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EFFECT OF SOIL SALINITY ON SOME SOIL PROPERTIES, SALINITY TOLERANCE AND PRODUCTIVITY OF SOME SUNFLOWER GENOTYPES

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ABSTRACT

Two field experiments were conducted at the Experimental Farm of Sakha Agricultural Research Station during two successive seasons 2010 and 2011. The objectives of this investigation are to study the tolerance of some sunflower genotypes to different soil salinity levels and some soil properties. Four Sunflower genotypes i.e. line 350, line 450, line 800 and Sakha 53 were grown under three levels of soil salinity where: EC values were namely, (S_1 2: < 4), (S_2 4: < 6) and (S_3 6: < 8) dSm^{-1}. Split plots design was used, the main plots were assigned by the salinity levels and the sunflower genotypes were allocated in sub plots with four replicates.

The obtained results can be summarized as follow:

Sodium adsorption ratio (SAR) of soil paste extracts after harvesting greatly increased with increasing salinity. Total nitrogen, available phosphorus and available potassium increased with increasing soil salinity. Soil salinity significantly affected sunflower yield and yield component. Sunflower seed yield (kg /fed.) had the following sequence at the salinity level: Sakha 53 > line 350 > line 880 > line 465 with S_1, line 880 > line 350 > line 465 > Shakha 53 with S_2 and line 465 > line 350 > Sakha 53 > line 880 with S_3.The investigated Sunflower genotypes can be arranged according to oil yield (kg/fed.) as follows:-

Sakha 53 > line 880 > line 465 >line 350 with S_1, line 880 >Sakha 53 > line 350 >line 465 with S_2 and line 880 >Sakha 53 >line 465 >line 350 with S_3. Head diameter/ plant, Weight of seed /plant and 100-seed weight significantly decreased with increasing soil salinity levels.

Sunflower genotypes line 465 and line 880 were the highest tolerant genotypes to soil salinity, whereas the line 350 and Sakha 53 had moderate tolerance to soil salinity.

Keywords: sunflower, soil salinity, yield and seed oil percent.

INTRODUCTION

Sunflower is considered one of the most promising oil crops in Egypt. It is proposed to close up the gap of oil consumption. Soil salinity is one of the most important environmental factors affecting the growth and yield of most field crops, especially in arid and semi-arid regions as in Egypt. Saline soil is wide-spread in the Northern part of the country especially in Kafr El-Sheikh Governorate. The problem of salinity received much attention in Egypt in both old and newly reclaimed lands. Effects on growth and yield may be due to ionic imbalances which can be caused by high salt concentration and soluble salts which depress the water potential of nutrient medium and hence restrict water uptake by plant roots. The managements of salt affected soil require a good understanding of crop-salinity relations, particularly under field condition. Salinity seriously constrains crop yield in irrigated agriculture throughout the world. Nearly one third of the world's irrigated agricultural land is saline, and salt-affected soil estimates by about 400 - 950 × 10^6 ha., (Shannon, 1984). Salinity is one of the major problems that face the farmers all over the world. More than 25% of irrigated land is saline in Egypt, Iran, Iraq, India, Pakistan and Syria (Choukr-Allah, 1996). Increasing soil salinity in Egypt is very alarming problem. Soil salinity inhibits plants growth as result of stomata closure, which reduces the CO_2 fixation as a result of the rate of leaf elongation enlargement and cells division was reduced. Furthermore, salt in soil water solution can reduce evapotranspiration by making soil water less available for plant root extraction, (Shalhevet, 1994). Sunflower *(Helianthus annuus L.*) is becoming an increasingly important source of edible vegetable oils throughout the world because of its high poly unsaturated fatty acids content. Allen *et al*., (1998) showed that sunflower is moderately sensitive to soil salinity where it can tolerate salinity up to EC equals to 1.7dSm^{-1}. Sunflower yield was greatly reduced when plants were grown under salinity condition. Leaching salts from the soil by increasing irrigation amount is a practice used in Egypt to improve growth and yield of crops grown under saline conditions, (Gaballah *et al*., 2006). Katerji *et al*., (2000), Mass and Hoffman (1977) and Schleiff (2008) evaluated the relative salt tolerance of agricultural crops and obtained relationships between relative yield and soil salinity. They concluded that the yield decreased approximately linearly as salinity increased beyond the threshold salinity level. Mohamedin *et al.,* (2004) and Abd El-Kader *et al.,* (2006) revealed that Sunflower yield linearly decreased as a ground water table rise. Objective of the present work is to evaluate the impact of soil salinity level on some soil properties, yield and yield components of some sunflower genotypes.

MATERIALS AND METHODS

Two field experiments were conducted at the experimental farm of Sakha Agricultural Research Station during two successive summer seasons of 2010 and 2011 at 1st July in the two seasons to study the effect of three levels of soil salinity (S_1 2: <4), (S_2 4: <6) and (S_3 6: <8) dSm^{-1} under field conditions on yield and yield components of four Sunflower genotypes i.e line 350, line 465, line 800 and sakha 53. The experiments were conducted in a split plot design, the main plots were assigned by the salinity levels and the sunflower genotypes were allocated in sub plots with four replicates. The land was prepared for planting and divided into 48 plots; each plot consisted of 8 ridges. The ridge was (3m) in length and (0.6m) in width and irrigated to distribute salinity in each plot. Then, it was left for ten days after which eight samples for each plot (from 4 ridges) at depths of 0-30 and 30-60 cm were collected.

Seeds were sowing by hand at distance 20cm between hills and the plants were thinned before first irrigation (20 days after sowing) to one plant/hill. The other agricultural practices were carried out as recommended. Soil samples were analyzed for EC_e, total N%, available P and K and soluble ions, according to standard methods of Page *et al*. (1982) and Piper (1950). Some chemical and physical properties of the two experimental sites are shown in Table (1). Ten guarded plants of Sunflower genotypes were taken randomly at harvesting to determine the following characters: Head diameter, Seed weight per plant (gm), 100-seed weight, Seed yield (kg/fed), and oil yield (kg/fed) is extracted by petroleum ether using sukslat apparatus.

Data were subjected to statistical analysis according Gomez and Gomez (1984) for split plot design for all studies characters by using Irristat Computer Program, (Duncan's 1955).

Soil samples before planting were air dried, ground sieved to be ready for the following analysis, particle size distribution, soluble ions, pH, EC, total N, available P and K. A map was done for salinity distribution (average 0-60 cm soil depth) for each season.

The soil under study is surrounded by buildings from three sides while the fourth side was limited by main drain. So, the drainage was restricted. The experimental plots were treated with 15.5 kg P_2O_5 / fed. as superphosphate fertilizer (15.5%) added broadcast before land preparation. Nitrogen was applied at rate of 45kg N/ fed (urea 46.5%N) in two equal doses. Potassium fertilizer was added in form of potassium sulphate (48%) at rate 24 K_2O kg/fed after one month of planting.

Table 1. Some properties of soil samples (0 – 60 cm depth) before sowing in the two seasons 2010 and 2011.

Variable	EC_e, dSm^{-1}					
	S_1		S_2		S_3	
	2010	2011	2010	2011	2010	2011
pH*	7.85	7.82	7.95	7.95	8.10	8.05
Soluble ions, meq/l						
Ca^{2+}	11.20	10.50	15.00	14.60	20.66	18.20
Mg^{2+}	4.22	5.20	4.33	5.60	12.20	13.10
Na^{+}	15.20	16.20	22.40	23.20	34.22	35.20
K^{+}	1.40	1.20	2.00	1.80	3.00	2.40
CO_3^{2-}	0.20	0.30	0.40	0.50	0.40	0.60
HCO_3^{-}	3.20	4.10	5.20	5.80	6.00	6.20
Cl^{-}	14.40	14.60	20.20	22.00	32.40	33.20
SO_4^{2-}	14.20	14.10	24.20	16.90	31.20	28.90
SAR	5.49	5.78	7.21	7.30	8.44	8.89
Total N, %	0.09	0.08	0.10	0.08	0.10	0.07
Available-P, mg/Kg soil	8.2	7.2	8.0	7.3	10.0	7.6
Available-K, mg/kg soil	280	240	230	260	330	280
Particle size distribution						
Sand, % / Silt, % / Clay, % / Texture class						
53.5 / 22.9 / 23.6 / clayey						

***determined in 1:2.5 soil water suspension.**

RESULTS AND DISCUSSION

Soil chemical properties after harvesting:

Data presented in Table (2) showed that sodium adsorption ratio (SAR) of soil paste extract after harvesting slightly increased with increasing salinity compared to before harvesting. This may be due to the restricted drainage of the soil under study. Total nitrogen (%) and available phosphorus and potassium (mg kg-1) increased with increasing soil salinity. This may be due to limited growth of the plants under salinity and stunted, which reduced elements consumption, in addition to the limited amounts of organic matter decayed under saline condition. Mass (1986) and Marschner (1986) revealed that increasing soluble ions in the soil solution cause decreasing water and nutrient availability due to increasing osmotic pressure of the soil solution. This causes nutrient deficiencies and growth reduction. Also, high concentrations of Na+ increase pH, deflocculated humic colloids and disperse clay particles. This leads to a destruction of soil structure with impaired drainage and root growth.

Table 2. Some properties of soil samples (0 – 60 cm depth) after sunflower harvesting in the two seasons 2010 and 2011.

Variable	EC_e, dSm^{-1}					
	S_1		S_2		S_3	
	2010	2011	2010	2011	2010	2011
pH	7.75	7.80	7.90	7.95	8.16	8.15
Soluble ions, meq/l						
Ca^{2+}	10.60	10.70	14.60	13.80	18.96	16.40
Mg^{2+}	4.00	4.20	4.50	5.80	13.00	14.00
Na^{+}	16.00	17.00	23.40	23.60	32.22	36.30
K^{+}	1.20	1.10	2.20	1.40	3.20	2.20
CO_3^{2-}	0.30	0.40	0.40	0.40	0.40	0.60
HCO_3^{-}	3.60	4.20	5.40	5.90	6.20	6.30
Cl^{-}	15.20	15.00	21.20	23.00	31.90	34.10
SO_4^{2-}	11.90	13.40	17.10	15.30	28.90	27.90
SAR	5.92	6.22	7.69	7.53	8.06	9.31
Total N, %	0.10	0.07	0.11	0.07	0.11	0.07
Available-P,mg/kg soil	8.30	7.10	9.00	7.20	11.00	7.40
Available-K, mg/kg soil	300	250	310	270	330	275

Yield characters:

Data in Tables 3 to 8 and Figs. 1, 2 showed that increasing soil salinity reduced all the studied yield characters.

Seed yield (kg /fed.)

Sakha 53 and line 880 appeared to be more moderate to high soil salinity (S_3) as compared with the other studied genotypes, (Table 3 and Fig. 1). The maximum mean values of seed yield (kg /fed.) were (1122.0, 1125), (1039, 1041) with Sakha 53, line 800 at S_1 in the first and second seasons, respectively. Also, the maximum mean values of seed yield (kg /fed.) were (825.8, 830.25) and (817.5, 820) at S_2 with line 880 and line 350 in both seasons, respectively. While the maximum mean values of seed yield (kg /fed.) were (707.8, 709.0) and (703.8, 704.0) at S_3 with line 465 and line 350 in both seasons, respectively.

The used genotypes were arranged according to seed yield (kg/fed.) as follow: Sakha 53 >line 350 > line 880 > line 465 with S_1, line 880 > line 350 > line 465 > Shakha 53 with S_2 and line 465 > line 350 > Sakha 53 > line 880 with S_3. The above sequences indicated that the most sensitive genotypes to salinity were line 465 and line 880 where it gave lowest yield under the main of salinity levels in two seasons.

Oil yield, kg/fed:

Data in Table (4) and Fig. (2) showed that the decrease occurred in oil yield due to effect of salinity stress was less than the corresponding are occurred in seed yield. The maximum mean values of oil yield were found to be (451.648, 451.25 kg/fed) with Sakha 53 at S_1 in the two seasons, respectively. While the maximum mean values of oil yield were found at S_2 were (345.5, 345.75) with line 880 in the two seasons, respectively. Also, at S_3 the maximum mean values were (271.0, 271.25) with line 880 in both seasons, respectively. Data showed that there is no significant difference between oil yields in the high level of soil salinity (S_3).

Table 3. Effect of soil salinity range (s), Sunflower genotypes (g) and (s × g) interaction on seed yield (kg/fed.) during the two growing seasons

Genotypes	Soil salinity			Mean
	S_1	S_2	S_3	
1st season				
line 350	1039.5b	817.5a	703.8a	853.6
line 465	952.2c	788.8b	707.8a	816.3
line 880	970.5c	825.8a	651.5b	815.9
Sakha 53	1122.0a	768.3b	674.8b	855.0
Mean	1021.1	800.1	684.4	835.2
2nd season				
line 350	1043.5b	818ab	703.5a	855.0
line 465	952.5c	787.5bc	706.5a	815.0
line 880	972.5c	823.75a	666.00b	820.75
Sakha 53	1124.25a	775.00c	709.75a	869.67
Mean	1023.16	801.06	696.44	840.23

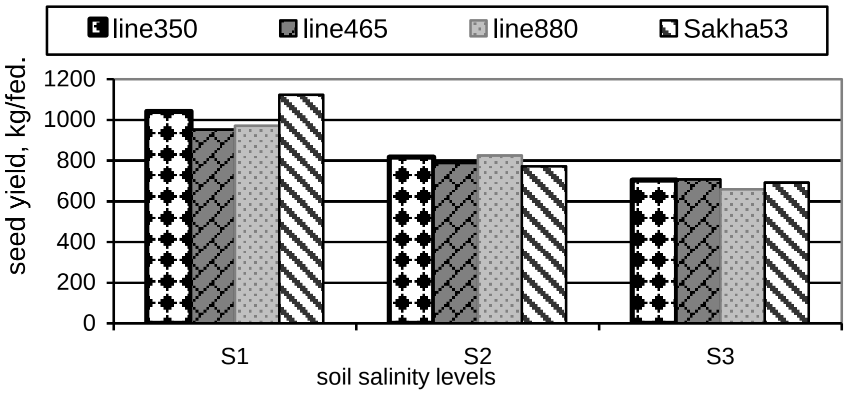

Fig. 1. Two seasons average of seed yield, kg/fed. of sunflower genotypes under different soil salinity

Genotypes	Soil salinity	Mean

	S_1	S_2	S_3	
		1^{st} season		
line 350	387.82c	301.67b	262.5a	317.33
line 465	392.75bc	294.5b	265.5a	317.58
line 880	406.00b	345.5a	271.0a	340.88
Sakha 53	451.648a	305.75b	268.25a	341.88
Mean	409.554	311.855	266.813	329.41
		2^{nd} season		
line 350	388.40c	302.50b	262.75a	317.88
line 465	393.75bc	295.5b	266.5a	318.58
line 880	407.00b	345.75a	271.25a	341.33
Sakha 53	451.25a	306.75b	269.25a	342.42
Mean	410.10	312.625	267.438	330.05

Table 4. Effect of soil salinity range (s), Sunflower genotypes (g) and (s × g) interaction on oil yield (kg/fed.) during the two growing seasons

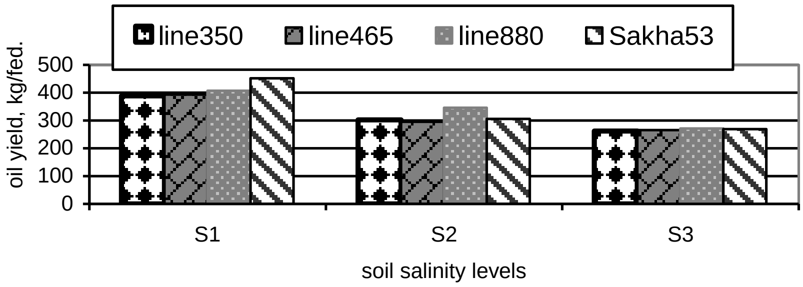

Fig. 2. Two seasons aveage of oil yield, kg/fed. of sunflower genotypes under different soil salinity

The investigated sunflower genotypes can be arranged according to oil yield (kg/fed.) as follow: Sakha 53 > line 880 > line 465 >line 350 with S_1, line 880 > Sakha 53 > line 350 > line 465 with S_2 and line 880 >Sakha 53 >line 465 >line 350 with S_3.

Seed oil %:

Data in Table (5) indicated that the seed oil (%) decreased by increasing soil salinity at all genotypes of sunflower. Also, the highest value of seed oil was obtained under the low level of soil salinity with all the tested genotypes there is no significant effect with soil salinity in 2^{nd} seasons at low salinity level (S_1). The highest values were found (39.05 and 38.90) under S_1 and the lowest values were found (23.04 and 23.875) at S_3 with Sakha 53 in the two seasons, respectively.

Table 5. Effect of soil salinity range (s), Sunflower genotypes (g) and (s × g) interaction on seed oil (%) during the two growing seasons

Genotypes	Soil salinity			Mean
	S_1	S_2	S_3	
1st season				
line 350	38.10b	29.95 a	26.00 a	31.35
line 465	38.03b	28.65 c	25.73 a	30.80
line 880	38.55ab	32.78 a	25.85 a	32.39
Sakha 53	39.05a	26.35 d	23.40 b	29.60
Mean	38.43	29.43	25.24	31.04
2nd season				
line 350	38.025a	29.775b	26.125a	31.308
line 465	38.050a	28.375c	25.875a	30.767
line 880	38.475a	32.50a	26.125a	32.367
Sakha 53	38.900a	26.625d	23.875b	29.80
Mean	38.363	29.319	25.5	31.060

Head diameter (cm):

Data in Table (6) show that the head diameter significantly reduced by raising soil salinity level. The maximum values of head diameter were obtained with sakha 53 at all salinity levels in all seasons.

Table 6. Effect of soil salinity range (s), Sunflower genotypes (g) and (s × g) interaction on head diameter (cm) during the two growing seasons

Genotypes	Soil salinity			Mean
	S_1	S_2	S_3	
1st season				
line 350	19.0a	14.0bc	11.3b	14.8
line 465	16.3b	12.5c	9.8b	12.8
line 880	16.0b	14.8ab	10.0b	13.6
Sakha 53	18.5a	16.5a	14.5a	16.5
Mean	17.4	14.4	11.4	14.4
2nd season				
line 350	18.75a	14.25ab	11.50b	14.833
line 465	17 .00b	13.50b	10.5b	13.667
line 880	16.75b	15.50a	10.23b	14.167
Sakha 53	19 .00a	16.00a	14.50a	16.5
Mean	17.875	14.813	11.688	14.792

Seed yield/plant (gm):

Weights of seed per head of Sunflower genotypes were significantly decreased with increasing soil salinity (Table 7). The highest value of weight of seeds /plant was recorded with Sakha 53, line 880 and line 350 under S_1, S_2 and S_3, respectively.

100-seeds weight (g):

Data presented in Table (8) show that, there is a significant decrease in weight of 100 seed of Sunflower genotypes caused by the increase of soil salinity levels. The maximum values of this character were (6.2, 6.3) (6.15, 6.12) and (6.15, 6.1 g) at S_1, S_2 and S_3 with Sakha 53 at the first and second seasons, respectively.

Yield characters data were in agreement with those obtained by Khatoon *et al*., (2000). They revealed that all salinity level had a drastic effect on yield and quality of sunflower. Seed yield per plant decreased significantly with the increasing level of salinity. Also, similarly with Rehman and Hussain (1998) who showed that salinity stress significantly depressed yield and yield component of sunflower.

Table 7. Effect of soil salinity range (s), Sunflower genotypes (g) and (s × g) interaction on weight of seed/head (gm) during the two growing seasons

Genotypes	Soil salinity			Mean
	S_1	S_2	S_3	
1st season				
line 350	34.65a	27.25a	23.50a	28.4679
line 465	31.75b	26.28a	23.59a	27.2089
line 880	32.34ab	27.51a	21.598a	27.1529
Sakha 53	35.05a	25.67a	22.490a	27.74119
Mean	33.45	26.681	22.794	27.642
2nd season				
line 350	34.90b	27.3a	24.00a	28.733
line 465	32.00c	26.5ab	24.00a	27.50
line 880	32.75c	27.50a	21.75b	27.333
Sakha 53	37.00a	25.635b	22.75b	28.458
Mean	34.163	26.731	23.125	28.006

Table 8. Effect of soil salinity range (s), Sunflower genotypes (g) and (s × g) interaction on weight of 100 seed during the two growing seasons

Genotypes	Soil salinity			Mean
	S_1	S_2	S_3	
1st season				
line 350	5.55b	5.475bc	5.375b	5.467
line 465	4.45b	5.350c	5.275b	5.358
line 880	5.8b	5.725b	5.425b	5.650
Sakha 53	6.2a	6.150a	6.150a	6.167
Mean	5.750	5.675	5.556	5.660
2nd season				
line 350	5.425c	5.375c	5.500b	5.433
line 465	5.375c	5.300c	5.200c	5.292
line 880	5.775b	5.800b	5.350bc	5.642
Sakha 53	6.200a	6.100a	6.075a	6.125
Mean	5.694	5.644	5.531	5.623

Generally, salinity is known to have a dramatic effect on plant growth through its influence on several functions of plant metabolism such as osmotic adjustment, ion uptake, protein and nucleic acids synthesis, photosynthesis, enzyme activities and hormonal balance in plant. Also, salinity had adverse effects not only on the biomass yield and relative growth rate, but also on other morphological parameters such as plant height, number of leaves, roots length and shoots / root weight ratio. Findings obtained in the present study are in agreement to a great extent with Yousef *et al*. (2008).

Guide line for tolerant sunflower genotypes to soil salinity:

The relative yield decrement % was calculated by difference between the obtained yield highest of the genotype and yield under salinity level divided by the highest yield. Then make a correlation between the relative decrements yield and salinity corresponding to the relatively decreasing yield and then get on a regression relationship under each genotype of sunflower crop. The yield of the genotypes is taken as a criterion when cultivated plants are compared together according to their tolerance to salt. The relative yield of the genotypes grown in saline soil is compared with its absolute yield with a normal soil. The salt level of soil causing a 25% yield reduction is taken as the tolerable soil salt level for the given crop (FAO, 1985). Data of relative yield decrement of sunflower genotypes as influenced by different levels of soil salinity are shown in Table (9).

Table 9. Regression equations for relative yield decrements and values of soil salinity that cause this decrement for different Sunflower genotypes.

genotype	y = a X + b	EC_e,dS/m				
		relative yield decrements %				
		0	25	50	75	100
line 350	y = 7.833x -16.69	2.13	5.32	8.51	11.71	14.90
line 465	y =6.066x -14.85	2.45	6.56	10.69	14.81	18.93
line 880	y = 7.071 x -18.25	2.59	6.11	9.65	13.19	16.72
Sakha 53	y = 11.22x -28.61	2.55	4.77	7.00	9.23	11.46

The relative yield decrement % represents the dependent variable and the equation takes the form Y = a X + b

Where*:*

y = Relative decrement %X = soil salinity

a = slope (yield reduction % with increasing EC_e by one unit.

b = intercept

Table (9) gives the predicted guide line introduced by FAO (1985) for the effect of soil salinity on relative yield decrement of sunflower genotypes grown on Kafr El-Sheikh soils. It could be concluded that the values of ECe which cause 25% reduction of yield were 6.56 and 6.11 dS/m for line 465 and line 880.

Thus it can be concluded that recommendation with cultivation genotypes 465 and 880 in soils have high salinity and recommended by genotypes 350 and Sakha 53 when soil salinity be low.

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تـأثير ملوحـة التربـة علـى بعض خـواص التربـة وتحمـل الملوحـة وإنتاجيـة بعض التراكيب الوراثية لمحصول عباد الشمس

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أجريت تجربتان حقليتان بمحطة البحوث الزراعية بسخا – كفر الشيخ خلال موسمي صيف ٢٠١٠ ،٢٠١١ بهدف دراسة تأثير مستويات ملوحة التربة المختلفة وهى: S_1 (2-4 dS/m), S_2 (4-6 dS/m), S_3 (6-8 dS/m) على أربعة تراكيب وراثية من عباد الشمس وهى السلالة ٣٥٠، السلالة ٤٦٥ ، السلالة ٨٨٠، سخا ٥٣ . وكان التصميم الإحصائى المستخدم هو Split Plot حيث كانت القطع الرئيسية تمثل مستويات ملوحة التربة والقطع تحت الرئيسية التراكيب الوراثية من عباد الشمس.

ويمكن تلخيص أهم النتائج المتحصل عليها في التالي :

- زيادة SAR والفسفور والبوتاسيوم الميسرين مع زيادة ملوحة التربة.
- تـأثرت كل التراكيب الوراثية تحت الدراسة بمستويات ملوحة التربة المختلفة بتأثيرها على المحصول ومكوناته.
- تـأثر محصول البذور(كيلو جرام/ فدان) بملوحة التربة لكل التراكيب الوراثية وأخذ الترتيب التالى مع مستويات ملوحة التربة المختلفة تحت مستوى الملوحة الأول S_1 : كان سخا ٥٣ >سلالة ٣٥٠ > سلالة ٨٨٠ > سلالة ٤٦٥. ومع مستوى الملوحة الثانى S_2 :سلالة ٨٨٠ > سلالة٣٥٠ > سلالة٤٦٥ > سخا٥٣ بينما عند مستوى الملوحة S_3 : كان الترتيب سلالة ٤٦٥ > سلالة ٣٥٠ سخا٥٣> سلالة ٨٨٠
- تـأثر محصول الزيت (كيلو جرام /فدان) بملوحة التربة لكل التراكيب الوراثية واخذ الترتيب التالي مع مستويات ملوحة التربة المختلفة تحت مستوى الملوحة الاولS1 كان سخا٥٣>سلالة ٨٨٠> سلالة ٤٦٥>سلالة ٣٥٠ بينما تحت مستوي الملوحة الثانيS2 كان الترتيب التالي سلالة ٨٨٠> سخا>٥٣ سلالة ٣٥٠> سلالة٤٦٥ بينما كان تحت مستوي الملوحة الثالثS3 سلالة ٨٨٠> سخا>٥٣ سلالة>٤٦٥> سلالة٣٥٠
- زيادة ملوحة التربة أدت إلى نقص قطر القرص ووزن البذور لكل قرص ووزن ١٠٠ بذرة.
- أظهرت السلالة ٤٦٥ والسلالة ٨٨٠ تحملا أكثر لملوحة التربة بينما السلالة ٣٥٠ وسخا ٥٣ كانت متوسطة التحمل للملوحة طبقاً للـ FAO (١٩٨٥).

قام بتحكيم البحث

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