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PHYSIOLOGICAL RESPONSE OF QUINOA TO SALT STRESS UNDER SHAD HOUSE CONDITION

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ABSTRACT

Quinoa is a halophytic species emerging as a potential new crop in many regions of the world because of the nutritional composition of their seeds. This study has been carried out at the Faculty of Environmental Agricultural Science, Arish University, Egypt during the two successive growing seasons 2016/2017 and 2017/2018. The experiment has been done at the shad net house of the experimental crop farm using quinoa seedlings (one month old), which grow in pots. Seedlings have been irrigated every two days using four treatments of irrigation water (control, 100, 150, 200 mM), where control was tap water 85 mM. It was observed that vegetative parameters of quinoa seedling were significantly decreased with increasing water salinity concentration .The highest value for each of plant height, root length, number of leaves, leaf dry weight, shoot dry weight, root dry weight, water relative content was obtained with low saline control, followed by 100, 150 and 200mM which gave the lowest values in this respect. Concerning growth analysis, the maximum value for each of leaf area duration, relative growth rate, crop growth rate and net assimilation rate was achieved by control, followed by the other respected studied concentration which gave the lowest values. The obtained results cleared that the concentration of nitrogen, phosphorus and potassium, pigments decreased in plant tissue with increasing water salinity concentration. However, sodium and proline concentrations increased in plant tissue with increasing salinity concentration. It worthy to note that there were significant differences between Giza1 and Giza2 in most studied parameters.

Key words: Salinity, varieties, quinoa, proline, growth analysis, sodium.

INTRODOCTION

Salinity is common adverse environmental factor that affect the growth of plants and is considered as the main factor determining the global geographic distribution of vegetation and restriction of crop yields in agriculture **(Schulze *et al.*, 2005; Gregory 2006).** Desertification and salinization are rapidly increasing on a global scale declining average yields for most major crop plants by more than 50% **(Bray *et al.*, 2000**). The need to minimize the effects of salt stress on plant growth and crop yield is urgent. A possible approach is the introduction of species capable of tolerating high soil salinities and guarantee acceptable yields. One of these tolerant species is quinoa, (*Chenopodium quinoa* Willd.) a seed crop, native to the Andean mountains. This traditional Andean seed crop has been cultivated in the Peruvian and Bolivian Andes **(Jacobsen, 2011)** for more than 7000 years **(Pearsall, 1992)**, and the crop is rapidly gaining interest throughout the world **(Jacobsen 2003; Bhargava *et al.*, 2006)**. Quinoa is well adapted to grow under unfavorable soil and climatic

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conditions **(Garcia *et al.*, 2003)**. Its robust character is because of a high tolerance level of frost **(Jacobsen *et al.*, 2005),** soil salinity **(Jacobsen *et al.,* 2003; Hariadi *et al.* 2011)**. Quinoa is a halophytic species emerging as a potential new crop in many regions of the world because of the nutritional composition of their seeds **(Mujica** and **Jacobsen 2006; Comai *et al.* 2007).**

MATERIALS AND METHODS

This study was carried out at faculty of Environmental Agricultural Sciences, El-Arish, Arish University, Egypt under shade net house during 2016/17–2017/18. The plant materials of experiment were obtained from Agriculture Research Center, Giza, Egypt. Pots were arranged in Complete randomized design (CRD) with three replication because the net shad house was not under control. Seeds were sown in mixture of sand and peatmoss 1:1 *V/V*. Seedlings were irrigated with NaCl solutions of (100, 150, 200mM) which equal to (5850, 8775, 11700ppm) every two days and with tap water as control which was. 85mM (4972.5ppm). The treatments applied after one month from sowing.

Recorded Data

Morphological and Physiological Characters

The following data were recorded after 60 days from treatment application for seedling of *in vivo* experiment: plant height (cm), root length(cm), number of leaves/ plant, leaf dry weight (g/plant), shoot dry weight (g /plant), root dry weight (g/plant), relative water content (RWC%), leaf area, leaf area duration (LAD), relative growth rate (RGR, g.g/week, net assimilation rate (NAR, g.dm-^{2}. week) and Crop growth rate (CGR, g/week).

Chemical analyses

The following chemical analyses were taken after 60 days from treatment application:

2.1. Nitrogen was determined according to **Bremner and Mulvanc (1982).**

2.2. Phosphorus was measured according to **Jackson (1973).**

2.3. Potassium was determined according to **Chapman and Part, (1961).**

2.4. Sodium was determined using flame photometer according to **Chapman and Part, 1961.**

2.5. Pigments contents Chlorophyll a, b and carotenoides were determined according to **Saric *et al.* (1967)**

2.6. Proline content was determined according to the modified nonhydrin method **(Troll and Lindsley1955)**

Statistical analysis

Data of the tow seasons for experiment were subjected to proper statistical analysis of variance **(Snedecor and Cochran, 1990)** using M-STATC program. Mean values were compared at P≤0.05 using the multiple range test **(Duncan, 1955).**

RESULTS AND DISCSSION

Varietal Differences and Salt Stress Effect

There were significant difference between the two studied season, this may refer to Meteorological Data Table, so, each season will be discussed separately.

Results presented in Tables 1, 2, 3 show the effect of salt stress on morphological parameters (plant height (cm), root length (cm), No. of leaves, leaf dry weight, shoot dry weight and root dry weight) and physiological parameters (relative water content, crop growth rate, leaf area duration, net assimilation rate and relative growth rate).

Generally, it could be concluded that, the most of studied growth were significantly decreased with increasing salinity water concentration. It cleared from Table 1 that there were significant differences in plant

Table (1): Effect of salt stress on plant height, root length, number of leaves and leaf dry weight of quinoa seedlings, (90 days old) at 2016/2017 and 2017/2018 seasons.

Treatment Seasons		Plant height (cm)		Root length (cm)		Number of leaves		Leaf dry weight (g)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Cultivar									
	Giza1	24.595a	29.774a	12.482a	17.511a	61.136a	71.358a	0.602a	0.868a
	Giza2	20.491b	24.752b	10.869b	16.221b	49.831b	51.442b	0.389b	0.725b
Salinity concentration (mM)									
	Control	30.97a	33.70a	16.39a	22.09a	70.33a	73.55a	1.097a	1.015a
	100	25.46b	29.50b	12.47b	19.56b	61.77b	67.05b	0.488b	0.883b
	150	18.52c	24.68c	9.885c	15.10c	51.50c	56.83c	0.262c	0.668c
	200	15.22d	21.17d	7.958d	10.71d	38.33c	48.17d	0.135d	0.619c
Cultivar x Salinity concentration									
Giza$_1$	**Control**	35.44a	35.33a	17.55a	23.19a	77.55a	82.33a	1.493a	1.079a
	100	28.72b	31.89b	13.61c	20.52b	67.66b	76.44b	0.477c	0.948b
	150	19.00e	27.77c	10.61e	15.79d	54.22d	68.77c	0.312d	0.748d
	200	15.22f	24.11d	8.163g	10.55e	45.11f	57.89e	0.125f	0.694d
Giza$_2$	**Control**	26.50c	32.07b	15.23b	21.00b	63.11c	64.78d	0.701b	0.951b
	100	22.20d	27.11c	11.33d	18.61c	55.88d	57.66e	0.499c	0.817c
	150	18.05e	21.59e	9.163f	14.41d	48.78e	44.88f	0.212e	0.588e
	200	15.22f	18.24f	7.753g	10.87e	31.55g	38.44g	0.144f	0.543e

Table (2): Effect of salt stress on shoot dry weight, root dry weight, relative water content and crop growth rate of quinoa seedlings, (90 days old) at 2016/2017 and 2017/2018 seasons.

Treatment Seasons		Shoot dry weight (g)		Root dry weight(g)		Relative water content (%)		Crop growth rate g/week	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Cultivar									
	Giza1	0.541a	0.674a	0.146a	0.206a	43.407a	42.078a	0.252a	0.334a
	Giza2	0.202b	0.352b	0.070b	0.099b	40.545b	40.752a	0.125b	0.226b
Salinity concentration (mM)									
	Control	0.867a	0.659a	0.270a	0.207a	54.81a	48.96a	0.456a	0.359a
	100	0.347b	0.554b	0.094b	0.163ab	39.96	40.13b	0.17b	0.309a
	150	0.176c	0.459c	0.046bc	0.135bc	38.17b	38.86b	0.084c	0.236b
	200	0.094d	0.378d	0.020c	0.104c	34.95c	37.71b	0.035c	0.213b
Cultivar x Salinity concentration									
Giza$_1$	**Control**	1.356 a	0.866a	0.386 a	0.276a	61.25a	53.57a	0.667 a	0.425a
	100	0.437 b	0.719b	0.116bc	0.223ab	39.68c	37.98d	0.194bc	0.359b
	150	0.238 c	0.594c	0.063cd	0.189bc	38.09c	38.20d	0.107 de	0.285c
	200	0.132d	0.516d	0.018 d	0.137cd	34.61d	38.56d	0.038 f	0.264c
Giza$_2$	**Control**	0.379 b	0.452e	0.155b	0.1391cd	48.38b	44.34b	0.245 b	0.293c
	100	0.257c	0.389f	0.071cd	0.1033de	40.25c	42.28bc	0.160 cd	0.259c
	150	0.113 d	0.324g	0.029 d	0.0828de	38.26c	39.52cd	0.060 ef	0.188d
	200	0.056d	0.240h	0.022 d	0.0712e	35.29d	36.86d	0.033f	0.161d

Table (3): Effect of salt stress on leaf area duration, relative growth rate and net assimilation rate of quinoa seedlings, (90 days old) at 2016/2017and 2017/2018 seasons.

	Treatment	Leaf area duration cm.^{2} week^{-1}		Relative growth rate g week^{-1}		Net assimilation rate g.cm-2.week^{-1}	
	Seasons	1st	2nd	1st	2nd	1st	2nd
				Cultivar			
	Giza1	2.113a	2.786a	0.257a	0.645a	5.160a	6.717a
	Giza2	2.327a	2.018b	0.258a	0.376b	2.525b	4.449b
				Salinity concentration (mM)			
	Control	2.482a	2.717a	0.311a	0.694a	9.441a	7.358a
	100	2.386a	2.436a	0.283ab	0.594b	3.604b	6.191b
	150	2.171a	1.916a	0.244bc	0.416c	1.656c	4.660c
	200	1.842 a	2.541a	0.1886c	0.335d	0.669d	4.123c
				Cultivar x Salinity concentration			
Giza$_1$	Control	2.284a	2.622ab	0.321a	0.817a	13.82a	8.752a
	100	2.512a	2.726ab	0.277a-c	0.707b	3.98 c	7.252b
	150	2.224a	2.072ab	0.248b-d	0.557c	2.13 e	5.680cd
	200	1.431b	3.725 a	0.178 e	0.496d	0.704f	5.184d
Giza$_2$	Control	2.680 a	2.811ab	0.301ab	0.5713c	5.059 b	5.964c
	100	2.260a	2.145ab	0.290 a-c	0.4813d	3.226 d	5.130d
	150	2.117a	1.760b	0.240 cd	0.2753e	1.181f	3.640e
	200	2.252a	1.357b	0.198 de	0.1743f	0.635 f	3.062e

height, root lengths, No. of leaf and leaf dry weight between Giza1 and Giza2 in both seasons. Concerning to salinity concentration, plant height decreased significantly from 30, 97 and 33.70 to15.22 and 21.17 cm in both seasons as salinity concentration increased from 85 mM to 200mM. Root length decreased significantly from 16.39 and 22.09 to 7.958 and 10.71cm in both seasons as salinity concentration increased from 85 mM to 200 mMs. the maximum number of leaves/plant (70.33 and 73.55) was obtained when control treatment was applied, where, the minimum values of number of leaves/plant (38.33 and 48.17) were achieved when 200 mM salinity concentration was used. Leaves dry weight of plant was decreased significantly from 1.097 to 0.1352 g in the first season and it was decreased from 1.015 to 0.6190 g in the second season as salinity concentration increased from 85 mM to 200mM. It worthy to note that the maximum value for each of plant height, root length, No. of leaves and leaf dry weight were obtained in the case of Giza1 cultivar under control condition in the both seasons. However, the minimum values of plant height were obtained in the case of Giza$_2$ under 200mM concentration which recorded as 15.22 and 18.24 0cm in both seasons, respectively. The same responses were noted in number of leaf, the least values were obtained in the case of Giza2 under 200 mM concentration which recorded 31.55 and 38.44 in both seasons, respectively. In both seasons, the lowest values of leaves dry weight were obtained in the case of Giza 2 under 200 mM concentration which recorded 0.144 and 0.543g, respectively. These results are in line with those obtained by **Carillo *et al.* (2011), Alborzi Hagigi *et al.* (2012), Panuccio *et al.* (2014), Harter *et al.* (2014), Arshadullah *et al.* (2016), Ouhaddach *et al.* (2018), Hussain *et al.* (2018), Tahmasebpour *et al.* (2018) and Rezende *et al.* (2018)** and they mentioned that, the depressive effect of salinity on plant growth may be due to the increase in the osmotic potential of the soil which caused in a reduction in the availability of water to the plant.

Table 2 clearly indicate that there were significant decrease in shoot dry weight, root dry weight, relative water content and crop growth rate between Giza1 and Giza 2 in both seasons except relative water content that there were insignificant differences between quinoa studied varieties in the second season. Regarding to salinity, shoot dry weight decreased significantly from 0.8676 and 0.6596 to 0.0947 and 0.3784 g in both seasons as salinity concentration increased from 85 mM to 200 mM. Root dry weight decreased significantly from 0.2706 and 0.2077 to 0.0203 and 0.1041 g in both season as salinity concentration increased from 85 mM to 200mM. The maximum values of relative water content (54.81 and 48.96%) were obtained when 85mM salinity concentration was applied in both seasons. The minimum of relative water content (34.95 and 37.71%) was achieved when 200 mM was used in both seasons. Crop growth rate decreased significantly from 0.456 and 0.359 to 0.035 and 0.213g/week in both seasons as salinity concentration increased from 85 mM to 200mM. It worthy to note that the maximum shoot dry weight, root dry weight, relative water content and relative crop rate were obtained in the case of Giza1 which was irrigated with 85mM water salinity concentration in the both seasons. However, the minimum values of shoot dry weight was obtained in the case of Giza2 which was irrigated with 200 mM water salinity concentration (0.056 and 0.240g) in both season, respectively. The same responses were noted in root dry weight, the least values were obtained in the case of Giza2 which was irrigated with 200 mM water salinity concentration which recorded 0.022 and 0.0712g in both seasons, respectively. In both season, the lowest values of relative water content were obtained in the case of Giza2 under 200 mM water salinity concentration which recorded as 35.29 and 36.86%, respectively. In the other hand, the lowest values of relative crop rate (0.033, 0.161 g/week) were obtained in the case of Giza2 which was irrigated with 200 mM salinity concentration. These results are in harmony with those obtained by, **Jacobsen *et al.* (2009)**, **Sade *et al.* (2012), Alborzi Haghigi *et al.* (2012), Shabani *et al.* 2013** and **Rezende *et al.* (2018)**.

From results in Table 3 it can be observed that there were insignificant differences in leaf area duration and relative growth rate between Giza1 and Giza2 in the first season. However, there were significant differences in leaf area duration and relative growth rate between Giza1 and Giza2 in the second seasons in favour to Giza1. In both seasons, there were significant differences in net assimilation rate between quinoa studied varieties in both season in favoure of Giza1. Regarding to salinity. In the other hand, there were insignificant differences in leaf area duration between Giza1 and Giza 2 in the first season. In the second season, there were significant differences in leaf area duration between Giza1 and Giza (2 2.786 and 2.018 cm^2week), respectively. However, there were insignificant differences in leaf area duration between salinity treatments in both seasons. Concerning to the effect of interaction between cultivar and salinity concentration, there was insignificant decrease in leaf area duration in the first season. However, there were significant effect in leaf area duration in the second season. The maximum of relative growth rate (0.311, 0.694 g $week^{-1}$) where obtained when 85 mM salinity concentration was applied in the both season. The minimum of relative growth rate (0.1886, 0.336g $week^{-1}$) were achieved when 200 mM salinity concentration was used in both season. Net assimilation rate decreased significantly from 9.441 and 7.358 to 0.669 and 4.123 g/cm/week in both season as salinity concentration decreased from 85 mM to 200mM. The same responses were noted in leaf area duration, the least value 1.431 $cm.^2$ $week^{-1}$ was obtained in the case of Giza1 which was irrigated with 200 mM salinity concentration in first season. Meanwhile, the lowest value (1.357$cm.^2$ $week^{-1}$) was obtained in the case of Giza2 which was irrigated with 200 mM salinity concentration. In the first season, the lowest value of relative growth rate (0.178g $week^{-1}$) was obtained in the case of Giza1 which was irrigated with 200 mM salinity concentration. In the other hand, the lowest value (1.1743 g $week^{-1}$) of relative growth rate obtained in the case of Giza2 which was irrigated with 200 mM concentration. In the both season, the lowest values of relative growth rate (0.635, 3.062 g/cm/week) were obtained in the case of Giza2 which was irrigated with 200 mM salinity concentration. These results are in harmony with those obtained by **El-Hendawy *et al.* (2005), Zheng *et al.* (2008), Rahimi *et al.* (2011), Alborzi Haghigi *et al.* (2012), Abbasdokht and Edalatpishe (2013), Gul *et al.* (2016) and Abbas *et al.* (2014).**

Results illustrated in Table 4 reflect that increasing salinity concentration effected significantly chemical characters (nitrogen, phosphorus, potassium, sodium %) between Giza1 and Giza2 in both seasons. In the one hand, nitrogen decreased significantly from 2.150 and 2.397 to 1.573 and 1.977% in both seasons as salinity concentration increased from 85 mM to 200mM. Phosphorus decreased from 0.234 and 0.259 to 0.141 and 0.202% in both seasons as salinity concentration increased from 85mM to 200mM. The maximum values of potassium 2.552 and 2.422% when 85mM was applied in both seasons. The minimum values of potassium 2.070 and 2.065were achieved when 200 mM was used in both seasons. It worthy to note that sodium increased from 1.840 and 1.755 to 2.453 and 2.338% in both seasons as salinity concentration increased from 85 mM to 200mM. In the other hand, the maximum value for each nitrogen, phosphorus and potassium was obtained in the case of Giza1 which irrigated with 85 mM salinity concentration.

The minimum value for each of nitrogen, phosphorus and potassium was obtained in the case of Giza2 which irrigated with 200 mM salinity concentration in both seasons. However, the highest value for each of sodium was obtained in the case of Giza2 which irrigated with 200 mM salinity concentration. The lowest value for each of sodium was obtained in the case of $Giza_1$ when irrigated with 85mM salinity concentration.

Results illustrated in Table 5 reflect that increasing salinity concentration effected significantly in chemical parameters (chlorophyll a, chlorophyll b, carotenoid, proline) of quinoa cultivars $Giza_1$ and $Giza_2$ in both seasons. In the one hand, chlorophyll a decreased significantly from 1.530 and 0.973 to 0.494 and 0.456 $\mu g/ml^{-1}$ in both seasons as salinity concentration increased from 85 mM to 200 mM. Chlorophyll b decreased from 0.552 and 0.521 to 0.309 and 0.294$\mu g/ml^{-1}$ in both season as salinity concentration increased from 85 mM to 200 mM. The maximum value for each of carotenoids (0.336, 0.262) were obtained when 85mM salinity concentration was applied in 1^{st} and 2^{nd}. It worthy to note that proline was increased from 0.191 to 0.477 mg/g in the first season. The same response was noted in proline at the second season, it increased from 0.212 to 0.502 mg/g. In the other hand, the maximum value for each of chlorophyll a, chlorophyll b and carotenoid was obtained in the case of Giza1 which irrigated with 85mM salinity concentration. The minimum value for each of chlorophyll a, chlorophyll b and carotenoid was obtained in the case of Giza2 which was irrigated with 200 mM salinity concentration in the both seasons. However, the highest value of proline was obtained in the case of Giza2 which was irrigated with 200mM salinity concentration. The lowest value of proline

Table (4): Effect of salt stress on nitrogen, phosphorus, potassium and sodium concentration of quinoa leaves (90 days old) at 2016/2017 and 2017/2018 seasons.

Treatment		N%		P%		K%		Na%	
Seasons		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Cultivar									
	Giza1	1.923a	2.307a	0.200a	0.235a	2.387a	2.322a	2.098b	1.998b
	Giza2	1.757b	2.135b	0.180b	0.218b	2.268b	2.162a	2.246a	2.122a
Salinity concentration (mM)									
	Control	2.150a	2.397a	0.234a	0.259^{a}	2.552a	2.422a	1.840d	1.755d
	100	1.962b	2.322b	0.209ab	0.228a	2.428b	2.320b	2.158c	2.022c
	150	1.674c	2.188c	0.173bc	0.216a	2.262c	2.163c	2.237b	2.127b
	200	1.573d	1.977d	0.141c	0.202^{a}	2.070d	2.065d	2.453a	2.338a
Cultivar x Salinity concentration									
Giza$_1$	**Control**	2.30a	2.482a	0.249a	0.273a	2.660a	2.540a	1.737g	1.647g
	100	2.034b	2.377b	0.224ab	0.244ab	2.537b	2.417b	2.127e	1.990e
	150	1.748d	2.286c	0.184bc	0.219ab	2.293de	2.223d	2.163de	2.050d
	200	1.604e	2.084d	0.141c	0.203b	2.060f	2.110e	2.367b	2.307b
Giza$_2$	**Control**	1.994b	2.311c	0.220ab	0.246ab	2.443c	2.303c	1.943f	1.863f
	100	1.891c	2.268c	0.194abc	0.212ab	2.320d	2.223d	2.190d	2.053d
	150	1.599e	2.091d	0.163bc	0.213ab	2.230e	2.103e	2.310c	2.203c
	200	1.542f	1.870e	0.141c	0.201b	2.080f	2.020f	2.540a	2.370a

Table (5): Effect of salt stress on Chlorophyll a, Chlorophyll b, carotenoid (µg/ml^{-1}) and proline (mg/g) concentration of quinoa leaves, (90 days old) at 2016/2017 and 2017/2018 seasons.

Treatment		Chlorophyll a		Chlorophyll b		Carotenoids		Proline	
Seasons		1st	2nd	1st	2nd	1st	2nd	1st	2nd
Cultivar									
	Giza1	1.155a	0.750a	0.470a	0.441a	0.289a	0.228a	0.293b	0.317b
	Giza2	0.847b	0.709b	0.412b	0.396b	0.244b	0.220b	0.366a	0.390a
Salinity concentration (mM)									
	Control	1.530a	0.973a	0.552a	0.521a	0.336a	0.262a	0.191c	0.212d
	100	1.166b	0.826b	0.477b	0.447b	0.305a	0.252a	0.301b	0.320c
	150	0.815c	0.652c	0.425b	0.410b	0.228b	0.192b	0.347b	0.379b
	200	0.494d	0.465d	0.309c	0.294c	0.194b	0.187b	0.477a	0.502a
Cultivar x Salinity concentration									
Giza$_1$	**Control**	1.803a	0.990a	0.591a	0.554a	0.358a	0.248ab	0.159e	0.181e
	100	1.474b	0.871b	0.514b	0.480b	0.325ab	0.241ab	0.278c	0.298cd
	150	0.890d	0.652d	0.454c	0.433bc	0.252cd	0.212bc	0.294c	0.329c
	200	0.454e	0.485e	0.319d	0.295d	0.220de	0.209bc	0.441b	0.459b
Giza$_2$	**Control**	1.257c	0.956a	0.513b	0.489b	0.315ab	0.276a	0.222d	0.244d
	100	0.858d	0.782c	0.440c	0.413c	0.285bc	0.263ab	0.325c	0.342c
	150	0.739d	0.652d	0.396c	0.388c	0.204de	0.171c	0.401b	0.429b
	200	0.533e	0.445e	0.299d	0.292d	0.169e	0.166c	0.514a	0.545a

was obtained in the case of Giza1which irrigated with 85mM salinity concentration. These results are in agreement with those outlined by each of **Datta *et al.* (2009), Eisa *et al.* (2012), Alborzi Haghigi *et al.* (2012), Adolf *et al.* (2013), Chamekh *et al.* (2014), Razzaghi *et al.* (2014), Arshadullah *et al.* (2016), Shaaban (2016), Ruiz *et al.* (2016) and Waqas *et al.* (2017).**

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استجـــابة الكينوا الفسيولوجية للإجهاد الملحي تحت ظروف صوبة الظل

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الملخص العربى

أجريت هذه الدراسة بكلية العلوم الزراعية البيئية جامعه العريش خلال الموسمين الزراعيين المتتالين ٢٠١٦-٢٠١٧ و٢٠١٧-٢٠١٨م حيث تمت هذه التجربة تحت ظروف صوبة الظل الشبكية في الحقل التجريبي باستخدام شتلات عمرها شهر والتي زرعت في اصص (قطر ٢٠ سم وارتفاع ١٨ سم) وتم ريها كل يومين بمياه ري ذات اربع تركيزات ملوحة مختلفة بالإضافة الى المعاملة القياسية بمياه الصنبور وكانت هذه التركيزات كالتالي: كنترول، ١٠٠، ١٥٠، ٢٠٠ ملليمول، وقد لوحظ أن الصفات الخضرية انخفضت معنويا بزيادة تركيز ملوحة مياه الري حيث ان اكبر القيم لكلا من (طول النبات، طول الجذر، عدد الأوراق، الوزن الجاف للأوراق، الوزن الجاف للساق، الوزن الجاف للجذر) تم الحصول عليها عند معاملة النباتات بمعاملة الكنترول (مياه الصنبور ٨٥ ملليمول) يليها استخدام تركيز ١٠٠، ١٥٠، ٢٠٠ ملليمول على الترتيب، أما بخصوص تحليل النمو، فكانت اعلي القيم المتحصل عليها من كل مقاييس تحليل النمو كان عند استخدام معاملة الكنترول يليها استخدام تركيزات (١٠٠، ١٥٠، ٢٠٠) على الترتيب، كما أن النتائج أوضحت أن تركيز النيتروجين والبوتاسيوم والفسفور وكلوروفيل أ وكلوروفيل ب والكاروتين في انسجة الأوراق تقل بزيادة تركيز ملوحة مياه الري بينما تركيز الصوديوم و البرولين يزداد معنويا بزيادة تركيزات ملوحة مياه الري وجدير بالذكر انه يوجد اختلافات معنوية بين صنف جيزة ١ وجيزة ٢ في معظم الصفات المدروسة.

الكلمات الإسترشادية: الملوحة، أصناف، كينوا، أصناف، برولين، تحليل النمو، صوديوم.

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