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Impact of Foliar Spray by Proline on the Production and Quality of Quinoa under Saline Soil Conditions at Toshka Region

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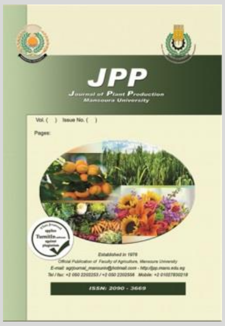

ABSTRACT

High Salinity on the soil is one of the widespread environmental problems in arid and semi-arid regions. A field experiment was conducted at the Agricultural Experimental Station Farm of Water Studies & Research Complex (WSRC), National Water Research Center, located in Toshka Region-Abu-Simbel, Egypt, during 2017/2018 and 2018/2019 seasons to evaluate the effect of four proline concentration (0.0, 25,50 and 75 ppm) and number of application (once=30 days after planting (DAP), twice=30 and 45DAP and thrice times=30, 45 and 60 DAP) on growth, yield and quality traits of quinoa plant grown in saline soil. Using a strip-plot in RCBD with three replications. Results revealed that the Growth, yield and quality traits of quinoa were significantly increased by high proline concentration with 75ppm compared to the other concentrations in both seasons. Increased number of proline adding times had a significant effect on growth, yield and quality traits of quinoa in both seasons, except plant height and shoot fresh weight plant^{-1} in the two seasons and number of leaves plant^{-1} in the second season.There were significant effects of the interaction between proline concentrations and spray times on growth, yield and quality traits of quinoa crop except for plant height, shoot fresh weight plant^{-1} and protein% in both seasons, for ach% in 2nd season and saponine% in 1st season. From the above-mentioned results, it concluded that the plants spraying three times with proline at 75ppm recorded the highest growth, yield, quality and net return of quinoa under salt-affected soil conditions at Toshka, Egypt.

Keywords: Quinoa – Saline soil - Proline – Yield and quality – Net return – Toshka region

INTRODUCTION

Quinoa *(Chenopodium quinoa* Willd*)* crop was chosen by (FAO, 2013) as one of the most important crops which play a major role in food security assuring in many countries because of its high nutritional value and its good tolerance to adverse environmental conditions to give high grain yields as it resists the salinity, drought, frost and can grow in poor soil (Nowak *et al.*, 2016 and Wu, 2016). It is garnered much attention in recent years because it is an excellent source of plant-based protein (from 12 to 17%) depending on environment and inputs (Rojas *et al.*, 2015) and recommended as useful essential food industries for formulations of baby gluten-free foods (Ogungbenle, 2003). Also, because this crop can grow in the sandy soil of arid and semi-arid regions. So, it is used to replenish part of the food gap. Additionally, quinoa seed contained higher total mineral contents, carbohydrates, flavonoids, vitamins, and phytosterols with possible extra health benefits than the other cereals such as corn, rice, rye, and wheat (FAO, 2011).

In 2013, the area cultivated with quinoa in the world was 126.000 ha, which produced 103.000 tons, with average productivity of 1.22 ton ha^{-1} (FAOStat, 2013). Quinoa is more adaptable to limiting factors in the production such as drought, frost, flooding, and saline soils as compared to other cultivated crops. The adaptation and resistance of this species still will not know.

Nowadays, soil salinity is one of the major widespread constraints in irrigated agriculture, particularly the last 20 years due to poor irrigation management and is predicted to become more pronounced in near future as a result of climate changes (Nguyen, 2016). About 7% of world agricultural land is influenced by salinity and expected to reach 20% in the future due to land salinization as a result of artificial irrigation and unsuitable land management. Salinity is a continuous threat to crops because elevated levels of NaCl are naturally present in many agricultural fields, which results in serious metabolic perturbation reducing crop productivity and yield. Likewise, salinity stress caused adverse metabolic changes (e.g. ion toxicity, loss of chloroplast activity, decreased photosynthetic rate and increased photorespiration rate that leads to an increased reactive oxygen species (ROS) production (Parida and Das, 2005). Previous studies have focused on quinoa's tolerance to soil salinity, with particular emphasis on plant physiology (Shabala *et al.*, 2013 and Wu *et al.*, 2016) and agronomic parameters such as plant height, leaf fresh and dry weight, number of leaves and inflorescence plant^{-1}, yield and harvest index (Peterson and Murphy, 2015 and Ebrahim *et al.*, 2018). Proline is a several function amino acid that besides acting as an excellent osmolyte is also known for stabilizing sub-cellular structures such as proteins and cell membranes, scavenging free radicals (Chen and Dickman, 2005), balancing cellular homeostasis and signaling molecule and buffering redox potential under stress conditions (Szabados and Savoure, 2009). The use of proline as a precursor of plant growth promoters is one approach to minimize the effect of salinity

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stress on plant growth and production. Application of trehalose and proline in alleviating salinity stress adverse influences is very important for both wheat and flax production (Mervat, 2019 and Mervat *et al*. 2019, respectively).

Application of osmoprotectant compounds as a foliar spray can be an economically viable strategy to improve stress tolerance under adverse environmental conditions (Ali and Ashraf, 2011; Dawood *et al.,* 2014a and Mervat, 2016). Proline is one of these compounds, which plays a major role as a stress protectant in various plant species (Abdelhamid *et al.,* 2013, Amer 2017 and Elewa *et al.,* 2017). Soaking seeds of Fenugreek with 100 ppm proline for 24 hours before exposed to salinity stress markedly reduced the harmful effects of salinity stress (Rehab *et al.,* 2017). Ayesha *et al.* (2019) reported that foliar application of 100 mM proline at growth stages of quinoa was found to be most effective in enhancing the quantum yield, by increasing seed yield plant^{-1} and also increased contents of carbohydrate, length and width of leaves, leaf chlorophyll content and photosynthetic efficiency.

The objective of the present research was to evaluate the effect of proline concentration and spraying time on quantitative and qualitative aspects of quinoa (cv. Regalona) grown under saline soil conditions, in the Toshka region.

MATERIALS AND METHODS

Plant materials and experimental conditions:

A field experiment was conducted at the Agricultural Experimental Station Farm of Water Studies & Research Complex (WSRC), National Water Research Center, located in Toshka Region-Abu-Simbel, Egypt, during the two successive winter seasons of 2017 - 2018 and 2018 - 2019, to identify the influence of proline concentrations and spraying time on growth, yield and some biochemical aspects of quinoa (cv. Regalona) under saline soil conditions. The seeds of quinoa were obtained from the Desert Research Center, Cairo, Egypt.

Soil Sampling and Analysis:

Before the starting of the experiment a complex soil sample represents the whole experimental are we collected for the upper 30 cm of the soil surface, air-dried, and then subjected to some physical and chemical analyses. Also, an irrigation water sample was collected and chemically analyzed. The analyzed the soil and water presented in Table 1 according to (Klute, 1986).

Table 1. Some selected properties of irrigation water and soil used of the experimental site before cultivation.

parameters	**pH**	**EC dS.m^{-1}**	**TDS mg L^{-1}**	**Cations meq L^{-1}**				**Anions meq L^{-1}**			**CaCO3 %**	**SAR**
				Ca	**Mg**	**Na**	**K**	**Cl**	**SO_4**	**HCO_3**		
Water	6.7	0.8	512	2.6	1.8	3.4	0.1	3.2	1.3	1.6	1.8	2.30
parameters	pH	EC dS.m^{-1}	TDS mg L^{-1}	Cations meq L^{-1}				Anions meq L^{-1}			CaCO3 %	OM%
				Ca	Mg	Na	K	Cl	SO_4	HCO_3		
Soil	7.8	5.11	2350	19.8	6.7	23.3	1.3	24.2	25.4	1.5	9.7	0.40
		SP%		Particle size distribution (%)							Texture class	
				Clay		Silt			Sand			
		29.27		2.56		6.21			91.23		Sand	

Treatments and experimental design:

The experiments were laid out in Randomized Complete Block Design (RCBD) using a strip plot arrangement with three replications. The studied treatments were four proline concentrations (A_1=0.0 as control, A_2=25, A_3=50 and A_4=75 ppm) which were allocated horizontally, and three number spraying times of proline [B_1: once time =30 days after planting (DAP), B_2: twice times=30 and 45 (DAP), B_3: thrice times=30, 45 and 60 (DAP)] were arranged vertically. The area of each plot was 20 m^2 (4x5m, 4 ridges 100 cm apart). A drip irrigation system was used in the study with a 30 cm distance between dippers (2L h^{-1}). Seeds of quinoa were cultivated on one side of the drip-irrigated ridge in hills spaced 15 cm apart on November 20th in both seasons. After germination completed, the plants were thinned to maintain two plants hill^{-1}. Plots were kept free of weeds through hand hoeing. The preceding summer crop was maize in both seasons. The other agricultural practices needed for quinoa were done as recommended by the agriculture ministry.

The plants were sprayed with different concentrations of proline freshly prepared solutions at 0. 25, 50, and 75 ppm and application time in three levels (once=30 days after planting (DAP), twice=30, and 60 DAP and thrice times=30, 45 and 60 DAP). Meanwhile, untreated plants (0.0 proline concentration) were sprayed with distilled water to serve as a control.

Studied Characters:

Data were recorded on means of ten individual plants concerning growth characters after the spraying at 75 DAP which taken randomly from each plot representing the three replications. Quinoa plants were harvested after 120 days from the planting. For yield characters, at harvest time another sample was assigned for this purpose. The procedure of recording the various data was carried out in the following manner:

A. Growth, yield, and yield attribute characters

1- Plant height (cm).	8- Root dry weight (g).
2- Number of branches plant^{-1}.	9- Leaf area (cm^2).
3- Number of leaves plant^{-1}.	10- Number of plants m^{-2}.
4- Number of inflorescence plant^{-1}.	11- Weight of seeds plant^{-1} (g).
5- Shoot fresh weight plant^{-1} (g).	12- Weight of 1000 seeds (g).
6- Shoot dry weight plant^{-1} (g).	13- Seed yield (kg fed^{-1}).
7- Root fresh weight (g).	14- Economic return.

The economic return was calculated by four estimates follows as:

1) Total costs = Average total costs fed^{-1} of all operations for quinoa crop = 416 US$ fed^{-1}. (Shams, 2018).
2) Total income = Price (US$ ton^{-1}) x Seed yield (ton fed^{-1}). Price of quinoa seeds (1 ton= 1171.5 US$ in Peru, 2018) source FAOStat data, 2018.
3) Net return = Total income – Total costs.
4) Economic efficiency = Net return / Total costs.

B. Chemical analysis:

Total chlorophyll in fresh leaves was analyzed by SPAD-502 plus. Konica Minolta, INC., Japan according to Mielke, *et al*. (2010). Protein content, ash content, ether extract were determined according to the method described in (A.O.A.C., 2000). Saponin content was determined according to (A.O.A.C., 2007).

C. Statistical analysis:

The data were subjected to statistical analysis of variance for randomized complete block design in a strip-plot arrangement, according to the method described by Gomez and Gomez (1984). Means were compared using the least significant difference (LSD) at 5% level of probability as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

I- Effect of proline concentration :

Results presented in Tables 2, 3, 4 and 5 reveal that using proline as foliar application treatment at different concentrations caused a significant increase in growth, yield and chemical composition of quinoa in the two growing seasons, as compared to their corresponding control treatment. The highest mean value of plant height (42.66 and 42.64 cm), number of branches plant^{-1} (29.09 and 29.48), number of leaves plant^{-1} (105.76 and 105.48), number of inflorescence plant^{-1} (35.64 and 35.48), shoot fresh weight plant^{-1} (51.74 and 51.20 g), shoot dry weight plant^{-1} (11.57 and 11.61 g plant^{-1}), root fresh weight plant^{-1} (5.31 and 5.21 g), root dry weight plant^{-1} (2.00 and 2.01 g), leaf area (18.42 and 20.86 cm^2), number of plants m^{-2} (49.03 and 47.96 plants), weight of seeds plant^{-1} (43.78 and 44.10 g), weight of 1000-seeds (4.55 and 4.55 g), seed yield (1084.49 and 1136.27 kg fed^{-1}), total chlorophyll (28.39 and 27.68), seed protein content (12.76 and 12.59%), ash percentages (4.54 and 4.02 %), seed oil percentages (6.78 and 6.90%) and seed saponins percentages (3.16 and 3.29%) were recorded at 75 ppm proline (A_4) in the 1st and 2nd seasons, respectively.

The proline application with 75 ppm (A_4) led to an increase in leaf area by (65.65 and 104.11%) and seed yield by (79.31 and 82.67%) as compared with control treatment (A_1) in 1st and 2nd seasons, respectively. Salt stress imposed the severe effects on plant growth and productivity by interrupting the normal metabolic processes, the addition of proline may alleviate the negative impact of salt by decreasing osmotic stress that consequently maintain the membrane integrity and its function and improved the growth of plants. Proline is produced and accumulate in plant cells under salinity stress to alleviate hyperosmotic stress by increasing the efficiency of water uptake and utilization as well as improved the growth and physiological attributes (Chen and Jiang, 2010; Dawood *et al.,* 2014b and Mervat, 2019). Amino acid-like proline plays a role in metabolic activities relevant to growth through protecting the photosynthetic pigments and increasing IAA contents which enhancing cell division and cell enlargement. Furthermore, the positive influence of proline may be due to that, an amino acid is an acceptable nitrogen source for the increased growth rate of shoots (Maha *et al.*, 2015). Maha *et al.* (2016) pointed that proline treatment on quinoa plants led to an improvement in growth parameters concomitantly with an increase in the levels of photosynthetic pigments, IAA, carbohydrates and yield components as compared to their corresponding control plants. Mahmoud *et al.* (2016) showed that a foliar application of 25 ppm proline on quinoa plants increased lengths of shoots and roots, number of branches plant^{-1}, number of leaves plant^{-1}, plant biomass and weight of 1000-seed. Our results are in line with some earlier studies such that found by (Elewa *et al.,* 2017).

Data in Table 5 show that foliar application of proline at 75ppm (A_4) led to significant increases in protein%, ash%, oil% and total saponin percentages of yielded seeds of quinoa by (40.48 and 43.23%), (43.67 and 33.11%), (31.65 and 37.45%) and (93.86 and 89.08%) as compared to the untreated plants in 1st and 2nd seasons, respectively. The increases in some biochemical composition of quinoa seed me be due to the increase in the efficiency of solar energy conversion which maximum the vegetative growth of quinoa plant and nutrients uptake and consequently increased its productivity.

Similar results were found by Bakry *et al*. (2016) they reported that plants treated with proline contained higher nutritional value of carbohydrate%, protein%, and oil contents and total flavonoids in yielded seeds.

II- Effect number spraying times of proline:

Data in Tables 2,3,4 and 5 show that the application of proline at different times resulting in a significant effect in all growth, yield and chemical composition of quinoa in both seasons, except plant height and shoot fresh weight plant^{-1} in the two seasons and number of leaves plant^{-1} in the second season. Growth, yield and quality traits of quinoa plants, were increased with increasing proline number of the applications. The plants spraying three times with proline gave the highest average of all studied parameters in both seasons. Thus, the greatest seed yield (985.75 and 1000.06 kg fed^{-1}) was observed when the plants received three sprays with proline in the 1st and 2nd seasons, respectively. The seed yield of quinoa treated at three times (B_3) increased by 25.01 and 26.27% compared with using proline at once a time (B_1) in the 1st and 2nd seasons, respectively. This is to be logic since the same trend was observed with regard to the number of plants m^{-2} and seed weight plant^{-1} and consequently produced the highest mean values of seed yield fed^{-1}.

Foliar application of proline at thrice times increased total chlorophyll, protein, ash and saponin percentage as compared to the other studied number of applications, this was may be due to enhanced ability of quinoa plant absorption of macro and micronutrients. These elements are present in a form acceptable to plants, consequently leads to an increase in the rate of synthesis of plant pigments, total chlorophyll, and chemical constituents of quinoa.

III- Effect of the interaction between applications number and proline concentrations:

Data in Tables 2,3,4 and 5 focus that number of leaves plant^{-1}, leaf area, shoot dry weight plant^{-1}, root fresh weight plant^{-1}, root dry weight plant^{-1}, number of plants m^{-2}, weight of seeds plant^{-1}, 1000-seed weight, seed yield, total chlorophyll, and oil% were significantly influenced by the interaction between proline concentrations and foliar applications number in both seasons, number of branches and inflorescence plant^{-1} in the 1st season. Plant height and shoot fresh weight plant^{-1} were not affected significantly by the interaction in both seasons.

The highest mean values of leaves number plant^{-1} (115.53 and 113.73 plant^{-1}), leaf area (19.84 and 22.44 cm), shoot dry weight plant^{-1} (11.98 and 12.96 g), root fresh weight plant^{-1} (6.11 and 6.15 g), root dry weight plant^{-1} (2.26 and 2.36 g), number of plants m^{-2} (50.57 and 50.26 plants), weight of seeds plant^{-1} (46.07 and 46.33 g), 1000-seed weight (4.70 and 4.73 g), seed yield (1249.62 and 1333.06 kg fed^{-1}), total chlorophyll (29.51 and 29.05) and oil% (7.12 and 7.13%) were obtained from quinoa plants which were sprayed by 75 ppm proline at thrice times in the first and second seasons, respectively. Foliar application of proline with 75 ppm at thrice times increased seed yield by (36.02 and 47.66%) and (15.15 and 13.65%) compared with one and twice times by the same concentration in the first and second seasons, respectively.

Table 2. Effect of different concentrations of proline, spraying time and their interaction on some growth traits of quinoa grown in 2017/2018 and 2018/2019 seasons

Treatments		Plant height (cm)		Number of leaves plant^{-1}		Number of branches plant^{-1}		Number of inflorescence plant^{-1}		Leaf area (cm^2)	
Proline concentration ppm(A)	Spraying number (B)	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
0.0 ppm	once	28.70	30.20	56.27	59.07	17.03	17.23	18.23	19.70	11.36	10.19
	twice	29.03	29.00	54.00	56.47	16.60	16.83	18.53	19.33	10.99	10.32
	thrice	28.70	29.93	55.27	55.37	17.20	17.80	18.40	20.03	11.03	10.14
Mean		28.81	29.71	55.48	56.97	16.94	17.29	18.39	19.69	11.12	10.22
25 ppm	once	33.43	34.57	63.50	64.37	19.33	17.97	23.00	21.77	13.05	12.80
	twice	33.87	33.20	69.73	71.20	19.80	20.63	25.23	25.40	13.57	13.66
	thrice	34.00	34.73	73.13	72.67	21.10	21.23	26.77	26.13	13.80	13.90
Mean		33.77	34.17	68.79	69.41	20.08	19.94	25.00	24.43	13.47	13.45
50 ppm	once	39.47	39.33	96.57	94.70	25.63	24.03	30.20	31.87	15.20	15.98
	twice	43.40	42.20	104.07	107.37	28.23	29.03	36.27	35.87	15.98	17.34
	thrice	43.50	45.00	115.13	111.66	32.77	33.27	37.60	38.53	15.99	17.79
Mean		42.12	42.18	105.26	104.58	28.88	28.87	34.69	35.42	15.72	17.03
75 ppm	once	40.13	39.63	94.47	100.60	24.73	24.73	31.47	32.00	16.22	19.40
	twice	42.67	44.37	107.27	102.10	29.53	29.80	36.90	35.73	19.19	20.75
	thrice	45.17	43.93	115.53	113.73	33.00	33.90	38.57	38.70	19.84	22.44
Mean		42.66	42.64	105.76	105.48	29.09	29.48	35.64	35.48	18.42	20.86
Mean of B	once	35.43	35.93	77.70	79.68	21.68	20.99	25.73	26.33	13.96	14.59
	twice	37.24	37.19	83.99	84.28	23.54	24.14	29.23	29.08	14.93	15.52
	thrice	37.84	38.40	89.77	88.36	26.02	26.55	30.33	30.85	15.16	16.07
LSD at 0.05	A	3.70	3.88	6.38	6.60	3.43	3.61	2.13	2.45	1.00	0.45
	B	NS	NS	4.01	NS	1.33	1.21	2.24	2.28	0.49	0.25
	A×B	NS	NS	3.60	7.08	2.43	NS	2.79	NS	0.56	0.76

Table 3. Effect of different concentrations of proline, spraying time and their interaction on some growth traits of quinoa grown in 2017/2018 and 2018/2019 seasons

Treatments		Shoot fresh weight plant^{-1} (g)		Shoot dry weight plant^{-1} (g)		Root fresh weight plant^{-1} (g)		Root dry weight plant^{-1} (g)	
Proline concentration ppm(A)	Spraying number (B)	1st	2nd	1st	2nd	1st	2nd	1st	2nd
0.0 ppm	once	25.21	27.43	5.73	6.13	1.74	1.66	0.66	0.62
	twice	26.90	28.17	5.98	6.30	1.70	1.58	0.66	0.63
	thrice	26.29	27.27	5.83	6.23	1.70	1.62	0.67	0.61
Mean		26.13	27.62	5.85	6.22	1.71	1.62	0.67	0.62
25 ppm	once	35.47	35.63	7.87	8.03	2.41	2.15	0.94	0.85
	twice	36.27	35.63	7.99	8.06	2.42	2.84	0.95	1.11
	thrice	37.20	37.20	8.26	8.51	2.61	2.95	1.06	1.14
Mean		36.31	36.16	8.04	8.20	2.48	2.65	0.98	1.03
50 ppm	once	49.29	48.83	10.83	10.83	3.33	3.09	1.19	1.21
	twice	52.17	51.40	11.67	11.59	3.84	3.52	1.45	1.36
	thrice	53.57	53.07	11.87	12.12	4.33	4.13	1.64	1.61
Mean		51.67	51.10	11.46	11.52	3.83	3.58	1.43	1.40
75 ppm	once	48.83	48.03	10.99	11.07	4.72	4.22	1.80	1.64
	twice	52.00	51.90	11.75	11.71	5.09	5.26	1.95	2.03
	thrice	54.38	53.67	11.98	12.96	6.11	6.15	2.26	2.36
Mean		51.74	51.20	11.57	11.61	5.31	5.21	2.00	2.01
Mean of B	once	39.70	39.98	8.86	9.02	3.05	2.78	1.15	1.08
	twice	41.83	41.78	9.35	9.42	3.26	3.30	1.25	1.28
	thrice	42.86	42.80	9.49	9.73	3.69	3.71	1.41	1.43
LSD at 0.05	A	2.01	3.02	0.12	0.16	0.16	0.33	0.06	0.04
	B	NS	NS	0.20	0.20	0.11	0.10	0.08	0.06
	A×B	NS	NS	0.36	0.18	0.25	0.12	0.11	0.03

Table 4. Effect of different concentrations of proline, spraying time and their interaction on some yield traits of quinoa grown in 2017/2018 and 2018/2019 seasons

Treatments		Number of plants m^{-2}		1000-seed Weight (g)		Weight of seeds $Plant^{-1}$ (g)		Seed yield (Kg fed^{-1})	
Proline concentration ppm(A)	Spraying number (B)	1st	2nd	1st	2nd	1st	2nd	1st	2nd
	once	40.24	40.14	3.03	3.16	15.77	16.00	604.27	615.89
0.0 ppm	twice	40.89	40.09	3.01	3.10	17.13	18.27	604.78	621.81
	thrice	41.34	40.04	3.04	3.08	16.73	19.03	605.39	628.38
Mean		40.82	40.09	3.03	3.11	16.54	17.77	604.81	622.03
	once	44.18	41.44	3.48	3.50	26.78	26.63	770.47	783.43
25 ppm	twice	45.52	42.13	4.02	4.11	30.15	31.33	797.16	810.42
	thrice	46.08	42.44	4.09	4.10	32.60	33.17	830.64	826.15
Mean		45.26	42.00	3.87	3.90	29.84	30.38	799.42	806.67
	once	45.53	41.99	4.32	4.31	41.87	43.17	860.62	865.74
50 ppm	twice	47.11	43.91	4.66	4.63	43.61	44.27	1005.64	1006.04
	thrice	48.57	45.56	4.62	4.62	43.93	42.97	1257.33	1212.65
Mean		47.07	43.82	4.54	4.52	43.14	43.47	1041.20	1028.14
	once	47.25	45.04	4.29	4.32	42.07	42.67	918.69	902.79
75 ppm	twice	49.28	48.57	4.65	4.61	43.20	43.30	1085.17	1172.96
	thrice	50.57	50.26	4.70	4.73	46.07	46.33	1249.62	1333.06
Mean		49.03	47.96	4.55	4.55	43.78	44.10	1084.49	1136.27
	once	44.30	42.15	3.78	3.82	31.62	32.12	788.51	791.97
Mean of B	twice	45.70	43.68	4.09	4.11	33.52	34.29	873.19	902.81
	thrice	46.64	44.58	4.11	4.13	34.83	35.38	985.75	1000.06
	A	1.18	0.43	0.12	0.27	2.09	2.58	89.62	75.35
LSD at $_{0.05}$	B	0.38	0.39	0.17	0.19	1.36	2.22	64.74	30.06
	A×B	0.87	0.53	0.19	0.21	2.94	2.31	86.96	54.91

Table 5. Effect of different concentrations of proline, spraying time and their interaction on some chemical composition in seeds of quinoa grown in 2017/2018 and 2018/2019 seasons

Treatments		Total chlorophyll		Protein %		Ash %		Oil %		Total saponins %	
Proline Conc. ppm(A)	Spraying number (B)	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
	once	20.64	19.80	8.68	8.62	3.15	3.00	5.18	4.98	2.27	1.66
0.0 ppm	twice	20.68	20.09	9.05	8.85	3.18	3.03	5.14	5.04	1.61	1.75
	thrice	20.31	20.52	9.46	8.90	3.14	3.02	5.14	5.06	1.71	1.82
Mean		20.54	20.14	9.06	8.79	3.16	3.02	5.15	5.02	1.63	1.74
	once	23.61	22.39	10.59	9.27	3.61	3.54	6.14	6.13	1.83	2.25
25 ppm	twice	24.84	22.86	10.61	9.74	3.55	3.63	6.17	6.17	2.08	2.65
	thrice	24.98	23.22	11.10	9.88	3.65	3.72	6.59	6.23	2.19	2.86
Mean		24.47	22.82	10.77	9.63	3.60	3.63	6.30	6.18	2.03	2.59
	once	26.01	24.32	11.45	10.62	4.03	3.63	6.28	6.21	2.68	2.97
50 ppm	twice	26.68	25.24	11.94	10.75	4.14	3.75	6.45	6.28	2.86	3.11
	thrice	27.94	25.86	12.19	11.04	4.24	3.84	7.11	6.57	2.91	3.12
Mean		26.87	25.14	11.86	10.80	4.13	3.74	6.61	6.35	2.82	3.07
	once	27.36	26.06	12.44	12.21	4.08	3.94	6.19	6.46	3.00	3.15
75 ppm	twice	28.28	27.94	12.88	12.86	4.73	4.04	7.03	7.10	3.20	3.25
	thrice	29.51	29.05	12.95	12.69	4.80	4.08	7.12	7.13	3.28	3.46
Mean		28.39	27.68	12.76	12.59	4.54	4.02	6.78	6.90	3.16	3.29
	Once	24.40	23.14	10.79	10.18	3.72	3.53	5.95	5.94	2.27	2.51
Mean of B	Twice	25.12	24.03	11.12	10.55	3.90	3.61	6.20	6.15	2.43	2.69
	Thrice	25.68	24.66	11.42	10.63	3.96	3.67	6.49	6.25	2.53	2.82
	A	0.49	0.36	0.68	0.66	0.31	0.06	0.12	0.05	0.19	0.59
LSD at $_{0.05}$	B	0.55	0.34	0.26	0.33	0.16	0.03	0.20	0.02	0.12	0.09
	A×B	0.69	0.73	NS	NS	0.18	NS	0.18	0.08	NS	0.19

IV- Economic analysis of quinoa:

The effect of proline concentration and the number of applications on economic analysis of quinoa production are presented in Table 6. Data show that the differences among treatments from 25 to 75 ppm proline and the control treatment (0.0 proline) in total income fed^{-1} were 221.41, 494.37 and 582.24 US$ on average the two seasons, respectively. In the case of total costs, fed^{-1} the increases were 10, 15 and 20 US$ in both seasons, respectively. Increasing total costs is attributed to spraying more proline (75 ppm) and correlated with a number of proline application times (thrice times). These results are in harmony with those obtained by Jacobsen (2003) and Shams (2012) who reported that quinoa can be grown under different conditions and improved results will be obtained with either an increased yield or a higher price. Foliar spraying with 75 ppm of proline gave the highest mean values of net return (864.37 US$ fed^{-1}) and economic efficiency (1.98), as well as twice times of application, gave the highest mean values of net return (731.13 US$ fed^{-1}) and economic efficiency (1.71) in average two seasons.

This due to the highest seeds productive from treating plants by proline at 75 ppm thrice times (1.291 ton fed-1) comparing to the other treatments.

Table 6. Effect of different concentrations of proline, spraying time and their interaction on economic evaluation of quinoa (average 1st and 2nd seasons).

Treatments		Average grain yield (ton fed^{-1})	Total income (US$ fed^{-1})	Total costs (US$ fed^{-1})	Net return (US$ fed^{-1})	Economic efficiency
Proline concentration ppm(A)	**Spraying number (B)**					
0.0 ppm	once	0.610	714.62	416.00	298.62	0.718
	twice	0.613	718.13	416.00	302.13	0.726
	thrice	0.617	722.82	416.00	306.82	0.738
Mean of A1		0.613	718.13	416.00	302.13	0.727
25 ppm	once	0.777	910.26	421.00	489.26	1.16
	twice	0.804	941.89	426.00	515.89	1.21
	thrice	0.826	967.66	431.00	536.66	1.25
Mean of A2		0.802	939.54	426.00	513.54	1.21
50 ppm	once	0.863	1011.00	426.00	585.00	1.37
	twice	1.006	1178.53	431.00	747.53	1.73
	thrice	1.235	1446.80	436.00	1010.80	2.32
Mean of A3		1.035	1212.50	431.00	781.50	1.81
75 ppm	once	0.911	1067.24	431.00	636.24	1.48
	twice	1.129	1322.62	436.00	886.62	2.03
	thrice	1.291	1512.41	441.00	1071.41	2.43
Mean of A4		1.110	1300.37	436.00	864.37	1.98
Mean of B	once	0.790	925.49	424.00	501.49	1.18
	twice	0.888	1040.29	427.00	613.29	1.44
	thrice	0.992	1162.13	431.00	731.13	1.70

CONCLUSION

From the preceding results and discussion, it concluded that the quinoa plants which were sprayed by proline at 75 ppm three times gave the maximum seed yield and obtaining the best chemical compositions of quinoa. In addition to the economic evaluation of the research at the same previous treatments recorded the highest net return and economic efficiency under salt-affected soil conditions at Toshka region, Egypt.

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تأثير الرش الورقى بالبرولين على إنتاج وجودة الكينوا تحت ظروف التربة الملحية فى منطقة توشكى

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تعد الملوحة العالية فى التربة واحدة من المشكلات البيئية الواسعة الإنتشار بالمناطق الجافه وشبه الجافه . لذا أجريت هذه الدراسة بمزعة تجارب الأبحاث بمجمع الدراسات والبحوث المائية بتوشكى بمحافظة أسوان خلال موسمى الزراعة 2018/2017 و 2019/2018 بهدف دراسة تأثير تركيز وعدد مرات الرش الورقى بالبرولين على محصول وجودة الكينوا صنف ريجالونا النامية تحت ظروف الأراضى الملحية. تم إستخدم تصميم الشرائح المتعامدة فى ثلاث مكررات. وقد رتبت تركيزات البرولين (صفر ، 25 ، 50 و 75 جزء فى المليون) فى الشرائح الأفقية بينما رتبت عدد مرات الرش بالبرولين (مرة (30 يوم) ، مرتين (30 و 45 يوم) ، ثلاث مرات (30 و 45 و60 يوم من الزراعة) فى الشرائح الرأسية. 1-أوضحت النتائج وجود تأثر معنوى لمعظم صفات المحصول ومساهماته وكذلك صفات الجودة لمحصول الكينوا وهى صفات إرتفاع النبات ، عدد الفروع لكل نبات ، عدد أوراق النبات ، عدد النورات لكل نبات ، الوزن الطازج والجاف للمجموع الخضرى ، الوزن الطازج والجاف للجذر ، الكلوروفيل الكلى ، عدد النباتات /م^2 ، مساحة الورقة ، وزن بذور النبات ، وزن ألالف بذرة ، محصول البذور للفدان وصفات الجودة و صافى العائد بالرش بالتركيز الأعلى من البرولين (75 جزء فى المليون) خلال موسمى الدراسة . 2-عدد مرات الرش الورقى للبرولين كان له تأثير معنوى على صفات المحصول ومساهماته وكذلك صفات الجودة بينما لم يكن له أى تأثير على إرتفاع النبات والوزن الطازج للمجموع الخضرى فى موسمى الدراسة ، وعدد أوراق النبات بالموسم الثانى.3- كما كان هناك تأثير معنوى للتفاعل بين تركيز البرولين وعدد مرات الرش على جميع الصفات ما عدا صفة إرتفاع النبات والوزن الطازج للمجموع الخضرى والبروتين بموسمى الدراسة ، وصفة الرماد بالموسم الثانى والسابونين بالموسم الأول. التوصية : أظهرت النتائج أن نباتات الكينوا صنف ريجالونا التى رشت ثلاث مرات بتركيز 75 جزء فى المليون من البرولين أعطت أفضل محصول من حيث الكمية والجودة والقيمة الإقتصادية تحت ظروف الأراضى المتأثرة بالأملاح بمنطقة توشكى ـــ مصر.