THE RESPONSE OF THE PHYSICAL AND CHEMICAL CHARACTERISTICS OF CHINESE CABBAGE (*Brassica pekienensis L.*) PLANTS TO DIFFERENT LEVELS OF SALINE WATER.

BY

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Abstract: A pot experiment was conducted during the two winter seasons of 2011/2012 and 2012/2013 to study the effect of irrigation with agriculture saline drainage water brought from Karoun Lake at El-Fayoum Governorate, Egypt on the physical and chemical characteristics of Chinese cabbage plants. The hybrid Hero was the material used in this study. The tested concentrations of saline water were 1000, 2000, 3000 and 4000 ppm beside tap water at 260 ppm which considered as a check treatment. The results showed that the plant leaf number and fresh weight increased significantly up to the level of 1000 ppm meanwhile the content of ascorbic acid, dry weight, nitrogen, phosphorus and potassium contents increased up to 2000 ppm after which gradual decreases occurred with the increase in subsequent high levels. Another picture existed showing that the contents of T.S.S., titratable acidity, total sugars, proline, sodium beside the water saturation deficit were significantly increased with each increase in the saline water.

INTRODUCTION

Chinese cabbage (*Brassica pekienensis, L.*) is a cool season crop belonging to the family cruciferae. This crop has many other English names mainly spoon cabbage, white cabbage, shantung cabbage, chefoo cabbage, flowering cabbage, celery cabbage and Pekin cabbage. It is grown for its leaves which is the edible portion of this crop and 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 A.R. Egypt flow unused to the Mediterranean Sea and the coastal lakes that connected with the sea. Part of this water should 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 question arise, to what extent the Chinese cabbage can endure the various concentrations of saline water during irrigation. This point is scanty in the literature. So, some of the related crops which belong to the same family may give approximate picture for this relation. Thus, the previous work in A.R. Egypt on Brussels sprouts revealed that irrigation with agriculture drainage saline water ranged from 1000 to 4000 ppm decreased gradually the fresh weight and size of plant but at the same time increased the contents of T.S.S., titratable acidity, sodium and proline (Mady, 2008). On another vegetable crop, 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 after which a decline took place with the increase in these levels till 4000 ppm (Kamal, 2004). The same trend was noticed on parsley. It was found that irrigation with saline water increased significantly the number of leaves, fresh weight, ascorbic acid and dry weight till the concentration of 2000 ppm then using higher levels decreased these attributes. Another picture araised for T.S.S. and proline which significantly increased with each increase in saline levels up to 2000 ppm while nitrogen, phosphorus and potassium did not significantly differ due to the application of the various saline concentrations (Ahmed, 2001).

The present work involved studies to have good knowledge and full understand about endure of the Chinese cabbage plants to the various saline levels in irrigation water. This particular item was weighty 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 resolve shortage of water resources in Egypt especially with the increase in the population.

MATERIAL AND METHODS

Pot experiment was conducted in the experimental farm of the Faculty of Agriculture, AL-Azhar University at Cairo in the two winter successive seasons of 2011/2012 and 2012/2013. Studies took place on the effect of irrigation with agriculture saline drainage water on the plants of the hybrid Hero of Chinese cabbage. The used water was brought from Karoun Lake at El-Fayoum Governorate in Egypt. The concentration of the saline water in the lake was about 26000 ppm which was diluted with tap water to the required four concentrations of 1000, 2000, 3000 and 4000 ppm. The control plants were 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 20th and 24th in the first and second seasons, respectively. One transplant was planted per pot after 40 days from sowing where the used pots (No. 40) was filled with sandy clay loam soil and provided with an outlet at the bottom to get rid of the excess of water. The design of the experiment was completely randomized blocks. Pots were arranged in three replicates and every replicate consisted of nine pots where each represented one seedling. Irrigation of seedlings with saline drainage water started after 10 days from transplanting where it received two to three irrigations per week and each pot received 2.5 liter water to maintain soil continuously moistened in pots.

Table (1): The chemical analyses 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	1.2	0.1	1.7	1.4	1.1	0.2
1000 ppm	1.48	-	3.1	9.9	0.2	2.2	3.3	7.4	0.3
2000 ppm	3.11	-	3.1	22.5	0.4	2.7	6.4	16.5	0.4
3000 ppm	4.81	-	3.1	33.5	0.8	3.4	9.9	23.5	0.6
4000 ppm	6.50	-	3.1	44.8	1.2	3.9	13.8	30.6	0.8

The obtained data were recorded on plant age of 55 days from transplanting after harvest on all plants from each replicate (nine). The determined physical and chemical characteristics included: 1- Leaf number per plant. 2-Plant fresh weight (g). 3- Ascorbic acid was determined using the dye 2.6 dichlorophenol indophenol method (A.O.A.C., 1990). 4- Total soluble solids (T.S.S.) were determined as percentage by refractometer (A.O.A.C., 1990). 5- Titratable acidity was determined by using the standard solution of Na OH (0.01 N) and phenolphythaline indicator (A.O.A.C., 1990). 6- Total sugars were determined according to the method reported by Smith et al., (1956). 7- Free proline was determined colorimetrically after Bates et al., (1973). 8- Dry weight was determined by drying 100g in an oven at 70 °C till constant weight was reached (A.O.A.C., 1990). 9- Water saturation deficit (W.S.D) was determined as percentage according to equation of Catasky (1963).

$$W.S.D\ \% = \frac{\text{Saturated wt. - fresh wt.}}{\text{Saturated wt. - dry wt.}} \times 100$$

10- Total nitrogen was determined according to the micro-Kjeldahl method (A.O.A.C., 1990). 11- Total phosphorus was determined colorimetrically using the hydroquinone and sodium sulphite method (A.O.A.C., 1990). 12- Total potassium and sodium were determined using flamephotometer according to the method of Dewis and Freitas, (1970).

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

RESULTS AND DISCUSSION

A- The physical characteristics:

The effect of using the different saline water levels ranged from 1000 to 4000 ppm on the plant leaf number reflect significant increase in this character till 1000 ppm which was followed by significant decreases correlated with the increase in saline levels till the highest applied level of 4000 ppm. Similarly, the same effect was noticed on the plant fresh weight which exhibit also that this characteristic increased significantly with the increase in saline water levels till 1000 ppm after which significant decreases were associated with the increase in the saline levels up to 4000 ppm.

B- Chemical characteristics:

The obtained data of the plant ascorbic acid content indicate that the increase in the saline levels up to 2000 ppm simultaneously increased significantly this content while more increase in this level reduced proportionally and significantly this vitamin. Considerable attention paid to the effect of the various levels of saline water on plant T.S.S. percentage which reflect that this content increased continuously with the increase of the various saline levels but the differences reached the significance levels only when the high levels over 2000 ppm were used. Concerning the effect of irrigation with the different levels of saline water on plant titratable acidity, the picture show that the increase in the various saline levels resulted significant gradual increases in this content till the highest level of 4000 ppm. Extending studies on the effect of the various saline levels on the other chemical contents illustrate that the plant total sugars significantly increased with each increase in the saline levels up to 4000 ppm. The same trend was true for the proline content as significant increases were correlated with each increase in the saline levels. Another view was seen in the content of plant dry weight where significant increases were found with each increase in the saline levels up to 2000 ppm then significant declines were followed with more increase in these levels. From another point of view the response of water saturation deficit to the application of the various saline water levels demonstrate that this characteristic increased significantly with the increase in the saline levels up to the highest level of 4000 ppm. Dealing with the obtained results on the minerals content, it was obvious that the plant sodium content increased proportionally and significantly with every increase in the saline levels. However, the values of N, P, K reflect significant increases up to the level of 2000 ppm then a proportional significant decrease trend was followed with the increase in these levels.

To discuss the pervious results on Chinese cabbage, it is reasonable to commence first with the results obtained on the physical characteristics as number of leaves and plant fresh weight which gave comparatively the highest significant records due to the irrigation with salt water up to 1000 ppm after which a drop occurred with each increase in the levels of saline water. The second point exhibited the results of the chemical contents which reflected an increase in ascorbic acid, dry weight, nitrogen, phosphorus and potassium up to irrigation with 2000 ppm salt water which was followed by a decrease trend with the increase in the water saline levels. Another picture in the behavior of the chemical contents showed that the increase in water saline concentrations till 4000 ppm induced continuous proportional significant increase in the contents of T.S.S., titratable acidity, sugars, proline, water saturation deficit and sodium.

The increase in the physical features of Chinese cabbage by the low levels of saline water may be related to some reasons. Thus, 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 amounts of salt in the growth medium or in other words need moderate saline conditions which positively promote plant growth, enhance productivity and improve quality than salts free conditions (Pasternake, 1987; Lo-Casico et al., 1988 and Gupta, 1990). So, plant adaptation to salinity stress requires some means to adjust the osmotic potential of plant organs to at least matching that of the soil solution in order to maintain turger pressure and a gradient for water uptake. To accomplish this, some plants produce organic solutes as sucrose in carrots, while others take up salts to accomplish the same as beets (Subbarao & Chris, 1994 and Raul et al., 1997). 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).

Physiologically speaking, the first picture of the increase of physical characteristics may be attributed to that sodium chloride which is the main salt in saline water plays an important role through ionic Na which shown by Australian workers to be an essential element for a group of plants exhibiting the so called hatch-slack pathway of carbohydrate metabolism that threw light on stimulation of crops by application of sodium (Tisdale and Nelson, 1975).

From another point of view, the drop happened in the various physical characteristics started after using the concentration beyond 1000 ppm may be attributed to the reduction in the osmotic potential of the soil solution which lead to reduction in plant available water, ion imbalance and a specific ion toxicity (Subbarao & Chris, 1994 and Dudley, 1994). So, Salts decrease the availability of water to the plant by reducing the free energy of water and exert detrimental effects on plant growth through the toxicity of one or more specific ions present in higher relative concentrations (Alam, 1994). On the other hand, water stress and salinization inhibit proline oxidation in the mitochondria and alter the permeability of the mitochondria membranes which further leading to inhibit incorporation of proline into protein that established proline accumulation (Boggess and Stewar, 1980). In general salinity stress recognized as injurious to plants by disturbing the electrolyte balance, resulting in the deficiency of some essential nutrient elements and in an excess of certain unwanted salts in plant tissue. Salt tolerance under such conditions is usually related to the ability to regulate Na and Cl uptake by plant roots and subsequent translocation to the shoots (Johnson, 1991).

Table (2): Effect of irrigation with the various levels of saline water levels on the number of leaves and fresh weight of Chinese cabbage in 2011/2012 and 2012/ 1013 seasons.

Saline level (ppm)	Number of leaves/ plant		Fresh weight (g)./ plant	
	2011/2012 season	2012/2013 season	2011/2012 season	2012/2013 season
260 Control	17.36	17.91	275.90	291.46
1000	19.88	19.96	312.69	326.13
2000	18.57	18.80	281.20	289.42
3000	16.43	17.05	238.59	253.14
L. S. D at 5 %	1.25	0.82	25.68	10.81

Table (3): Effect of irrigation with the various saline water levels on the Chinese cabbage plants contents of ascorbic acid, T. S.S and titratable acidity in 2011-2012 and 2012-2013 seasons.

Saline level (ppm)	Ascorbic acid (mg/100g.f.w.).		T. S.S %		Titratable acidity (mg/100g.f.w).	
	2011/2012 season	2012/2013 season	2011/2012 season	2012/2013 season	2011/2012 season	2012/2013 season
260 Control	39.24	37.04	3.23	3.13	189.00	194.80
1000	41.89	41.52	3.25	3.16	210.00	213.16
2000	43.66	43.73	3.58	3.27	235.20	231.79
3000	37.17	35.46	4.16	4.07	267.75	244.23
4000	32.45	33.48	5.33	4.70	280.35	258.59
L. S. D at 5 %	2.07	1.466	0.37	0.24	8.75	4.66

Table (4): Effect of irrigation with the various saline water levels on the Chinese cabbage plants contents of total sugars, proline, dry weigbt and water saturation deficit in 2011-2012 and 2012-2013 seasons.

Saline level (ppm)	Total sugars		Proline		Dry weight		Water saturation	
	2011/2012 season	2012/2013 season	2011/2012 season	2012/2013 season	2011/2012 season	2012/2013 season	2011/2012 season	2012/2013 season
260 Control	3.58	3.54	0.12	0.14	7.51	7.12	22.97	23.47
	3.92	3.99	0.17	0.18	8.31	7.86	27.18	29.78
1000	4.22	4.32	0.23	0.25	8.83	8.62	32.34	34.17
2000	4.46	4.63	0.31	0.32	7.86	7.94	34.32	36.51
3000	4.79	4.92	0.37	0.40	7.13	6.17	36.71	38.90
L. S. D	0.27	0.153	0.02	0.016	0.434	0.35	3.35	1.86

Table (5): Effect of irrigation with the various saline water levels on the Chinese cabbage plants content of sodium, nitrogen, phosphorus and potassium in 2011-2012 and 2012-2013 seasons.

Saline level (ppm)	Sodium		Nitrogen		Phosphorus		Potassium	
	2011/2012	2012/2013	2011/2012	2012/2013	2011/2012	2012/2013	2011/2012	2012/2013
260	0.26	0.28	1.55	1.48	0.51	0.45	0.58	0.53
Control	0.35	0.38	1.91	1.88	0.60	0.58	0.62	0.60
1000	0.43	0.50	2.20	2.05	0.65	0.64	0.67	0.64
2000	0.55	0.59	1.45	1.38	0.46	0.41	0.53	0.46
3000	0.64	0.70	1.13	1.17	0.36	0.34	0.27	0.24
L. S.	0.03	0.039	0.055	0.86	0.044	0.039	0.05	0.04

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استجابة الصفات الطبيعية والكيماوية لنباتات الكرنب الصيني لمستويات مختلفة من الماء المالح

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أجريت هذه الدراسة في أصص خلال الموسم الشتوى لعامى ٢٠١٢/٢٠١١ و ٢٠١٣/٢٠١٢ لدراسة تأثير الرى بمياه الصرف الزراعى على الصفات الطبيعية والكيماوية لنباتات الكرنب الصيني هجين "Hero" حيث استخدمت تركيزات المياه الملحيه ١٠٠٠، ٢٠٠٠، ٣٠٠٠، ٤٠٠٠ جزء فى المليون فى رى النباتات الى جانب الرى بمياه الصنبور بتركيز ٢٦٠ جزء فى المليون للمقارنة، وقد اتضح من النتائج أن الصفات الطبيعية والتى تضمنت عدد الأوراق والوزن الطازج للنباتات زادت معنوياً مع الرى بالماء المالح حتى تركيز ١٠٠٠ جزء في المليون ثم حدث لها نقص مع زيادة تركيز الملوحة في ماء الري حتى ٤٠٠٠ جزء في المليون.

ومن ناحية أخرى زادت بعض الصفات الكيميائية مع زيادة تركيز الملوحة في ماء الري حتى ٤٠٠٠ جزء فى المليون حيث شملت المواد الصلبة الذائبة والحموضة و السكريات الكلية والصوديوم والبرولين ونقص التشبع المائى للأوراق.

هذا من جهة ومن جهة أخرى زادت كمية حامض الأسكوربيك والوزن الجاف والنتروجين والفوسفور والبوتاسيوم بزيادة ملوحة مياه الري حتى ٢٠٠٠ جزء في المليون ثم حدث لها نقص مع زيادة تركيز الملوحة حتى ٤٠٠٠ جزء فى المليون.

توصى الدراسة بأنه يمكن الري حتى تركيز ١٠٠٠ جزء في المليون من مستويات الماء المالح لنباتات الكرنب الصيني دون تأثر شديد لصفات المحصول والجودة.