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Effect of exogenous addition of proline on the growth and chemical compositions of *Inga edulis* Mart. seedlings under salinity conditions

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Abstract

The present experiment was conducted during two seasons of 2020 and 2021 at Al- Marashda Agricultural Research Station, Qena, Egypt. It was intended to determine the effect of exogenous proline addition on the vegetative growth and chemical compositions of *Inga edulis* seedlings grown under salt stress conditions. Seedlings were treated with proline at 100 and 200 ppm as a foliar spray either with or without salinity at 2000, 4000 and 6000 NaCl + $CaCl_2$. In both seasons, different plant growth stem and root length, fresh and parameters and chemical compositions were significantly affected by proline and salinity with or without proline. However, seedlings sprayed with proline often had greater growth parameters as dry weight of stem and roots as well as a number of leaves than those of other treatments. Also, the highest values of nitrogen, phosphorus, potassium, chlorophyll a & b contents were noticed with proline treatments. The addition of proline at 100 and 200 ppm with 2000 ppm salinity produced vigor seedlings compared to the control. Meanwhile, the addition proline with salinity at 4000 or 6000 ppm did not exhibit a pronounced effect on the growth and chemical compositions compared to the control in both seasons. Seedling vigor and its chemical composition was reduced in response to salt stress without proline addition, while proline content in leaves was raised. These findings suggest that addition proline treatments can ameliorate the negative effects of salinity as NaCl + $CaCl_2$ on the growth and chemical compositions of *Inga edulis* seedlings.

Keywords
Inga edulis, proline, saline stress, growth parameters, chemical compositions.

INTRODUCTION

Inga edulis Mart. (Leguminosae) is a woody tree species used for reforestation due to its rusticity to adverse environmental conditions and as a biological nitrogen fixation capacity. It is commonly used as a shade tree in intercropped plantations (Nygren *et al*., 2013). Also, it has the potential for the management of non-timber products as flavonoids (Silva *et al*., 2013). Egypt is considered one of the countries in arid and semi-arid regions, that suffer from the problem of lack of fresh water as the focus is currently on reducing the consumption of fresh water in irrigating agricultural soils by introducing modern irrigation systems and developing field irrigation systems. There is a need to use other sources of irrigation, especially in the newly reclaimed soils. Among these sources is irrigation with groundwater, agricultural drainage water, sewage and industrial drainage, especially for wood trees. These sources often have a high percentage of salinity, which may be harmful to some plant species. Kefu *et al*. (2003) pointed out that some halophytes are tolerate to salt stress but not drought, while some xerophytes can tolerate drought conditions but not salt stress. However, salinity is considered the most serious limiting factor for the growth and production of crops in many regions, especially in arid and semi-arid ones. The saline substrates have adverse effects on plants, which include the toxic effect of ions and secondary injury, nutrition deficiency and osmotic effect (Bernstein, 1964). Also, Souza *et al*. (2016) reported that, it is difficult to increase the productivity of many crops in periods of drought and high temperatures especially under high salinity conditions. The results of Dejampour *et al*. (2012) indicate that increased salinity level had significant negative effects on dry and fresh weight of root and shoot, leaf chlorophyll content and leaf area of *Prunus dulcis*. Meanwhile, increasing the salinity level caused an increase in leaf proline concentration as well as decrease in total chlorophyll and chlorophyll b content. Proline as amino acid plays an adaptive role in the tolerance of plants to salinity stress by increasing the cultural osmotic components in order to equalize the osmotic potential of cytoplasm (Wated *et al*., 1983). The increase in proline content in plant tissues as a result of the increase in salinity retards protein synthesis and consequently accumulates free amino acids, including proline (Yurekli *et al*., 1996 and El-Leboudi *et al*., 1997). Therefore, the objective of this study was to identify the role of proline as foliar addition in alleviating the damaging effects of salinity stress on *Inga edulis* seedlings.

MATERIALS AND METHODS

The present study was carried out at Al- Marashda Agricultural Research Station, Qena Governorate (26° 9’ N, 32° 42’ E) Egypt during the two successive seasons of 2020 and 2021. This study aimed to identify the proline role as foliar addition in alleviating saline condition, growth parameters as well as the chemical compositions of *Inga edulis* seedlings. Three months old *I. edulis* seedlings were planted in plastic pots 20 cm diameter; one seedling/pot, the average height of seedlings were 14 cm and each pot was filled with clay soil. The chemical analysis of the soil was in Table (1). The experiment comprised of four salinity treatments; 0, 2000, 4000 and 6000 ppm using a mixture of NaCl and $CaCl_2$ (1:1 w/w) as soil drench, and three proline treatments 0, 100 and 200 ppm as foliar addition. *I. edulis* seedlings were planted on 15th March 2020 and 2021 for the 1st and 2nd seasons, respectively. In both seasons, the established seedlings were treated with the salinity treatments after two weeks (first week of April) from transplanting. Irrigation treatments were adopted four times with salinized water, followed by one irrigation with tap water till the end of the experiment (30 August for each season). The four salinity levels of irrigation water were adopted with and without proline levels. The first application of the proline treatments with or without salinity after two weeks from applied salinity and every month till the end of the experiment. The pots were under open field conditions and the experiment was in a randomized complete block design with 12 treatments, each treatment included three replicates. The treatments as follows: 1- control (without salinity or proline), 2- 100 ppm proline, 3- 200 ppm proline, 4- 2000 ppm salinity, 5- 4000 ppm salinity, 6- 6000 ppm salinity, 7- 2000 ppm salinity + 100 ppm proline, 8- 2000 ppm salinity + 200 ppm proline, 9- 4000 ppm salinity + 100 ppm proline, 10- 4000 ppm salinity + 200 ppm proline, 11- 6000 ppm salinity + 100 ppm proline, and 12- 6000 ppm salinity + 200 ppm proline.

For the 1st and 2nd seasons, a representative plant sample was collected from each treatment. The recorded data includes: stem length (cm), number of leaves/ plant, root length (cm), fresh and dry weight of stem and roots (g). Meanwhile, chemical analysis was determined, chlorophyll a and b according to Nornai (1982), total carbohydrates (%) according to Dubois *et al.* (1956), nitrogen (%) according to Cottenie *et al.* (1982), phosphorus (%) according to Snell and Snell (1949) and potassium (%) according to Chapman and Pratt (1978). Also, free proline content in the dry leaves of *I. edulis* was extracted in aqueous sulphosalicylic acid and determined using ninhydrin according to Bates *et al*. (1973). The obtained data were subjected to the statistical analysis of variance and the means were compared using the least significant difference (L.S.D.) test at 5% level according to Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Vegetative Growth Parameters

The different treatments of proline and salinity with or without proline had significant effects on the different plant growth characters i.e. stem and root length, stem fresh and dry weight, root fresh and dry weight as well as number of leaves of *I. edulis* seedlings during the two seasons (Tables 2- 5). The studied growth parameters at 165 days after seedling establishment responded to the effects of salinity and proline application. Results indicated that these parameters were greatly influenced by both water salinity and proline treatments. A gradual decline in the growth characters was noticed with the increasing salinity concentration in the irrigation water. However, proline addition at 200 or 100 ppm without salinity improved the growth traits of seedlings as compared with those of the other treatments in the 1st and 2nd seasons. Also, results of the present study pointed out that all seedlings grown under salinity stress conditions and receiving proline levels showed highest values of growth parameters compared to those grown under salinity without proline addition for both seasons. Addition proline at 200 ppm level resulted in higher growth values than those of 100 ppm with or without salinity conditions. Proline at 100 or 200 ppm levels as a foliar spray with 2000 ppm salinity resulted in the highest values of growth parameters compared to untreated seedlings (control) in the 1st and 2nd seasons. Moreover, the lowest values of the stem length (57.25 cm), root length (8.30 cm), stem fresh weight (86.10 cm), stem dry weight (31.85 cm), root fresh weight (31.70 g), root dry weight (8.80 g) and number of leaves (11.25), were recorded in 6000 ppm NaCl + $CaCl_2$ treatment in the mean of both seasons. Meanwhile, the highest values of stem length (85.70 cm), root length (18.35 cm), stem fresh weight (153.30 g), stem dry weight (56.45 g), root fresh weight (59.75 g), root dry weight (18.23 g) and number of leaves (27.38) were noticed with 200 ppm proline without salinity in the mean of seasons. Our study found that there was a gradual decrease in the stem and root length, fresh and dry weight of stem and roots as well as number of leaves of *I. edulis* seedlings under salt stress. The fact that salinity adversely inhibited the seedling vigor was also reported by other researchers as Mesquita *et al.* (2012); El-Shazly *et al*. (2015); Liang *et al*. (2018); Mesquita *et al*. (2018). They revealed that the obvious reduction in seedling vigor under salinity stress is due to decrease in a water absorbing potential under such stresses, consequently decreasing the water available for plants. Also, addition of proline with or without salinity improved vegetative growth, while only saline treatments led to a lack of growth. In this respect, Wated *et al.* (1983) pointed out that proline as amino acid plays an important role in tolerance of plant cells to salinity, increasing of the cultural osmotic components and equalize the osmotic potential of the cytoplasm.

Chemical compositions

Nitrogen, Phosphorus and potassium%

Also, as the case with the effects of proline and salinity with or without proline on vegetative growth, they have similar effects on the nitrogen, phosphorus and potassium contents of the leaves of *I. edulis* (Tables 5 & 6). However, proline and salinity with or without proline treatments caused significant differences in nitrogen, phosphorus and potassium contents compared to the control. It is verified that treatment with proline or salinity at 2000 ppm with proline stimulated the content of N, P and K% in leaves of *I. edulis* at 165 days after seedling establishment.

Meanwhile, application of salinity at 4000 or 6000 ppm with proline caused a significantly decrease of N, P and K% in the two seasons compared to the control. The lowest values (0.54, 0.13 and 0.67%) of nitrogen, phosphorus and potassium, respectively resulted from addition salinity only at 6000 ppm in the mean of seasons. Meanwhile, the highest values (1.28, 0.35 and 1.23 %) of nitrogen, phosphorus and potassium, respectively as a result of salinity at 6000 ppm in the mean of seasons. Exogenous application of amino acids influenced the physiological activities in the plant growth and development and have been reported to modulate the growth and quality of tomato (Boras *et al*., 2011). Spraying of *I. edulis* with proline with or without salinity significantly increased N, P and K % in the leaf tissues than only salinity ones. The results are in agreement with those of Abo Sedera *et al*. (2010) and Sadak *et al*. (2015).

Chlorophyll a&b

Results of the 1st and 2nd seasons showed that chlorophyll a & b content in leaves of *I. edulis* significantly decreased with the different proline and salinity with or without proline treatments (Table 7). The combined effect of salinity with proline, showed that the addition of proline to the seedlings under salinity significantly increased the content of chlorophyll a & b compared to those grown under salinity without proline. However, The data indicated that a significant increase in leaf chlorophyll a & b was noticed with seedlings receiving proline at 200 ppm and resulted in the highest values (0.70 and 0.49 mg/g FW), respectively as compared with those not supplemented with proline application. Meanwhile, the lowest values (0.17 and 0.21 mg/g FW) as a result of 6000 ppm salinity, respectively in mean of the 1st and 2nd seasons. Chlorophyll a & b declined in the 1st and 2nd seasons as plants were subjected to salinity stress, while proline addition stimulated these contents in leaves tissue. The decreasing effect of saline stress is reflected in the biosynthesis of pigments, which is in agreement with the results of Azooz (2009) and Sadak *et al*. (2015). Meanwhile, the increase in chlorophyll a & b contents might be due to the availability of proline as amino acids to the treated seedlings as amino acids help to increase the chlorophyll content and this may lead to the increase in different growth parameters (Awad *et al*., 2007).

Total carbohydrates (%)

Table (8) shows the effect of salinity stress conditions and proline on total carbohydrates in *I. edulis* seedlings during the two seasons of 2020 and 2021. The results indicated that addition of the different salinity treatments without proline significantly decreased the total carbohydrates for both seasons. In the 1st and 2nd seasons, seedlings irrigated with 2000 of salinity level with proline at 200 and 100 ppm showed an increment of carbohydrates in comparison with the control. Application of salinity levels with proline caused a substantial increase in leaf carbohydrates compared to those without proline in both seasons. Moreover, the highest value of total carbohydrates (28.52 %) was recorded with proline at 200 ppm level compared to the rest treatments, while the lowest one (12.20 %) as a result of salinity at 6000 ppm treatment in the both seasons. Our results show that all salinity levels caused significant decreases in total carbohydrate content in *I. edulis* leaves. These effects might be a result of reduction in photosynthetic activity and respiration. These founding are in good agreement with Sadak *et al*. (2010); Taie *et al*. (2013); Sadak *et al*. (2015).

Proline content

Data representing the effect of salinity stress conditions and proline on proline content in leaves of *I. edulis* seedlings are shown in Table (8). The results of both experimental seasons revealed that addition the salinity treatments significantly increased proline content. This increase was more pronounced under 6000 ppm salinity level with (7.36) or without (8.68) 100 ppm proline in the mean of seasons. Meanwhile, the lowest value (2.60 and 3.39 µ moles/ g FM) of proline content was noticed with the control followed by treated plants with proline at 100 ppm level, respectively in the mean seasons. The increase in proline content in leaves tissues with the salinity treatments retards protein synthesis, and then accumulates of the free amino acids as proline (Barakat and Abdel-Latif (1995); Yurekli *et al*. (1996); El-Leboudi *et al.* (1997) and Sadak *et al*. (2015).

Table (1) Chemical analysis of the used soil in the study.

Character	EC (mmohs)	pH	P_2O_5 (%)	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	K^+
Value	1.43	7.70	0.17	5.25	17.67	4.33	26.41	8.43	6.00

Table (2) Effect of proline as foliar addition on the stem and root length (cm) of *Inga edulis* seedlings under salinity conditions during seasons of 2020 and 2021.

Treatments	Stem length			Root length		
	1st season	2nd season	Mean	1st season	2nd season	Mean
Control	75.70	71.80	73.75	15.00	15.50	15.25
Proline 100 ppm	82.80	81.60	82.20	17.70	17.10	17.40
Proline 200 ppm	85.50	85.90	85.70	18.30	18.40	18.35
2000 ppm NaCl +$CaCl_2$	69.90	67.60	68.75	12.60	12.60	12.60
4000 ppm NaCl +$CaCl_2$	67.00	63.70	65.35	10.90	10.50	10.70
6000 ppm NaCl +$CaCl_2$	59.00	55.50	57.25	8.50	8.10	8.30
2000 ppm NaCl +$CaCl_2$+ 100 ppm proline	74.30	68.40	71.35	16.50	16.40	16.45
2000 ppm NaCl + $CaCl_2$ + 200 ppm proline	78.30	72.10	75.20	18.20	18.00	18.10
4000 ppm NaCl + $CaCl_2$ + 100 ppm proline	66.70	64.80	65.75	14.30	12.80	13.55
4000 ppm NaCl + $CaCl_2$ +200 ppm proline	72.00	68.30	70.15	16.20	15.40	15.80
6000 ppm NaCl + $CaCl_2$ + 100 ppm proline	61.50	62.00	61.75	9.30	8.60	8.95
6000 ppm NaCl + $CaCl_2$ +200 ppm proline	62.90	61.80	62.53	11.80	11.50	11.65
LSD 5 %	2.239	4.376	--	1.49	1.37	--

Table (3) Effect of proline as foliar addition on the stem fresh and dry weight (g) of *Inga edulis* seedlings under salinity conditions during seasons of 2020 and 2021.

Treatments	Stem F.W			Stem D.W		
	1st season	2nd season	Mean	1st season	2nd season	Mean
Control	122.80	126.90	124.85	45.30	48.20	46.75
Proline 100 ppm	148.80	152.60	150.70	53.80	54.80	54.30
Proline 200 ppm	150.30	156.30	153.30	55.60	57.30	56.45
2000 ppm NaCl +$CaCl_2$	113.00	116.10	114.55	41.70	41.80	41.75
4000 ppm NaCl +$CaCl_2$	106.10	106.90	106.50	37.50	36.00	36.75
6000 ppm NaCl +$CaCl_2$	87.70	84.50	86.10	32.70	31.00	31.85
2000 ppm NaCl +$CaCl_2$+ 100 ppm proline	141.00	140.00	140.50	48.90	48.30	48.60
2000 ppm NaCl + $CaCl_2$ + 200 ppm proline	145.40	149.90	147.65	51.00	51.20	51.10
4000 ppm NaCl + $CaCl_2$ + 100 ppm proline	121.30	115.70	118.50	39.90	38.80	39.35
4000 ppm NaCl + $CaCl_2$ +200 ppm proline	127.70	133.10	130.4	44.40	42.50	43.45
6000 ppm NaCl + $CaCl_2$ + 100 ppm proline	91.70	90.60	91.15	33.10	32.00	32.55
6000 ppm NaCl + $CaCl_2$ +200 ppm proline	97.40	92.00	94.7	36.30	35.80	36.05
LSD 5%	5.13	6.68	--	4.13	3.04	--

Table (4) Effect of proline as foliar addition on the root fresh and dry weight (g) of *Inga edulis* seedlings under salinity conditions during seasons of 2020 and 2021.

Treatments	Root F.W			Root D.W		
	1st season	2nd season	Mean	1st season	2nd season	Mean
Control	51.50	50.00	50.75	13.70	13.70	13.70
Proline 100 ppm	57.30	56.40	56.85	17.85	17.45	17.65
Proline 200 ppm	60.20	59.30	59.75	18.10	18.35	18.23
2000 ppm NaCl +$CaCl_2$	44.40	42.60	43.50	12.80	14.30	13.55
4000 ppm NaCl +$CaCl_2$	41.00	39.60	40.30	12.10	11.60	11.85
6000 ppm NaCl +$CaCl_2$	31.50	31.90	31.70	8.70	8.90	8.80
2000 ppm NaCl +$CaCl_2$+ 100 ppm proline	52.60	53.30	52.95	14.40	15.40	14.90
2000 ppm NaCl + $CaCl_2$ + 200 ppm proline	57.70	54.90	56.30	17.20	16.70	16.95
4000 ppm NaCl + $CaCl_2$ + 100 ppm proline	39.20	39.20	39.20	10.10	9.50	9.80
4000 ppm NaCl + $CaCl_2$ +200 ppm proline	42.60	43.70	43.15	11.40	12.40	11.90
6000 ppm NaCl + $CaCl_2$ + 100 ppm proline	34.70	34.80	34.75	10.00	9.20	9.60
6000 ppm NaCl + $CaCl_2$ +200 ppm proline	34.70	35.20	34.95	9.60	10.00	9.80
LSD 5%	3.05	4.10	--	1.22	1.30	--

Table (5) Effect of proline as foliar addition on no. of leaves and nitrogen content (%) of *Inga edulis* seedlings under salinity conditions during seasons of 2020 and 2021.

Treatments	No. leaves			Nitrogen (%)		
	1st season	2nd season	Mean	1st season	2nd season	Mean
Control	21.40	21.30	21.35	0.81	0.81	0.81
Proline 100 ppm	26.10	26.45	26.28	1.13	1.10	1.11
Proline 200 ppm	27.25	27.50	27.38	1.25	1.30	1.27
2000 ppm NaCl +$CaCl_2$	17.20	18.20	17.70	0.71	0.73	0.72
4000 ppm NaCl +$CaCl_2$	15.90	14.90	15.40	0.67	0.63	0.65
6000 ppm NaCl +$CaCl_2$	11.60	10.90	11.25	0.57	0.52	0.54
2000 ppm NaCl +$CaCl_2$+ 100 ppm proline	21.90	22.90	22.40	0.85	0.83	0.84
2000 ppm NaCl + $CaCl_2$ + 200 ppm proline	25.20	24.90	25.05	0.98	1.03	1.01
4000 ppm NaCl + $CaCl_2$ + 100 ppm proline	15.40	14.80	15.10	0.70	0.68	0.69
4000 ppm NaCl + $CaCl_2$ +200 ppm proline	18.40	18.40	18.40	0.79	0.83	0.81
6000 ppm NaCl + $CaCl_2$ + 100 ppm proline	13.60	11.80	12.70	0.62	0.57	0.59
6000 ppm NaCl + $CaCl_2$ +200 ppm proline	13.50	13.20	13.35	0.61	0.61	0.61
LSD 5%	1.28	1.39	--	0.09	0.07	--

Table (6) Effect of proline as foliar addition on phosphorus and potassium content (%) of *Inga edulis* leaves under salinity conditions during seasons of 2020 and 2021.

Treatments	Phosphorus %			Potassium %		
	1st season	2nd season	Mean	1st season	2nd season	Mean
Control	0.22	0.26	0.24	1.08	1.03	1.05
Proline 100 ppm	0.31	0.33	0.32	1.20	1.19	1.20
Proline 200 ppm	0.34	0.36	0.35	1.24	1.22	1.23
2000 ppm NaCl +$CaCl_2$	0.20	0.20	0.20	0.92	0.91	0.92
4000 ppm NaCl +$CaCl_2$	0.18	0.16	0.17	0.84	0.82	0.83
6000 ppm NaCl +$CaCl_2$	0.12	0.13	0.12	0.69	0.65	0.67
2000 ppm NaCl +$CaCl_2$+ 100 ppm proline	0.25	0.29	0.27	1.17	1.07	1.12
2000 ppm NaCl + $CaCl_2$ + 200 ppm proline	0.29	0.28	0.29	1.19	1.16	1.17
4000 ppm NaCl + $CaCl_2$ + 100 ppm proline	0.18	0.16	0.17	0.80	0.80	0.80
4000 ppm NaCl + $CaCl_2$ +200 ppm proline	0.21	0.23	0.22	0.97	0.91	0.94
6000 ppm NaCl + $CaCl_2$ + 100 ppm proline	0.15	0.14	0.14	0.75	0.72	0.73
6000 ppm NaCl + $CaCl_2$ +200 ppm proline	0.14	0.14	0.14	0.77	0.74	0.75
LSD 5%	0.025	0.027	--	0.062	0.052	--

Table (7) Effect of proline as foliar addition on chlorophyll a & b content (mg/g fresh weight) of *Inga edulis* leaves under salinity conditions during seasons of 2020 and 2021.

Treatments	Chlorophyll a			Chlorophyll b		
	1st season	2nd season	Mean	1st season	2nd season	Mean
Control	0.60	0.58	0.59	0.40	0.39	0.40
Proline 100 ppm	0.67	0.66	0.67	0.46	0.45	0.46
Proline 200 ppm	0.71	0.69	0.70	0.49	0.48	0.49
2000 ppm NaCl +$CaCl_2$	0.29	0.26	0.27	0.33	0.35	0.34
4000 ppm NaCl +$CaCl_2$	0.22	0.22	0.22	0.28	0.28	0.28
6000 ppm NaCl +$CaCl_2$	0.17	0.16	0.17	0.22	0.21	0.21
2000 ppm NaCl +$CaCl_2$+ 100 ppm proline	0.63	0.57	0.60	0.42	0.41	0.42
2000 ppm NaCl + $CaCl_2$ + 200 ppm proline	0.65	0.65	0.65	0.44	0.44	0.44
4000 ppm NaCl + $CaCl_2$ + 100 ppm proline	0.41	0.39	0.40	0.33	0.32	0.33
4000 ppm NaCl + $CaCl_2$ +200 ppm proline	0.43	0.42	0.43	0.35	0.37	0.36
6000 ppm NaCl + $CaCl_2$ + 100 ppm proline	0.33	0.31	0.32	0.26	0.26	0.26
6000 ppm NaCl + $CaCl_2$ +200 ppm proline	0.35	0.35	0.35	0.28	0.29	0.29
LSD 5%	0.051	0.041	--	0.018	0.020	--

Table (8) Effect of proline as foliar addition on total carbohydrates (%) and proline content (µ moles/ g fresh matter) of *Inga edulis* leaves under salinity conditions during seasons of 2020 and 2021.

Treatments	Total carbohydrates (%)			Proline (µ moles/ g FM)		
	1st season	2nd season	Mean	1st season	2nd season	Mean
Control	20.55	20.58	20.56	2.64	2.57	2.60
Proline 100 ppm	28.01	27.11	27.56	3.45	3.33	3.39
Proline 200 ppm	29.00	28.04	28.52	3.90	3.70	3.80
2000 ppm NaCl +$CaCl_2$	18.88	19.74	19.31	4.78	4.68	4.73
4000 ppm NaCl +$CaCl_2$	16.33	16.77	16.55	6.63	6.57	6.60
6000 ppm NaCl +$CaCl_2$	12.02	12.37	12.20	8.47	8.89	8.68
2000 ppm NaCl +$CaCl_2$+ 100 ppm proline	23.21	23.28	23.24	4.04	4.07	4.05
2000 ppm NaCl + $CaCl_2$ + 200 ppm proline	25.02	26.30	25.66	3.18	3.21	3.19
4000 ppm NaCl + $CaCl_2$ + 100 ppm proline	15.25	14.64	14.94	4.81	5.48	5.14
4000 ppm NaCl + $CaCl_2$ +200 ppm proline	16.61	16.87	16.74	4.53	4.53	4.53
6000 ppm NaCl + $CaCl_2$ + 100 ppm proline	13.46	12.84	13.15	7.59	7.14	7.36
6000 ppm NaCl + $CaCl_2$ +200 ppm proline	14.51	14.88	14.69	6.53	6.51	6.52
LSD 5%	1.49	1.71	--	0.55	0.52	--

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الملخص العربي

تأثير الاضافة الخارجية للبرولين علي النمو والمكونات الكيميائية لشتلات انجا ديوليس تحت ظروف الملوحة

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أجريت هذه الدراسة خلال موسمي 2020 و 2021 بمحطة البحوث الزراعية بالمراشدة- قنا بهدف دراسة تأثير الاضافة الخارجية للبرولين علي النمو الخضري والمكونات الكيميائية لشتلات اشجار انجا ديوليس النامية تحت ظروف الملحية. أضيف البرولين بتركيز 100 و 200 جزء في المليون بينما كانت تركيزات الملحية 2000 و 4000 و 6000 جزء في المليون من خليط متساوي (1:1 وزنا) من كلوريد الصوديوم وكلوريد الكالسيوم بالاضافة لمعاملة الكنترول بدون ملحية و بدون برولين. وكان أهم النتائج المتحصلة ما يلي: تأثرث صفات النمو الخضرية المتمثلة في طول الساق وطول الجذر والوزن الطازج والجاف للساق والجذر وعدد الأوراق وأيضا الصفات الكيميائية معنويا عند استخدام المعاملات المختلفة مقارنة بالكنترول. نتج عن معاملة الرش بالبرولين فقط بمستوي 200 أو 100 جزء في المليون أعلي القيم الخاصة بصفات النمو الخضري للشتلات. أيضا نتج عنها أعلي القيم الخاصة بمحتوي الورقة من النيتروجين والفوسفور والبوتاسيوم وكلوروفيل أ و ب والكربوهيدرات مقارنة بباقي المعاملات. اضافة البرولين بتركيز 200 أو 100 جزء في المليون في حالة الشتلات المروية بمستوي ملوحة 2000 جزء في المليون أدت الي زيادة قوة الشتلة مقارنة بالكنترول. المعاملة بمستوي ملحية 6000 أو 4000 جزء في المليون نتج عنها أقل الشتلات قوة ، وأن اضافة البرولين مع معاملات الملحية يخفف من حدة تأثيرها علي نمو الشتلات ومحتواها الكيميائي. زاد محتوي الشتلة من البرولين في حالة المعاملة بالتركيزات الأعلي من الملحية .