Effect of irrigation with saline water on growth and chemical composition of celery

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ABSTRACT

Celery crop belongs to the family Umbelliferae. The present study aims to understand the physical and chemical changes in celery plants that affected by using saline water in irrigation. A pot experiment was conducted during the two winter seasons of 2017/2018 and 2018/2019 to study the effect of irrigation with agriculture saline drainage water brought from Karoun Lake in El-Fayoum Governorate, Egypt on the growth and chemical contents of celery plants cv. Balady. The used saline water concentrations were 1000, 2000, 3000 and 4000 ppm and tap water at 260 ppm was used as control. The results showed that the plant length, fresh weight and number of leaves were increased significantly at a concentration of 1000 ppm as compared with control. Meanwhile, gradual decrease occurred in these characters with increasing salinity levels. The contents of ascorbic acid, total chlorophyll, carotenoids, nitrogen, phosphorus, potassium and dry weight were significantly increased up to the level of 2000 ppm then gradual decrease was occurred with increasing salinity levels. As for the contents of total soluble solids (TSS.), sodium and proline significantly increased with each increase in the saline level. In conclusion, celery cv. Balady can be irrigated with the limit of 1000 ppm saline water.

Keywords: Celery; Irrigation; Saline water; Growth; Chemical contents.

INTRODUCTION

Celery is a cool crop that belongs to the family Umbelliferae. It is grown for its leaves that are the edible portion of this crop, Celery leaves can be prepared as a cooked vegetable or eaten raw in salads.

The quantity of drainage water which reached approximately about 13.5 billion m^3/year in Egypt flow unused to the Mediterranean Sea and the coastal lakes that connected with the sea Apart of this water could be reused for irrigation purposes to overcome water shortage in the agricultural area. The use of saline water for irrigation is feasible, however, when water is alternated or combined with good quality water supplies (Abd EL-Sayed *et al*., 1993).

The previous work revealed that irrigation of parsley with saline water significantly increased the plant length, fresh weight, number of leaves, ascorbic acid and dry weight up to 2000 ppm. However, using higher levels of saline water decreased these attributes. Another picture araised for TSS. and proline which significantly increased with each increase in saline levels up to 4000 ppm while ascorbic acid and dry weight started with an increase up to 2000 ppm then decreased in the higher levels (Ahmed, 2001). In another study, on cabbage, it was shown that using saline water levels up to 2000 ppm increased the number of leaves, fresh weight, ascorbic acid, dry weight, nitrogen, phosphorus and potassium, then a decline took place with the increase in these levels till 4000 ppm (Kamal, 2004).

The present study aims to understand the physical and chemical changes in celery plants that affected by using saline water in irrigation. This particular item is vital in the field of irrigation because the application of saline agriculture drainage water alone or mixed with river Nile water for irrigation is a national target to solve the problem of water resources shortage in Egypt, especially with the increase in the population.

MATERIALS AND METHODS

Two pot experiment was conducted in the experimental farm of the Faculty of Agriculture, AL-Azhar University Nasr City, Cairo in the two successive winter seasons of 2017/2018 and 2018/2019 to study the effect of irrigation with saline drainage water on the growth and chemical composition of celery plants cv. Balady. The saline water was brought from Karoun Lake in El-Fayoum Governorate at the concentration of 26000 ppm. This water was diluted to 1000, 2000, 3000 and 4000 ppm with tap water to have the required concentrations. The control treatment was irrigated with tap water at the concentration of 260 ppm. The chemical analysis of the diluted saline drainage water was shown in Table (1).

Sowing seeds took place in the nursery on September 24th in the two seasons. Five

transplants were planted per pot after 40 days from sowing, where the used pots (No. 40) were filled with sandy clay loam soil and provided with an outlet at the bottom to get rid of the excess water. The design of the experiment was complete randomized. Pots were arranged in four replicates and every replicate consisted of 12 pots, where each pot contained five seedlings. Irrigation of seedlings with saline water started after 10 days from transplanting, where it received two irrigations per week and each pot received 2.5 L water to maintain soil continuously moistened in pots.

The obtained data were recorded on 3 plant ages of 45, 60 and 75 days after transplanting items: 1- Plant length was estimated by a ruler. 2- Plant fresh weight (g). 3- Leaf number per plant. 4- Total soluble solids (TSS.) were determined as a percentage by Abbe refractometer (A.O.A.C., 1990). 5- Ascorbic acid was determined using the dye 2.6 dichlorophenol indophenol method (A.O.A.C., 1990). 6- Chlorophylls and carotene were determined after Lichtenther (1987). 7- Dry weight was determined by drying 100g in an oven at 70 ºC till constant weight was reached (A.O.A.C., 1990). 8- Nitrogen content was determined according to the micro-Kjeldahl method (A.O.A.C., 1990). 9- Phosphorus content was determined colorimetrically using the hydroquinone and sodium sulphite method (A.O.A.C., 1990). 10- Potassium and sodium were determined using flamephotometer according to the method of Dewis and Freitas, (1970). 11- Free proline was determined colorimetrically after Bates et al., (1973).

The obtained data were statistically analyzed using the analyses of variance method according to Snedecor and Cochran, (1980).

RESULTS AND DISCUSSION

The physical characteristics:

The effect of using the different saline water levels ranged from 1000 to 4000 ppm on the physical characteristics in all the stage of growth in both seasons (Table 2) show that using saline water up to 1000 ppm gave significant increases in plant length, fresh weight and leaf number while more salt concentrations till 4000 ppm gradually reduced them.

Chemical characteristics:

Generally, the chemical analyses of all examined ages in both seasons (Table 3) indicates that the increase in salinity concentrations levels from 1000 to 4000 ppm induced proportional significant increase in the TSS., sodium and proline contents. However, concerning the effect of irrigation with the different levels of saline water on plant ascorbic acid. The results showed that with increasing saline levels up to 2000 ppm, the content was significantly increased, while the higher levels of saline had lower (proportional or significant) vitamin at the various ages. The same trend was noticed also in the total chlorophyll and carotenoids contents in the examined ages which reflect that these contents increased with the increase of the various saline levels up to 2000 ppm then a reduction occurred due to higher concentrations. Regarding, the content of plant dry weight in the various ages, significant increases were found with each increase in the saline levels up to 2000 ppm, then followed by significant declines with higher saline levels (up to 400 ppm). However, N. P, K showed significant increases with the increasing saline levels up to 2000 ppm, then a significant decrease trend was followed by increasing these levels in all experimental ages (Table 4 and 5).

To discuss the pervious results on celery, it is obvious that the physical characteristics as plant length, fresh weight, and number of leaves gave the highest significant values due to the irrigation with saline water in concentration of up to 1000 ppm. The second noticeable point exhibited that the results of the chemical contents reflected an increase in ascorbic acid, total chlorophyll, carotenoids, dry weight, nitrogen, phosphorus, and potassium in irrigation with a concentration up to 2000 ppm salt water, which was followed by a decrease trend with increasing the water saline levels. The chemical contents showed an increase in water saline levels till 4000 ppm, which induced continuous proportional significant increase in the contents of TSS., sodium and proline.

The increase in the physical features of celery by the low levels of saline water may be related to some reasons. To illustrate, it was reported that many halophytes have a special and distinguishing feature which enables their growth to be improved by low levels of salts but beyond certain levels this growth is reduced (Ruskin *et al*., 1990). This view was observed on some plants that require moderate saline conditions which positively promote plant growth, enhance productivity and improve quality compared to salts free conditions (Pasternake, 1987; Lo-Casico *et al*., 1988; Gupta, 1990). Several reports correlated

this phenomenon of stress resistance to proline accumulation which led to good survival and better performance. Nevertheless, the corroborate proline action may be due to compatible regulating and reducing water losses from dehydrated cells (Venekamp and Koot, 1988). Moreover, injurious effect of specific ions such as NaCl, $CaCl_2$ and $NaSo_4$ inhibited the production of chlorophyll in leaves. High sodium concentration induced calcium and magnesium nutritional deficiencies beside influencing the respiratory pathway in root (Abel and Mackenzie, 1964).

The increase of physical characteristics may be attributed to the fact that sodium chloride (the main salt in saline water) plays an important role through ionic Na as shown by Australian workers who described the role of essential element for a group of plants exhibited so called hatch-slack pathway of carbohydrate metabolism which led to stimulate crops by application of sodium (Tisdale and Nelson, 1975).

From another point of view, the drop in the various physical characteristics that started after using a concentration higher than 1000 ppm may be attributed to the reduction in the osmotic potential of the soil solution which led to reduction in plant water availability, ion imbalance, and a specific ion toxicity (Dudley, 1994; Subbarao and Johansen, 1999).

The results of the chemical constituents of the age 75 days showed that TSS, sodium and proline contents significantly increased with every increase in the salinity levels while ascorbic acid, total chlorophyll, total carotenoids, dry weight, nitrogen, phosphorus and potassium also increased up to 2000 ppm then turned to decrease by the high saline levels. Reviewing these results, considerable attention had been paid many works to follow the changes happened in the chemical constituent of plants subject to irrigation with various saline water concentrations. Hence, the increase in TSS may be attributed to the effect of saline water on increasing the movement of soluble solids to the plants and accumulation of glucose and ion mainly chlorides (Plaut, 1997).

Regarding the decrease in the chemical contents as a result of using saline water, irrigation with saline water till 2000 ppm increased chlorophyll content then turned to decrease with increasing the saline concentration may be attributed to the increase in the activity of the chlorophyllase degrading enzyme (Rao and Rao, 1981). Also, the decrease in carotene content with the increase in saline water levels after 2000 ppm might be due to the photooxidative damage of chloroplast (Sieferman-Harms, 1987). The enhanced values of ascorbic acid arising from watering with the level of 2000 ppm saline water may be due to the consequent accumulation of monosaccharide (Cuartero and Fernandez, 1999). Moreover, the initial increases in dry weight with the increase in saline levels till 2000 ppm may be related in part to lower content of water (Satti *et al*., 1996). Nitrogen content increased till the saline concentration of 2000 ppm then it was inhibited by the higher levels of salinity. This may be attributed to the interaction occurred by No_3 /Cl at the sites for ion transport (Cram, 1983), as sodium induced server membrane depolarization in plants (Suhayda *et al*., 1990). Phosphorus content increased as the saline level increased till 2000 ppm, then it was reduced proportionally with the increase in saline water levels. The reduction in P as a result of high salinity may be related to the reduction in phosphate availability due to ionic strength in addition to the tight control of phosphate concentration in soil solution by adsorption processes and by the low solubility of Ca-P minerals (Grattan and grieve, 1999). An increase was recorded in potassium content with increasing saline water level up to 2000 ppm, then it was reduced with high saline levels. Thus, latter decrease with using high levels of salinity may be explained as salinity often leads to unfavorable cation uptake which induces reduction in K and Ca cations. So, both K and Ca concentrations are affected by the increase in Na, leading to growth reduction caused by ion imbalance stress (Graifenberg *et al*., 2004).

CONCLUSION

According to this study, it is reasonable to recommend that celery cv. Balady must be irrigated with the limit of 1000 ppm saline water.

REFERENCES

Abd EL-Sayed, S.M., Shehata, M.M., Sorour, A.M., 1993. Reuse of drainage water and soil salinity under sugar beet. Egypt. J. Agric. Res., 71, 601-606.

Abel, G.H., Mackenzie, A.J., 1964. Salt tolerance of soybean varieties (Glycine Max L.) during germination and later growth. Crop Sci., 4, 157-161.

Ahmed, E.M., 2001. Effect of irrigation with saline water on seed germination, growth and chemical composition of parsley. Al-Azhar J. Agric. Res., 33, 231-242.

Association of official methods of Analytical Chemists (A.O.A.C.)., 1990. Official methods of analysis 15th ed., Washington, D.C., U.S.A.

Bates, L.S., Woldrem, J.R.P., Teare, I.D., 1973. Rapid determination of free proline for water-stress studies. Plant Soil, 39, 205-207.
Cram, W.J., 1983. Chloride accumulation as a homeostatic system: Set points and perturbation. J. Exper. Bot., 34, 1484-1502.
Cuartero, J., Fernandez, R., 1999. Tomato and salinity. Sci. Hort., 78, 83-125.
Dewis, J., Freitas, F., 1970. Physical and chemical methods of soil and water analysis. Food and Agric. Organ United Nations. Soils Bulletin, No. 10, FAO, Rome.
Dudley, L.M., 1994. Salinity in the soil environment, P.13-30. In: Pessarakli, M., (Ed). Handbook of plant and crop stress. Marcel Dekker., N.Y.
Graifenberg, A., Curradi, M., Bortrini, L., Giustiniani, L., 2004. Effect of saline sodic condition on growth of globe artichoke, cardoon and wild cardoon. Acta Hort., 660, 327-332.
Grattan, S.R., grieve, C.M., 1999. Salinity-Minerals nutrient relations in horticulture crops. Sci. Hort., 78, 127-157.
Gupta, I.C., 1990. Use of Saline Water in Agriculture in Arid and Semi-arid Zones of India. Oxford & IBH Publishing Co., New Delhi, pp. 225-252.
Kamal, Z.A.A., 2004. Physiological studies on growth and production of red cabbage. MSc. Thesis, Fac. Agric., Al-Azhar Univ., Cairo, Egypt.
Lichtenther, H.K., 1987. Chlorophylls and carotenoids: pigments of photosynthetic bio membranes. Methods Enzymol., 148, 350-382.
Lo-Casico, B., Lompardo, V., Lo-Casico, B., Fierotti, G., 1988. Reflection on soil and crops irrigated with saline water. Agric. Ricerca., 10, 13-32.
Pasternake, D., 1987. Salt tolerance and crop production a comprehensive approach. Ann. Rev. Phytopathol., 25, 271-291.
Plaut, Z., 1997. Irrigation with low quality water: effect on productivity, fruit quality and physiological processes of vegetable crops. Proc. 2nd Int. Sympos. Irrigation Hort. Crops. Acta Hort., 449, 591-597.
Rao, G.G., Rao, G.R., 1981. Pigment composition and chlorophyllase activity in pigeon pea (Cajanus indicus Spreng) & Gingelley (*Sesamum indicum* L.) under NaCl salinity. Ind. J. Exper. Biol. 19, 768-770.
Ruskin, F.R., John, H., Michael, M.D., 1990. Saline Agriculture. National Academy Press. Washington D.C.
Satti, S.M.E., Al-Yhyai, R.A., Al-Said, F., 1996. Fruit quality and partitioning of mineral elements in processing tomato to nutrient solution concentration at two light levels. J. Am. Soc. Hort. Sci., 127, 984-990.
Sieferman-Harms, D., 1987. The light harvesting and protective function of carotenoids in photosynthetic membrane. Plant Physiol., 69, 561-568.
Snedecor, G.W., Cochran, W.G., 1980. Statistical methods. 7th Ed. Iowa State University Press, Iowa, USA.
Subbarao, G.V., Johansen, C., 1999. Strategies and scope for improving salinity tolerance in crop plants. In: Pessarakli, M., Ed., Handbook of Plant and Crop Stress, Marcel Dekker, NY, USA, pp. 1069–1088.
Suhayda, C.G., Giannini, J.L., Briskin, D.P., Shannon, M.C., 1990. Electrostatic changes in *Lycopersicon esculenyum* root plasma membrane resulting from salt stress. Plant Physiol., 93, 471-478.
Tisdale, S., Nelson, W., 1975. Soil fertility and fertilizers. 3rd Ed., Macmillan Publishing Con. INC. NY, pp. 98-99.
Venekamp, J.H., Koot, J.T.M., 1988. The sources of free proline and asparagin in field bean plants, *Vicia faba* L. during and after a short period of water withholding. Plant Physiol., 132 (1), 102-13.

Table 1. The chemical analysis of the agriculture saline drainage water (meq/L) applied in irrigation.

Concentrations	EC (dS/m)	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
260 ppm	**0.41**	**-**	**3.1**	**1.4**	**0.1**	**1.8**	**1.4**	**1.1**	**0.3**
1000 ppm	**1.52**	**-**	**3.1**	**9.8**	**0.2**	**2.2**	**3.4**	**7.1**	**0.4**
2000 ppm	**3.12**	**-**	**3.1**	**22.5**	**0.4**	**2.5**	**6.2**	**16.8**	**0.5**
3000 ppm	**4.75**	**-**	**3.1**	**32.5**	**0.7**	**3.3**	**9.1**	**24.2**	**0.7**
4000 ppm	**6.38**	**-**	**3.1**	**45.7**	**1.2**	**3.9**	**14.1**	**31.1**	**0.9**

Table 2. Effect of irrigation with saline water on plant physical characteristics at various ages in 2017-2018 and 2018-2019 seasons.

2017-2018 season									
Plant age (days) / **Salinity (ppm)**	**Plant length (cm)**			**Plant fresh weight (g)**			**Plant leaf number**		
	45	60	75	45	60	75	45	60	75
Control (260)	14.06	21.60	32.40	20.13	41.83	59.80	8.73	11.13	15.11
1000	15.83	23.26	34.73	23.36	45.73	65.51	10.89	12.89	17.04
2000	13.00	19.96	29.33	18.36	36.30	52.33	7.47	9.55	12.73
3000	9.96	14.16	19.50	15.16	25.93	34.09	6.61	8.31	11.30
4000	8.40	12.36	17.73	10.66	17.21	25.39	6.29	7.33	8.61
L.S.D. at 5 ٪	1.55	1.70	1.86	1.17	2.77	3.28	1.07	1.19	1.65
2018-2019 season									
Control (260)	15.33	21.66	32.43	17.18	34.77	47.35	9.81	13.35	16.37
1000	18.00	24.86	35.70	23.47	40.33	53.58	11.64	14.40	18.07
2000	13.40	19.54	29.43	16.19	31.86	41.00	8.52	10.25	14.57
3000	10.43	13.33	15.50	12.53	19.46	28.06	7.35	9.16	12.03
4000	8.91	11.83	13.37	10.86	16.19	21.19	6.63	8.10	9.88
L.S.D. at 5 ٪	1.78	1.92	3.27	2.75	3.07	4.33	1.003	1.64	1.12

Table 3. Effect of irrigation with saline water on plant TSS., ascorbic acid, total chlorophyll and carotene contents at various ages in 2017-2018 and 2018-2019 seasons.

2017-2018 season												
Plant age (days) / **Salinity (ppm)**	**T.S.S. (٪)**			**Ascorbic acid (mg/100g. f.w.)**			**Total chlorophyll (mg/100g. f.w.)**			**Total carotene (mg/100g. f.w.)**		
	45	60	75	45	60	75	45	60	75	45	60	75
Control (260)	2.63	4.06	4.64	53.49	75.16	117.08	81.28	92.83	95.41	60.84	68.86	86.17
1000	3.07	4.72	5.03	56.17	81.62	123.18	84.10	95.67	100.66	64.93	72.99	95.52
2000	3.65	5.11	5.38	59.39	84.16	128.44	85.06	96.33	105.23	64.56	74.29	98.65
3000	4.29	5.49	5.83	50.97	62.33	109.16	74.40	85.99	88.43	49.79	56.46	70.36
4000	4.73	5.77	6.13	48.93	59.17	99.08	65.28	75.05	82.33	37.28	44.11	65.16
L.S.D. at 5 ٪	0.48	0.43	0.31	1.20	2.12	4.29	2.63	2.60	3.74	2.39	2.46	2.09
2018-2019 season												
Control (260)	3.17	3.96	4.49	57.38	81.18	119.99	92.60	100.90	115.49	64.70	75.84	90.28
1000	3.60	4.25	5.09	61.76	86.13	126.04	97.92	103.15	120.66	67.21	76.68	91.35
2000	3.95	4.67	5.76	65.21	90.03	129.81	96.82	104.85	122.77	68.68	78.62	92.78
3000	4.59	4.99	5.77	53.64	66.40	113.71	74.85	84.97	97.93	60.96	70.19	84.65
4000	4.96	5.67	6.49	50.24	59.69	103.84	68.97	78.66	89.88	57.90	66.94	81.00
L.S.D. at 5 ٪	0.22	0.23	0.49	2.10	1.59	3.69	2.98	5.03	3.19	1.29	1.38	1.41

Table 4. Effect of irrigation with saline water on plant dry weight, nitrogen, phosphorus and potassium contents at various ages in 2017-2018 and 2018-2019 seasons.

2017-2018 season												
Plant age(days) / **Salinity (ppm)**	**Dry weight (g/100g. f.w.)**			**Nitrogen (g/100g. d.w.)**			**Phosphorus (g/100g. d.w.)**			**Potassium (g/100g. d.w.)**		
	45	60	75	45	60	75	45	60	75	45	60	75
Control (260)	6.28	8.75	11.30	1.29	1.57	2.12	0.11	0.35	0.50	1.50	2.07	2.39
1000	7.35	9.17	11.79	1.39	1.67	2.35	0.12	0.39	0.53	1.76	2.26	2.90
2000	8.01	9.67	12.71	1.46	1.83	2.39	0.15	0.41	0.56	1.85	2.62	3.03
3000	5.99	7.81	11.21	1.27	1.37	1.89	0.13	0.39	0.49	1.67	2.04	2.52
4000	5.29	6.87	10.14	1.21	1.32	1.66	0.11	0.36	0.43	1.48	1.41	2.23
L.S.D. at 5 ٪	0.39	0.59	0.65	0.05	0.06	0.19	0.01	0.03	0.01	0.10	0.19	0.11
2018-2019 season												
Control (260)	5.87	8.33	10.99	1.24	1.42	2.07	0.12	0.39	0.51	1.33	1.89	2.29
1000	7.44	9.21	11.50	1.35	1.50	2.37	0.14	0.43	0.56	1.56	2.11	2.77
2000	8.04	10.25	12.05	1.46	1.85	3.46	0.16	0.47	0.60	1.71	2.44	2.95
3000	6.56	7.55	11.11	1.31	1.36	1.72	0.14	0.40	0.46	1.48	2.13	2.48
4000	5.89	6.82	10.09	1.18	1.26	1.54	0.12	0.35	0.42	1.17	1.79	2.17
L.S.D. at 5 ٪	0.36	0.43	0.55	0.038	0.132	1.41	0.11	0.015	0.03	0.08	0.11	0.09

Table 5. Effect of irrigation with saline water on plant Sodium and proline contents at various ages in 2017-2018 and 2018-2019 seasons.

2017-2018 season						
Plant age (days) / **Salinity (ppm)**	**Sodium (g/100g. d.w.)**			**Proline (mg/1g. f.w.)**		
	45	60	75	45	60	75
Control (260)	0.14	0.22	0.27	0.08	0.13	0.17
1000	0.17	0.26	0.37	0.11	0.17	0.22
2000	0.20	0.32	0.49	0.14	0.19	0.29
3000	0.25	0.42	0.55	0.19	0.23	0.33
4000	0.29	0.46	0.62	0.21	0.31	0.38
L.S.D. at 5 ٪	0.09	0.03	0.02	0.014	0.018	0.016
2018-2019 season						
Control (260)	0.12	0.21	0.26	0.08	0.14	0.18
1000	0.15	0.26	0.41	0.11	0.19	0.22
2000	0.19	0.33	0.53	0.16	0.23	0.31
3000	022	0.42	0.59	0.20	0.27	0.35
4000	0.26	0.51	0.65	0.23	0.33	0.39
L.S.D. at 5 ٪	0.015	0.022	0.016	0.019	0.014	0.015

تأثير الري بالماء المالح على النمو والمحتوي الكيماوي لنبات الكرفس

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الملخص العربي

ينتمي محصول الكرفس إلى العائلة الخيمية. تهدف هذه الدراسة إلي فهم التغيرات الفيزيائية والكيميائية في نباتات الكرفس التي تأثرت بإستخدام المياه المالحة في الري.أجريت هذه الدراسة في أصص خلال الموسم الشتوي لعامي 2018/2017 و 2019/2018 لدراسة تأثير الري بمياه الصرف الزراعي من بحيرة قارون بالفيوم على النمو والمحتوي الكيماوي لنباتات الكرفس البلدي وكانت التركيزات المستخدمة لمياه الري الملحية هي 4000،3000،2000،1000 جزء في المليون، كما تم ري نباتات الكنترول بماء الصنبور بتركيز260 جزء في المليون، وقد اتضح من النتائج أن الصفات الطبيعية والتي تضمنت طول النبات والوزن الطازج وعدد الأوراق زادت بشكل ملحوظ مع الرى بالماء المالح حتى تركيز 1000 جزء في المليون مقارنةً بنباتات الكنترول ثم حدث لها نقص مع زيادة تركيز الملوحة. ومن جهة آخرى زادت كمية حامض الإسكوربيك والكلوروفيل والكاروتين والوزن الجاف والنتروجين والفوسفور والبوتاسيوم بزيادة تركيز الملوحة في ماء الري حتى 2000 جزء في المليون ثم حدث لها نقص مع زيادة تركيز الملوحة وزاد أيضاً محتوى المواد الصلبة الذائبة والصوديوم والبرولين بشكل ملحوظ مع كل زيادة في مستوى الملوحة. وفي الختام، يمكن ري الكرفس البلدي بالماء المالح حتى تركيز 1000 جزء في المليون.

الكلمات المفتاحية: الكرفس، الري، المياه المالحة، النمو، المحتويات الكيميائية.