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EFFECT SALINITY LEVELS AND IRRIGATION WITH MAGNETIZED WATER ON THE GROWTH, ESSENTIAL OIL CONTENT OF THE FRUITS AND CHEMICAL CONSTITUENTS OF *CARUM CARVI* L. PLANTS

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ABSTRACT: *Two pot experiments were conducted at the Experimental Farm of the Faculty of Agriculture, Menoufia University, Shibin El-Kom, Egypt during two successive seasons of 2009/2010 and 2010/2011 for studying the effect of four levels of soil salinity (0.0, 0.10, 0.20 and 0.30%) from a mixture from $CaCl_2$ and NaCl (2 : 1, w/w) and irrigation with either magnetized water or with ordinary water (Tape water) on the growth, yield and chemical constituents of Carum carvi L. plants. The seeds (fruits) of caraway plants were sown in plastic pots (30 cm diameter), which were filled with 4.5 kg/pot from air dried clay loamy soil after its mixing with the different used salinity levels. The plants were irrigated along the growing period with either magnetized or ordinary water and the soil moisture was kept at 60% water holding capacity. The experiments were designed in a factorial complete randomized block design with three replicates for each treatment. The obtained results showed that growth and yield parameters (namely, plant height, number of branches / plant, stem diameter, root length, fresh and dry weight / plant and number of umbels and fruit yield / plant) were decreased with increasing soil salinity levels up to 0.3% when compared with the control in the two growing seasons. Meanwhile, irrigating the plants with magnetized water caused an improvement in this respect and reduced the harmful effect of soil salinity in comparison with those irrigated with ordinary water. Also the essential oil content in the fruits, N, P and K% as well as total carbohydrate percentage in the dried herb followed the previously stated trend. The best results of growth, essential content and chemical constituents were obtained by the treatment of irrigation with magnetically treated water without salt addition in the two growing seasons.*

Key words: *Carum carvi L., soil salinity, magnetized water.*

INTRODUCTION

Carum carvi L. plants belong to family umbelliferae (Apiaceae) and considered as one of the most important medicinal and aromatic plants grown in Egypt, which usually used in dried state (fruits) or as fresh herb as household remedies or as medicinal ingredients. Furthermore, the fruits of caraway contains essential oil which is used medically as carminatives, mild stomachic, antispasmodic as a tonic in treatment digestive disorders. Dried fruits of caraway are used at a large scale in food industries for flavouring bread, cake, confectionery cheese and kinds of food products. In the last few decades there has been more interest in drugs obtained from plant sources than any time in history. Owing to the increase in population and their demands from medicinal and aromatic plants such as caraway in the recent time and the decrease in per capita available arable land as well as shortage in irrigation water supplies, it has become very difficult to find fertile land for expansion in cultivation of medicinal and aromatic plants. Therefore, the cultivation of medicinal and aromatic plants on degraded lands, biosaline agriculture is feasible and profitable. Otherwise, the cultivation of medicinal and aromatic plants on degraded lands under salinity stress causes a considerable reduction in the growth and productivity of the plants. This trend was reviewed by Ashraf and Akhtar (2004) on *Foeniculum rulgare* L., Queslati *et al.* (2010) on *Mentha pulegium* L., Khorasanijad (2010) on *Mentha piperita* L. and Ben Taarit *et al.* (2012) on *Salvia officinalis* L. Therefore, several attempts were done by many investigators for not only for overcoming the

harmful effect of salinity stress on plant growth and productivity, but also for improving both quantitative and qualitative characteristics of the produced plants. In this respect recently it was found that irrigating treated water was very effective in improving the growth and yield of the investigated plants. In this concern, Duarte Diaz *et al.* (1997), Khatab *et al.* (2000), Mostafa (2002), Maheswari and Grewal (2009) and Ameen and Kassin (2009), mentioned that watering the studied plants with magnetized water proved to be very effective in reducing the harmful effect of salinity when compared to irrigation with ordinary water. Furthermore, the application of magnetic technique in watering the plants improved water use efficiency (WUE) and hence it assists in saving water supplies, which help coping with the future water scarcity. Takachenko (1995) found that magnetized water was more ready absorbed by roots, improving leaching process in hard soils, thus reduce soil salination and enhance growth parameters of the plants as mentioned by Nasher (2008) on chick pea, Maheshwari and Grewal (2009) on celery, Midan and Tantawy (2013) on snap bean and Esfandiar *et al.* (2012) on *Foeniculum vulgare* L.

In this regard, it could be noticed that using magnetized water in irrigation showed a promising effect in reducing the harmful effect of soil salinity on the plant growth and productivity, which may help in expansion of cultivation of medicinal and aromatic plants in degraded saline lands. Otherwise, more studies in this respect are still needed as the available investigations in this concern are still limited. Therefore, the objection of our investigation will be dealing with studying the effect of irrigation with magnetized water on the growth, yield measurements as well as essential oil content in the fruits of *Carum carvi* L. plants grown under saline conditions.

MATERIALS AND METHODS

A pot experiment was carried out at the Experimental Farm of the Faculty of Agriculture, Menoufia University during two successive seasons of 2009/2010 and 2010/2011. This investigation was conducted to study the effect of salinity stress and irrigation with magnetically treated water on the growth parameters, fruit yield and essential oil production of *Carum carvi* L. plants.

The seeds of caraway (*Carum carvi* L.) plants were obtained from the Research Center of Medicinal and Aromatic Plant Section, Giza, Egypt. These seeds were sown on the 15th of October in each growing season in plastic pots of 30 cm diameter. Each pot was filled with 4.5 kg / pot air dried soil, which physical and chemical properties as shown in Tables (1 a and b).

Table (1). The physical and chemical properties of the experimental soil according to the methods described by Jakson (1967).

a) The physical properties of the experimental soil.

Water field capacity %	Organic matter %	Total $CaCO_3$ %	Particle size distribution %				Texture grade
			Coarse sand %	Fine sand %	Silt %	Clay %	
38.82	2.84	2.32	3.84	27.39	44.23	23.20	Clay loamy

b) The chemical analysis of the experimental soil.

pH 1:2.5 soil water ratio	E.C. (mm/hos/ cm at 25°C)	C.E.C. (mg/100 g)	Total N %	Total P_2O_5 %	Soluble ions (mg/100 g)			
					Ca^{++}	Mg^{++}	Na^{++}	K^{+}
7.90	1.73	25.60	0.10	0.26	0.42	0.68	0.60	0.12

Soil salinity treatments were prepared by mixing sodium chloride (NaCl with purity 95%) and calcium chloride ($CaCl_2$ with purity 90%) at ratio of 2 : 1, w/w and then were mixed with the experimental soil at four levels of 0, 0.10, 0.20, and 0.30%. Directly, after sowing the seeds in pots, they were irrigated either with tap water or with magnetically treated water, which passed through magnetron tube of 2 inches diameter and 4000 Gaus strength (Ameen and Kassim, 2009). The soil moisture level was kept at about 60% from its water holding capacity during the growing period by daily weighing. After one and half month from sowing date, the plants were thinned to two plants / pot.

The plants under experiment were fertilized with a diluted soluble fertilizer Kristalon (19 N : 19 P : 19 K) at a rate of 2 g./pot ppm five times at monthly intervals starting from mid of November (after thinning) till mid of March (full flowering stage) in both experimental seasons. The experiments layout was a factorial in a complete randomized block design. Each treatment was represented with three replicates, each of them contained 10 pots. The treatments could be summarized as follows:

1. Irrigation with non-magnetized tap water (M_0) without salt addition (S_0).
2. Irrigation with non-magnetized tap water (M_0) + 0.10% salinity level (S_1).
3. Irrigation with non-magnetized tap water (M_0) + 0.20% salinity level (S_2).
4. Irrigation with non-magnetized tap water (M_0) 0.30% salinity level (S_3).
5. Irrigation with magnetized water (M_1) without salt addition (S_0).
6. Irrigation with magnetized water (M_1) + 0.10% salinity level (S_1).
7. Irrigation with magnetized water (M_1)+ 0.20% salinity level (S_2).
8. Irrigation with magnetized water (M_1) + 0.30% salinity level (S_3).

Random samples from each replicate of every applied treatment were taken at full flowering stage and the below mentioned data were recorded and statistically analyzed according to Snedecor and Cochran (1980):

1. Plant height (cm).
2. Number of branches / plant.
3. Stem thickness at base in (cms).
4. Root length in cms.
5. Fresh weight of herb/plant in (g)
6. Dry weight of herb/plant in (g)

Furthermore, at the end of the growing seasons, when fruits were ripe the caraway plants were harvested at the beginning of May in both experimental seasons by cutting off the plants and were left for two weeks in well ventilated shaded place then hammered for fruit separation. The following data were recorded and statiscally analyzed as mentioned before:

7. The mean number of umbels / plant before hammering.
8. Fruit yield / plant (g).

Concerning the chemical analysis the following measurements were carried out in both experimental seasons in:

9. Essential oil content in the dry ripped fruits was determined and essential oil yield per plant was calculated in ml/plant, according to the method described by British Pharmacopea (1963).

Furthermore, in well dried (70°C) and fine powdered samples from the dried herb during flowering stage N, P, K percentages as well as total carbohydrate percentage were determined according to the mentioned methods described by Bremner (1996), Olsen and Sommers (1982), Richards (1954) and Dubios *et al.* (1956), respectively.

RESULTS AND DISCUSSION

1. Vegetative growth:

1.1. Effect of soil salinity levels:

The data in Table (2) clearly indicate that, the vegetative growth measurements of *Carum carvi* L. plants (namely, plant height, number of branches / plant, stem diameter and root length) were decreased with increasing soil salinity levels up to 0.30% (S_3) compared with the control without salt addition in both growing seasons. The treatment of the lowest level of salinity (0.10%) resulted in non significant reduction in the measured growth parameters expect in the case of plant height in comparison with

the control (S_0) in the two experimental seasons. Meanwhile, the treatment of the moderate salinity level (S_2) gave significantly lower values in this respect when compared to those of the low level (S_1) and the control without salt addition (S_0) in the two growing seasons. Otherwise, the least recorded vegetative growth measurement were found in the case of the highest level of soil salinity in the two growing seasons. For example, in the second season the recorded plant height was 87.25, 78.32, 73.63 and 65.82 cm, whereas the mean number of branches / plant was 11.69, 10.75, 9.68 and 8.25, otherwise the root length was 16.84, 16.32, 14.49 and 11.05 cm for the treatments of 0.0, 0.10, 0.20 and 0.30% salinity levels, respectively. Furthermore, the fresh and dry weights / plant, the mean number of compound umbels / plant and the obtained fruit yield / plant followed the previously mentioned trend in the two growing seasons as shown in Table (2). The produced fruit yield was 10.54, 10.29, 7.37 and 6.04 g / plant in the fruits season, meanwhile in the second one it was 11.64, 11.35, 8.43 and 6.16 g / plant for the treatments of S_0, S_1, S_2 and S_3, respectively.

Table (2): Effect of soil salinity levels, irrigation with magnetized water and their interaction on plant height, No. of branches / plant stem diameter and root length of *Carum carvi* L. plants during the growing seasons of 2009/2010 and 2010/2011.

Treatments	The First season (2009/2010)					The second season (2010/2011)				
S. levels (S) / Magn. (M)	S_0	S_1	S_2	S_3	Mean	S_0	S_1	S_2	S_3	Mean
	Plant height (cms)									
M_0	80.85	70.39	69.65	64.68	71.39	83.17	77.55	70.88	62.83	73.61
M_1	91.08	76.27	70.67	67.17	76.30	91.32	79.08	76.38	69.80	78.90
Mean	85.97	73.33	70.16	65.93	-	87.25	78.32	73.63	65.82	-
L.S.D. at 0.05	S=1.85 M=1.30 M×S=2.60					S=3.40 M=2.47 M×S=4.94				
	No. of branches / plant									
M_0	10.32	9.82	8.25	6.77	8.79	10.90	10.10	8.45	6.90	9.09
M_1	12.83	12.44	9.78	8.79	10.84	12.48	11.40	10.91	9.60	4.09
Mean	11.58	11.13	9.02	7.53	-	11.69	10.75	9.68	8.25	-
L.S.D. at 0.05	S=0.81 M=0.57 M×S=1.14					S=0.97 M=0.68 M×S=1.36				
	Stem diameter (cms)									
M_0	0.73	0.68	0.55	0.38	0.59	0.68	0.62	0.42	0.32	0.51
M_1	0.88	0.85	0.65	0.50	0.72	0.83	0.80	0.52	0.45	0.65
Mean	0.81	0.77	0.60	0.44	-	0.76	0.71	0.47	0.39	-
L.S.D. at 0.05	S=0.06 M=0.04 M×S=0.08					S=0.08 M=0.05 M×S=0.10				
	Root length (cms)									
M_0	15.39	14.39	12.85	10.80		16.48	15.23	13.91	10.22	13.96
M_1	16.50	16.10	14.85	11.83		17.20	17.40	15.09	11.87	11.39
Mean	15.95	15.25	13.85	11.32	-	16.84	16.32	14.49	11.05	-
L.S.D. at 0.05	S=0.99 M=0.70 M×S=1.40					S=0.68 M=0.48 M×S=0.96				

* S = Salinity levels M = Magnetic treatment of water

The reduction in the obtained vegetative growth parameters and consequently the produced fruit yield / plant could be attributed to salinity effect in reducing the ability of the plant to take up water from the growing media, which was reflected negatively on vegetative growth and yield parameters. Similar results were obtained by Francios *et al.* (1990) on guar plants, Afify (2009) on *Mentha spicata* L., Kandil and El-Eiwa (2002) on *Ammi majus* L. and El-Dabh *et al.* (2011) on *Moringa oleifera* lam., who assured the previously stated trend.

1.2. Effect of irrigation with magnetized water:

It is evident from the data in Tables (2 and 3) that, irrigation caraway plant with magnetically treated water (M_1) resulted in significantly improvement not only in vegetative growth parameters (plant height, number of branches / plant, stem thickness, root length and fresh and dry weights / plant) but also in enhancing the produced number of compound umbel / plant and consequently the produced fruit yield / plant in comparison with those irrigated with non-magnetized water (M_0) in the two growing seasons. The produced fruit yield / plant was 7.50 and 9.62 g / plant in the first season and it was 8.58 and 10.21 g / plant in the second one for the treatments of irrigation with non-magnetized (M_0) and magnetized water (M_1), respectively.

These results could be explained through the interpretation of Midan and Tantaway (2013) who found that watering snap bean plants with magnetically treated water resulted in an increasing the availability of both macro and micronutrients in the soil and consequently increasing their absorption by plant roots, which was reflected in promoting plant growth and yield measurement as shown in Tables (2 and 3). These results are in accordance with those obtained by Mostafa (2002) on *Calendula officinalis* L. and *Dimorphotheca ecklonis* L., Maheswari and Grewal (2009) on celery and Vashisth and Nagarjan (2010) on *Helianthus annus* plants.

1.3. Effect of interaction between soil salinity levels and irrigation with magnetized water:

The reported data in Tables (2, 3) clearly show that the irrigation of *Carum carvi* L. grown under the different salinity levels with magnetized water (M_1) resulted in significantly better vegetative growth and yield parameters in comparison with those grown under the same saline condition and irrigated with ordinary water (M_0) in the two experimental seasons. The best results in this respect were obtained by the plants irrigated with magnetically treated water without salt addition ($M_1 + S_0$) in both growing seasons. On the other hand, the significantly lowest values in this concern were obtained by the treatment of irrigation with non magnetized water (M_0) and application of the highest level of salinity (S_3). For example, in the second growing season the fresh weight / plant ranged between 59.40 and 96.10 g / plant. Meanwhile the dry weight / plant was between 7.92 and 14.40 g / plant, whereas the mean number of compound umbels / plant flacuated between 9.66 and 20.40 umbel / plant for the treatments of irrigation with ordinary water (M_0) + the highest level soil salinity (S_3) and that of irrigation with magnetically treated water without salt addition respectively. Also, the obtained fruit yield / plant ranged between 5.45 and 11.64 g / plant for example in the second growing season for the treatments of $M_0 + S_3$ and that of $M_1 + S_0$, respectively.

The improvement in the produced fresh and dry weights of the plants, mean number of umbels / plant and the obtained fruit yield / plant as a result of irrigation with magnetized water of caraway plants grown under the different levels of salinity could be explained through the effective role of magnetized water in enhancing the related growth parameters such as plant height, mean number of branches / plant, stem thickness and root length as shown in Table (2) which may lead to an increase in water absorption contained the required both macro and micro-nutrients and consequently a stimulatory influence in this

respect was occurred. These results were similar to those obtained by Nasher (2008) on chick pea, Ameen and Kassim (2009) on *Jerbera jamisonil* L., Vashisth and Nagarjan (2010) on *Helianthus annus* L. plants and Midan and Tantaway (2013) on snap bean.

2. Chemical analysis:

2.1. Effect of soil salinity levels:

The data in Tables (2, 3) clearly indicate that essential oil percentage in the fruits of *Carum carvi* L. plants as well as the produced essential oil yield / plant were decreased with increasing soil salinity levels in the two experimental seasons. The treatment of the low levels of salinity 0.10% (S_1) gave significantly lower essential oil percentage in caraway fruits in comparison with the control (S_0) in both growing seasons, meanwhile it resulted in significantly higher values in this respect were compared with those of 0.20% (S_2) and 0.30% (S_3) salinity levels in the two experimental seasons. Otherwise, the least grown under the highest level of salinity (0.30%) in the two growing seasons. The measured essential oil percentages in caraway fruits were 3.53, 3.42, 3.35 and 3.21% in the first season, whereas in the second one it was 3.43, 3.34, 3.26 and 3.22% for the treatments of S_0, S_1, S_2 and S_3, respectively as shown in Table (2).

Table (3): Effect of soil salinity levels, irrigation with magnetized water and their interaction on fresh and dry weight / plant, No. of umbels / plant, fruit yield / plant and essential oil percentage in the fruits of *Carum carvi* L. plants during the growing seasons of 2009/2010 and 2010/2011.

Treatments	The First season (2009/2010)					The second season (2010/2011)				
S. levels (S) / Magn. (M)	S_0	S_1	S_2	S_3	Mean	S_0	S_1	S_2	S_3	Mean
	Fresh weight / plant (g)									
M_0	88.28	85.30	70.70	62.27	76.51	91.20	88.47	71.83	59.40	77.73
M_1	91.70	89.27	75.33	65.47	80.44	96.10	95.45	74.07	61.12	81.69
Mean	89.99	87.29	72.75	63.87	-	93.65	91.96	72.95	60.26	
L.S.D. at 0.05	S=3.06 M=2.16 M×S=4.32					S=2.68 M=1.90 M×S=3.80				
	Dry weight / plant (g)									
M_0	12.36	11.79	9.12	7.48	10.19	13.23	13.24	9.34	7.92	10.93
M_1	13.30	12.48	11.30	9.16	11.56	14.40	13.66	10.11	8.25	11.61
Mean	12.83	12.14	10.21	8.32	-	13.82	13.45	9.73	8.09	-
L.S.D. at 0.05	S=0.45 M=0.32 M×S=0.64					S=0.51 M=0.36 M×S=0.72				
	No. of umbels / plant									
M_0	15.10	14.34	11.27	9.26	12.49	18.39	17.77	12.17	9.66	14.50
M_1	20.02	19.75	14.23	11.44	16.36	20.40	19.96	14.65	12.05	16.77
Mean	17.56	17.05	12.75	10.35	-	19.40	18.87	13.41	10.86	-
L.S.D. at 0.05	S=1.30 M=0.92 M×S=1.84					S=1.46 M=1.03 M×S=2.06				
	Fruit yield / plant (g)									
M_0	9.06	8.80	6.63	5.51	7.50	11.03	10.90	6.95	5.45	8.58
M_1	12.02	11.78	8.10	6.57	9.62	12.24	11.80	9.92	6.87	10.21
Mean	10.54	10.29	7.37	6.04	-	11.64	11.35	8.43	6.16	-
L.S.D. at 0.05	S=0.70 M=0.53 M×S=1.06					S=0.80 M=0.56 M×S=1.12				
	Essential oil (%) in the fruits									
M_0	3.51	3.38	3.28	3.17	3.34	3.41	3.33	3.26	3.19	3.30
M_1	3.55	3.46	3.42	3.25	3.42	3.45	3.34	3.25	3.24	3.32
Mean	3.53	3.42	3.35	3.21	-	3.43	3.34	3.26	3.22	-
L.S.D. at 0.05	S=0.04 M=0.02 M×S=0.06					S=0.05 M=0.03 M×S=0.07				

* S = Salinity levels M = Magnetic treatment of water

The data in Table (4) show that the produced essential oil yield / plant followed the previously stated trend of both fruit yield and its essential oil percentage which reflects the negative effect of soil salinity in this respect. The produced essential oil yield was 0.38, 0.36, 0.25 and 0.19 ml / plant in the first season, whereas in the second one it was 0.40, 0.38, 0.28 and 0.26 ml / plant for the treatments of S_0, S_1, S_2 and S_3, respectively. These results could be attributed to the effect of salinity stress on the produced number of umbels and the obtained fruit yield / plant as shown in Table (2). These results are similar to those obtained by Ashraf and Akhtar (2004) on *Foeniculum vulgare* L., Ashraf *et al.* (2004) and Kandil and El-Eiwa (2008) on *Ammi magjus* L.

Table (4): Effect of soil salinity levels, irrigation with magnetized water and their interaction on essential oil yield / plant, NPK and total carbohydrate percentages in the dried herb of *Carum carvi* L. plants during the growing seasons of 2009/2010 and 2010/2011.

Treatments	The First season (2009/2010)					The second season (2010/2011)				
S. levels (S) / Magn. (M)	S_0	S_1	S_2	S_3	Mean	S_0	S_1	S_2	S_3	Mean
	Essential oil yield (ml / plant)									
M_0	0.32	0.30	0.22	0.18	0.76	0.38	0.36	0.223	0.17	0.28
M_1	0.43	0.41	0.28	0.21	0.33	0.42	0.39	0.32	0.22	0.34
Mean	0.38	0.36	0.25	0.19	-	0.40	0.38	0.28	0.26	-
L.S.D. at 0.05	S=0.04 M=0.03 M×S=0.06					S=0.03 M=0.02 M×S=0.04				
	N % in the dried herb									
M_0	2.79	2.58	2.46	2.17	2.50	2.78	2.66	2.45	2.14	2.51
M_1	3.01	2.80	2.55	2.26	2.66	3.16	2.97	2.66	2.36	2.79
Mean	2.90	2.69	2.51	2.22	-	3.19	2.82	2.56	2.25	-
L.S.D. at 0.05	S=0.15 M=0.10 M×S=0.20					S=0.12 M=0.08 M×S=0.16				
	P % in the dried herb									
M_0	0.18	0.17	0.15	0.12	0.16	0.16	0.15	0.12	0.11	0.14
M_1	0.20	0.19	0.17	0.14	0.18	0.19	0.17	0.13	0.12	0.15
Mean	0.19	0.18	0.16	0.13	-	0.18	0.16	0.13	0.12	-
L.S.D. at 0.05	S=0.02 M=0.01 M×S=0.03					S=0.03 M=0.02 M×S=0.04				
	K % in the dried herb									
M_0	3.21	3.12	2.87	2.40	2.90	2.81	2.58	2.36	2.31	2.50
M_1	3.32	3.21	2.99	2.58	3.03	3.05	2.88	2.62	2.38	2.73
Mean	3.27	3.17	2.93	2.49	-	2.93	2.73	2.49	2.35	-
L.S.D. at 0.05	S=0.09 M=0.06 M×S=0.12					S=0.11 M=0.08 M×S=0.16				
	Total carbohydrate (%)									
M_0	12.58	12.32	11.70	10.42	11.76	11.80	11.36	10.42	9.56	10.79
M_1	14.70	14.15	13.40	11.35	13.40	13.90	12.80	11.38	10.80	12.22
Mean	13.64	13.24	12.5	10.88	-	12.85	12.08	10.90	10.18	-
L.S.D. at 0.05	S=0.68 M=0.48 M×S=0.95					S=1.17 M=0.83 M×S=1.64				

* S = Salinity levels M = Magnetic treatment of water

Furthermore, the recorded data in Table (3) indicate clearly that the mineral content (N, P and K%) as well as the total carbohydrate percentage in the dried herb were negatively influenced by the different levels of soil salinity compared with the control without salt application in both growing seasons. These results could be attributed to the harmful effect of salinity on the root system (Table 2) and consequently reducing the uptake of the available N, P and K elements which affected negatively on plant growth and its content from synthesized total carbohydrates. Such results were obtained by Mohamed (2000) on *Carandrum sativum* L., Abd El-Wahab (2006) on *Foeniculum vulgare* L.and El-Dabh *et al.* (2011) on *Moringa oleifera* plants.

2.2. Effect of irrigation with magnetized water:

The data in Tables (2, 3) show that, irrigation of caraway plant with magnetically treated water increased essential oil content in the fruits, mineral contents (N, P and K%) as well as total carbohydrate percentage in the dried herb in comparison with those irrigated with non magnetized water in the two experimental seasons. This effect could be explained by the findings of Al-Nimer *et al.* (2011) who found that the magnetized treated water was an effective solvent and has the ability to dissolve the nutrient elements easier and faster than purified water (non magnetized) and consequently enhance the metabolic process in the plant which was reflected in improving essential oil content in the fruits of caraway plants and augmented N, P and K nutrients uptake and the synthesis of carbohydrates as shown in Tables (3, 4). These results are similar to those obtained by Mostafa (2002) on *Calendula officinalis* L. and *Dimorphotheca ecklonis* L., Maheswari and Grewal (2009) on celery and Midan and Tantaway (2013) on snap bean.

2.3. Effect of interaction between soil salinity levels and irrigation with magnetized water:

It is evident from the data in Tables (2, 3) that essential oil percentage, essential oil yield / plant, N, P and K% as well as total carbohydrate content in the dried herb of *Carum carvi* L. plants grown under the different levels of salinity were considerably improved as a result of irrigating the plants with magnetized water in comparison with those grown under the same saline conditions and irrigated with ordinary water (non magnetized) in the two growing seasons. The best results in this concern were obtained by the treatment of irrigation with magnetized water (M_1) without salt addition (S_0). Meanwhile the lowest recorded values in this respect were obtained by the treatment of irrigation with ordinary water + the highest level of soil salinity (0.30%) in the two experimental seasons.

These results reflect the effective role of watering with magnetically treated water in enhancing the metabolic process in the plant and reducing the harmful effect of salinity on the plants grown under saline conditions. This trend was reviewed also by Ameen and Kassim (2009) on *Jerbera jamisonii* L., Mostafa (2002) on *Calendula officinalis* L. and *Dimorphotheca ecklonis* L., El-Khazan *et al.* (2011) on Jojoba plants and Midan and Tnataway (2013) on snap bean.

Conclusion:

From the obtained results in this investigation it could be concluded that, the vegetative growth and yield measurements as well as chemical constituents of the plant (essential oil content in the fruits, N, P and K% and total carbohydrate content in the dried herb) were markedly improved as a result of irrigating caraway plants grown under different levels of soil salinity with magnetized water in comparison with those irrigated with non magnetized water. The best results in this respect were obtained by the treatment of irrigation with magnetized water without salt addition to the soil (S_0). Meanwhile, the treatment of irrigation with ordinary water (non magnetized) plus the highest level of soil salinity (0.30%) resulted in significantly the lowest values in this concern. Also, it could be noticed that irrigation with magnetized water reduced the harmful effect of salinity stress on the growth

and chemical constituents of caraway plant if compared with those irrigated with non magnetized water (M_0).

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تأثير مستويات الملوحة والرى بالماء الممغنط على النمو ومحتوى الثمار من الزيت الطيار والمكونات الكيميائية لنباتات الكراوية

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الملخص العربى

أجريت تجربة أصص بمزرعة كلية الزراعة بشبين الكوم – جامعة المنوفية خلال موسمى 2010/2009 ، 2011/2010 وذلك بهدف دراسة تأثير أربعة مستويات للملوحة الأرضية هى صفر ، 0.1 ، 0.2 ، 0.3% مع الرى بالماء الممغنط وكذلك الماء العادى على صفات النمو والمحصول ومحتوى الثمار من الزيت الطيار وكذلك التركيب الكيماوى لنباتات الكراوية المنزرعة فى أصص بلاستيكية قطرها 30 سم وملئت بـ 4.5 كجم من التربة الطمية بعد خلطها بتركيزات الأملاح السالفة الذكر (مخلوط من كلوريد الكالسيوم وكلوريد الصوديوم بنسبة 2 : 1) وقد صُممت التجربة كتجربة عاملية فى قطاعات كاملة العشوائية ومُثلث كل معاملة بثلاث مكررات .

وتتلخص النتائج المتحصل عليها فى الآتى :

1- أدى استعمال التركيزات المختلفة للملوحة إلى حدوث نقص تدريجى بزيادة تركيزات الملوحة فى صفات طول النبات ، عدد الأفرع / للنبات ، سُمك الساق ، طول الجذور وكذلك الوزن الطازج والوزن الجاف للنبات مقارنةً بالكنترول (بدون إضافة ملح للتربة). وقد سجلت المعاملة بالتركيز الأعلى من الملوحة (0.3%) أقل القيم فى هذا الخصوص .

2- أدت معاملة الرى بالماء الممغنط إلى حدوث تحسن ملحوظ فى قياسات النمو السابقة مقارنةً بالرى بالماء العادى . وقد سجلت معاملة التفاعل فى حالة استعمال الرى بالماء الممغنط مع عدم إضافة أملاح للتربة إلى تحقيق أفضل النتائج فى هذا الخصوص .

3- أثرت مستويات الملوحة المختلفة سلباً على كلٍ من عدد النورات / للنبات وكذلك محصول الثمار / للنبات مقارنةً بالكنترول . وقد سجلت معاملة المستوى العالى من الملوحة (0.30%) أقل القيم فى هذا الصدد .

4- أدى الرى بالماء الممغنط إلى حدوث تحسن واضح فى كلٍ من عدد النورات / النبات وكذلك وزن الثمار / للنبات فى كلٍ من موسمى التجربة مقارنةً بالرى بالماء العادى . وقد سجلت معاملة الرى بالماء الممغنط مع عدم إضافة أملاح للتربة أفضل القيم فى هذا الخصوص .

5- أدت معاملة الملوحة إلى حدوث نقص واضح فى كلٍ من النسبة المئوية للزيت الطيار ومحصوله وكذلك فى محتوى العشب من عناصر النيتروجين والفوسفور والبوتاسيوم والكربوهيدرات الكلية وكانت أقل القيم فى هذا الخصوص عند استعمال التركيز العالى من الملوحة بينما أدت معاملة الرى بالماء الممغنط إلى حدوث تحسن واضح فى هذا الصدد مقارنةً بالرى بالماء العادى . وسجلت معاملة الرى بالماء الممغنط مع عدم إضافة أملاح للتربة أعلى القيم فى هذا الصدد فى كلا الموسمين مقارنةً بباقى المعاملات .