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Effect of citrus root stocks and melatonin spraying on some biochemical characteristics under salt stress conditions

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Abstract

This research was conducted determine the impact of spraying the increase regulator melatonin on the tolerance of some rootstock to salt stress. The results showed that Sour Orange root was significantly superior to the rest of the rootstocks, and recorded the highest increase in the rate (Height, diameter, quantity, and the area for leaves of plant), while the root Volkamer lemon was significantly the best by recording the highest rate of arid mass of the root system and plant life. Furthermore, irrigation with electrical connection water (1.7 $ds.m^{-1}$) led to obtaining the highest values for vegetative plant girth growth characteristics (plant girth, stem diameter, number of leaves, leaf area, dry weight of the vegetative and root system and root length). Moreover, treatment with the growth regulator melatonin at a concentration of (100 $mg.L^{-1}$) showed greatest percentage in the trait (plant height, diameter of the stem, number of leaves, size of the leaves, and dry weight of the vegetative both root system and root length). As well as, the binary and triple interactions between these study factors led to a clear significant superiority in the studied traits compared to the comparison treatment, as the triple interaction treatment (Sour Orange root + melatonin at 100 $mg.l^{-1}$ as the concentration+ Irrigation of salinity water with concentration 1.7 $ds.m^{-1}$) was the most significant treatment by giving the highest increase in the rate of vegetative characteristics. Finally, the treatment (rootstocks Volkamer lemon + melatonin at 100 $mg.l^{-1}$ as the concentration + Irrigation of salinity water with concentration 1.7 dm. m^{-1}) recorded the highest rate of length and weight of the root when it is dry system.

Keywords: melatonin, rootstocks, salinity

Introduction

Citrus fruits Belongs to the Rutaceae, which includes a number of genera, the most important of which are the genus Citrus, as well as the genus Poncirus, to which one species belongs, Trifoliate orange, and the genus Fortunella, to which the kumquat type belongs. It gives a distinctive aromatic smell, as citrus trees take an important place among fruit trees due to their nutritional, economic, medical,

aesthetic and environmental importance. The genus Citrus is the most economically important among the mentioned genera, as this genus includes 14 species divided into four groups: the orange group, the linke (tangerine), the grapefruit and the acid group [1]. One of the common rootstock used in Iraq is Sour Orange. which is characterized as a semi-shortened root compatible with most commercial cultivars of citrus, tolerant of limestone soils, medium resistance to cold, and resistance to root rot and gum disease, but it is susceptible to Tristeza disease and nematodes [2]. The Rootstock is Volkamer lemon Citrus reticulate, which is characterized by its rapid growth and its stimulating effect on the growth of grafts and its adaptation to a wide range of soils, especially sandy soils, resistant to Tristeza, exocortis and xyloporosis, but sensitive to nematodes [3]. The Rootstock Swingle Citrumelo (*Citrus paradise* X *Poncirus trifoliata*) was used recently in Iraq, which is characterized by its drought tolerance, medium tolerance to salinity and its resistance to severe cold to a large extent due to the large variety of rootstock. It is also considered a root resistant to Tristeza, exocortis, xyloporosis, root rot and nematode infection [4]. It is believed that the original home of citrus is Southeast Asia, especially Western India, China and Indonesia, some parts of Burma and southwest Asia [5]. One of the most important problems faced by plant production is salinity in many irrigated areas in the world, especially arid and semi-arid areas [6]. The problem of salinity, whether soil or irrigation water, is one of the most important obstacles to the development of agricultural production in general and citrus production in particular, especially in the dry and semi-arid regions of the world, as rainfall decreases and temperatures rise and agriculture depends mainly on irrigation [7]. As it leads with the passage of time to the accumulation of salts in the soil, thus becoming saline and decreasing its suitability for agriculture, knowing that 20-30% of the world's lands are affected by salinity [8]. Including Iraq, where he indicated [9]. That 70-80% of the lands of the center and the south are located within the medium to highly saline soils. The problem of salinity is one of the most important challenges facing the agricultural sector, especially in arid and semi-arid areas, which affects growth and production. Iraq is at the forefront of the Arab countries affected by salinity [10] . The high concentrations of salinity in recent decades, whether soil salinity or irrigation water, is due to the decrease in the levels of the Tigris and Euphrates rivers due to the reduction of the water share from the upstream countries, which forced farmers in many regions of Iraq to use unconventional water in agriculture, such as sewage water and groundwater containing proportions of salt, which negatively affected the growth and production of fruit trees by inhibiting metabolic and physiological processes and disturbing the water balance of plants [11]. Salinity reduces the growth and production of plants due to the damage it causes to the integrity of the cell membranes as a result of the plasmonic effect, disruption of the hormonal and enzymatic balance, as well as the toxic effect of ions [12]. An increase in the concentration of sodium and chloride ions in the cytoplasm of plant cells causes damage to the cell membrane protein and thus loses its ability to perform its primary function of control, control and protection, and an increase in sodium concentration

in the cytoplasm inhibits the work of many enzymes and this inhibition depends to a large extent on the ratio of sodium to Potassium [13]. Thus, salt stress leads to a high inhibition of plant growth and development and an ionic imbalance within the plant due to an increase in the accumulation of sodium ions and an increase in the production of active oxygen species ROS [14]. In recent years, plant hormones have attracted the attention of many researchers and scholars in the field of environmental stresses as one of the most important actors in stimulating the response of plants to carry out biological processes. Many researchers have shown that the addition of plant hormones in low concentrations to plants exposed to salt stress has an effective role in overcoming the harmful effects of salt stress in plants [10, 12, 11]. Among the plant hormones regulating growth, melatonin, which can be used during soaking the seeds or spraying it on the vegetative system. Melatonin was first found in plants in 1995, and since then there has been extensive research to reveal the physiological roles that melatonin plays in plants [13]. Most studies have shown that melatonin has a role in regulating seed germination, rooting, flowering, photosynthesis and delaying aging [15,14]. Several recent studies showed that adding Melatonin to cucumber, maize and tomato helped reduce the effect of salinity and the tolerance of plants to salt stress and improved growth [18, 17, 16].

Materials and Methods

The experiment was carried out in the vegetable canopy of the Department of Horticulture and Landscaping / College of Agriculture / Karbala University / Al-Hussainiya district for the period from March 1l3l2022 TO 15l10l2022 know the effect of spraying with the growth regulator melatonin on the tolerance of some rootstock to salt stress.

162 seedlings were selected for three citrus rootstocks, as homogeneous as possible, with strong growth obtained from the Horticultural and Forestry station / Al-Hindia district, planted in polyethylene bags (1.25 kg), transferred on 15/2/2021 10 kg bags filled with sandy mixture.

A factorial experiment (3×3×3) was followed by designing randomized complete blocks (R.C.B.D) and with three replications, as each replicate contains (27) treatments with 3 seedlings for each experimental unit. The second was irrigation with three different saline concentrations (1.7, 4 and 8 ds.m-1) at an irrigation rate every week, while the third factor was spraying with the growth regulator melatonin with three concentrations (0,50 and 100 $mg.l^{-1}$) starting from 15/3/ 2021 and until 15/9/2021 at a rate of one spray every 30 days until complete wetness.

Studied traits

Measurements were taken on 1/10/2021 as follows:

- The leaves content of the chlorophyll.
- The leaves content of the Carbohydrates The total soluble ($mg.g^{-1}$.dry weight).
- Proline (the amount of enzyme in the leaves (international units/gm of fresh weight).
- Catalase as much as the enzyme in the leaves (IU/gm of fresh weight

Attributes and measurements studied during the experiment
phenotypic traits:

Leaf length (frond) cm

It was measured by measuring tape (five fronds were taken from the center of the tree) for each treatment.

Leaf Length (Alkhassa) cm

It was measured using a ruler (ten tufts were taken from the center of the fronds taken at random).

The average dry weight of the leaf (Alkhassa) %:

The wet weight of the vegetative mass was calculated by a sensitive scale, then placed in paper bags and dried in an electric oven at a temperature of (70) m^0 for a period of (48) hours, until the weight was established and the percentage of dry matter was extracted.

Dry matter percentage = dry weight / wet weight x 100

The fresh weight of the stalk leaves (mg. g^{-1}):

It was done using a sensitive scale, as the above wicker were taken and the fresh weight of the wicker was recorded.

Total chlorophyll content of fresh leaves (mg. g^{-1} wet weight):
The content of fresh leaves of total chlorophyll was calculated according to the method described in (9) where a weight of 0.2 gm of fresh leaves was taken and cut into several small pieces by scissors and ground in a ceramic mortar by adding 20 ml of 80% acetone until it became a color The precipitate is free of green dye, then the filtrate was separated from the sediment using a centrifuge at 3000 rpm / 10 minutes, then the extract was collected in volumetric tubes covered with opaque paper in order to block the light from chlorophyll to prevent photo-oxidation of the dye. The volume was completed by adding acetone, then the optical density of the filtrate was measured. Absorbance using a spectrophotometer type UV-1700 at wavelengths 645 and 663 nanometers, the total chlorophyll concentration was estimated according to the following equation :

Total chlorophyll={ 20.2 (D 645)+ 8.02 (D 663)} x V/W x 1000

As V: the final volume of the filtrate after completing the separation process by the centrifuge.

D.O: Optical density reading of the extracted chlorophyll.
W: the fresh weight of the sample.

Results and Discussion

Total chlorophyll content of leaves (mg. 100gm^{-1}. fresh weight):

It was found through the results of Table (1) significant differences between the roots in the content of leaves of total chlorophyll, as the Sour Orange root outperformed and gave the highest rate of (5.295 mg. 100 g^{-1}. Fresh weight) compared with the origin Volkamer lemon, which gave the lowest rate of (3.706 mg). 100 gm-1 fresh weight, as for the melatonin hormone, it is noted from the same table that increasing the concentration caused a significant increase in the content of chlorophyll in leaves, where the concentration (100 mg. L^{-1}) exceeded by giving the highest rate of (4.672 mg. 100 g^{-1}). Fresh weight) compared to concentration (0 mg. L^{-1}), which gave the lowest rate of (3.904 mg. 100 g^{-1}. fresh weight), as for salinity, the salinity of irrigation water was recorded at a concentration (1.7 ds. m^{-1}) the highest rate was (6.354). 100 mg^{-1} fresh weight (as measured by concentration (8 ds.m^{-1}) which gave the lowest rate was (2.842 mg. 100 g^{-1}- fresh weight). The results of the same table show that there is a significant effect of the bilateral interaction between the original and melatonin, where the treatment (Origin citrus + melatonin at a concentration of 100 mg.L^{-1}) outperformed by recording the highest rate of (5.761 mg. 100 g^{-1}. Fresh weight) compared to the other treatments, while the treatment recorded The interaction (Volkamer lemon + melatonin at a concentration of 0 mg. L^{-1}) was the lowest rate (3.402 mg. 100 g^{-1}. Fresh weight). As for the bilateral interaction between the original and the salinity of the irrigation water, the treatment (Sour Orange root + the salinity of the irrigation water at a concentration of 1.7 ds.m^{-1}) was superior, with the highest rate of (7.291 mg. Volkamer lemon + salinity of irrigation water at a concentration of 8 ds. m^{-1}) the lowest rate was (2.046 mg. 100 g^{-1}. fresh weight). The dual interaction treatment in the same table indicates the superiority of the treatment (melatonin at a concentration of 100 mg.l^{-1} + salinity treatment at a concentration of 1.7 ds.m^{-1}) by recording the highest rate of (6.670 mg. 100 g^{-1}. fresh weight), while the dual interaction treatment recorded (Melatonin at a concentration of 0 mg. L^{-1} + saline treatment at a concentration of 8 ds.m^{-1}) the lowest rate was (2.126 mg. 100 g^{-1}. Fresh weight). The same table shows that the triple interaction between the study factors (origin, melatonin and irrigation water salinity) found significant differences in the total chlorophyll content of the leaves. The treatment (Sour Orange root + melatonin at a concentration of 100 mg.L^{-1} + salinity of irrigation water at a concentration of 1.7 ds. m^{-1}) was superior. The highest rate was recorded (7.819 mg. 100 g^{-1}.m. fresh weight), while the triple interaction treatment (Volkamer lemon + melatonin at a concentration of 0 mg. L^{-1} + irrigation water salinity at a concentration of 8 ds.m^{-1}) recorded the lowest rate of (1.606 mg. 100 gm^{-1}). soft weight.

Table (1): Effect of origin, melatonin, salinity of irrigation water and the interaction between them on chlorophyll content of leaves (mg 100gm^{-1} fresh weight)

Salinity in ds.m-1 of irrigation water			melatonin mg. liter^{-1}			Rootstocks
6.354		1.7	3.904	0	3.956	Swingle Citrumelo
3.760		4	4.380	50	5.295	Sour Orange
2.842		8	4.672	100	3.706	Volkamer lemon
0.2613			0.2613		0.2613	L.S.D
Salinity in ds.m-1 of irrigation water			Rootstocks	melatonin mg. liter-1		Rootstocks
8	4	1.7		100	50	0
2.550	2.924	6.394	Swingle Citrumelo	4.245	3.985	3.637	Swingle Citrumelo
3.931	4.664	7.291	Sour Orange	5.761	5.450	4.675	Sour Orange
2.046	3.694	5.377	Volkamer lemon	4.010	3.705	3.402	Volkamer lemon
0.4525			L.S.D	0.4525			L.S.D
Salinity in ds.m-1 of irrigation water							melatonin mg. liter-1
8			4		1.7		
2.126			3.547		6.040		0
3.007			3.782		6.351		50
3.393			3.953		6.670		100
0.4525							L.S.D
Salinity in ds.m-1 of irrigation water					melatonin mg. liter-1		Rootstocks
8			4	1.7			
2.104			2.772	6.035	0		Swingle Citrumelo
2.541			2.888	6.527	50		
3.005			3.112	6.619	100		
2.669			4.432	6.923	0		Sour Orange
4.516			4.704	7.131	50		
4.608			4.855	7.819	100		
1.606			3.437	5.162	0		Volkamer

1.965	**3.753**	**5.396**	**50**	lemon
2.568	**3.891**	**5.572**	**100**	
0.7838				**L.S.D**

Total soluble carbohydrates content of the leaves (mg.g^{-1}.dry weight):

The results presented in Table (2) show that the single treatments had a significant effect on the leaves content of total soluble carbohydrates, as the Sour Orange root outperformed and gave the highest rate of (18.635 mg. As for the melatonin hormone, it is noted from the same table that the increase in the concentration caused a significant increase in the content of the leaves of total soluble carbohydrates, where the concentration exceeded (100 mg. L^{-1}) by giving the highest rate of (17,162 mg. gm^{-1}. Dry weight) compared to concentration (0 mg. L^{-1}), which gave the lowest rate of (15.138 mg. g^{-1}. dry weight). As for salinity, the salinity of the irrigation water was recorded at a concentration of (1.7 ds. m^{-1}) the highest rate of (19.567 mg. g^{-1}. dry weight) compared to concentration (8 ds. m^{-1}), which gave the lowest rate of (12,832 mg. g $^{-1}$. dry weight). The binary interactions between (origin and melatonin), (origin and irrigation water salinity) and (melatonin and irrigation water salinity) showed a significant effect on the leaves content of total soluble carbohydrates, where the treatment (Origin and melatonin at a concentration of 100 mg.L^{-1}) outperformed, with the highest rate reached. 19,886 mg.gm^{-1}.dry weight) compared to the other treatments, while the interaction treatment (Volkamer lemon + melatonin at a concentration of 0 mg.l^{-1}) recorded the lowest rate (12.149 mg.gm^{-1}.dry weight). As for the bilateral interaction between the original and the salinity of the irrigation water, the treatment (Sour Orange root + the salinity of the irrigation water at a concentration of 1.7 ds.m^{-1}) was superior by recording the highest rate of (23.256 mg.g.g^{-1}.dry weight) compared to the other treatments, while the treatment was recorded (Volkamer lemon + salinity of irrigation water at a concentration of 8 ds. m^{-1}), the lowest rate was (10.698 mg. g-1.dry weight). The dual interaction treatment in the same table indicates the superiority of the treatment (melatonin at a concentration of 100 mg.L^{-1} + salinity treatment at a concentration of 1.7 ds.m^{-1}) by recording the highest rate of (20,364 mg. g^{-1}.dry weight), while the dual interaction treatment recorded (Melatonin at a concentration of 0 mg.L^{-1} + salinity treatment at a concentration of 8 ds.m^{-1}) the lowest rate was (11.325 mg.g^{-1}.dry weight). As for the triple interaction between the original and melatonin and the salinity concentration in the same table, the treatment (Sour Orange root + melatonin at a concentration of 100 mg.L^{-1} + the salinity of irrigation water at a concentration of 1.7 ds.m^{-1}) gave the highest average content of leaves of total soluble carbohydrates, which reached (24,733 mg.g^{-1}.dry weight), while the triple interaction treatment (Volkamer lemon + melatonin at a concentration of 0 mg.l^{-1} + Irrigation of salinity water with concentration 8 ds.m^{-1}) recorded the lowest rate of (10,092 mg. g^{-1}.dry weight)).

Table (2): Effect of origin, melatonin and salinity of irrigation water and the interaction between them on the carbohydrate content of leaves (mg 100 g^{-1} dry weight)

Salinity in ds.m-1 of irrigation water		melatonin mg. liter-1		Rootstocks	
19.567	1.7	15.138	0	17.129	Swingle Citrumelo
16.097	4	16.197	50	18.635	Sour Orange
12.832	8	17.162	100	12.732	Volkamer lemon
0.3353		0.3353		0.3353	L.S.D

Salinity in ds.m-1 of irrigation water			Rootstocks	melatonin mg. liter-1			Rootstocks
8	4	1.7		100	50	0	
13.198	17.515	20.675	Swingle Citrumelo	18.267	17.143	15.978	Swingle Citrumelo
14.600	18.048	23.256	Sour Orange	19.886	18.732	17.287	Sour Orange
10.698	12.728	14.770	Volkamer lemon	13.334	12.715	12.149	Volkamer lemon
0.5807			L.S.D	0.5807			L.S.D

Salinity in ds.m-1 of irrigation water			melatonin mg. liter-1
8	4	1.7	
11.325	15.284	18.804	0
13.210	15.846	19.534	50
13.962	17.161	20.364	100
0.5807			L.S.D

Salinity in ds.m-1 of irrigation water			melatonin mg. liter-1	Rootstocks
8	4	1.7		
11.311	17.022	19.599	0	Swingle Citrumelo
13.169	17.314	20.946	50	
15.115	18.208	21.479	100	
12.572	17.114	22.175	0	Sour Orange
15.429	17.907	22.861	50	
15.800	19.124	24.733	100	
10.092	11.716	14.638	0	Volkamer

11.033	**12.317**	**14.794**	**50**	lemon
10.970	**14.152**	**14.879**	**100**	
1.0058				**L.S.D**

Proline content of leaves (mg.g^{-1}):

The results presented in Table (3) show that the single treatments had a significant effect on the leaf content of proline, as the origin Volkamer lemon outperformed and gave the highest rate of (91.41 mg. 1). As for the melatonin hormone, it is noted from the same table that the increase in the concentration caused a significant increase in the content of the leaves of proline, where the concentration (100 mg. L^{-1}) exceeded by giving the highest rate of (89.79 mg. g^{-1}) compared to concentration (0 mg). L^{-1}), which gave the lowest rate (71.52 mg g^{-1}). As for salinity, the salinity of irrigation water was recorded at a concentration of (1.7 ds. m^{-1}) the highest rate of (115.18 mg. g^{-1}) compared to concentration (8 ds. m^{-1}), which gave the lowest rate of (51.80 mg. g^{-1}). dry weight). The binary interactions between (origin and melatonin), (origin and irrigation water salinity) and (melatonin and irrigation water salinity) showed a significant effect on the leaf content of proline, where the treatment (Volkamer lemon + melatonin at a concentration of 100 mg.l^{-1}) with the highest rate of (109.41 mg. .gm^{-1}.) compared to the other treatments, while the interaction treatment (Swingle Citrumelo + melatonin at a concentration of 0 mg.l^{-1}) recorded the lowest rate of (65.69 mg. g^{-1}). As for the bilateral interaction between the rootstock and the salinity of the irrigation water, the treatment (Volkamer lemon + the salinity of the irrigation water at a concentration of 8 decimens.m^{-1}) was superior by recording the highest rate of (137.34 mg.gm^{-1}) compared to the other treatments, while the treatment (Sour Orange root + the salinity of the irrigation water was recorded) At a concentration of 1.7 dS.m^{-1}, the lowest rate was (49.04 mg. g-1.dry weight). The bilateral interaction treatment between melatonin and salinity in the same table indicates the superiority of the treatment (melatonin at a concentration of 0 mg.l^{-1} + salinity treatment at a concentration of 8 ds.m^{-1}) by recording the highest rate of (133.56 mg. g^{-1}) while the dual interaction treatment was recorded. Melatonin at a concentration of 100 mg.l^{-1} + salinity treatment at a concentration of 1.7 dS.m^{-1}) the lowest rate was (47.25 mg.g^{-1}). As for the triple interaction between origin, melatonin, and salinity in the same table, the treatment (Volkamer lemon + melatonin at a concentration of 0 mg.l^{-1} + salinity of irrigation water at a concentration of 8 decimens.m^{-1}) gave the highest average in the leaves content of proline, which reached (180.33 mg.g^{-1}) Whereas, the triple interaction treatment (Sour Orange root + melatonin at a concentration of 100 mg.L^{-1} + Irrigation of salinity water with concentration of 1.7 decimens.m^{-1}) recorded the lowest rate of (44.41 mg. g^{-1}).

Table (3): Effect of origin, melatonin and salinity of irrigation water and the interaction between them on the leaves content of proline (mg.gm-1)

Salinity in ds.m-1 of irrigation water		melatonin mg. liter-1		Rootstocks	
115.18	1.7	71.52	0	70.58	Swingle Citrumelo
73.56	4	79.24	50	78.55	Sour Orange
51.80	8	89.79	100	91.41	Volkamer lemon
1.635		1.635		1.635	L.S.D

Salinity in ds.m-1 of irrigation water			Rootstocks	melatonin mg. liter-1		Rootstocks
8	4	1.7		100	50	0
110.50	70.82	54.34	Swingle Citrumelo	79.82	76.30	65.69	Swingle Citrumelo
97.7	64.99	49.04	Sour Orange	83.65	69.73	72.67	Sour Orange
137.34	84.87	52.02	Volkamer lemon	109.41	88.64	76.19	Volkamer lemon
2.833			L.S.D	2.833			L.S.D

Salinity in ds.m-1 of irrigation water			melatonin mg. liter-1
8	4	1.7	
133.56	80.01	55.80	0
112.00	73.35	52.35	50
99.97	67.33	47.25	100
2.833			L.S.D

Salinity in ds.m-1 of irrigation water			melatonin mg. liter-1	Rootstocks
8	4	1.7		
118.02	78.22	54.72	0	Swingle Citrumelo
112.36	68.89	56.76	50	
101.11	65.36	51.53	100	
102.33	72.78	53.80	0	Sour Orange
97.65	62.64	48.91	50	
93.11	59.56	44.41	100	
180.33	89.02	58.89	0	Volkamer lemon
126.00	88.53	51.38	50	
105.69	77.07	45.80	100	

4.906	L.S.D

Leaf content of catalase (mg.gm^{-1}.min. fresh weight):

It was found through the results of Table (4) significant differences between the roots in the leaves of content the catalase, as the Sour Orange root outperformed by giving the highest rate of (0.442 mg. As for the melatonin hormone, it is noted from the same table that the increase in the concentration caused a significant increase in the content of the leaves of catalase, where the concentration exceeded (100 mg. L^{-1}) by giving the highest rate of (0.406 mg. g^{-1}) Minute of fresh weight) compared to concentration (0 mg. L^{-1}), which gave the lowest rate of (0.263 mg. gm^{-1}.min of fresh weight) As for salinity, the salinity of irrigation water was recorded at a concentration of (8 ds. m^{-1}) the highest rate reached (0.476 mg. g^{-1}. min fresh weight) compared to concentration (1.7 dm. m^{-1}), which gave the lowest rate (0.219 mg. g^{-1}. min fresh weight). The results of the same table show that there is a significant effect of the bilateral interaction between the original and melatonin, where the treatment (Origin citrus + melatonin at a concentration of 100 mg.l^{-1}) outperformed by recording the highest rate of (0.526 mg.g^{-1}.min fresh weight) compared to the other treatments, while it was recorded The interaction treatment (Volkamer lemon + melatonin at a concentration of 0 mg.l^{-1}) the lowest rate was (0.223 mg.gm^{-1}.min fresh weight). As for the bilateral interaction between the rootstock and the salinity of the irrigation water, the treatment (Sour Orange root + the salinity of the irrigation water at a concentration of 8 ds.m^{-1}) was superior by recording the highest rate of (0.616 mg. The origin of Volkamer lemon + salinity of irrigation water with a concentration of 1.7 ds. m^{-1}), the lowest rate was (0.166 mg. g^{-1}. Fresh weight). The dual interaction treatment in the same table indicates the superiority of (melatonin at a concentration of 100 mg.L^{-1} + salinity treatment at a concentration of 8 ds.m^{-1}) by recording the highest rate of (0.565 mg.g^{-1}.min fresh weight), while the dual interaction treatment recorded (Melatonin at a concentration of 0 mg. L^{-1} + salinity treatment at a concentration of 1.7 ds. m^{-1}) the lowest rate was (0.177 mg. g^{-1}. Min. fresh weight). The same table shows that the triple interaction between the study factors (origin, melatonin, and salinity of irrigation water) found significant differences the leaves of content the catalase. The treatment of (Sour Orange root + melatonin at a concentration of 100 mg.l^{-1} + Irrigation of salinity water with concentration of 8 ds.m-1) scored higher The rate reached (0.735 mg.g.g-1.min fresh weight), while the triple interaction treatment (Volkamer lemon + melatonin at a concentration of 0 mg.l^{-1} + Irrigation of salinity water with concentration of 1.7 decimens.m-1) recorded the lowest rate of (0.154 mg.g $^{-1}$. Min Fresh Weight).

Table (4): Effect of origin, melatonin, salinity of irrigation water and the interaction between them on the content of catalase (mg.gm-1.min. fresh weight)

Salinity in ds.m-1 of irrigation water		melatonin mg. liter-1		Rootstocks	
0.219	1.7	0.263	0	0.323	Swingle Citrumelo
0.335	4	0.361	50	0.442	Sour Orange
0.476	8	0.406	100	0.265	Volkamer lemon
0.0171		0.0171		0.0171	L.S.D

Salinity in ds.m-1 of irrigation water			Rootstocks	melatonin mg. liter-1			Rootstocks
8	4	1.7		100	50	0	
0.423	0.307	0.239	Swingle Citrumelo	0.381	0.321	0.266	Swingle Citrumelo
0.616	0.457	0.253	Sour Orange	0.526	0.498	0.300	Sour Orange
0.389	0.240	0.166	Volkamer lemon	0.310	0.263	0.223	Volkamer lemon
0.0296			L.S.D	0.0296			L.S.D

Salinity in ds.m-1 of irrigation water			melatonin mg. liter-1
8	4	1.7	
0.354	0.258	0.177	0
0.508	0.342	0.233	50
0.565	0.404	0.248	100
0.0296			L.S.D

Salinity in ds.m-1 of irrigation water			melatonin mg. liter-1	Rootstocks
8	4	1.7		
0.348	0.273	0.177	0	Swingle Citrumelo
0.393	0.305	0.265	50	
0.526	0.342	0.275	100	
0.405	0.296	0.199	0	Sour Orange
0.707	0.515	0.273	50	
0.735	0.558	0.286	100	
0.310	0.204	0.154	0	Volkamer lemon
0.423	0.206	0.162	50	

0.433	0.312	0.184	100	
0.0513				L.S.D

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