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THE EFFICIENCY OF USING SALICYLIC ACID, GIBBERELLIC ACID AND SILICON, ON THE PRODUCTIVITY OF THE MAIZE PLANT (ZEA MAIZE L.) UNDER SALT-AFFECTED SOIL CONDITIONS .

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ABSTRACT

Soil salinity is one of the important factors affecting new reclaimed Sahl El-Tina soil at North Sinai. To face this problem, two field experiments were carried out during the two summer growing seasons of 2011 and 2012 to investigate the effect of foliar application of salicylic acid (SA) (50 – 100 mg L^{-1}), Gibberllic acid (GA3) (100 – 200 mg L^{-1}) and potassium silicate (Si) (50 – 100 mg L^{-1}) on the straw, grain yields and the mineral contents of maize (Zea maize L. CV. single hybrid 10) grown in a salt affected soil. Plants were sprayed by the each of the three afore materials at 30, 45 and 60 days from sowing. It was found that the application of the three materials increased both the straw and grain yields significantly. Na^{+} concentration in leaves and grains was inhibited while N, Mg, Fe, Mn and Cu were stimulated. The chlorophyll pigmented (a and b) and carotenoid contents were significantly increased due to application of SA, Si and GA3. These results suggested that SA, GA3 and Si can be used as potential growth regulators to improve salinity stress resistance.
keywords*:* Maize, Salicylic acid, Gibberellic acid, Silicon.

INTRODUCTION

Crops grown in arid and semi-arid regions are often exposed to adverse environmental factors such as high soil salinity, Gunes *et al* 2007). Salinity inhibits the seed germination, height, fresh and dry weights of the roots and shoots, chlorophyll and carotenoid contents of wheat while increased the proline content, Levent *et al* (2007).

Salinity may increase, decrease, or have no effect on the micronutrients (e.g. Cu, Fe, Mn, Mo and Zn) concentration in plant shoots (Bengu, 2012).

When plants are subjected to stress conditions, highly reactive activated oxygen species ROS(cytotoxic species) are produced that can seriously disrupt normal metabolism through oxidative damage to lipids, protein , nucleic acids and chlorophyll breakdown, Levent*et al* (2008 b).

The excess salt in the soil affects the plant growth either through osmotic inhabitation of water uptake by roots or specific ion effects. Salt stress leads to metabolic changes, like loss of chloroplast activity, decrease in photosynthetic rate and increase in photorespiration rate which in turn leads to the increased production of ROS (Parida and Das, 2005).

The exogenous application of plant growth regulators (PGRs) such as salicylic (SA) and gibberellic acids (GA3) was found to alleviate the adverse effects of salinity stress on the above mentioned parameters (Parida and

Das, 2005 and Bengu, 2012). PGRs are responsible for seed germination, stem elongation, leaf expansion, and flowering. They also prevent chlorophyll breakdown and decreases ROS levels that lead to cell death (Wen et. al., 2010). However, the use of PGRs must be under control. They may cause organ damages, including the brain, alarming toxicity to the breast, lung, kidney, liver and neurotoxicity of experiment mice (Troudia et. al. 2012). A combination of GA3 with a high concentration of EDTA causes severe soil and ground water pollution, (Hadi, et. al., 2010). Bejaoui (1989) concluded that the effects of GA3 may be caused by the activation of special enzymes which participate in the RNA and protein synthesis. Levent *et al* (2008) found that the foliar application of GA3 counteracted the accumulation of proline which maintained membrane permeability and increased macro and micronutrient levels. GA3 reduced the effect of salinity on the germination, growth and yield of maize, (Chowdhury and Sarwar, 2000).

Salicylic acid (SA); a hormone-like plant phenolic, is widely distributed in plants. It plays an important role in the regulation of plant growth and development (Klessing and Malamy, 1994). Bhupinder and Usha, (2003) and Gunes *et al*. (2007) found that SA application inhibited Na^+ accumulation but stimulated N, P, K, Mg, Fe, Mn and Ca uptake. An increase in the ion constriction of K and Ca in plants under salt stress could ameliorate the deleterious effect of salinity on growth and yield, Alteration of mineral uptake due to the SA application may be one mechanism for the alleviation of salt stress, (Levent, *et al*. 2007). Kothule *et al*. (2003) showed that salicylic acid (SA) at (200 mg L^{-1}) was the most effective in increasing seed yield per ha and harvest index of soybean plant. Hasan and Mohaddeseh (2011) indicated that vegetative growth of maize was improved by increasing SA concentration up to 200 mg L^{-1}. The highest amount of SA application was accompanied with 38.66% increase in chlorophyll concentration in the leaves. Gunes *et al*. (2007) reported that the SA could be used to improve plant salinity tolerance. Yamane *et al*. (2004) reported that the reduction in chlorophyll by salt stress is due to induced injury in chloroplasts that is dependent on the light. (Mady, 2009) found that the foliar application of SA effectively had improved N, P, K, Fe, Zn and Mn content in tomato leaves compared with those of the control plants in two seasons.

Silicon (Si) is abundant in soil and is the major constituent of many plants, but its role in the plant biology is poorly understood (Naeem, *et al*. 2010). Improvement of salt tolerance by the addition of Si has been reported for maize and wheat where it was found to correct to some extent the negative effects of salinity on growth, yield, nutrients uptake or photosynthetic activity, (Moussa, 2006; Mukkram *et al*., 2006 and Pei *et al*., 2010). Liang *et al* (2003) reported that the addition of Si to salt treated barley, significantly increased super oxide dismutase (SOD) activity in barley roots. (Hanafy *et al*., 2008) found that the lowest level of Si (250 mg L^{-1}) significantly increased all the studied growth parameters of wheat plants, while all levels of Si significantly increased the number of spikes and grains as well as grains yield compared with the control non-sprayed plants. Gharib and Hanafy (2005) noted that, Si foliar application enhanced N and K concentrations in pea shoots and played an important role in improving P nutrition.

A number of possible mechanisms are proposed through which silicon may increase the salinity tolerance in plants, e.g. improving water status (Romero *et al*. 2006), increasing photosynthetic activity and ultring structure of leaf organo-celles, (Shu and Lui, 2001) or by H- ATPase (Liang *et al* 2005).

Maize as an important cereal crop in Egypt, its cultivation has been recently extended to the newly reclaimed soil to meet the increasing population. Therefore, the aim of this study was to investigate the effect of SA; GA3; and Si foliar application on the yield and nutrients content of maize grown in salt affected soil.

MATERIALS AND METHODS

Two field experiments were conducted at Sahl El-Tina , North Sinai Governorate during two summer seasons 2011 and 2012, to study the effect of foliar application salicylic acid (AS) ; Gibbrillic acid (GA) and Silicon (Si) on maize plant grown in salt - affected soil. Some chemical and physical characteristics of studied soil are presented in Table (1). Treatments were designed as follows 1) control (without any treatment); 2) 50 mg l^{-1} SA; 3) 100 mg l^{-1} SA; 4) 100 mg l^{-1} GA, 5) 200 mg l^{-1} GA; 6) 50 mg l^{-1} Si; 7) 100 mg l^{-1} Si. Treatments were arranged in a randomized complete block design with four replicates.

Grains of maize (Zea mays L.) Varity of single hybrid 10 supplied by the Maize Department, Field Crop Research Institute were sown on 15^{th} and 20^{th} may 2011 and 2012, respectively.

Calcium super phosphate was added at a rate of 50 kg P_2O_5 fed^{-1} during soil preparation. Nitrogen was applied in a rate 100 kg N fed^{-1} as urea in three equal dose after 21; 45 and 60 days from planting. Potassium sulphat was added at a rate of 100 kg K_2O fed^{-1} in two doses after 30 and 50 days from planting. SA, GA3 and Si were foliar applied after 30, 45 and 60 days from sowing. All cultural practices for growing maize were done as recommended. Two leaves of four randomly chosen ten plants per replicated after 70 days from planting were collected from mid- sections of the plants in order to minimize age affects to determine it is chlorophyll and nutrients contents. At maize harvest (120 days) the total weights of ears and straw were recorded. Ears and straw were left for15 days to reach normal air dryness (above 11 % moisture) to support grains. Grain yield kg fed^{-1} and 100 grain (g) weight were recorded.

Soil analyses:

Particle size distribution was determined by the Pipette method (Piper 1950) and $CaCO_3$ content was determined by Calcimeter (Page *et al*. 1982). Soil organic matter was determined by the Walkly and Black method as described by Page *et al* (1982). Soil pH was measured using pH meter in soil: water suspension (1: 2.5) described by Jackson (1967). Total soluble salt expressed as EC dSm^{-1} was measured in soil past extract. Available N was extracted from soil using 2N KCl solution and measured according to the modified Kjeldahel method. Available P was extracted by 0.5 M sodium bicarbonate and determined calorimetrically according to Olsen method as described by Jackson (1967). Available K was determined using the flame photometer. Available micronutrients were extracted by Diethyline tetra amin penta Acitic acid (DTPA) according to Soltan, (1985) were determined by using Atomic Absorption (model GBC 932). Soil chemical physical properties show in Table (1).

Table (1). Physical and chemical properties of the investigated soil.

Coarse sand (%)	Fine Sand (%)	Silt (%)	Clay (%)	Textural class	O.M (%)	CaCO3 (%)
24.4	52.6	10.7	12.3	Sandy Loam	0.51	8.20

pH (1:2.5)	EC (dSm^{-1})	Cations $meql^{-1}$				Anins mq/l			
		Ca^{++}	Mg^{++}	N^{+}	K^{+}	CO_3^{-}	HCO_3^{--}	Cl^{-}	SO^{--}_4
8.32	**8.70**	**11.16**	**16.34**	**55.44**	**1.72**	**nil**	**5.95**	**43.07**	**37.98**

Available nutrients (mg kg)

Macronutrients			Micronutrients		
N	P	K	Zn	Fe	Mn
48	6.1	190	2.1	3.1	4.3

Plant analyses:

The oven dried plant part samples were ground, 0.5 g of each sample was digested using $H_2SO^{-}_4$, $HClO_4$ mixture according to the methods described by Chapman and Pratt (1961).The plant content of N, P, K, Fe, Mn, Zn and Cu was determined in plant digestion using the methods described by Jackson (1967), Cottenie *et al*. (1982) and Black (1965) . Fe, Mn, and Zn were determined by using Atomic Absorption (model GBC 932). Na and K content of the leaf analyzed with the flame photometer by the Versente method (Soliman and Doss, 1992)

Data were statistically analyzed according to Snedecor and Cochran (1990). Photosynthetic pigments (chlorophyll a +b) were measured in fresh leaf samples. Leaf samples (0.5) were homogenized with acetone (90 v/v), filtered and make up to a final volume of 50 ml. Pigment concentration was calculated from the absorbance of extract at 663, 645 and 470 nm using the formula (Lichtonthaler 1987).

RESULTS AND DISCUSSION

Grain and straw yield.

Data presented in Table (2) show both the grains and straw yields as affected by spraying SA, GA3 and Si applied at different rates. Analysis of variance revealed significant effect of three materials on increasing grain and straw yields of maize plants. The highest grain and straw yields were achieved when the plants were sprayed with 100 mg l^{-1} SA. Spraying plants with 200 mg l^{-1} GA_3 resulted in significantly higher grain and straw yields than the corresponding ones achieved due to spraying with 100 mg l^{-1} one. Also, when plant received 100 mg l^{-1} Si the straw and grain yields were higher compared with received 50 mg l^{-1} Si. The relative increases in grain yield were 27.8; 27.16 and 22.15 % respectively and corresponding to 26.6; 22.00

and 20.6 % in straw yield for the treatments 100 mg l^{-1} SA; 100 mg l^{-1} Si and 200 mg l^{-1} GA3, respectively. Growth reduction under saline condition has been well documented in various plants by many researchers such as Bengu (2012). Alleviated the deleterious affects of salinity by SA, GA3 and Si was studied by many author. Levent *et al* (2007), Gunes *et al*. (2007) and Fahad and Asha, (2012), pointed out that addition of SA to maize plants grown in salt affected soil was significantly increased dry matter yield. Increases in dry matter and yield of salt stressed plant in response to SA my be related to induction of antioxidant response and protective role of membranes that increase the tolerance of plant to damage (Gunes, *et al*. 2007). Levent *et al*. (2008) clear that foliar application of GA3 counter acted some of the adverse effect of salinity in maize plant with the accumulation of proline which maintained membrane permeability. Spraying with GA3 caused a significant increase in wheat grain yield under salt stress (Iqbal and Ashraf 2010). This effect of Si foliar allocation on maize yield under soil salinity is in agreement with the finding of Moussa (2006) who stated that oxegaus application of Si increased shoots and dry weight of maize plants grown in saline medias. They attributed the effect of Si on plant growth under soil salinity may be to role of membranes that increase the tolerance of plant to damage. In this respect, Hanafy *et al*. (2008) reported that silicon as a foliar application (50 or 100 mg l^{-1}) increased grain yield of wheat grown under saline condition. They refereed that to increases in plant water status and chlorophyll content.

Table (2). Effects of salicylic acid, gibbrillic acid and silicon on grain and straw yield of maize grown under saline soil conditions.

Treatments	Grain yield (kg fed^{-1})	Straw yield (kg fed^{-1})	100 seed weight (g)
Control	2194	3147	30.10
SA 50 (mg l^{-1})	2535	3410	32.21
SA 100 (mg l^{-1})	2805	3719	33.81
Si 50 (mg l^{-1})	2525	3325	31.80
Si 100 (mg l^{-1})	2790	3620	32.30
GA3 100 (mg l^{-1})	2450	3396	31.50
GA3 200(mg l^{-1})	2691	3590	31.8
L. S. D. at 5 %	195	170	1.10

The values are means of two seasons.

Macronutrients concentration in leaves and grains.

Data presented in Tables (3 &4)) show that the macronutrients (N, P, K and Mg^{++}) concentrations in maize leaves and grains were significantly, except Ca^{++} was no significant as affected with foliar application of SA, Si and GA3 respectively. The highest value of N, K, Ca^{++} and Mg^{++} concentration in leaves was 2.50 % , 2.90 % , 0.50 % and 0.35 % for Si (100 mg L^{-1}) foliar application, respectively, while the highest value of P concentration in leaves was 0.63 % for AG3 (100 mg L^{-1}) foliar application. On the other hand, the highest value of N, Ca^{++} and Mg^{++} concentration in grain were 1.90 %, 0.33 % and 0.19 % respectively for Si foliar application of rate 100 mg L^{-1}, while the highest P value was 0.48 % for GA3 foliar application by rate of (200 mg L^{-1}) and the highest value of K concentration in grain was 0.69 % for SA foliar application with rate 100 mg L^{-1}. From these results it could be concluded that N, P, K, Ca^{++} and Mg^{++} concentration in leaves and grains increased with increasing rate foliar application of Si, SA and GA3, respectively. These results are agreement by Singh *et al* (2006) reported that the application of silicon rate of 180 kg ha^{-1} caused increased N and P in the grain and straw of rice.

Table (3). Effect of salicylic acid, Gibbirellic acid and Silicon on macronutrients (%) in leafs of maize plants growing under saline soil conditions (the mean values of two seasons).

Treatments	N	P	K	Ca^{++}	Mg^{++}
Control	1.62	0.39	1.80	0.40	0.31
SA 50 (mg l-1	2.10	0.40	2.20	0.45	0.45
SA 100 (mg l-1)	2.40	0.45	2.80	0.49	0.51
Si 50 (mg l-1)	1.98	0.42	2.50	0.46	0.41
Si 100 (mg l-1)	2.5	0.45	2.90	0.50	0.53
GA3 100 (mg l-1)	2.20	0.63	2.30	0.42	0.39
GA3 200(mg l-1)	2.35	0.61	2.60	0.48	0.42
L. S. D. at 5 %	0.30	0.065	0.21	ns	0.05

Table (4). Effect of salicylic acid, gibbirellic acid and silicon on macronutrients (%) in maize grain under saline soil conditions combined (the mean values of two seasons).

Treatments	N	P	K	Ca^{++}	Mg^{++}
Control	**1.25**	**0.29**	**0.39**	**0.21**	**0.09**
SA 50 (mg l-1	**1.56**	**0.33**	**0.60**	**0.25**	**0.14**
SA 100 (mg l-1)	**1.60**	**0.35**	**0.69**	**0.31**	**0.15**
Si 50 (mg l-1)	**1.80**	**0.31**	**0.54**	**0.30**	**0.19**
Si 100 (mg l-1)	**1.90**	**0.30**	**0.60**	**0.33**	**0.19**
GA3 100 (mg l-1)	**1.60**	**0.45**	**0.55**	**0.27**	**0.17**
GA3 200(mg l-1)	**1.72**	**0.48**	**0.59**	**0.28**	**0.19**
L. S. D. at 5 %	**0.12**	**0.08**	**0.08**	**0.09**	**0.01**

Levent *et al* (2008) found that the foliar application of GA3 treatment increase macro and micronutrients levels.

Concerning that the addition of SA, Si and GA3 increased Mg^{++} concentration in maize leaves and grains compared with control. The Mg^{++} concentration in leaves and grains increases of value with increasing of rates (100 mg L^{-1} SA; 100 mg L^{-1} Si and 200 mg L^{-1} GA3). These results are agreement with Gunes *et al* (2007) showed that the SA foliar application increased Mg^{++} content in stressed maize leaves. Hanafy *et al* (2008) stated that Mg concentration in wheat grains and straw grown increased when plant treated with Si foliar application.

Sodium concentration in leaves and grains maize plants.

Data presented in Table (5) show that the foliar application of SA, Si and GA3 on Na^{+} concentration in leaves and grains maize plants was significantly decreased as compared to control. The highest value of Na^{+} concentration was 0.55 % for leaves and 0.71 % for grains of untreated plants (control).

Table (5). Effect of salicylic acid, gibberellic acid and silicon on Na^+ (%) concentration in maize plants leaves and grains grown under saline soil conditions(the mean values of two seasons).

Treatments	Leaves	Grains
Control	0.55	0.71
SA 50 (mg l-1	0.32	0.58
SA 100 (mg l-1)	0.28	0.49
Si 50 (mg l-1)	0.28	0.46
Si 100 (mg l-1)	0.24	0.38
GA3 100 (mg l-1)	0.35	0.50
GA3 200(mg l-1)	0.30	0.42
L. S. D. at 5 %	0.11	0.15

The corresponding relative decreases values of Na^+ concentration in leaves was 41.81and 49.10 % for SA rate (50 and 100mgL^{-1}); 49.10 and 56.36 % for Si of rate (50 and 100mg L^{-1}) and 36.36 and 45.54 % for GA3 of rate (100 and 200 mgL^{-1}) respectively, compared with control. Also, the relative decreases values of Na^+ concentration in grains was 18.31 and 30.98 % for SA rate (50 and 100mgL^{-1}); 35.21 and 46.47 % for Si of rate (50 and 100mg L^{-1}) and 29.58 and 40.84 % for GA3 of rate (100 and 200 mgL^{-1}) respectively, compared with control. The decrease value of Na^+ as affected by SA, Si and GA3 may explain reflect to the increased antioxidant activity, on the growth of salt stressed maize plants, (Farahbakhsh and Shamsaddin, 2010). These results are agreement by Gunes *et al* (2007) found that the foliar application of SA caused decreased Na^+ content of maize tissues under salinity. Levent *et al* (2008) pointed that treating maize plants grown under saline stressed soil with GA3 has decreased its Na+ contents in straw and root. Liang *et al* (2003) stated that addition of Si was found to reduce sodium but increases potassium concentration in shoots and roots of salt stress barley. Thus, Si enhanced salt tolerance is planting attributed to selective uptake and transport of potassium and sodium by plant.

Micronutrients content in leaves and grains of maize.

Effect of foliar application SA, Si and GA3 at different rates on Fe, Mn, Cu and Zn concentration in leaves and grains maize plants were positive effect under saline soil conditions. Data presented in Tables (6 &7) show that the foliar application of SA, Si and GA3 on Fe, Mn and Cu concentration in leaves and grains maize plants were significantly increase , while the Zn concentration in both leaves and grains was no significant. The highest mean values of Fe, Zn, Mn and Cu concentration in leaves maize plants were 151, 62, 105 and 5.2 mg kg^{-1} respectively, for planted treated with foliar application of Si (100 mg L^{-1}). Also, the highest mean values Fe, Zn, Mn and Cu concentration in grains maize plants were 78.00 mg L^{-1} for Fe of plants treated with Si (100 mg L^{-1}) ; 48.00 mg L^{-1} for Zn of plants treated with GA3 (100 mg L^{-1}) ; 36.00 mg L^{-1} for Mn of plants treated with GA3 (200 mg L^{-1}) and 2.80 mg L^{-1} for Cu of plants treated with SA (100 mg L^{-1}), respectively. Corresponding relative increases mean values of Fe, Zn, Mn and Cu concentration in leaves maize plants as affected by foliar application of SA at different rates (50 and 100 mg L^{-1}) were 23.81 and 33.33 % for Fe; 3.57 and 7.14 % for Zn; 25 and 39.70 % for Mn and 44.12 and 50.00 % for Cu , respectively, compared with control.

Table (6). The effect of salicylic acid, Gibbrillic acid and silicon on micronutrients (mg kg^{-1}) in leaves of maize plant combined (the mean values of two seasons).

Treatments	Fe	Zn	Mn	Cu
Control	105.00	56.00	68.00	3.40
SA 50 (mg l^{-1})	130.00	58.00	85.00	4.90
SA 100 (mg l^{-1})	140.00	60.00	95.00	5.10
Si 50 (mg l^{-1})	118.00	59.00	99.00	4.10
Si 100 (mg l^{-1})	151.00	62.00	105.00	5.20
GA3 100 (mg l^{-1})	120.00	58.00	80.00	4.40
GA3 200(mg l^{-1})	125.00	61.00	91.00	4.80
L. S. D. at 5 %	10.21	ns	13.42	0.42

Table (7). The effect of salicylic acid, Gibbrillic acid and silicon on micronutrients (mg kg-1) in maize grain combined over the two seasons.

Treatments	Fe	Zn	Mn	Cu
Control	53.00	42.00	24.00	1.80
SA 50 (mg l-1	65.00	43.00	29.00	2.60
SA 100 (mg l-1)	70.00	45.00	31.00	2.80
Si 50 (mg l-1)	71.00	45.00	30.00	2.20
Si 100 (mg l-1)	78.00	46.00	35.00	2.50
GA3 100 (mg l-1)	62.00	48.00	35.00	2.30
GA3 200(mg l-1)	61.00	46.00	36.00	2.50
L. S. D. at 5 %	3.20	ns	3.20	0.19

Concerning, the relative increases mean values of Fe, Zn, Mn and Cu concentration in leaves maize plant as plants treated with Si rates of (50 and 100 mg L^{-1}) were 12.38 and 43.81 % for Fe ; 5.36 and 10.71 % for Zn ; 39.70 and 45.60 % for Mn and 20.60 and 52.94 % for Cu, respectively compared with control, while the relative increases mean values of Fe, Zn, Mn and Cu concentration in leaves maize plant as plants treated with GA3 rates of (100 and 200 mg L^{-1}) were 12.50 and 19.05 % for Fe ; 3.57 and 7.14% for Zn ; 17.65 and 33.82 % for Mn and 29.41 and 41.17 % for Cu , respectively, compared with control.

It is evident from the concentration distribution patterns of Fe, Zn, Mn and Cu in leaves maize that it could be arranged into following orders:

Si > SA > GA3 > control for Fe, Zn, Mn and Cu of rate (100 mg L^{-1}).

SA > GA3 > Si > control for Fe and Cu of rate (50 mg L^{-1}).

SA > Si > GA3 > control for Zn and Mn of (50 mg L^{-1}).

On the other hand, the relative increases of mean values Fe, Zn , Mn and Cu concentration in grains maize plants as affected SA foliar application at rate (50 and 100 mg L^{-1}) were 22.64 and 32.07 % for Fe; 2.38 and 7.14% for Zn; 20.83 and 29.17 % for Mn and 44.44 and 55.55 % for Cu, respectively, compared with control, while the relative increases mean values concentration of Fe, Zn , Mn and Cu in grains maize plants as affected Si foliar application at rate (50 and 100 mg L^{-1}) were 33.96 and 47.17 % for Fe; 7.14 and 9.52 % for Zn ; 25.00 and 45.83 % for Mn and 22.22 and 38.89% for Cu, respectively compared with control. As well as, the relative increases of mean values Fe, Zn , Mn and Cu concentration in grains maize plants as affected GA3 foliar application at rate (100 and 200 mg L^{-1}) were 16.98 and 15.10 % for Fe ; 14.28 and 9.52 % for Zn ; 45.83 and 50.00% for Mn and 27.78 and 38.89 % for Cu compared with control , respectively. The relative increases of the studied micronutrients (Fe, Zn , Mn and Cu)concentration in grains maize plant are mainly depend on the used SA, Si and GA3 foliar application , as it could be arranged as followa :

Si > SA > GA3 > control for Fe and Zn.

GA3 > Si > SA > control for Mn.

SA> GA3 > Si > control for Cu at rate (50 mg L^{-1} SA, Si) and (100 mg L^{-1}) of GA3.

GA3 > Si > SA > control for Cu at rate of (100 mg L^{-1}) SA, Si and (200 mg L^{-1}) of GA3. These results are agreement by Tuna, *et al* (2008) foliar application of GA3 led to increased micronutrient levels in maize plant. Gunes *et al* (2007) concluded that addition of SA to maize plants grown under salinity increased Fe, Mn and Cu concentration in plant leaves. Also, Levent *et al* (2007) found that foliar application of 2mM SA increased Fe, Mn, Zn and Cu concentration in leaves maize under salt stressed conditions.

Finally, it is concluded that the concentrations of micronutrients in maize plants, generally, affected increase rates of rate SA, Si and GA3 foliar application.

Chlorophyll content.

Salinity causes the inhibition of pigments due to instability of protein complex and distribution chlorophyll pigments by inducing the activity of chlorophyllase degrading enzyme, (Pesserakli and Huber (1987).

Table (8) show that the chlorophyll (a +b) and carterniod contents were significantly increased due to application of AS, AG3 and Si, when compared to control. The relative increases of mean values of total chlorophyll (a+b) were 28.23 % and 42.65 % for plant treated by SA at rate (50 and 100 mg L^{-1}) ; 15.88 % and 42.10 % plant treated by Si at rate (50 and 100 mg L^{-1}) and 16.76 % and 36.18 % for plant treated by GA3 at rate (100 and 200 mg L^{-1}) compared with control. These results are agreement with Afroz *et al* (2005) who found that inhibition in chlorophyll biosynthesis and reduced chlorophyll content in salt stressed sorghum and maize plants, respectively. GA3 -treated plants exhibited higher values of chlorophyll than did the control or salinity-treated samples. Biglary *et al* (2011) showed that chlorophyll content was increased with the application of silicon compared to the control. Khodry (2004) and Levent *et al*. (2007) reported that application of SA to maize plants under salt stress increased total chlorophyll when compared to untreated plant. Ali *et al*. (2009) pointed out that silicon application significantly increased chlorophyll content of wheat and bean grown under salt stressed soil. Enhancing effect of As, GA3 and Si on photosynthetic capacity could be attributed to stimulatory effect on rublsco contents (Khodary, 2004).

Table (8). The effect of salicylic acid, gibbrillic acid and silicon on chlorophyll and carotene contents in leaves of maize grown in salt affected soil, combined over the two seasons.

Treatments	Chlorophyll (a) mg/g f.w	Chlorophyll (b) mg/g f.w	Chlorophyll (a+ b) mg/g f.w	Carotene mg/g f.w
Control	2.10	1.30	3.40	0.98
SA 50 (mg l-1	2.85	1.51	4.30	1.25
SA 100 (mg l-1)	2.95	1.90	4.85	1.60
Si 50 (mg l-1)	2.51	1.43	3.94	1.39
Si 100 (mg l-1)	2.93	1.90	4.83	1.73
GA3 100 (mg l-1)	2.62	1.35	3.97	1.30
GA3 200(mg l-1)	2.95	1.68	4.63	1.45
L. S. D. at 5 %	0.35	0.11	0.35	0.12

The highest carteniod content was achieved due to in 100 mg l^{-1} SA. On the other hand, the effect of SA, Si and GA3 different rates foliar application on maize plants were significant on carotene. The photosynthesis is a major controlling of reaction for plant growth and yield. The relative increases of the studied carteniod in maize plant content is mainly depend on the used SA, Si and GA3 foliar application , as it could be arranged as follow : Si > GA3 > Si > control at rate 50 mg L^{-1} for Si and SA and at rate 100 mg L^{-1} for GA3. SA > Si > GA3 > control at rate 100 mg L^{-1} for Si and SA and at rate 200 mg L^{-1} for GA3, respectively, compared with control. These results are agreement by Digdem *et al* (2007) reported that the SA foliar application was increased pigments content , chl a, b and carotenoids under salinity conditions. Moreover, Khan *et al*. (2003) showed that SA increased photosynthetic rate in corn and soybean.

Conclusion.

SA, Si and GA3 foliar application on maize productivity under saline conditions was significant increased and its nutrients contents and chlorophyll and Carotene contents of leaves and suggest that SA, Si, and GA3 could be used as potential growth regulator to improve plant growth and nutrient utilization under salt stress. These may be depending on the plant species and further research is needed to confirm our results.

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كفاءه استخدام حمض السيلسيك وحمض الجبريلك والسليكون على انتاجية الذره تحت ظروف الأراضى المتاثرة بالاملاح

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ملوحة التربة هى واحده من اهم الوامل التى تؤثر فى انتاجية الأراضى المستصلحة حديثا بمنطقة سهل الطسنة فى شمال سيناء . لمواجهة هذه المشكلة اجريت تجربتان حقليتان فى موسمين متتالين صيف ٢٠١١ و ٢٠١٢ لدراسة تاثير التسميد الورقى من حمض السيلسيلك (SA) بمعدل (٥٠ – ١٠٠ ملليجرام /لتر) والسليكون فى صورة سليكات بوتاسيوم (Si) بمعدل (٥٠ – ١٠٠ ملليجرام /لتر) وحمض الجبريلك (GA3) بمعدل (١٠٠ – ٢٠٠ ملليجرام /لتر) على انتاجية محصول القش والحبوب ومحتوياتهم من العناصر لمحصول الذرة صنف (فردى هجين ١٠) تحت ظروف الاراضى المتاثرة بلاملاح. كان رش المعاملات الثلاثة على ثلاث فترات بعد ٣٠ و ٤٥ و٦٠ يوم من الزراعة .

النتائج المتحصل عليها : وجد ان اضافة المعاملات الثلاثة رشا الى زيادة محصول القش والحبوب زيادة معنوية وخاصة مع المعدلات المرتفعة. كما وجد زيادة فى تركيز العناصر النتروجين والفوسفور والبوتاسيوم والماغنسيوم و الحديد واالمنجنير والنحاس زيادة معنوية بينما كانت زيادة الزنك فى القش والحبوب غير معنوية.

من النتائج السابقة وجد انة يمكن ان نستخدم حمض الجبريلك والسليكون و حمض السليسيلك كمنظمات للنمو ومنشطات لتحسين مقاومة نبات الذرة للاجهاد الملحى.

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