Effect of salinity of irrigation water and spraying with selenium and Humic acid on the growth of yellow corn

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ABSTRACT

The experiment was conducted during the spring season (2018-2019) in one of the fields belonging to the Department of Horticulture, College of Agriculture, Al-Qasim Green University. After placing the silty clay loam soil in wooden containers (60 × 60 × 40 cm). The split-plot design (factorial experiment) was used according to The Randomized Complete Block Design (RCBD) to study the effect of the interaction between the salinity of irrigation water, spraying with selenium, and Humic acid on the soil traits and the growth and yield of yellow corn. The experiment included 54 treatments, which are the result of interaction between three factors: salinity of irrigation water (W) at three levels (1.8, 3, 6 $dS.m^{-1}$), spraying with selenium at three concentrations of (0, 20 40 $mg.L^{-1}$), spraying with humic acid at two concentrations of (0, 2 $mg.L^{-1}$), with three replicates. The increase in the salinity of irrigation water led to a significant decrease in most studied plant traits, as well as concentrations of N, P, and K elements in the leaves. As for spraying with selenium and humic, it led to reducing the harmful effect of soil salinity. Thus, it led to a significant increase in the traits of studied plants and concentrations of N, P, K.

Keywords: quality of irrigation water, selenium, humic, yellow corn.

*Research paper from thesis for the first author.

تأثير ملوحة مياه الري والرش بالسيلينيوم وحامض الهيوميك في نمو نبات الذرة الصفراء

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المستخلص

اجريت التجربة اثناء الموسم الربيعي (2018-2019) في احد الحقول التابعة الى قسم البستنه كلية الزراعة –جامعة القاسم الخضراء . بعد وضع التربة المزيجية الطينية الغرينية المنقولة في حاويات خشبية (60*60*40 سم) استخدم تصميم الالواح المنشقة(تجربة عامليه) باستعمال تصميم القطاعات العشوائية الكاملة RCBD لدراسة تأثير التداخل بين ملوحة مياه الري والرش بالسيلينيوم وحامض الهيومك في بعض صفات التربة ونمو وحاصل الذرة الصفراء . تضمنت التجربة 54 معاملة هي نتيجة التداخل بين ثلاث عوامل هي ملوحة مياه الري (W) بثلاث مستويات (6،3،1.8)ديسيمنز.م$^{-1}$ والرش بالسيلينيوم وبثلاث تراكيز (40،20،0)ملغم.لتر$^{-1}$ والرش بحامض الهيومك وبتركيزين (2،0) ملغم لتر$^{-1}$ وبثلاث مكررات. لقد ادت زيادة ملوحة مياه الري الى انخفاض معنوي في اغلب صفات النبات المدروسة وكذلك تراكيز العناصر N,P,K في الاوراق اما الرش بالسيلينيوم والهيومك ادى الى تقليل التأثير الضار لملوحة التربة وبالتالي ادى الى حصول زيادة معنوية في صفات النبات المدروسة وتراكيز N,P,K.

الكلمات المفتاحية: نوعية مياه الري, السيلينيوم, الهيومك, الذرة الصفراء.

*البحث المستل للباحث الاول.

1. INTRODUCTION

The problem of salinity of irrigation water has emerged as one of the main problems that stand in the way of increasing agricultural production due to the direct negative effects (toxicity and osmosis) that it causes to the plant, as well as the imbalance of nutrients and indirect effects on the physical and chemical properties for the soil. Drainage and Well water have been used in several countries of the world, especially those located in dry and semi-dry regions. Selenium is considered one of the rare elements and has an effective role in raising the activity of enzymatic antioxidants where it is entered as an agent to these antagonists, especially the Glutathione Peroxidase enzyme, which transforms the toxic hydrogen peroxide (H_2O_2) resulting from the effect of saline stress on water molecules (7). Selenium is also characterized by its association with amino acids, especially methionine and cysteine, and the formation of what is known as Selenoproteins, which have a miraculous ability to increase cellular membranes' tolerance to saline stress and prevent denaturation of protein and Protein metabolism compounds. Humic acid is considered one of the humic organic acids that are produced naturally from the humic substance resulting from the analysis of the organic matter, which caused its added to the soil or plant an increase in the absorption of mineral elements, especially when exposed to saline stress. It also improves the physical, chemical, and biological properties of the soil and reducing the problems and harms of excess salinity and alkalinity, thus increasing the strength of the root system and its absorbability. Therefore, the study aims to know the effect of the interaction between the salinity of irrigation water and spraying with selenium and humic acid in the growth of yellow corn.

2. MATERIALS AND METHODS

The experiment was conducted in the spring season (2018-2019) in one of the fields belonging to the Department of Horticulture, College of Agriculture, Al-Qasim Green University. The soil was placed in wooden containers (60 × 60 × 40 cm) and the texture of soil was a silty clay loam. Containers (experimental units) were distributed in three sectors, the distance between one sector and another 1 m, each sector divided into 18 experimental units, the distance between an experimental unit and another 30 cm. Ten seeds of yellow corn were planted in each experimental unit that thinned to three plants after three weeks of cultivating. Three levels of salinity of irrigation water were used (control treatment 1.8, 3, and 6 $dS.m^{-1}$) which are symbolized by (W0, W1, W2), respectively, three concentrations of selenium (0, 20 and 40 $mg.L^{-1}$) which are symbolized by (Se0, Se1, Se2), respectively, two concentrations of Humic acid (0 and 2 $mg.L^{-1}$) which are symbolized by (H0, H2), with three replicates and the number of experimental units are 54. The experiment was conducted according to The Randomized Complete Block Design (RCBD) within the split- split plots system. The variance analysis method was used to determine the statistical differences between the arithmetic averages using (Genstat, 2007) program. The averages were compared according to the least significant difference (L.SD) test with a significant level of (0.05). 240 $kg.ha^{-1}$ (46% N) urea nitrogen was added in two batches and 120 $kg.ha^{-1}$ phosphorus was added in the form of superphosphate fertilizer (21% P) and 120 $kg.ha^{-1}$ potassium in the form of potassium sulfate (41% K) according to fertilizer recommendation (Al-Sahuki, 2000). The Diazinon 10% GR was added at a concentration of 10% $kg.ha^{-1}$ to control the Lesser Cornstalk Borer after 20 days of germination. All experimental units were irrigated with river water (1.8 $dS.m^{-1}$) in the first irrigation and irrigation was then done according to the treatments when draining 50% of the available water with adding 0.15 as the washing requirements of (LR). Measurements were taken for the studied traits in the flowering stage.

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Table 1: Some chemical traits of irrigation water used in the experiment.

Trait	Units	Treatment		
		W1	W2	W3
Electrical conductivity	$ds.m^{-1}$	1.8	3	6
Degree of interaction	-	7.52	7.65	8.1
Calcium	$mmol.L^{-1}$	3.78	5.1	8.2
magnesium		1.62	4.3	9.1
Sodium		3.14	10.15	18.4
Potassium		0.12	0.18	0.21
Chloride		3.88	10.7	21.2
Sulfate		4.47	8.2	17.48
Bicarbonate		2.15	2.70	3.81
Sodium adsorption ratio (SAR)	$(mmol.q.L^{-1})^{1/2}$	1.35	3.31	4.36
Water type according to the American classification	-	C3S1	C4S1	C5S1

Table 2: Some chemical and physical traits of the soil.

Traits	Units	Value
Electrical conductivity (ECe)	$ds.m^{-1}$	4.64
Degree of reaction (PH)	-	7.76
Dissolved ions		
Calcium	$mmol.L^{-1}$	10.45
magnesium		7.09
Sodium		10.31
Potassium		0.72
Chloride		17.32
Sulfate		11.66
Bicarbonate		4.85
Carbonate		0.00
Sodium adsorption ratio (SAR)	$(mmol.q.L^{-1})^{1/2}$	2.46
Cation exchange capacity	$cmol.kg^{-1}$	26.33
Carbonate minerals	$g.kg^{-1}$	253
Gypsum		0.81
Bulk density	$\mu g.m^{-3}$	1.28
Organic matter (O.M)	$g.kg^{-1}$	9.94
Nitrogen availability	$mg.kg^{-1}$	40
Phosphorous availability		14
Potassium availability		190
Sand	$g.kg^{-1}$	153
Silt		557
Clay		290
Texture	**Silty clay loam**	
Gravimetric Water Content at water stresses		
Saturation 0 kPa	%	48.57
33 kPa		33.98
1500 kPa		21.60
Water availability		12.38

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3. RESULTS AND DISCUSSION

The leaves content of total chlorophyll

The increase in the salinity of irrigation water led to a significant decrease in the concentration of chlorophyll in the yellow corn leaves as shown in Table (3), where its highest value was at the level of salinity of irrigation water (W0) which amounted to (44.70 spads) compared to the level of salinity of irrigation water at the W2 treatment, which gave the lowest value amounted to (38.30 spads), with a level of the decline of 14.31%, because the increase in soil salinity effects in deaccelerating the speed of the process of building chlorophyll because of its impact on factors Necessary for its formation, such as absorption of water and mineral elements necessary for its construction, such as iron, magnesium, and nitrogen, thus reducing the total concentration of total chlorophyll (10). The concentration of chlorophyll increased significantly when spraying with humic acid, and its highest value was at the H2 treatment, which amounted to (42.14 spads) compared to the H0 treatment, which amounted to (39.85 spads). The reason for this may be due to the effect of humic acid on some of the plant's metabolic processes such as the respiration process and photosynthesis process, as well as its increase in antioxidants, thus preserving the leaves content of chlorophyll from the demolition processes. The spraying with selenium affected increasing the concentration of chlorophyll and its highest value was at the Se2 treatment, which amounted to (41.62 spads) compared to the control treatment (Se0), which amounted to (40.46 spads). The increase in the concentration of total chlorophyll in the leaves when sprayed with selenium may be attributed to its effect in increasing the potassium concentration in the leaves as well as its inhibitory effect in the production of abscisic acid and the increase in gibberellin production. It also has a common role in both enzymatic and non-enzymatic antioxidants, which enters in the synthesis of glutathione peroxidase and increasing its effectiveness and works to remove a toxic oxidized hydrogen peroxide radical for plastid membranes and converting it into water molecules, thus reducing its concentration and toxicity. It was also found that when the bi-interaction between the salinity of irrigation water with selenium was found that the highest value was at the W0Se2 interaction treatment which amounted to (45.05 spads) compared to the W2Se0 interaction treatment which gave the lowest value amounted to (37.82). The results of the interaction between spraying with humic and selenium indicated that the highest value was when treating the Se2H2 interaction, which amounted to (42.77 spads) compared to the lowest value at the Se0H0 treatment, which amounted to (39.32 spads), with an increase of 8.77%. It is clear from the triple interaction between the salinity of irrigation water, spraying with selenium and humic acid that all of these factors were affected significantly in the concentration of chlorophyll and the highest value was at the Se2H2W0 treatment which amounted to (46.90 spads) compared to the lowest value was at the Se0H0W2 treatment which amounted to (37.43 spads), with an increase of 25.30%.

Plant height

The increase in the salinity of irrigation water from (1.8 to 6 $dS.m^{-1}$) led to a significant decrease in the plant height, with a percentage of 18.69 % as shown in Table (4). This may be attributed to the fact that the increase in the salinity of irrigation water has led to the inhibition of growth processes and the evolution and detection of plants, especially the effect in reducing the value of the water effort and increasing the osmotic effort leading to a decrease in the value of cell expansion and the closure of stomata, negatively affecting the efficiency of photosynthesis, causing a decrease in the size of the protoplast. The plant height has increased significantly when spraying with humic acid, and its highest value was at the H2 treatment, which amounted to (126.2 cm) compared to the H0 treatment, which amounted to (119.8 cm), with a percentage of increase

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amounted to 5.34%. The reason may be attributed to the fact that humic acid has an effect on increasing the bio-activities of the plant and raising the absorption rate of nutrients, which leads to an increase in the rate of plant growth, and this result agrees with (4). As for spraying with selenium, the plant height increased insignificantly, and its highest value was at the Se2 treatment amounted to (124.9 cm) compared to the control treatment which amounted to (120.2 cm). This is due to spraying with selenium has reduced the saline effects that negatively affect the plant height. It is clear from the interaction between the salinity of irrigation water and spraying with humic that the highest plant height was at the W0H2 treatment amounted to (141.0 cm) compared to the interaction treatment (W2H0) which gave the height amounted to (108.9 cm). The interaction between the salinity of irrigation water and selenium has significantly affected the plant height and its highest value was at the interaction treatment (W0Se2), which amounted to (139.0 cm) compared to the interaction treatment (W2Se0), which gave the lowest value to the plant height amounted to (108.5 cm). The interaction between spraying with humic and selenium affected significantly on the plant height, and its highest value was at the interaction treatments (Se2H2 Se1H2) which amounted to (127.6 cm) compared to the lowest value at theSe0H0 treatment which amounted to (116.9 cm). Triple interaction indicated that its highest value was at the W0Se2H2 treatment which amounted to (144.1 cm) compared to the lowest value at the W2Se0H treatment which amounted to (103.6 cm).

Table 3: Effect of salinity of irrigation water and spraying with selenium and humic acid on the leaves content of chlorophyll (spad)

The salinity of irrigation water ($dS.m^{-1}$) W	**Humic acid (H)**	**Concentration of selenium ($mg.L^{-1}$) Se**			**Interaction between (H ×W)**
		Se_0 (10)	**Se_1 (20)**	**Se_2 (40)**	
W_0	H_0	42.80	43.00	43.20	43.00
	H_2	45.97	46.33	46.90	46.40
W_1	H_0	37.73	38.53	40.47	38.91
	H_2	40.63	40.97	41.53	41.04
W_2	H_0	37.43	37.73	37.73	37.63
	H_2	38.20	38.83	39.87	38.96
LSD0.05			**4.94**		**3.23**
Effect of Se		40.46	40.90	41.62	Salinity of irrigation water ($dS.m^{-1}$) W
LSD0.05			**2.01**		
Interaction between (Se ×W)	W0	44.38	44.67	45.05	44.70
	W1	39.18	39.75	41.00	39.98
	W2	37.82	38.28	38.80	38.30
LSD0.05			**3.48**		**2.66**
					Effect of spraying with humic acid
Interaction between (Se ×H)	H_0	39.32	39.76	40.47	39.85
	H_2	41.60	42.04	42.77	42.14
LSD0.05			**2.95**		**2.17**

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Table 4: Effect of salinity of irrigation water and spraying with selenium and Humic acid on the plant height (cm) of yellow corn.

The salinity of irrigation water ($dS.m^{-1}$) W	Humic acid (H)	Concentration of selenium ($mg.L^{-1}$) Se			Interaction between (H ×W)
		Se_0 (10)	Se_1 (20)	Se_2 (40)	
W_0	H_0	129.9	133.6	134.9	132.8
	H_2	137.3	141.7	144.1	141.0
W_1	H_0	117.3	116.7	118.8	117.6
	H_2	119.4	127.2	124.2	123.7
W_2	H_0	103.6	109.3	113.8	108.9
	H_2	113.4	113.8	114.2	113.8
LSD0.05			**14.34**		**10.57**
Effect of Se		120.2	123.9	124.9	Salinity of irrigation water ($dS.m^{-1}$) W
LSD0.05			**5.56**		
Interaction between (Se ×W)	W0	133.6	138.1	139.0	136.9
	W1	118.4	121.6	121.9	120.6
	W2	108.5	111.6	114.0	111.3
LSD0.05			**11.60**		**10.62**
					Effect of spraying with humic acid
Interaction between (Se ×H)	H_0	116.9	120.2	122.1	119.8
	H_2	123.4	127.6	127.6	126.2
LSD0.05			**7.35**		**4.43**

The dry weight of the total vegetative

The increase in the salinity of irrigation water from (1.8 to 6 $dS.m^{-1}$) led to a significant decrease in the dry weight of the total vegetative, with a percentage of 29 % as shown in Table (5). The reason may be due to the decrease in the leaf area and chlorophyll for the plant in addition to the direct salinity effect on the effectiveness of the enzymes that are reflected in the photosynthesis process and its effect on the vegetative growth indicators. As for spraying with humic acid, It has led to a significant increase in dry weight, and its highest value was at the H2 treatment, which amounted to (58.69 $g.plant^{-1}$) compared to the H0 treatment, which amounted to (50.74 $g.plant^{-1}$), with a percentage of increase amounted to (15.66%). The reason may be attributed to the fact that humic has a role in increasing plant height as shown in table (4) and chlorophyll content as shown in table (3), which together contributed to increasing the dry weight of the plant, and this result agrees with (1). As for spraying with selenium, the dry weight increased insignificantly, and its highest value was at the Se2 treatment amounted to (58.59 $g.plant^{-1}$) compared to the control treatment which amounted to (51.01 $g.plant^{-1}$). The reason for the significant increase when spraying with selenium is that under stress conditions, selenium works when adding it as an auxiliary in the enzyme system to produce types of modified sugars called the Trehalose containing the glycosidic bonds interfering with the place of fructose when its deficiency works to resist the effects of free radicals and this increases the CO_2 fixation process. This agrees with (12, 11) on the potato plant and (9) on the lettuce plant. It is clear from the interaction between the salinity of irrigation water and spraying with humic has significantly affected and the highest dry weight was at the W0H2 treatment which amounted to (69.58 $g.plant^{-1}$) compared to the interaction treatment W2H0 which amounted to (41.72 $g.plant^{-1}$). The

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interaction between spraying with humic and selenium was significant, where the highest value was at the interaction treatment (Se2H2), which amounted to (60.17 g.plant^{-1}) compared to the lowest value at the Se0H0 treatment, which amounted to (48.69 g.plant^{-1}). It appears from the triple interaction for the levels of salinity of irrigation water and spraying with selenium and humic acid had a significant effect that the highest dry weight was at triple interaction treatment (W0H2Se2) which amounted to (72.00 g.plant^{-1}) compared to its lowest value at triple interaction treatment (W2H0Se0) which amounted to (39.48 g.plant^{-1}), with a percentage of increase amounted to (82.37%).

Table 5: Effect of salinity of irrigation water and spraying with selenium and Humic acid on the dry weight of the total vegetative (g.plant^{-1}) of yellow corn.

The salinity of irrigation water (dS.m^{-1}) W	**Humic acid (H)**	**Concentration of selenium (mg.L^{-1}) Se**			**Interaction between (H ×W)**
		Se_0 (10)	**Se_1 (20)**	**Se_2 (40)**	
W_0	H_0	59.79	61.05	61.09	60.64
	H_2	67.80	68.94	72.00	69.58
W_1	H_0	45.79	49.98	53.77	49.85
	H_2	54.05	56.55	57.86	56.15
W_2	H_0	39.48	41.50	44.18	41.72
	H_2	45.14	51.19	54.66	50.33
LSD0.05			**6.79**		**5.80**
Effect of Se		51.01	54.54	58.66	Salinity of irrigation water (dS.m^{-1}) W
LSD0.05			**2.05**		
Interaction between (Se ×W)	W0	63.80	65.00	66.54	65.11
	W1	49.92	53.27	55.82	53.00
	W2	45.31	45.35	47.42	46.02
LSD0.05			**4.56**		**4.30**
					Effect of spraying with humic acid
Interaction between (Se ×H)	H_0	48.69	50.51	53.01	50.74
	H_2	57.33	58.56	60.17	58.69
LSD0.05			**4.48**		**4.17**

The dry weight of the root system

Table (5) shows that the increase in the salinity of irrigation water from (1.8 to 6 dS.m^{-1}) led to a significant decrease in the dry weight of the root system. The reason may be due to the osmotic effect caused by the increase in soil salts, and this leads to a lack of water absorption by the plant, which in turn leads to a lack of entry of nutrients, which reflects negatively on cellular metabolism and bio-activities within the cell affecting major activities such as photosynthesis and respiration (6), which led to a decrease in the dry weight of the root system. The spraying of humic acid had a significant effect in reducing the effect of salinity of irrigation water and increasing dry weight and its highest value was at the H2 treatment, which amounted to (10.37 g.plant^{-1}) compared to the H1 treatment, which amounted to (6.17 g.plant^{-1}), with a percentage of increase amounted to (68.07%). The reason for this may be attributed to the fact that humic acid has a vital and chemical role that affects when adding it in liquid or solid form to the soil due to its ability to adsorb on the surfaces of the cell membranes of the plant because it contains loving and hydrophobic sites (8), It also has a role in increasing the nutrients availability and their absorption by the plant. As for the effect

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of selenium, spraying with selenium led to a significant increase in the dry weight of the root system and its highest value was at the Se2 treatment, which amounted to (9.38 g.plant^{-1}) compared to the Se0 treatment, which amounted to (7.08 g.plant^{-1}), with an increase of 32.48%. This is due to the role of this element in increasing the rate of vegetative growth and leaf area, which improves the growth of the root system, thus increasing the absorption area of the nutrients in the growth media (5). The spraying with humic and selenium led to a significant increase in the dry weight of the root system and its highest value was at the interaction treatment (Se2H2), which amounted to (11.66 g.plant^{-1}) compared to the lowest value was at the Se0H0 treatment, which amounted to (5.10 g.plant^{-1}). It is clear from the triple interaction between the salinity of irrigation water and spraying with humic acid and selenium that its highest value was at the W0H2Se2 treatment which amounted to (14.51 g.plant^{-1}) compared to the lowest value was at the W2H0Se0 treatment which amounted to (4.48 g.plant^{-1}).

Table 6: Effect of salinity of irrigation water and spraying with selenium and Humic acid on the dry weight of the root system (g.plant^{-1}) of yellow corn.

Salinity of irrigation water (dS.m^{-1}) W	**Humic acid (H)**	**Concentration of selenium (mg.L^{-1}) Se**			**Interaction between (H ×W)**
		Se_0 (10)	**Se_1 (20)**	**Se_2 (40)**	
W_0	H_0	5.71	7.62	8.39	7.24
	H_2	11.09	13.57	14.51	13.05
W_1	H_0	5.10	6.33	6.87	6.10
	H_2	8.90	9.42	11.35	9.89
W_2	H_0	4.48	4.96	6.05	5.16
	H_2	7.21	8.19	9.14	8.18
LSD0.05			**0.84**		**0.65**
Effect of Se		7.08	8.35	9.38	Salinity of irrigation water (dS.m^{-1}) W
LSD0.05			**0.30**		
Interaction between (Se ×W)	W0	8.40	10.59	11.45	10.15
	W1	7.00	7.88	9.11	8.00
	W2	5.84	6.57	7.60	6.67
LSD0.05			**0.68**		**0.65**
					Effect of spraying with humic acid
Interaction between (Se ×H)	H_0	5.10	6.30	7.10	6.17
	H_2	9.06	10.39	11.66	10.37
LSD0.05			**0.43**		**0.29**

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