main goal of this work was to estimate humic acid effects as a soil and/or foliar application to decrease the harmful effects of salinity stress on sunflower growth and yield traits.

MATERIALS AND METHODS

Experimental site:

A field experiment was conducted in the two successive seasons 2018 and 2019 at the Experimental Farm of El-bostan, Faculty of Agricultural, Damanhur University, (lies between 30.8282º N, 30.5349 Eº) to study the effect

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of humic acid method of application (foliar spray, soil addition and combination of both) on growth, yield, its components and seed quality of three genotypes (Sakha 53, Giza 102 and Line 120) of sunflower (*Helianthus annuus* L.). Soil samples were randomly taken from the experimental site at depth of 0 to 30 cm from soil surface and were analyzed for both physical and chemical characteristics according to (Klute, 1986 and Page *et al*., 1982) as presented in Table (1).

Experimental details:

A split- plot design in four replicates was used in this work, where:

I- Main plots: are used for Sunflower genotypes **(**Sakha 53, Giza 102 and Line 120**).**

II- Sub plots: Humic acid treatments (HA):

HA treatments were control without HA, foliar spray (6g HA/L), soil application (was added during soil preparation at the rate of 36 kg HA/ha) and combination of both spray& soil application. Spraying was done twice at 20 and 35 days after sowing.

Sunflower seeds were sown on 15th and 21th of June in the first and second seasons, respectively**.** Sunflower seeds were obtained from Oil Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt. The plot area was 12 m^2 (3 m width and 4 m length), each plot contains 5 rows and seeds were sown by hand and the distance between hills were 20 cm. Two rows were used for growth analysis data sampling and the other three rows were left for determining seed yield and its components. The plants were thinned to one plant per hill at 21days from sowing. Other cultural practices for growing sunflower were conducted as recommended. Nitrogen was applied at the rate of 72 kg N/ha as ammonium sulfate (20.5% N) and Phosphorus was applied at a rate of 240 kg P/ha, using calcium super phosphate (15.5% P_2O_5). Sunflower was harvested on September (4th and 9th) for Giza 102 and (16th and 20th) for Sakha 53 and Line 120 genotypes in the first and second seasons, respectively (when the back of the capitula was yellow and the bract was brownish). A detailed description of name and pedigree, of the tested genotypes are presented in Table (A).

Table A. The pedigree of tested sunflower genotypes.

Genotypes	Pedigree
Sakha 53	Mayak x Bulgarian line 1
Giza 102	Indian line x Mayak
Line 120	Mayak x Bulgarian line

Table 1. Means of some physical and chemical properties of the experimental site during the two growing seasons 2018 and 2019.

Determination	2018	2019
Mechanical analysis		
Sand %	18.78	15.99
Silt %	20.52	24.12
Clay %	60.74	59.89
Field capacity %	40.03	40.11
Wilting point	21.71	21.75
Balk density (g/cm^3)	1.70	1.71
Chemical analysis		
PH	8.00	8.20
E.C. (mmohs/cm)*	5.70	5.79
Organic matter (O.M) %	0.22	0.20
Available N ppm	5.00	5.00
Available P ppm	34.00	36.00
Available K ppm	175.00	122.00

*** EC were estimated at 1:5 soil extract, and corrected at 25 °C.**

Growth parameters:

Five plants were randomly harvested after 50 days from sowing to estimate shoot dry weight and leaf area/ plant. Total leaf area/plant was determined as follows: the area of 10 disks (10 x 3.14 x (1.5)^2) was calculated (70.65 cm^2) then dried and weighed, the remaining according to the formula of Hunt (1990):

$$LA = 70.65\ x\ \frac{\textbf{dry weight of leaves per plant}}{\textbf{dry weight of leaves disks}}$$

Days to flowering

Days to flowering was measured as the number of days to reach 50% flowering of whole plants in each treatment.

Yield and its components

At maturity five guarded plants were taken randomly and the following characters were recorded i.e. Plant height (cm), stem diameter (cm), head diameter (cm), number of seeds/ head, 1000-seed weight (g) and seed weight/ plant.

Seed yield (kg/ha): heads of bagged plants from inner ridges of each plot were harvested and left for two weeks until fully air dried and seed weight was calculated to estimate seed yield (kg/ha).

Chlorophyll content in leaves

About 0.5 g fresh weight of mixed leaves was homogenized in 5 ml of 85% cold acetone and centrifuged. The extract was diluted to the appropriate volume before the optical density was measured at 663 and 647 nm **(**Metzener *et al*., 1965). The following equations were applied to calculate chlorophyll content of the samples as mg/g fresh weight after 50 days after sowing (DAS).

Chlorophyll a (Chl. a) = 11.79 E_{663} – 2.29 E_{647}

Chlorophyll b (Chl. b) = 20.05 E_{647} – 4.77 E_{663}

Nitrogen, phosphorus, potassium and sodium (%) in leaves

At 50 DAS, elemental percentages were determined in sunflower leaves. Total nitrogen content (N) was determined using Micro-Kjeldahl method described by A.O.A.C. (1995). Phosphorus (P), potassium (K) and sodium (Na) were determined according to (Chapman and Pratt, 1978).

Relative water content (RWC %)

After 50 days from sowing, leaf samples were collected and immediately weighed (fresh weight; FW) and transferred into sealed flasks then immersed in distilled water for 5 hrs until fully turgid at 4 ºC, surface swabbed and reweighed (turgid weight; TW). Then oven dried at 70 ºC for 48 hrs and reweighed (dry weight; DW). Relative water content (RWC %) was calculated according to Lazcano-Ferrat and Lovatt (1999) using the following equation:

$$\boldsymbol{RWC}\ (\%) = \frac{(\boldsymbol{FW} - \boldsymbol{DW})}{(\boldsymbol{TW} - \boldsymbol{DW})}\boldsymbol{X100}$$

Proline content

Proline content of leaves was determined after 50 days from sowing according to a modification of the method of Bates *et al*. (1973). Its absorbance was measured at 520 nm in a spectrophotometer. The content of proline was calculated from a standard curve in mg/g dry weight.

Seed oil (%)

Oil was determined according to A.O.A.C. (1995) using Soxhlet apparatus using petroleum ether as a solvent, for oil extraction.

Seed protein %

Protein was determined according to A.O.A.C. (1995) method. It was calculated by multiplying the values of total nitrogen by 6.25 (Hymowitz *et al*., 1972).

Statistical analysis

The SPSS statistical analysis package (version 16; SPSS Inc., Chicago, IL) was used for data analysis. Data were statistically analyzed by analysis of variance, and means were compared using the least significant difference test at $P \leq 0.05$ (Snedecor and Cochran, 1982). Treatment means were compared by Duncan's multiple range test (Duncan's, 1955).

RESULTS AND DISCUSSION

Growth parameters

With regard to genotypes the results in Table (2) appeared that Line 120 significantly gave the heaviest shoot dry weight/plant (g) with average of (58.23 g) in the second season only and the highest leaf area with averages of (2507.25 and 2640.71 cm^2) in both seasons, respectively compared to Sakha 53 and Giza 102. This might be due to the genetic differences between genotypes and their ability to cob with the environmental stresses especially salinity (Hafiz and Damarany, 2006 and Zaki *et al*., 2009).

Analysis of variance showed significant and highly significant effects for humic acid treatments on shoot dry weight. Combination of foliar and soil application of HA had the highest effect on shoot dry weight/ plant with averages (56.26 and 63.75 g) in 1st and 2nd seasons, respectively as compared to foliar spray or soil application alone. However, magnitude of increase was higher in soil than foliar application. These results are in harmony with obtained by (Barakat *et al*., 2015). Also, (Nardi *et al*., 2002; Cimrin *et al*., 2010 and Saruhan *et al*., 2011) found that humic acid can enhance plant growth by improving the uptake of nutrients, photosynthesis and by decreasing water loss. Also, Sunarpi *et al*., (2005) found that foliar application of humic acid had a significant effect on the dry weight.

Table 2. Effect of genotypes and humic acid application on shoot dry weight and leaf area/ plant in summer seasons 2018 and 2019.

Treatment	Shoot dry weight/ plant (g)		Leaf area/plant (cm^2)	
	2018	2019	2018	2019
Genotypes (G)				
Sakha 53	52.08	53.82 ^{b}	2336.21^{ab}	2581.14 ^{b}
Giza 102	47.98	49.45 ^{c}	1816.13 ^{b}	2109.13 ^{c}
Line 120	49.83	58.23 ^{a}	2507.25 ^{a}	2640.71 ^{a}
LSD at 0.05	NS	3.92	533.77	98.37
Humic acid (H)				
Control	40.86 ^{c}	46.16 ^{d}	2168.21	2117.19
Soil	54.45 ^{ab}	53.07 ^{b}	2448.38	2470.17
Spray	48.29 ^{b}	52.36 ^{c}	2427.54	2416.32
Soil + Spray	56.26 ^{a}	63.75 ^{a}	2730.52	2771.63
LSD at 0.05	6.62	8.35	NS	NS

Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test.

Days to flowering, plant height and stem diameter

The obtained results in Table (3) indicated that, days to flowering in both seasons and plant height in the first season were significantly affected by different genotypes, where, Giza 102 had the lowest days to flowering with averages (47.91 and 47.83) in both seasons and the shortest plant height with average (105.33 cm) in the first season. These results were in agreement with those obtained by (Hafiz and Damarany, 2006 and Zaki *et al*., 2009). The differences may be due to the differences between genotypes and tolerance of stresses.

Table 3. Effect of genotypes and humic acid application on days to flowering, plant height and stem diameter in summer seasons 2018 and 2019.

Treatment	Days to flowering		Plant height (cm)		Stem diameter (cm)	
	2018	2019	2018	2019	2018	2019
Genotypes (G)						
Sakha 53	51.00 ^{a}	51.33 ^{a}	113.25 ^{a}	114.08	1.34	1.38
Giza 102	47.91 ^{b}	47.83 ^{b}	105.33 ^{b}	102.75	1.19	1.17
Line 120	50.75 ^{a}	51.58 ^{a}	112.91 ^{a}	113.41	1.35	1.42
LSD at 0.05	0.915	1.06	5.04	NS	NS	NS
Humic acid (H)						
Control	49.55	49.88	103.11 ^{b}	101.22 ^{c}	1.14 ^{c}	1.15 ^{c}
Soil	50.33	50.22	110.0 ^{ab}	112.22 ^{b}	1.28 ^{b}	1.28 ^{b}
Spray	49.55	50.22	108.55 ^{b}	104.88 ^{bc}	1.23 ^{bc}	1.28 ^{b}
Soil + Spray	49.88	50.66	120.33 ^{a}	122.00 ^{a}	1.53 ^{a}	1.59 ^{a}
LSD at 0.05	NS	NS	11.40	8.47	0.088	0.069

Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test.

With regard to humic acid application, it was significantly affected on plant height and stem diameter in the two seasons. Soil and foliar spray gave the tallest plant height with averages (120.33 and 122.00 cm) and the highest stem diameter (1.53 and 1.59 cm) as compared to foliar spray or soil application alone. This increases may be due to the role of humic acid in increasing endogenous hormone as IAA which led to enhancing cell division and cell enlargement and this in turn improve plant growth (Abdel Mawguad *et al*., 2007). Also, Khan *et al*. (2012) reported that, soil or foliar application of humic acid increased plant height. Moreover, foliar spraying micronutrients combined with potassium humate increased plant height and stem diameter for sunflower under saline stress conditions (El-Nasharty *et al*., 2017).

Head diameter, number of seeds/head and 1000-seed weight

The results in Table (4) indicated that the genotypes and humic acid application had significant effect on head diameter, number of seeds/ head and 1000-seed weight in the first and second seasons except HA for 1000-seed weight in the second season.

Table 4. Effect of genotypes and humic acid application on head diameter, number of seeds/ head and 1000-seed weight in summer seasons 2018 and 2019.

Treatment	Head diameter (Cm)		No. of seeds/head		1000-seed weight (g)	
	2018	2019	2018	2019	2018	2019
Genotypes (G)						
Sakha 53	18.84 ^{a}	17.79 ^{b}	703.16 ^{b}	713.66 ^{ab}	58.67 ^{ab}	61.29 ^{a}
Giza 102	15.99 ^{b}	16.20 ^{c}	687.25 ^{b}	693.58 ^{b}	56.48 ^{b}	57.74 ^{b}
Line 120	19.20 ^{a}	17.95 ^{a}	757.58 ^{a}	763.75 ^{a}	61.75 ^{a}	63.76 a
LSD at 0.05	1.24	0.194	48.83	53.41	3.67	2.93
Humic acid (H)						
Control	16.67 ^{c}	15.91 ^{c}	600.00 ^{d}	622.77 ^{d}	53.38 d	55.52
Soil	18.30 ^{b}	17.65 ^{b}	750.66 ^{b}	760.66 ^{b}	59.78 ^{b}	61.17
Foliar spray	17.81 ^{b}	17.17 ^{b}	710.77 ^{c}	704.88 ^{c}	58.32 c	59.67
Soil + Foliar	19.05 ^{a}	18.53 ^{a}	802.33 ^{a}	806.33 ^{a}	64.38 ^{a}	67.36
LSD at 0.05	0.59	0.85	28.31	37.02	1.81	NS

Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test.

Line 120 had superior effect on head diameter, number of seeds/ head and 1000-seed weight with averages (19.20 and 17.95 cm), (757.58 and 763.75) and (61.75 and 63.76 g) in the two seasons, respectively.

Soil and foliar spray of humic acid gave the highest head diameter (19.05 and 18.53 cm) and number of seeds/ head (802.33 and 806.33) in both seasons, respectively. These results were in agreement with those obtained by (Ounia *et al*., 2014). Also, El-Nasharty *et al*. (2017) found that foliar spraying micronutrients combined with potassium humate increased weight of 100-seed and head diameter for sunflower under saline stress conditions.

Seed yield

The results in Table (5) showed those genotypes, humic acid application and their interaction had significant effect on seed yield/ plant and seed yield/ha.

Line 120 had superior effect compared with Sakha 53 and Giza 102 for seed yield/ plant (60.60 and 56.53 g) and seed yield/ha (1939.25 and 1809.22 kg).

Humic acid application (soil + spray) gave the highest values for seed yield/ plant (63.11 and 60.54 g) and seed yield/ha (2019.52 and 1937.38 kg) compared with soil or foliar spray humic acid. These results were in agreement with those obtained by (El-Nasharty *et al*., 2017) . Moreover, addition of humic substances has been recorded to enhance plant growth and soil properties, which are positively affected in higher crop yields and quality (Selim *et al*., 2009 and Osman and Rady, 2012).

Table 5. Effect of genotypes and humic acid application on seed yield/ plant and seed yield/ha in summer seasons 2018 and 2019.

Treatment	Seed yield/plant (g)		Seed yield (kg/ha)	
	2018	2019	2018	2019
Genotypes (G)				
Sakha 53	50.22 b	46.80 b	1607.12 b	1502.34 b
Giza 102	41.20 c	42.39 c	1318.50 c	1356.69 b
Line 120	60.60 a	56.53 a	1939.25 a	1809.22 a
LSD at 0.05	4.39	2.47	140.59	107.62
Humic acid (H)				
Control	41.56 d	40.35 d	1329.95 d	1307.37 c
Soil	50.63 b	48.00 b	1620.23 b	1525.93 b
Spray	47.40 c	45.42 c	1516.80 c	1453.65 b
Soil + Spray	63.11 a	60.54 a	2019.52 a	1937.38 a
LSD at 0.05	2.14	2.95	68.57	85.31

Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test.

With regard to the interaction between genotypes and humic acid application significantly effect on seed yield/ plant and seed yield/ha. The results showed that the highest values of seed yield/ha were recorded with Line 120 (V_3) treated with humic acid (soil and foliar spray treatment) Fig. (1&2).

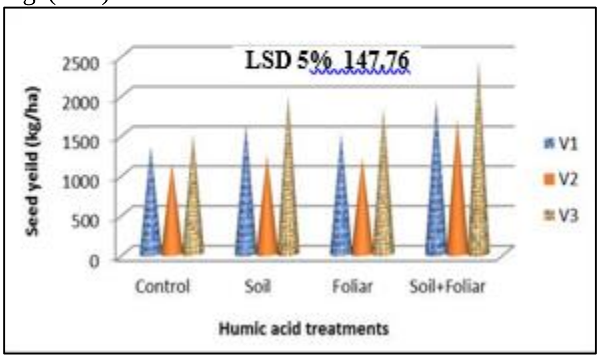

Fig. 1. Seed yield (kg/ha) as affected by the interaction between genotypes and humic acid application in 2018 season (V_1: Sakha 53, V_2: Giza 102 and V_3: Line 120).

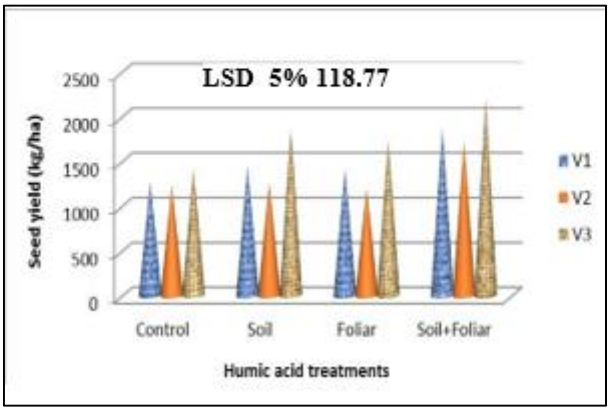

Fig. 2. Seed yield (kg/ha) as affected by the interaction between genotypes and humic acid application in 2019 season (V_1: Sakha 53, V_2: Giza 102 and V_3: Line 120).

Chlorophyll content in leaves

Data in Table (6) showed that the genotypes and humic acid application significantly effect on chlorophyll (a) and (b). Giza 102 gave the lowest values of chlorophyll (a) and (b) in the two summer seasons.

Table 6. Effect of genotypes and humic acid application on chlorophyll content (mg/g fresh weight) in summer seasons 2018 and 2019.

Treatment	Chlorophyll a		Chlorophyll b	
	2018	2019	2018	2019
Genotypes (G)				
Sakha 53	2.493 ab	2.646 a	1.075 a	1.120 a
Giza 102	2.388 b	2.216 b	0.968 b	1.030 c
Line 120	2.620 a	2.638 a	1.060 a	1.074 b
LSD at 0.05	0.188	0.050	0.067	0.041
Humic acid (H)				
Control	2.243 c	2.266 b	0.967 c	0.985 c
Soil	2.378 b	2.384 b	1.018 b	1.054 bc
Foliar spray	2.641 a	2.626 a	1.037 b	1.110 ab
Soil + Spray	2.740 a	2.724 a	1.115 a	1.150 a
LSD at 0.05	0.112	0.142	0.073	0.084

Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test.

The results cleared that the application of HA had better effect in enhancing chlorophyll content especially with combination of soil and foliar spray. It had the highest values for chlorophyll (a) and (b) with averages (2.740 and 2.724) and (1.115 and 1.150) in both seasons, respectively. These results are in agreement with obtained by (Ahmed *et al*., 2013 and Al-Erwy *et al*., 2016). Humic acid application caused an improvement in the synthesis of the chlorophyll and/or delayed chlorophyll degradation even under different stress conditions as reported by (Megahid *et al*., 2015). Application of humic acid has significant effect on photosynthetic pigments may be due to an increase in photosynthetic rate and CO_2 assimilation (Ameri and Tehranifar, 2012).

Concerning, the interaction between sunflower genotypes and humic acid application significantly effect on chlorophyll (a) in the two seasons. The results showed that the highest values chlorophyll (a) were recorded with Line 120 (V_3) treated with humic acid (soil and foliar spray) Fig. (3&4).

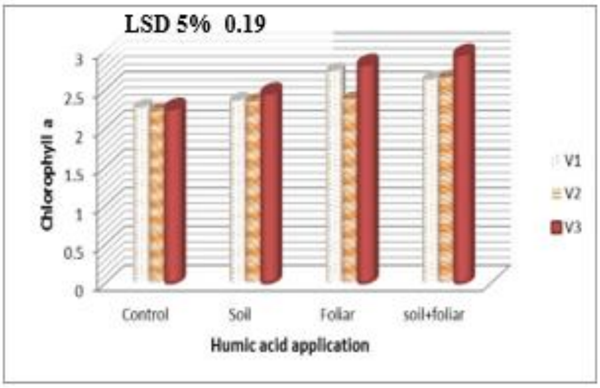

Fig. 3. Chlorophyll (a) as affected by the interaction between genotypes and humic acid application in 2018 season (V_1: Sakha 53, V_2: Giza 102 and V_3: Line 120).

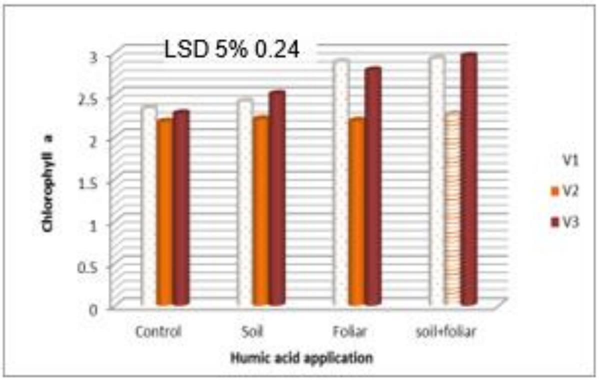

Fig. 4. Chlorophyll (a) as affected by the interaction between genotypes and humic acid application in 2019 season (V_1: Sakha 53, V_2: Giza 102 and V_3: Line 120).

Nitrogen, phosphorous and potassium (%) in leaves

Data in Table (7) showed that, the three genotypes had significant effect on N and P percentages in both seasons. On contrast, no significant effect was showed on K percentage.

Table 7. Effect of genotypes and humic acid application on N, P and K (%) in leaves in summer seasons 2018 and 2019.

Treatment	N %		P %		K %	
	2018	2019	2018	2019	2018	2019
Genotypes (G)						
Sakha 53	2.285 c	2.313 a	0.344 a	0.348 a	1.323	1.359
Giza 102	2.184 b	2.219 b	0.307 b	0.305 b	1.345	1.372
Line 120	2.315 a	2.337 a	0.349 a	0.360 a	1.369	1.379
LSD at 0.05	0.061	0.046	0.023	0.026	NS	NS
Humic acid (H)						
Control	1.722 d	1.762 d	0.297 c	0.297 c	1.130	1.133
Soil	2.463 b	2.456 d	0.344 ab	0.336 b	1.417	1.500
Spray	2.185 c	2.202 c	0.321b c	0.317 b	1.317	1.337
Soil + Spray	2.674 a	2.738 a	0.371 a	0.400 a	1.518	1.510
LSD at 0.05	0.046	0.028	0.029	0.019	NS	NS

Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test

The harmful effects of salt stress were significantly suppressed by application of humic acid where, the highest values of N with averages (2.674 and 2.738 %) and P (0.371 and 0.400 %) were recoded with sunflower plants treated with both soil and foliar application in the two seasons, respectively. El-Nasharty *et al*. (2017) found that humic acid increased the nutrient content of sunflower plants (N, K, Ca, and Mg) under saline stress conditions. Barakat *et al*. (2015) showed that application of potassium humate increased N, P and K contents. Furthermore, humic acid enhance chemical properties of the soil as it increases soil micro-organisms, which improve nutrient supply (Sayed *et al*., 2007).

With regard to the interactions, N % showed significant differences between genotypes and humic acid application whereas; no significant interactions were detected for P and K % in the two seasons. The highest values of N (%) were recorded with Line 120 (V_3) treated with soil and foliar spray of humic acid in the two studied seasons Fig. (5&6).

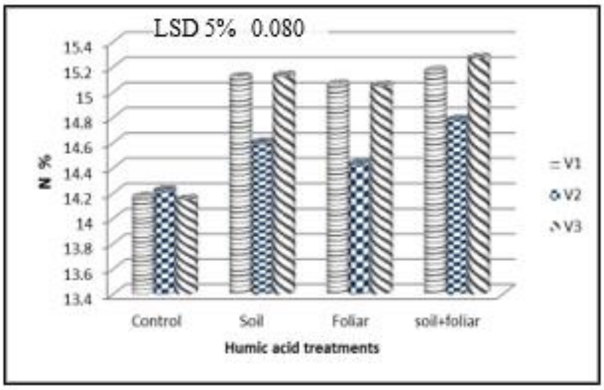

Fig. 5. Effect of the interaction between genotypes and humic acid application on nitrogen percentage in leaves in 2018 season (V_1: Sakha 53, V_2: Giza 102 and V_3: Line 120).

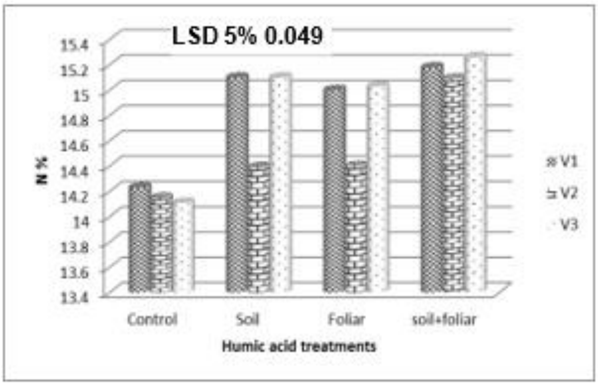

Fig. 6. Effect of the interaction between genotypes and humic acid application on nitrogen percentage in leaves in 2019 season (V_1: Sakha 53, V_2: Giza 102 and V_3: Line 120).

Sodium (%) and sodium/potassium ratio in leaves

The results in Table (8) showed that genotypes and humic acid had significant effect on Na and Na/K ratio in both seasons. Giza 102 had the highest values of Na % with averages (0.777 and 0.762 %) and Na/K ratio (0.589 and 0.568 %) in the leaves in the two studied seasons, respectively.

Soil application of HA led to significant reductions in the percentage of Na in the leaves. Similar results were obtained by (Barakat *et al*., 2015 and Rady *et. al*., 2016). Khalid and Fawy, (2011) showed that, humic substances, reduce the uptake of toxic elements and improve the uptake of many nutrients. Also, Al-Erwy *et al*. (2016) found that humic acid decrease the negative effects of saline conditions by reduction Na ions accumulation and on the other hand increase K uptake thus, increased the K/Na ratio in the tissues.

Table 8. Effect of genotypes and humic acid application on Na% and Na/K ratio in leaves in summer seasons 2018 and 2019.

Treatment	Na %		Na/K ratio	
	2018	2019	2018	2019
Genotypes (G)				
Sakha 53	0.719 b	0.713 b	0.546 b	0.537 b
Giza 102	0.777 a	0.762 a	0.589 a	0.568 a
Line 120	0.718 b	0.692 b	0.540 b	0.513 b
LSD at 0.05	0.0438	0.0366	0.0331	0.0288
Humic acid (H)				
Control	0.810 a	0.790 a	0.718 a	0.700 a
Soil	0.721 c	0.695 c	0.500 c	0.464 c
Spray	0.760 b	0.741 b	0.577 b	0.553 b
Soil+ Spray	0.662 d	0.664 c	0.437 d	0.441 c
LSD at 0.05	0.0195	0.0317	0.0263	0.0294

Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test.

Relative water content (RWC %) and proline

It is obvious from Table (9) the results showed that genotypes and humic acid application had significant effect on relative water content (RWC %) and proline content in both seasons except genotypes for RWC % in the first season. Line 120 recorded the highest values of RWC % with average of (60.84 %) in the second season only. The lowest values for proline were obtained by Giza 102 (0.700 and 0.701) in the two growing seasons.

Table 9. Effect of genotypes and humic acid application on relative water content (RWC %) and proline content in leaves in summer seasons 2018 and 2019.

Treatment	RWC (%)		Proline	
	2018	2019	2018	2019
Genotypes (G)				
Sakha 53	56.44	58.35 b	0.716 a	0.718 a
Giza 102	55.95	57.08 b	0.700 b	0.701 b
Line 120	58.70	60.84 a	0.717 a	0.722 a
LSD at 0.05	NS	1.43	0.010	0.009
Humic acid (H)				
Control	51.58 c	52.15 b	0.621 d	0.631 d
Soil	58.45 ab	60.12 a	0.734 a	0.734 b
Spray	57.40 b	59.12 a	0.720 c	0.721 c
Soil + Spray	60.64 a	62.82 a	0.769 a	0.769 a
LSD at 0.05	3.22	3.60	0.0073	0.009

Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test.

Perusal of the data in Table (9) revealed that, as compared to the control, the relative water content (RWC %) and proline were increased under humic acid application. The highest values of RWC % (60.64 and 62.82 %) and proline (0.769 and 0.769) were recorded with plants treated with combination of soil and foliar spray in the two studied seasons, respectively. These results demonstrated that, plant water relations play a main role in maintaining the physiological activities of sunflower plants. In this respect, Unyayar *et al*. (2004) stated that RWC % of the sunflower leaves decreased under water stress, thus the application of humic acid improve agricultural soil as increasing ability to retain moisture and reduce water evaporation (Delgado *et al*., 2002). In respect to proline, application of humic acid increased proline content when compared with control (Ahmed *et al*., 2013) under saline and sandy soil conditions. Also, Delavari *et al*. (2010) found that proline accumulation in plant tissues could be involved in the osmotic adjustment of plants when a plant is subjected to different stresses, plants maintain their water content by accumulation of proline.

Protein and oil (%) in seed

Concerning, the results in Table (10), Giza 102 recorded the lowest protein and oil percentage without significant differences between Sakha 53 and Line 120 in the two studied seasons.

Data showed also, that humic acid (soil and foliar) application gave the highest values for seed protein with averages (15.07 and 15.17 %) while, the minimum value (14.18 and14.16 %) was obtained due to lack of humic acid application for control in the two seasons, respectively. El-Hefny (2010) found that seed protein significantly increased with humic acid application under saline conditions. Also, the same trend was obtained for seed oil % where, combination of humic acid soil and foliar application had the highest values (37.15 and 37.22 %) in the two summer seasons, respectively. These results were in agreement with those obtained by (El-Nasharty *et al*., 2017) on sunflower under saline stress conditions.

Table 10. Effect of genotypes and humic acid application on seed protein and oil % in summer seasons 2018 and 2019.

Treatment	Seed protein (%)		Seed oil (%)	
	2018	2019	2018	2019
Genotypes (G)				
Sakha 53	14.88 a	14.88 a	36.35 a	36.42 a
Giza 102	14.50 b	14.51 b	35.66 b	35.63 b
Line 120	14.90 a	14.87 a	36.41 a	36.43 a
LSD at 0.05	0.17	0.17	0.353	0.680
Humic acid (H)				
Control	14.18 c	14.16 c	35.50 c	35.63 b
Soil	14.95 ab	14.86 b	36.13 b	35.99 b
Spray	14.84 b	14.81 b	35.77 c	35.80 b
Soil + Spray	15.07 a	15.17 a	37.15 a	37.22 a
LSD at 0.05	0.175	0.159	0.310	0.524

Mean values designed by the same letter in each column are not significant according to Duncan's Multiple Range Test.

In addition, the interaction effect between sunflower genotypes and humic acid application were significant on seed protein %. The highest percentage of protein was obtained by Line 120 (V_3) treated with soil and foliar spray of humic acid in the two growing seasons Fig. (7&8).

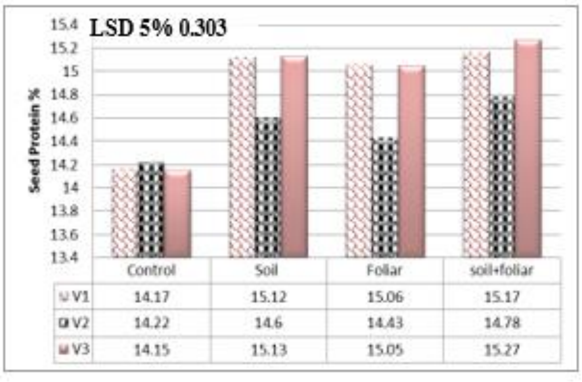

Fig. 7. Effect of interaction between humic acid application and sunflower genotypes on protein percentage in 2018 season (V_1: Sakha 53, V_2: Giza 102 and V_3: Line 120).

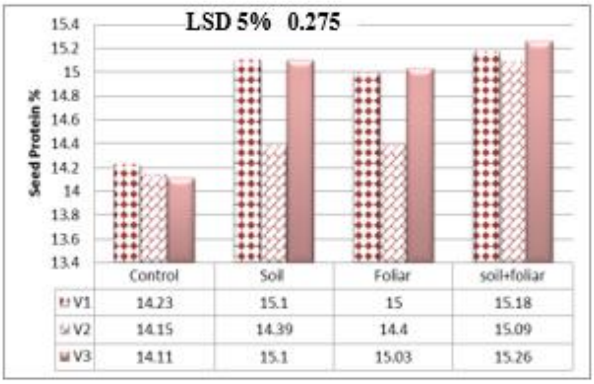

Fig. 8. Effect of the interaction between humic acid application and sunflower genotypes on protein percentage in 2019 season (V_1: Sakha 53, V_2: Giza 102 and V_3: Line 120).

CONCLUSION

It is inferred from this investigation that, application of humic acid (HA) to saline soils enhanced plant stress defense responses resulting better plant activity under stress. Thus, the application of HA may provide a useful improvement to decrease the harmful effects of salinity stress on sunflower plants especially Line 120 and Sakha 53.

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تأثير اضافة حمض الهيومك على نمو وانتاجيه زهرة الشمس تحت ظروف الاراضى الملحية

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أقيمت تجربة حقلية بمزرعة البستان – كلية الزراعة- جامعة دمنهور خلال موسمي الزراعة 2018 و2019م لدراسة بعض طرق اضافة حمض الهيومك على نمو وانتاجية ثلاثة تراكيب وراثية من زهرة الشمس تحت ظروف الاراضى الملحية. وكان التصميم الاحصائى المستخدم هو القطع المنشقة مرة واحدة فى أربعة مكررات حيث وضعت التراكيب الوراثيه فى القطع الرئيسيه (سخا 53 ، جيزة 102 ، سلالة 120) بينما وضعت معاملات اضافة حمض الهيومك فى القطع الشقيه وهى بدون رش (كنترول) ، اضافة أرضية ، رش ورقى ، خليط من الاضافة الارضية والرش الورقى. وقد أوضحت النتائج تفوق السلالة 120 فى المساحة الورقية للنبات وكذلك فى اغلبية صفات المحصول. كما اظهرت النتائج ان استخدام حمض الهيومك له تأثير كبير فى تحسين النمو والمحصول و صفات الجودة للبذور و كذلك الصفات الفسيولوجية تحت الدراسة. ومن خلال هذة الدراسه يمكننا التوصيه بزراعة السلالة 120أو سخا 53 مع اضافة حمض الهيومك فى صورة تسميد أرضى مع الرش الورقى تحت ظروف ملوحة التربه مما يؤدى الى التغلب على الاثر الضار للاجهاد الملحى لتلك النوعية من الاراضى.