Salt Stress of Jeursalim Artichoke Plants in Relation to The Pre-soaking Tubers with Hydrogen Peroxide

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ABSTRACT: Two main experiments were carried out during the growing seasons 2018 and 2019 on Jerusalem artichoke cv. Fuseau at the Soil Salinity Laboratory Research, Agricultural Research Center, Alexandria, Egypt. This investigation is being proposed to assess the advantages of H_2O_2-soaked tubers and salt stress exposure on growth, yield components, quality and tubers' elemental composition. Tubers were planted in cemented-butaminzed lysimeters (2*2*1m) in rows, 80 cm in wide and 2 m in length. The treatments were comprised of two variables in split-plot design with three replicates. Four levels of saline irrigation water were prepared by mixing the fresh tap and sea waters, to create salt concentrations of 500 (control), 2000, 3500 and 5000mg/L, then, were arranged in the main plots. Whereas, three levels of H_2O_2 – soaking tubers before planting (control, 100 and 200mM) were arranged in the sub plots. The H_2O_2- treated tubers were seeded in the cemented lysimeters, in rows of 80cm in width, 2m in length. At the flowering growth stage, characteristics of vegetative growth were registered and finally at the harvest stage, yield, yield components and quality as well as the elemental tubers composition, including N, P and K% were recorded. The results showed that increasing the salinity levels of irrigation water up to 5000 mg/L negatively affected most of the growth characteristics (plant height, plant fresh weight). It also led to a decrease in the yield of tubers (the number of tubers per plant - the average weight of a tuber (g) and the total yield / fad. (tons) . The results also showed that the increase in the salinity of irrigation water led to exhibited marked reductions in the tuber concentration content of elements N, P and K% as well as carbohydrate and inulin% during the two growing seasons. The data also revealed positive effects of 100mM H_2O_2 – soaked tubers on vegetative growth criteria and yield performance. Similar trend was achieved on carbohydrate, inulin tuber content and N% of tuber only in the first season of this study. The interaction study revealed that there are no marked significant variation appeared for the vegetative growth criteria during the respective seasons. The results detected on plant height and yield components indicated that growth performance was clearly manifested for the combined treatment of 100 mM H_2O_2-treated tubers and salinity exposure, defined from 500 up to 2000 mg/L. Similar trend was also registered on carbohydrate, inulin and only N% contents of tubers. In conclusion, it seems possibly, in particular under saline conditions, soaking the tuber in 100 mM H_2O_2 before planting for 2h would be essential to avoid the harmful effect of salt exposure and to achieve better records on yield component and quality and elemental composition content in tubers.

Keywords: Jerusalem artichoke, hydrogen peroxide solution, irrigation water salinity, salt stress.

INTRODUCTION

Jerusalem artichoke (*Helianthus tuberosus L.*) is a non- traditional tuberous crop ,which is recently introduced to Egypt for high nutritional and medicinal values. The tuber flesh of this plant is a rich source for nutrients and polysaccharides, particularly, inulin; that contains considerable levels of fructose sweetener that could be utilized for human-being without any side effects on blood sugar level (Seljåsen and Slimestad, 2007). Its protein has high food value due to the presence of almost all essential amino acids (Rakhimov *et al.,* 2003). Tubers are considred a suitable livestock feed (Seiler and Campbell, 2004). In the last decades Jerusalem artichoke has been concidered as a biomass crop for ethanol because it produces high levels of carbohydrates (Denoroy, 1996).

Salinity is one of the most important environmental stress variables that affects the growth and productivity of different crops (Lopez *et al*., 2002). The negative impact of salinity is increasing dramatically in the arid and semi-arid regions of the world where the majority of developing countries are located (Khan *et al*., 1999). Salinity not only exerts differences between average productivity and potential productivity, but also induces a marked drop the yield from year to year. It directly affects plant growth through its interaction with metabolic rates and pathways in plants (Rahimi *et al*., 2012).

Hydrogen peroxide (H_2O_2), produced naturally in plant cells under stress conditions, is characterized by high oxidative reactivity (Ogawa and Iwabuchi, 2001). Hydrogen peroxide is considered necessary for cell signaling, due to its important role in regulating oxidative stress (Rhee, 2006). Recently H_2O_2 has been regarded as a stress signaling molecule in regulating plant development and adaptation to abiotic and biotic stresses (Hung *et al*., 2005). Exogenous application of H_2O_2 at low concentrations ($\leq$ 2.5 mM) had stimulatory effect on growth traits of plants, while the concentration up to 5 mM played an opposite role (Deng *et al*., 2012). Hydrogen peroxide is found to be involved in the acclimation and tolerance of plants grown under salt stress (Li *et al*., 2011; Wang *et al*., 2013). Therefore H_2O_2, at low concentrations, is considered one of the exogenous materials that used to induce the defense mechanisms in plant cells (Chen *et al*., 1993) and have a central role in improving plant tolerance to environmental stresses such as salinity (Azevedo Neto *et al*., 2005; Ashraf *et al*., 2013). Furthermore, H_2O_2 seems to be a “master hormone” that controls a variety of stress responses and plays a key role in primary plant metabolism (Ślesak *et al*., 2007).

This study was carried out to investigate the potential role of H_2O_2 to improve the performance of growth and productivity of Jerusalem artichoke plants under different salt stressed conditions.

MATERIALS AND METHODS

The present investigation was carried out during the two successive summer seasons on mid of April 2018 and 2019 at Soil Salinity Laboratory Research, Alexandria, Agricultural Research Center. Jerusalem artichoke tubers of Fuseau cv. were planted in cemented-butaminzed lysimeters (2*2*1m). Tuber seeds were planted in rows, 80 cm in wide, 2 m in length.

Four levels of saline irrigation water, namely, tap water as a control, 2000, 3500 and 5000mg/L, were used as a source of irrigation, keeping the soil moisture content near the field capacity (27.85%). The saline water was prepared by mixing tap water (0.68 dS/m) with sea water (46 dS/m) at certain ratios. The tuber seeds were partitioned in three parts, the first and second parts of tubers were soaked in liquid H_2O_2 solutions (100 and 200 mM) for 2h. before planting. The third part of tubers (soaked tubers in distilled water) was used as the control.

Before planting, the following fertilizers were added to the soil at rates of kg, 20 m^3 organic manure /fed. plus 150 P_2O_5/fed.in the form of mono calcium phosphate, 15.5 % P_2O_5. Nitrogen fertilizer was added in the form of ammonium nitrate (33.5% N) at the rate of 300 kg ⁄ fed. at three equal doses ; after 4, 8 and 12 weeks from planting date. Potassium sulphate (48% K_2O) was applied at rate of 90 kg ⁄ fed. in two equal doses after 8 and 12 week from the planting date. All other recommended agro-managements such as disease pests and weed control were performed whenever they appeared to be necessary.

The physical and chemical analyses of the experimental soil are presented in Table (1) according to (Page *et al*., 1982).

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

Physical properties										
year	**Sand%**	**Silt%**	**Clay%**	**Texture**	**pH**	**EC dS/m**	**CaCO3 %**	**O.M%**		
2018	38.5	21.0	40.5	Clay loam	7.87	1.69	2.32	2.15		
2019	38.2	21.1	40.7	Clay loam	7.86	1.72	2.35	2.17		
	Soluble cations (meq/L)				**Soluble anions (meq/L)**			**Available nutrients mg/kg**		
year	**Ca^{++}**	**Mg^{++}**	**Na^{+}**	**K^{+}**	**$CO_3^{=}$**	**HCO_3^{-}**	**Cl^{-}**	**$SO_4^{=}$**	**N**	**P**	**K**
2018	5.48	4.66	9.88	0.23	--	8.46	3.67	8.12	80.0	17.9	38.2
2019	5.51	4.68	9.65	0.25	--	8.41	3.76	7.94	86.4	18.2	39.1

Vegetative characteristics were measured and recorded at the initial stage of flowering (150 days after planting). A random sample of three plants from each experimental plot was taken to estimate plant height (cm), number of main stems and plant fresh weight (kg).

At the harvest time (180 days old plants), each individual plant in the all treatment lysimeters was removed to measure the number of tubers, average tuber fresh weight (g) and total tubers' yield / feddan(ton) .

Random samples of ten fresh tubers per treatment were used to determine their dry matter percentage, at 70 °C. Inulin content was determined in tubers according to the method of Winton and Winton (1958). Total carbohydrate were determined colorimetrically as in terms of gram of glucose/100g dry weight of tubers roots according the methods described by James (1995). In the digested dry matter of tubers nitrogen was determined according to the methods described by Pregl (1945) using micro-Kjeldahl apparatus. Meanwhile, phosphorus was determined colorimetrically following Murphy and Riley (1962). Potassium was determined against a standard using air propane flame photometer following Chapman and Pratt (1961). The concentration of N, P and K were expressed as percentage.

The experimental design used was a split-plot design with three replicates, where the four levels of saline irrigation water, namely, tap water as a control, 2000, 3500 and 5000 mg/L were arranged in the main plots, whereas, tuber seeds was soaked with hydrogen peroxide (0,100 and 200 mM) were arranged in the sub plots. Each sub plot contained 2 rows. Collected data from the experiments were statistically analyzed, using the analysis of variance method. Comparisons among the means of different treatments were assessed, using least significant differences (L.S.D) test procedure at $p \leq 0.05$ level of probability, as illustrated by Snedecor and Cochran (1980) using Co-Stat software program.

RESULTS AND DISCUSSIONS

1. Mean performances of vegetative growth parameters of Jerusalem artichoke crop

a- The main effect of irrigation water salinity concentrations

The results given in Table 2 showed significant effects at $p \leq 0.05$ on plant height and foliage fresh weight/plant characters during the two seasons. Evidently, increasing irrigation water salinity concentration from 500 mg/L up to 5000 mg/L negatively affected plant height and foliage fresh weight/plant characters during the two seasons of this study. Unlike, the number of stems per plant was not significantly affected under the salt-stressed conditions at $p \leq 0.05$. Plant growth, as revealed from the data of plant height and foliage fresh were more superior in the control treatment. As the salinity of irrigation increased up to 5000 mg/L, adversable effects were clearly manifested. These results falls in line with the data reported by Mahmoud (2012) on potato plants. The reduction in plant growth under salinity stress conditions is consistent with the fact that salinity induces accumulation of certain ions and deficiency of the others and lowers the external water potential in the cell (Salem *et al*., 2017). Furthermore, the reduction in plant growing may be due to the interruption in metabolic activities affected by the decrease of water absorption and disturbance in water balance (Fahad *et al*., 2015).

b- The main effect of soaked tubers in H_2O_2 concentration

The results of Table (2) showed that most of the studied vegetative characters were significantly affected $p \leq 0.05$ with soaking tubers in H_2O_2

concentration treatments, except for No. of stems / plant. However, increasing H_2O_2 concentration exerted a significant positive effect on both plant height and foliage fresh weight/plant (g) traits during the two seasons. In this respect the highest mean values for plant height (cm) and fresh foliage weight/plant (g) were scored when the tubers soaked in 100mM H_2O_2 treatment, followed by with the soaking treatment of 200mM H_2O_2 treatment. In contrast, the lowest values were clearly noted in the control treatment. The results of Attia *et al*. (2017) showed that H_2O_2 priming can induce plants by modulating physiological and metabolic processes such as photosynthesis, proline accumulation detoxification, and that this ultimately leads to better growth and development.

c- The effect of tested interaction

The 2-way interaction of saline irrigation and H_2O_2 - soaked tubers (table 2) imposed significant effects on growth traits at $p \leq 0.05$. In general, soaking tubers with H_2O_2 concentration treatment gave the best results for the characteristics of plant height at any given level of salt stress treatment. As mentioned earlier, the characteristic of foliage fresh weight (g) and No. of stems /plant was not affected by the two independent variables, this trait was also not affected by the interaction between these two variables (Table, 2). A number of studies on plants have demonstrated that the pre-treatment with an appropriate level of H_2O_2 can enhance abiotic stress tolerance through the modulation of multiple physiological processes, such as photosynthesis, and by modulating multiple stress-responsive pathways (Hossain and Fujita 2013; Wang *et al.,* 2014).

2. Yield and yield components of Jerusalem artichoke crop

a- The main effect of irrigation water salinity concentrations

The documented results in Table 3 revealed clearly that total tuber yield and the corresponding its components *e. i*., number and weight of tuber /plant, average tuber weight as well as total yield/fed. were significantly affected ($p \leq 0.05$) by irrigations water salinity concentrations during the two seasons of the growth. In this respect, highest records in tubers yield/fed. and their related characters that include i.e., average tuber weight, number of tubers/plant and tubers weight yield/plant were clearly manifested in non-salt-stressed plants (control, 500 mg/L). With increasing the salinity levels of irrigation water, remarkable decrements on yield criteria were gradually noted, being the least at 5000 mg/L. As far as the total yield and its components are closely correlated with the vigorous of the vegetative growth. Therefore the reduction of the total yield and its components can be attributed to the fact that the vegetative characters were negatively affected by the high salinity of irrigation water (Table, 2). These results are in agreement with those reported by Elkhatib *et al.* (2004), Mahmoud (2012), Al-Hamdany and Mohammed (2014), Arafa and El-Howeity (2017) on potato. Abu-Muriefah (2015) attributed these results to changes in osmotic capacity due to reduction of water content in addition to the specific toxic effects resulting from the accumulation of sodium and chloride ions as observed in many plants. It was observed that salinity gradually reduced the size and number of marketable tubers per plant. In this respect, Ghosh *et al*. (2001) attributed the yield decrement in salt-stressed plants to the reduction of the tuber number per plant. It should be emphasized that the drop in yield, associated with salt- stress could be interpred to the nutritional imbalance, which consequently caused the inactivation of enzymes such as nitrate reductase (NR).

Table (2). Mean values of vegetative growth indices of Jerusalem artichoke plants during 2018 and 2019 seasons

Treatments		Vegetative growth characters / plant					
		2018			2019		
water salinity levels (ppm)	H_2O_2 Soaking levels (mM)	Plant height (cm)	No. of main stem/ plant	Plant fresh weight (kg)	Plant height (cm)	No. of main stem/ plant	Plant fresh weight (kg)
control	control	186.23a	9.26a	5.63a	188.31b	9.54a	5.26a
	100	188.91a	9.84a	6.12a	196.43a	9.96a	5.86a
	200	165.32c	9.23a	6.84a	178.10c	9.45a	6.41a
2000	Control	175.63b	8.56a	4.51a	189.36b	8.12a	5.45a
	100	187.25a	8.32a	5.65a	197.21a	9.45a	5.28a
	200	186.96a	9.54a	5.85a	179.36c	9.89a	5.63a
3500	control	169.25b	8.56a	4.56a	174.23c	8.52a	4.51a
	100	174.56b	8.23a	4.78a	163.25e	8.96a	4.56a
	200	163.23c	8.21a	4.96a	173.21d	8.42a	5.12a
5000	control	121.23f	7.23a	4.52a	145.63f	7.41a	4.02a
	100	146.23d	7.98a	4.48a	149.23e	7.76a	4.22a
	200	132.45e	7.12a	4.65a	146.12f	7.89a	4.45a
Main effect of saline irrigation water (A)							
Control		210.51a	9.23a	5.894a	243.52a	10.23a	6.175a
2000 mg/L		200.43b	8.12a	5.190b	214.56b	10.25a	5.635b
3500 mg/L		196.21c	8.25a	4.653c	195.34c	10.03a	5.056c
5000 mg/L		185.63d	7.36a	4.285d	186.23d	9.87a	4.229d
Main effect of soaked tuber in H_2O_2 (B)							
control		223.15c	8.56a	4.82c	186.21c	7.56a	4.63b
100 mM		246.45a	9.51a	5.86a	238.23a	8.23a	5.32a
200 mM		238.23b	9.26a	5.19b	206.58b	8.36a	4.89b

* Significant at 0.05 level of probability.

b. The main effect of soaked tubers in H_2O_2 concentration

The results of Table (3) appeared that tubers yield/plant were significantly affected ($p \leq 0.05$) by soaking tubers in H_2O_2 solutions during the two growing seasons. Regarding to the number of tubers/plant and total yield per feddan, the data showed that both traits were significantly decreased by soaking tubers in H_2O_2 with 100mM, only in 2019. The result obtained on the fresh tubers did not appear any significant variations along the H_2O_2-soaking treatments during both seasons. Similar results were recorded on wheat (Hameed *et al.,* 2004), indicating that exogenous application of H_2O_2 provided more vigorous root system in wheat. H_2O_2

applied in low doses can increase roots weight and length (Narimanov and Korystov, 1997). Recently, has been reported that intensive root growth acted well for higher nitrogen uptake in wheat (Liao *et al.,* 2004). More vigorous root grown will cause higher nitrogen uptake, creating better growth development of wheat plant. Niu and Liao (2016) showed that H_2O_2 mediates various developmental and physiological processes in plants. Also, the change of H_2O_2 level may impact metabolic and antioxidant enzyme activity related to plant growth and development (Barba-Espín *et al.,* 2014).

Table (3). The average values of Jerusalem artichoke tuber yield and its component characters as affected with water salinity concentrations, soaked tubers in H_2O_2 treatments and their interaction during the two study seasons

Treatments		2018			2019		
water salinity levels (ppm)	H_2O_2 Soaking levels (mM)	No. of tubers/ plant	Tuber fresh weight (g)	Total yield (ton/fed.)	No. of tubers/ plant	Average tuber fresh weight (g)	Total Yield (ton/fed.)
	control	54.26b	39.26c	13.26b	52.63b	49.54a	14.54a
control	100	59.32a	49.84a	14.54a	58.12a	50.96a	14.96a
	200	48.25cd	39.23c	12.56c	51.56b	39.45c	12.45a
	Control	44.23e	48.56a	12.69c	50.12b	48.12a	13.56a
2000	100	50.23c	48.32a	14.25a	53.60b	49.45a	14.87a
	200	47.84d	39.54c	13.25b	45.23e	40.89a	12.41a
	control	52.36bc	38.56c	12.74c	35.21f	38.52c	12.54a
3500	100	54.63b	48.23a	13.56b	46.23d	46.96b	12.89a
	200	47.21d	38.21c	11.45d	33.25g	38.42a	11.23a
	control	41.25e	37.23c	11.35d	33.85g	37.41c	10.52a
5000	100	36.98f	42.98b	12.36c	42.03e	39.76c	10.96a
	200	32.58g	36.12d	10.25e	36.25f	37.89c	10.12a
Main effect of saline irrigation water (A)							
Control		76.41a	48.21a	12.96a	70.12a	42.36a	12.36a
2000 mg/L		65.45b	41.52b	12.63a	63.45b	38.14b	12.12a
3500 mg/L		61.56c	36.84c	11.25a	54.32c	32.69c	11.52b
5000 mg/L		43.85d	30.58d	10.23b	46.23d	30.52d	10.56b
Main effect of soaked tuber in H_2O_2 (B)							
control		55.02a	45.13a	13.24a	48.45a	47.56a	14.25a
100 mM		58.41a	49.51a	13.85a	50.69a	48.23a	14.85a
200 mM		48.65a	39.26a	11.87a	39.69b	38.36a	12.55b

* Significant at 0.05 level of probability.

c. The interaction effect of combined treatment

The interaction effect of two combined treatments exerted significant trend at $p \leq 0.05$ on the number of tubers/plant and average tuber fresh weight traits during the two study seasons (Table, 3). In 2018, optimal results were realized when the tubers were soaked in 100mM H_2O_2 and irrigated with 500mg/L saline water, followed by water salinity concentrations of 2000 and 3500 mg/L, respectively. While the lowest positive results were at water salinity level of 5000 mg/L. As for the first season the significantly highest mean values for total yield / fed. were recorded with the saline irrigation , namely, 500 mg/L and 2000 mg/L , when the tubers were soaked in 100 mM H_2O_2 solution.

Table (4). The average values of Jerusalem artichoke tubers' quality traits as affected with water salinity concentrations, soaked tubers in H_2O_2 treatments and their interaction treatments during the two study seasons

Treatments		2018			2019		
water salinity levels (mg/L)	H_2O_2-Soaking Levels (mM)	Total carbohydrates (%)	Inulin (%)	Tubers dry matter (%)	Total carbohydrates (%)	Inulin (%)	Tubers dry matter (%)
control	control	55.62a	22.54a	23.45a	58.42a	23.45a	23.54a
	100	57.91a	23.41a	24.15a	61.23a	23.65a	24.32a
	200	51.32b	21.45a	24.28a	53.21b	22.10a	23.15a
2000	control	50.63b	21.56a	22.84a	52.36b	22.85a	22.45a
	100	58.16a	22.74a	24.85a	59.81a	23.41a	24.78a
	200	50.28b	21.36a	22.36a	57.22ab	21.35a	21.41a
3500	control	51.08b	21.52a	22.51a	50.21b	21.74a	22.54a
	100	52.41b	20.98a	22.87a	53.84b	21.53a	23.12a
	200	49.85c	20.74a	21.46a	47.63cd	20.71a	21.54a
5000	control	46.23d	21.56a	21.65a	49.36c	20.36a	21.54a
	100	48.53c	21.05a	21.85a	48.53c	20.17a	21.23a
	200	47.75c	19.45a	20.14a	47.23cd	20.67a	20.09a
Main effect of irrigation water salinity concentrations (A)							
control		55.89a	21.36a	22.45a	57.96a	22.23a	22.41a
2000 mg/L		52.96b	20.54b	21.36b	51.85b	21.25b	21.64b
3500 mg/L		48.21c	20.04c	20.54c	49.68c	20.03c	20.45c
5000 mg/L		45.86d	19.36d	19.78d	44.83d	18.87d	19.02d
Main effect of soaked tuber in H_2O_2 (B)							
control		59.21b	23.56a	20.74a	58.21a	22.56a	20.63a
100 mM		63.45a	23.51a	21.56a	61.23a	22.23a	20.32a
200 mM		54.28c	21.26b	19.54a	53.58a	21.36a	19.89a

* Significant at 0.05 level of probability.

Table (5). The averages of tubers′ mineral element contents as affected with water salinity concentrations, soaked tubers in H_2O_2 treatments and their interaction treatments during the two study seasons

Treatments		2018			2019		
water salinity levels (mg/L)	**H_2O_2-Soaking levels (mM)**	**N (%)**	**P (%)**	**K (%)**	**N (%)**	**P (%)**	**K (%)**
	control	1.521a	0.231a	4.325a	1.425a	0.24a	4.263ab
control	**100**	1.598a	0.245a	4.155a	1.486a	0.243a	4.562a
	200	1.536a	0.236a	4.361a	1.205cd	0.251a	3.814bc
	Control	1.421ab	0.243a	4.184a	1.496a	0.232a	4.204b
2000	**100**	1.325b	0.250a	4.815a	1.523a	0.241a	4.851a
	200	1.254c	0.232a	4.264a	1.352b	0.223a	3.296d
	control	1.342b	0.214a	3.514a	1.265c	0.214a	3.025d
3500	**100**	1.305b	0.216a	3.874a	1.312b	0.232a	2.654e
	200	1.145d	0.205a	3.026a	1.156d	0.182a	2.346f
	control	0.954e	0.168a	3.105a	0.896e	0.174a	2.410ef
5000	**100**	0.854ef	0.184a	2.815a	0.892e	0.179a	2.169f
	200	0.836e	0.173a	2.148a	0.853e	0.165a	2.135f
Main effect of irrigation water salinity concentrations (A)							
control		1.723a	0.267a	4.233a	1.625a	0.213a	4.436a
2000 mg/L		1.524b	0.242a	3.725b	1.478b	0.205b	3.687b
3500 mg/L		1.356c	0.154b	3.286c	1.306c	0.194c	3.045c
5000 mg/L		0.949d	0.125b	2.842d	1.021d	0.173d	2.874d
Main effect of soaked tuber in H_2O_2 (B)							
control		1.478a	0.189a	3.654a	1.529a	0.232a	3.512a
100 mM		1.458a	0.221a	3.436a	1.635a	0.214a	3.457a
200 mM		1.280b	0.170a	3.412a	1.486a	0.192a	3.419a

* Significant at 0.05 level of probability.

3. The performances of tubers′ quality and elemental composition

a. The main effect of saline irrigation water

The properties of tuber quality traits and the elemental composition of Jerusalem artichoke tubers are given in Tables 4 and 5. As for the tested water salinity irrigation concentrations, the results revealed that the tested tubers′ quality traits expressed as total carbohydrate , inulin and dry matter percentages and tuber elemental composition, including N, P and K content were significantly affected ($p \leq 0.05$) with increasing saline irrigation water during the two seasons. The results clearly showed a gradual decline in the mean values of the quality traits and tubers' elemental contents of nitrogen, phosphorus and potassium elements with increasing the level up to 3500 mg/L and severely dropped at the highest salinity exposure. Total dry matter production significantly decreased with increasing water salinity level. In contrast, Ghosh *et al*. (2001) illustrated that tuber N content increased by salt stress presumably due to the decrease in the carbohydrate content in the tubers. The decreases in K^+ could be attributed to the antagonism of Na^+ and K^+ at uptake positions in the roots, the effect of Na^+ on K^+

transport into the xylem or the inhibition of uptake processes (Hu and Schmldhlter, 2005). In a saline environment, plants take up an excessive amount of sodium at the expense of K^+ and Ghosh *et al*. (2001) illustrated that the decrease of dry matter production as a result of increasing salinity was relatively more pronounced in tubers than in the other parts of the plant. This result is consistent with El-Hedek (2013), who found a decrease in wheat plant phosphorus content with increased salt concentration in the soil.

b- The main effect of H_2O_2-soaked tubers

The results given in Table 5 indicated that except N% in 2018 & 2019 as well as K% in, 2019, no marked variations were detected at $p \leq 0.05$. Regarding to the tubers quality, including; carbohydrate and inulin %, the results reported in Table 4 indicated that, only in 2018, significant differences were appeared between the 2 concentration levels of H_2O_2 100 and 200 mM soaked-treated tubers. The results in Table 4 clarified that although the differences in the dry yield of tubers and P and K% between H_2O_2 –treated tubers along the all exposed salinity treatment did not impose any significant variations at $p \leq 0.05$ different results were reported by Samah *et al.* (2012), indicating that the highest percentage of tubers dry matter was possessed when potato plants were sprayed with 40mM hydrogen peroxide.

c- The effect of combined Treatments

The 2-way interaction of the combined treatment effects exhibited significant variations on total carbohydrate and nitrogen tubers content affected during the two growing seasons (Tables 4 and 5). Tubers potassium content was significantly affected only during the second season. The remaining estimated element P, inulin and dry matter percentage in tubers were not significantly affected by this interaction during the two growing seasons. In general, soaked tubers with H_2O_2 (100mM) generally gave the best values for the estimated elements and tubers′ quality traits, even if this increase was not significant in some cases.

Generally, it could be concluded that soaked Jerusalem artichoke tubers on concentration of 100mM hydrogen peroxide before planting was promising to achieve better results and was effective to alleviate the adverse effects of irrigation water salinity on the vegetative growth criteria ad inducing progressive in increases in total tubers yield per feddan, and tubers′ quality characteristics.

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الملخص العربي

الاجهاد الملحي لنباتات الطرطوفة وعلاقته بنقع الدرنات قبل الزراعة في محلول فوق اكسيد الهيدروجين

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تم إجراء تجربتين رئيسيتين خلال موسمي النمو ٢٠١٨ و ٢٠١٩ على نبات الطرطوفة صنف فيوزا في معمل بحوث الاراضي الملحية والقلوية ، مركز البحوث الزراعية ، الإسكندرية ، مصر. تم اقتراح هذا البحث لتقييم مزايا نقع الدرنات في محلول H_2O_2 والتعرض للإجهاد الملحي على النمو ومكونات المحصول والجودة ومحتوى الدرنات من العناصر الغذائية. استخدم فى تطبيق التجربة نظام القطع المنشقة فى ثلاث مكرارات حيث وزعت ٤ مستويات من مياه الري المالحة ، تم تحضيرها بخلط ماءالصنبور ومياه البحر ، لتكوين تركيزات ملحية (٥٠٠ (كنترول)، ٢٠٠٠ ، ٣٥٠٠ و ٥٠٠٠ مجم/لتر) عشوائيا على القطع الرئيسية بينما وزعت٣ مستويات من محلول فوق اكسيد الهيدروجين (كنترول ، ١٠٠ و ٢٠٠ ملليمول) لنقع الدرنات قبل الزراعة عشوائيا فى القطع تحت المنشقة. تم زراعة الدرنات المنقوعة بمحلول فوق اكسيد الهيدروجين في احواض أسمنتية (٢ * ٢ * ١ م) ، في خطوط بعرض ٨٠ سم ، وطول ٢ متر. في مرحلة الإزهار ، تم تسجيل بيانات النمو الخاصة بالنبات.و في مرحلة الحصاد ، تم تسجيل بيانات المحصول وقياس جودة المحصول بالإضافة إلى قياس محتوى الدرنات من العناصر المغذية N و P و K%.

أوضحت النتائج أن زيادة ملوحة مياه الري حتى ٥٠٠٠ مجم/لتر أثر سلبا على غالبية صفات النمو الخضرى (ارتفاع النبات ، وزن النبات الطازج) بالاضافة للتأثير السلبي على عدد الدرنات / نبات ، ووزن الدرنات الطازج والمحصول الكلي / فدان (الطن). كما أوضحت النتائج أن النباتات المعاملة بالملوحة أظهرت انخفاض ملحوظ في محتوى الدرنات من العناصر الغذائية Nو P و K وكذلك محتواها من الكربوهيدرات والإنيولين خلال موسمي النمو. وكشفت النتائج أيضًا عن االاثر الإيجابي للنقع في محلول فوق اكسيد لهيدروجين (١٠٠ ملليمول) على مقاييس النمو الخضري و المحصول. كما اثرت المعاملة السابقة نفس التأثير الايجابي على محتوى الدرنات من الكربوهيدرات والانيولين و N٪ فقط في موسم النمو ٢٠١٨. وكشفت دراسة التداخل بين ملوحة مياه الري ونقع الدرنات أنه لا يوجد اختلاف معنوي في مقاييس النمو الخضري خلال موسمي النمو.كما أظهرت النتائج ان معاملة الدرنات بالنقع في محلول فوق اكسيد لهيدروجين (١٠٠ ملليمول) والري بمياه ملوحتها ٥٠٠ إلى ٢٠٠٠ مجم/لتر اثر ايجابيا على ارتفاع النبات ومكونات المحصول ومحتوى الدرنات من الكربوهيدرات والإينولين والنتيروجين.

بناء على النتائج السابقة وتحت ظروف هذه التجربة فانه يوصى بنقع درنات الطرطوفة فى محلول فوق اكسيد الهيدروجين تركيز ١٠٠ (ملليمول) قبل الزراعة لمدة ساعتين سيكون ضروريًا لتجنب التأثير الضار للاجهاد الملحي على محصول درنات الطرطوفة وخصائص جودة الدرنات.