Middle East Journal of Agriculture Research
ISSN 2077-4605

Volume : 07 | Issue : 03 | July-Sept. | 2018
Pages:958-976

Improvement growth, yield and quality, nutritional value and essential oil content of sweet fennel plants grown under salinity stress using organic manure

Zaki M.F., A.A. Ahmed, A.M. El- Bassiony, Z. F. Fawzy and Yomna I. Helmy

Vegetable Res. Department, Agricultural and Biological Research Division, National Research Centre, 33 El Behouth St., (Former El Tahrir St.) 12622 Dokki, Giza, Egypt.

Received: 22 May 2018 / Accepted: 30 July 2018 / Publication date: 25 August 2018

ABSTRACT

An irrigation plants by using salinity water is a critical constraint to the production of certain vegetable crops, salinity has been considered as one of the most important factors of irrigation water. The objective of this study was to investigate the response of sweet fennel plants to various salinity levels of irrigation water (EC_w) and using natural organic manure to minimizing the adverse effective of irrigation water salinity in open field conditions.

Two pot experiments were conducted on sweet fennel cultivar "Zefa fino" amid two winter periods of 2013/2014 and 2014/2015 at El-Kassasein, Ismailia Governorate, Egypt. Treatments were combined between two rates of natural organic manure, for example, chicken manure (without and with) and six saline irrigation water concentrations, .i.e., well water (Control), 1000, 2000, 3000, 4000 and 5000 ppm.

Results demonstrated that utilizing natural organic manure treatment expanded all the vegetative development parameters recorded as plant height; leaves number per plant; fresh and dry weight of the total plant and its organs, i .e. leaves and bulbs ; total green yield and nutrients content in leaves and bulbs (N, P and K). Likewise, K/Na ratio, calcium, proline substance of bulbs and essential oil content of leaves and bulbs were increased by adding natural organic manuring.

Sodium content in bulbs was brought down by natural organic manure application. Vegetative growth and green yield parameters were not influence even at 1000 ppm which gave the standard characters of bulbs (Mean bulb weight < 250 g/plant) and there was a proportionate impact with each increase in saltiness to a greatest at 5000 ppm. Despite what might be expected, increasing saltiness of irrigation water diminished vegetative growth, green yield, bulb quality and chemical content in a descending order up to the highest level of salinity (5000 ppm).

Additionally, under salinity of irrigation water conditions; natural bulb quality, .i.e. length, width and thickness were essentially decreased. The interaction between natural organic fertilizer and saltiness concentrations of irrigation water gave positive results regarding the previously mentioned parameters and negative results with different parameters. Therefore, sweet fennel plant is sensitive to salt stress. Furthermore, the present study demonstrated that the continuous irrigation of saline water irrigation under open field conditions could lead to a significant increase in electric conductivity (ECe) level and Na^+ concentration in soil, as well as Na^+ concentration in leaves of crops.

Keywords: Sweet fennel, Salinity, Salt tolerance, Saline irrigation water, Organic manure, Chicken manure, Mineral fertilizer, Green yield, Free proline.

Introduction

Utilizing of saline irrigation water adverse effects soil – water – plant relations, periodically extremely confining the normal physiological activity and productive capacity of the crops (De Pascale *et al*., 2013 and Plaut *et al*., 2013).

Under high saltiness level, the crop growth, leaf surface expansion, and essential carbon metabolism of numerous crops are negatively affected due to osmotic impact, water shortage, nutritional imbalance, and oxidative stress (Kim *et al*., 2008). A few crops are delicate to saltiness and the negative impact on growth prompts the decreasing in potential benefits. Consequently, saltiness has been considered as a standout amongst the most essential factors of irrigation water (Beltran *et al*.,

Corresponding Author: Mohamed Fathy Zaki, Vegetable Res. Department, Agricultural and Biological Research Division, National Research Centre, 33 El Behouth St., (Former El Tahrir St.) 12622 Dokki, Giza, Egypt. E-mail: el_shakry2005@yahoo.com

1999). In updating saline irrigation water can likewise bring about salt gathering in soil, prompting the decrement in yield and decay in soil resource (Feizi *et al*., 2010).

Recently, untraditional vegetable crops became to more significance for exportation and local consumption. Sweet fennel plants are utilized fresh for salad and in cooking. Dried leaves could be utilized as a hot drink. Moreover, fennel oil implantation is utilized as aromatic carminative, stimulant and condiment. It is a new crop cultivated in scattered areas for exportation. So that, it became of great importance to study its cultivars, fertilization and irrigation requirement.

Sweet fennel is an essential medicinal and aromatic plant. Swollen stem bases, leaves and seeds contain essential oil and are used as flavoring agents in food products such as liqueurs, bread, pickles, pastries, and cheese. They are likewise utilized as a constituent of corrective and pharmaceutical items. Fennel is one of the real basic oil plants developed and the essential oil concentration in the plants is between 3-6% in the mature fruit (Telci *et al*., 2009).

In the most recently reclaimed soils, growing sweet fennel plants is faced by many different problems, for example, saltiness of soils and irrigation water in numerous areas, low amounts of available supplements and low organic matter content and additionally poor hydrophilic, chemical and biological properties. The best methods for keeping up soil fertility, profitability and salt tolerance could be through periodic addition of organic manures such as cattle, cheep, poultry manures and composts.

Although few studies were conducted to investigate the impacts of salinity on fennel, most investigations analyzed the impacts of Na Cl (Graifenberg *et al*., 1996; Ashraf and Akhtar, 2004) or diluted see water (Zaki *et al*., 2009 a and b) under sandy soils (>85% sand) which may result in Ca deficiency.

Some investigators studied the impact of irrigation with saline water on sweet fennel plant (Pascale and Barbieri, 1995; Graifenberg *et al*., 1996; Yadav *et al*., 1996; Ahmad, 1999; Caliandro *et al*., 2000; Abou El-Magd *et al*., 2008; Zaki *et al*., 2009 a and b; Tantawy *et al*., 2013; Gehan, 2015; Tantawy *et al*., 2016 and Abou El-Magd *et al*., 2017). Different agents detailed that, organic fertilization expanded salt resistance of some vegetable crops under saline conditions (El-Missery, 2003 on cabbage and spinach; Saleh *et al*., 2003 on onion and Hakkwan *et al*., 2016 on lettuce and Chinese cabbage).

So that, this work was studied to evaluate sweet fennel plants under saline water irrigation concentrations, to examine the long-term impacts of saline irrigation water on growth, green yield and bulb quality, and the salinity accumulation in soil and the role of organic fertilization in decreasing their salt affect's.

Materials and Methods

Two pot experiments were conducted on sweet fennel (*Foeniculum vulgare* Mill. var. Zefa fino) Fam. Apiaceae (Umbellifera) in a zone of recently reclaimed land at El-Kassasin, Ismailia Governorate, Egypt, during the two progressive winter seasons of (2013/2014 and 2014/2015).

Soil investigation is presented in Table (1); Soil physical properties were analyzed utilizing the methods described by Black *et al.* (1981). While soil chemical analysis was estimated according to the procedures described by Chapman and Pratt (1961). Soil analysis was done toward at the begin of experiments. Investigation of water system water is displayed in Table (2).

Sweet fennel seeds cv. Zefa fino were sown in the nursery in foam plate loaded with a mixture of peat moss and vermiculite (1:1 volume) on 15 th of August in 2013 season and 17 th of August in 2014 season. Plates were then kept under unheated plastic house conditions. All required agricultural managements for seedling production were carried out. Seedlings were then transplanted in the pots on the first of October and third of October in 2013 and 2014, respectively. Pots of 40 cm diameter were filled each with 20 kg sandy soil of the area. Five hundred grams of poultry manure were mixed carefully with the soil of each pot of the natural organic manure. Seedlings of sweet fennel were then transplanted in all pots. Plants were similarly inundated with well water for a month. Before salinization plants were thinned to remain three plants very well dispersed in each pot. Sea water was analyzed for determining its total saltiness.

Table 1: Physical and chemical properties of the experimental soil during the two seasons of 2013/2014 and 2014/2015.

A. Physical properties			
Characters		**2013/2014**	**2014/2015**
Soil texture		**Loamy sand**	**Loamy sand**
Clay %		11.38	13.54
Silt %		0.66	1.25
Sand %		87.96	85.21
B. Chemical properties			
PH		8.40	8.37
E.C(mmhos)		2.10	1.06
$CaCo_3$ %		1.00	1.25
Cations	**Ca^{++}(Milliequivalent/ L)**	23.00	22.00
	Mg^{+2}	12.00	11.00
	Na^{+1}	14.00	17.35
	K^{+1}	2.79	2.62
Anions	**Co_3^-**	-	-
	HCO_3^-	7.10	4.55
	Cl^{-1}	26.00	25.00
	$So_4^=$	18.69	23.42

Table 2: Chemical analysis of irrigation well water during two seasons of 2013/2014 and 2014/2015.

A. Chemical analysis :-		**2013/2014**	**2014/2015**
PH		7.10	7.51
E.C(mmhos)		1.29	1.17
Cations	**Ca^{++}(Mill equivalent/L)**	5.0	4.0
	Mg^{+2}	3.1	2.1
	Na^{+1}	4.82	6.73
	K^{+1}	0.44	0.53
Anions	**$Co3^-$**	-	-
	$HCO3^-$	4.2	3.4
	Cl^{-1}	4.32	5.80
	$So_4^=$	4.84	4.16

The concentration of the sea water stock utilized was 34000 ppm add up to salts which contained Ca 4000 ppm, Mg 1272.0 ppm, Na 9430.1 ppm, K 380.0 ppm, Co_3 12.0 ppm, HCO_3 97.9 ppm, SO_4 2496.0 and Cl 16312.0 ppm. Water irrigation was done with saline water utilizing one liter/pot/day to keep up soil water content at the range 60-65% of water holding capacity (WHC). All plants got the same agricultural practices. The untreated pots were irrigated with well water. Steady level of soil moisture (Field capacity + 25%) was kept up by utilizing the diluted saline sea water treatments for irrigation when the plants reached near the wilting point.
On the other hand, poultry manure content of total and available N, P and K and accessible was presented in Table (3) and their analysis followed the procedures of Black *et al*. (1981).

Treatments were as follows:-

A. Organic manure treatments:

Two treatments of poultry manure, i.e. control (without organic manure) and with organic manure. All the control plants received mineral fertilization without organic manure (4.0 g ammonium nitrate (33.5% N), 4.0 g calcium super phosphate (15.5% P_2O_5) added one time with soil before transplanting and 2.0 g potassium sulphate (48% K_2O) at monthly into three equal doses one month after transplanting 30 days from the first one, 30 days after the second one] beside plants. Whereas, the plants which received organic manure only took the same level of calcium super phosphate and potassium sulphate and the same times of adding fertilizers.

Table 3: Chemical analysis of poultry manure during the two seasons of 2013/2014 and 2014/2015.

Mineral contents	First season(2013/2014)	Second season (2014/2015)
N %	2.20	2.46
P %	0.91	1.80
K %	1.40	2.37
Fe ppm	240	230
Mn ppm	342	266
Zn ppm	140	180
Cu ppm	97	36
Pb ppm	1.01	1.20
Cd ppm	1.10	0.90
Ni ppm	2.10	3.60
Co ppm	8.00	6.00
C/N	4.29	7.40
D.M %	28.1	46.5
O.C %	16.3	27.0
Humidity%	17.20	17.48

B. Salinity concentrations:

Sea water was analyzed for determining its total salinity. Six irrigation water treatments were used. Control (Irrigation water of the location) and five dilutions of sea water were adjusted carefully at 1000,2000,3000,4000 and 5000 ppm.

Experimental design:

Each replicate included 12 treatments which were the combinations of two organic manure treatments and six saline water irrigation treatments. Every treatment was replicated in five pots. The split plots design with five replicates was used. The main plots were organic manure, whereas the sub plots were assigned for the salinity concentrations as the sub plots. Data were subjected to proper statistical analysis according to Snedecor and Cochran, 1980.

Data recorded: -

I) - Vegetative growth characteristics:

A random sample of three plants was taken at 120 days from transplanting during the two seasons and the following data were recorded, i.e., plant height (cm), leaf numbers/plant, bulb thickness (cm), bulb width (cm), bulb length (cm), fresh and dry weight of leaves, bulbs and total plant (g/plant).

II) - Chemical content:

A. Mineral content:

The percentages of nitrogen, phosphorus and potassium in the acid digested samples of dry leaves and bulbs, were determined as follows:
- Total nitrogen was determined according to the procedure described by Koch and McMeekin (1924).Phosphorus was determined colorimetric-ally according to the method described by Trough and Meyer (1939) and Potassium was determined using Flame Photometer according to Brown and Lilleland (1946).
- Sodium and calcium were determined in bulbs of sweet fennel using the methods suggested by A.O.A.C. (1995).

B. Free proline:

The proline content was determined on bulbs fresh weight basis according to Bates *et al*. (1973) using the following equation:

$$\mu \text{ moles proline /g F.W} = \frac{\text{mg proline} \times \text{ml Toluene}}{11.5 \times \text{g sample} \times 5}$$

III) - Total green yield and quality:

All the plants of every pot of the experiment were harvested at 120 days from transplanting and the data were recorded:-

1. Green yield (kg/pot).

2. Essential oil content: At harvest, samples of leaves and bulbs of each treatment were subjected to hydro distillation in order to determine the essential oil according to Guenther (1961):-

- Essential oil percentage (V/W) in leaves and bulbs.
- Essential oil content (ml. / plant) in leaves and bulbs.

3. Chemical bulb quality: (T.S.S; total Acidity; ascorbic acid and crude fiber).

- Total soluble solids (T.S.S.) were determined by a hand refract-meter, according to the method described by A.O.A.C. (1980).
- Ascorbic acid was evaluated using 2, 6 di-chlorophenol-indophenol method as described by A.O.A.C. (1995).

Results and Discussions

I) - Vegetative growth

A. Effect of organic fertilization:

Data presented in Table (4) demonstrated that natural organic fertilization led to statistical increases in the vegetative growth parameters of sweet fennel plants expressed as plant height, leaves number, bulb dimensions (Thickness, width and length) as well as fresh and dry weight of total plant and its organs, i. e. leaves and bulbs. These increments were statistical and similar in the two seasons of this study.

Bulb measurements (thickness, width and length) were adversely influenced by irrigation water saltiness (Table, 4). There was adverse impact in bulb dimensions due to salinity increase. Lower values of bulb thickness, width and length were obtained by the high irrigation water salinity. Bulb measurements are the summation of the vegetative growth and photosynthetic activity. So that, bulb dimensions were antagonistically influenced by saltiness increments. This adverse impact may be because of the unsafe impact of saltiness of irrigation water on the vegetative growth, photosynthesis, transpiration and dry matter accumulation. These harmful impacts reflect decreases in the NAR, RGR and CGR which in turn decreased bulbing and bulb dimensions. Bulb dimensions were increased as salinity if irrigation water decreased up to 1000 ppm. The highest values of bulb dimensions were obtained by the well water (control) followed by irrigation with 1000 ppm sea water.

Comparable results were acquired on sweet fennel by El-Kassas (1999); El-Desuki *et al.* (2001); Ali (2002); El-Ghawwas *et al*. (2002); Kandil (2002); Abou El-Magd *et al*. (2008) and Zaki *et al*. (2009a).

Saleh *et al*. (2003) on onion stated that natural organic fertilization enhanced the availability of certain elements and their supply to the plant during growth period. However, poultry manure increased the presence of P, K and Mg in the soil beside the solubility of Ca, Mg and NO_3 as a result of the continuous lowering of pH by organic fertilizer application and to the increase of electrical conductivity. The increase in vegetative growth might also be due to improvement of the structure of the soil by increasing the soil water holding capacity which gave rise to good aeration and drainage that encourage better root growth and nutrient absorption. Slow release of nutrients is a favorable form for roots absorption (Ohallorans *et al.*, 1993). In addition, organic matter may affect plant growth as a source of growth promoters, Axins, Vitamins, Amino acids which act on the vegetative

growth, yield and quality of the plant product (Melo and De -Oliveira, 1999).The increment in the green yield was the sum of the increments in the vegetative growth characteristics.

B. Effect of irrigation water salinity:

Data displayed in Table (5) demonstrate that vegetative growth of sweet fennel plants was statistically decreased by increasing irrigation water saltiness (EC_w). As irrigation water salinity concentration increased vegetative growth characteristics were decreased. Linear decrement was recorded in plant height, bulb dimensions (thickness, width and length) as well as fresh and dry weight of total plant and its organs, i. e. leaves and bulbs by increasing salinity of irrigation water up to the highest level (5000 ppm). These results were similar and statistical in the two seasons of the experiment. Irrigation by well water (control) and 1000 ppm treatments created the tallest plant, good quality of bulb dimensions (thickness, width and length) and the heaviest fresh and dry weight of total plant and its organs, i. e. leaves and bulbs. While, the shortest plants resulted from the highest salinity level (5000 ppm) in both seasons.

Similar results were obtained by Mangal *et al.* (1986) on coriander and fennel. They found that plant height was practically unaffected by low salinity mmhos/cm^3 but decreased rapidly under higher salinity levels. Also, Singh *et al*. (1986) found that plant height in some vegetable crops showed a characteristic continuous depression with the increase in salinity levels. These results are similar to those obtained by Amin (1994) who reported that salinity treatment (2000, 4000, and 6000 ppm) in most cases produced the low values of plant height of fennel. Pascal and Barbieri (1995) reported that plant height of some vegetable crops was significantly reduced by the high soil salinity levels. Ravender-Sing *et al.* (1995) working on fennel plants found that application of saline water decreased the plant height. (Ahmad, 1999) reported that the tallest sweet fennel plant, the greatest leaves number per plant and the heaviest fresh weight were resulted from irrigation with saline water at the medium concentration of 1000 and 2000 ppm while the lowest value were exerted from the highest concentrations of 3000 ppm.

Amin (1994) found that fresh and dry weights of sweet fennel plants were significantly decreased with increasing salinity. This reduction in fresh weight may be due to the increase of plant osmotic pressure which led to depression in water absorption. Graifenberg *et al.* (1996) working on fennel plants found that whole plant fresh weight began to decrease associated with increased salinity. In any case, the lessening in the vegetative growth and green yield of sweet fennel as a result of increasing salinity concentrations might be due to the increase in osmotic pressure that affects the ability of the plant to absorb water for its growth processes from the soil solution and/or the toxicity of specific ions to different plant physiological procedures. It may be additionally due to the secondary specific-ions effects of sodium as the excess of exchangeable sodium can lead to soil swelling and /or dispersion causing water infiltration, aeration and root penetration problems (Ayers, 1952). The harmful impacts of irrigation with saline water on sweet fennel might be related to the injurious effect of specific ions such as Na Cl, Ca Cl_2 and Na SO_4 which inhibited the production of chlorophyll and carotene in leaves, high sodium concentration that induced calcium and magnesium nutritional deficiencies and influenced the respiratory pathways in roots (Abel and Mackenzie, 1964).However, long term exposure of roots to high salt concentration make the plants suffer from drought (Bernstein, 1975), reduced water and nutrient availability, make direct toxic effect of different ions because of emplaces of mineral nutrition (Bower,1976), limited photosynthesis because of reduction in stomata conduction and increasing stomata limitations to CO_2 uptake (Pascale and Barbieri, 1995) and changed enzymatic activities in the plant (Abd el-Razaek,1997).

C. Effect of the interaction:

The recorded data in Table (6) demonstrate that the highest vegetative growth was obtained by the combined effect of organic fertilization and irrigation water salinity.

It is obvious from the data that application of organic manure treatment decreased the adverse effect of salinity on the vegetative growth of sweet fennel plants. The lowest values of vegetative growth characters were recorded when the plants received mineral fertilization with irrigation by the highest concentration of diluted sea water. These results were similar and true in the two seasons of

Table 4: Effect of organic manure on vegetative growth of sweet fennel plants at 120 days from transplanting during two seasons (2013/2014 and 2014/2015).

Organic manure	Plant height (cm)	Leaves No./ plant	Bulb dimensions			Fresh weight (g/plant)			Dry weight (g/plant)		
			Thickness (cm)	Width (cm)	Length (cm)	Leaves	Bulbs	Total	Leaves	Bulbs	Total
First season (2013/2014)											
Without	47.41	8.70	6.11	6.75	8.00	174.50	169.21	343.71	22.99	12.71	35.70
With	55.41	10.42	8.11	8.66	9.43	258.86	273.47	532.33	32.74	31.60	64.34
L.S.D. at $_{0.05}$	4.97	0.65	0.37	0.48	0.39	47.76	43.50	88.51	2.34	0.78	2.84
Second season (2014/2015)											
Without	46.22	8.80	6.76	6.65	7.82	171.43	164.41	335.84	21.25	12.63	33.88
With	52.44	9.70	7.88	8.26	8.87	247.72	259.32	507.04	30.59	28.29	58.88
L.S.D. at $_{0.05}$	1.11	0.60	0.22	0.19	0.49	6.15	24.46	30.19	2.06	1.35	2.25

Table 5: Effect of salinity concentrations on vegetative growth of sweet fennel at 120 days from transplanting during two seasons (2013/2014 and 2014/2015).

Salinity conc.	Plant height (cm)	Leaves No./ plant	Bulb dimensions			Fresh weight (g/plant)			Dry weight (g/plant)		
			Thickness (cm)	Width (cm)	Length (cm)	Leaves	Bulbs	Total	Leaves	Bulbs	Total
First season (2013/2014)											
Control	65.89	10.89	8.78	8.97	10.65	408.22	373.53	781.75	56.22	41.38	97.59
1000	57.50	10.22	8.38	8.58	9.99	360.22	316.33	676.56	41.06	33.89	74.95
2000	49.83	9.86	7.41	8.22	8.95	234.17	217.00	451.17	31.31	20.84	52.15
3000	47.44	9.44	6.82	7.93	8.21	153.08	164.00	317.07	17.62	16.48	34.11
4000	45.22	8.83	5.98	6.43	7.80	88.50	133.17	221.67	12.74	10.96	23.70
5000	42.56	8.11	5.29	6.12	6.69	55.89	124.00	179.89	8.22	9.38	17.60
L.S.D. at $_{0.05}$	2.12	0.28	0.40	0.29	0.41	15.24	10.91	20.89	2.59	0.77	2.61
Second season (2014/2015)											
Control	74.78	10.72	8.76	10.34	11.76	386.56	313.22	699.78	50.86	33.02	83.89
1000	67.19	10.39	8.22	9.14	10.48	280.39	284.12	564.51	34.10	28.02	62.12
2000	54.67	9.67	7.65	8.56	9.06	250.71	270.69	521.40	31.33	24.27	55.61
3000	44.56	9.50	6.97	6.88	7.83	146.43	160.85	307.28	16.78	14.69	31.47
4000	29.97	8.11	6.47	5.54	6.18	103.73	128.63	232.36	12.09	12.37	24.46
5000	24.79	7.11	5.84	4.27	4.78	89.64	113.68	203.32	10.35	10.38	20.73
L.S.D. at $_{0.05}$	0.67	0.27	0.09	0.13	0.21	3.17	16.89	16.02	1.37	0.91	1.62

Table 6: Effect of the interaction between Organic manure with Salinity Concentrations on vegetative growth of sweet fennel plants at 120 days from transplanting during two seasons (2013/2014 and 2014/2015).

Organic manure	Salinity conc.	Plant height (cm)	Leaves No./ plant	Bulb dimensions			Fresh weight (g/plant)			Dry weight (g/plant)		
				Thickness (cm)	Width (cm)	Length (cm)	Leaves	Bulbs	Total	Leaves	Bulbs	Total
First season (2013/2014)												
Without	Control	62.94	10.11	6.77	7.69	9.81	290.64	284.93	575.56	37.77	22.39	60.16
	1000	52.94	9.44	7.21	7.73	8.90	276.11	222.00	498.11	35.64	18.33	53.97
	2000	45.83	8.89	6.92	7.34	8.18	250.00	189.33	439.33	30.15	13.93	44.08
	3000	44.06	8.56	6.14	6.99	7.68	108.00	129.00	237.00	16.26	11.74	28.00
	4000	40.50	8.00	5.06	5.51	7.13	90.00	98.33	188.33	12.75	5.65	18.40
	5000	38.17	7.22	4.57	5.24	6.31	32.22	91.67	123.89	5.38	4.19	9.57
With	Control	68.83	11.67	10.79	10.24	11.49	525.81	462.13	987.93	74.67	60.36	135.03
	1000	62.06	11.00	9.54	9.43	11.09	444.33	410.67	855.00	46.49	49.44	95.93
	2000	53.83	10.83	7.90	9.10	9.72	218.33	244.67	463.00	32.47	27.75	60.22
	3000	50.83	10.33	7.50	8.87	8.73	198.15	199.00	397.15	18.99	21.23	40.21
	4000	49.94	9.67	6.90	7.36	8.47	87.00	168.00	255.00	12.72	16.27	29.00
	5000	46.94	9.00	6.01	6.99	7.07	79.56	156.33	235.89	11.07	14.57	25.64
L.S.D. at 0.05		N.S.	N.S.	N.S.	N.S.	N.S.	21.55	N.S.	29.55	N.S.	1.09	3.69
Second season (2014/2015)												
Without	Control	69.11	10.44	7.97	9.64	11.43	298.44	239.52	537.97	39.53	20.91	60.44
	1000	63.39	10.00	7.71	8.81	10.43	234.66	225.34	460.00	30.52	16.42	46.93
	2000	52.56	9.22	6.77	7.81	8.42	212.11	187.87	399.98	27.15	14.61	41.76
	3000	43.67	9.22	6.64	6.27	7.61	124.72	137.73	262.45	13.20	11.80	25.00
	4000	26.28	7.44	6.02	4.28	5.13	85.90	102.55	188.45	9.19	6.59	15.78
	5000	22.30	6.44	5.44	3.08	3.93	72.75	93.41	166.17	7.90	5.44	13.34
With	Control	80.44	11.00	9.54	11.04	12.09	474.67	386.92	861.58	62.19	45.13	107.33
	1000	71.00	10.78	8.73	9.48	10.53	326.11	342.90	669.01	37.69	39.62	77.31
	2000	56.78	10.11	8.53	9.30	9.69	289.30	353.51	642.81	35.52	33.93	69.45
	3000	45.44	9.78	7.30	7.49	8.06	168.13	183.97	352.10	20.36	17.59	37.95
	4000	33.67	8.78	6.92	6.81	7.24	121.55	154.71	276.27	14.98	18.15	33.13
	5000	27.29	7.78	6.23	5.46	5.63	106.53	133.95	240.48	12.80	15.32	28.11
L.S.D. at 0.05		N.S.	N.S.	N.S.	N.S.	N.S.	4.48	N.S.	22.65	N.S.	1.29	2.29

the experiments. These results were concurrence with those acquired by (Amer, 1999) who stated that supplementing fertilizer N with organic matter alleviated the adverse effect of salinity on nitrogen transformation in soil. Whereas, Saleh *et al*. (2003) revealed that the utilization of saline water irrigation decreased the yield of onion plants, and the reduction increased with increasing the salt concentration in irrigation water without natural organic manure. On the other hand, using of organic manure significantly increased onion yield. Similar results were obtained on spinach plants which irrigated with saline well water (4200 ppm), when chicken manure was added, significant increases were obtained in plant height, leaf numbers and plant fresh weight (El-Missery, 2003).

II. Chemical content:

A. Effect of organic fertilization:

The results in Table (7) cleared that utilization of organic manuring increased nitrogen, phosphorus and potassium content of sweet fennel plants (leaves and bulbs) compared with mineral fertilizer. Results were true and similar in the two seasons of the experiment. Organic manure enhanced the availability of certain elements and their supply to the plant during growth period (Saleh *et al*., 2003). In addition, poultry manure increased the presence of P, K and Mg in the soil beside the solubility of Ca, Mg and NO_3 as a result of the continuous lowering of the pH by organic manure applications and to the increase of electrical conductivity (Ohallorans *et al*., 1993). Additionally, K/Na ratio and Calcium substance of sweet fennel bulbs were marginally higher with organic manure compared with mineral fertilization in the two seasons of the experiments. Despite what might be expected, Na content was brought down when organic manure was utilized compared with mineral fertilization.

The results in Table (7) uncovered that plants grown in soil under organic fertilizer, contained less proline content than the control (mineral treatment) which may imply that natural organic manure reduced the stress of saline water by demonstrating good water relation, enhancing cations and anions exchange and solubility. Organic manure reduced free proline content under saline conditions which was reflected on producing better growth parameters, photosynthesis mechanical assembly and sugar content in the two seasons. This free amino acid accumulates in plant tissues in response to several types of stresses as salt, drought or temperature. The accumulation of proline may come about because of expanding of protein turn over (Singh *et al*., 1972), and / or might be due to enzyme stabilization and / or osmoregulation (Madan *et al*., 1994).

B. Effect of irrigation water salinity:

Nitrogen and potassium content of sweet fennel leaves and bulbs was diminished by increasing saltiness of irrigation water up to 5000ppm concentration (Table 8). These outcomes were comparable and valid in the two seasons of the experiment. Nitrogen content in umbellifera plants may or may not change due to the irrigation with saline water. This depends on plant age, saline concentration and the utilized crop. Numerous agents detailed that, increasing salt concentrations in irrigation water diminished N concentration of the plant tissues (Ahmad, 1999) on sweet fennel; Stoop *et al*., 1994 and Pardossi *et al*., 1999 on celery).Ahmad (1999) noticed that bulb N content significantly increased with the increase in saline water concentrations till 2000 ppm; at that point, a decrease occurred in this substance from the utilization of 3000 ppm. Phosphorus content in sweet fennel bulbs was not significantly influenced by the expansion of the distinctive saltiness levels.

Whereas, Pardossi *et al*. (1999) working on celery expressed that, sodium chloride stress reduced the accumulation of nitrate (No_3-N) in all plant tissues, however there were no pertinent impacts on the concentration of reduction N. The opposite picture was noticed when P content in the same crop was expanded with increasing irrigation water saltiness from 1.0 to 5.9 ds/m (Poss *et al.,* 1985).

Salinity was reported to increase or decrease potassium content of the plants according to its concentration as well as plant type and age. Ahmad (1999) on sweet fennel found that potassium content was not significantly influenced by the expansion of the diverse saltiness levels in all tested ages. On the other hand, Stoop and Mason (1994) on celery found that potassium concentrations in

Table 7: Effect of organic manure on N, P, K, Na, Ca, K: Na and free proline content in leave and bulbs of sweet fennel at 120 days from transplanting during two seasons (2013/2014 and 2014/2015).

Organic manure	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Ca (%)	Na (%)	K : Na (%)	Free proline (µ mole/g F. w)
	Leaves	Bulbs	Leaves	Bulbs	Leaves	Bulbs	Bulbs	Bulbs	Bulbs	Bulbs
First season (2013/2014)										
Without	3.81	2.71	0.34	0.34	2.87	3.15	0.53	1.51	2.35	28.33
With	4.01	3.85	0.49	0.48	3.16	3.39	0.55	1.45	2.67	34.17
L.S.D. at 0.05	0.09	0.40	0.07	0.01	0.08	0.09	0.01	0.02	0.10	2.14
Second season (2014/2015)										
Without	3.83	3.63	0.39	0.37	3.11	3.17	0.50	1.39	2.88	28.91
With	4.63	4.52	0.58	0.47	3.59	3.62	0.57	1.33	3.31	37.79
L.S.D. at 0.05	0.16	0.22	0.07	0.05	0.07	0.16	0.02	0.02	0.28	5.22

Table 8: Effect of salinity concentrations on N, P, K, Na, Ca, K: Na and free proline content in leaves and bulbs of sweet fennel at120 days from transplanting during two seasons (2013/2014and 2014/2015).

Salinity conc.	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Ca (%)	Na (%)	K : Na (%)	Free proline (µ mole/g F. w)
	Leaves	Bulbs	Leaves	Bulbs	Leaves	Bulbs	Bulbs	Bulbs	Bulbs	Bulbs
First season (2013/2014)										
Control										
1000	4.55	4.64	0.25	0.54	3.43	3.81	0.54	0.77	4.93	12.84
2000	4.22	3.99	0.32	0.51	3.24	3.52	0.58	1.28	2.75	17.90
3000	4.09	3.84	0.37	0.49	3.09	3.22	0.54	1.53	2.11	29.57
4000	3.78	3.37	0.40	0.39	2.87	3.17	0.55	1.62	1.99	36.56
5000	3.55	2.00	0.56	0.33	2.76	3.11	0.53	2.06	1.52	42.39
L.S.D. at 0.05	3.29	1.87	0.58	0.22	2.69	2.81	0.51	1.62	1.74	48.23
Second season (2014/2015)										
Control	5.16	5.40	0.40	0.54	3.83	3.77	0.53	0.64	5.97	14.67
1000	4.84	4.69	0.44	0.50	3.54	3.53	0.57	0.85	4.17	21.66
2000	4.58	4.13	0.47	0.46	3.43	3.48	0.53	1.20	2.91	32.32
3000	3.82	3.68	0.51	0.41	3.32	3.45	0.53	1.43	2.40	39.07
4000	3.58	3.29	0.54	0.36	3.13	3.41	0.52	2.26	1.57	45.10
5000	3.39	3.23	0.54	0.28	2.84	2.72	0.52	1.78	1.53	47.28
L.S.D. at 0.05	0.23	0.27	N.S.	0.03	0.05	0.08	N.S.	0.05	0.15	2.70

leaves, Petioles and roots of celery were not affected by increasing salinity levels in the media from 1.0 to 11.9 ds/m during the first 35 days of growth.

Na and Ca content were influenced by saltiness. Calcium rate was step by step and significantly diminished by expanding irrigation water salinity (EC_w) up to its highest level. In actuality, Sodium percentage increased linearly and significantly by the increase in irrigation water salinity up to its highest level. Graifenberg *et al*. (1996) working on fennel found that Na and Cl concentration of both cultivars was higher than that of alternate components broke down. In the two cultivars and at all ECi levels, the Na concentration was highest in bulb. Bulb Na concentration increased from 1.1 to 3.0 $ds.m^{-1}$, reaching values of 1835 and 1866 m mol.kg-1 dry weight in Monte Bianco and Everest, respectively. Bulb Na concentration remained constant > 3.0 $ds.m^{-1}$, reaching values of 1111 and 1302 m $mol.kg^{-1}$ dry weight in Monte Bianco and Everest, respectively from 0.75 to 3.0 $ds.m^{-1}$. Calcium concentration did not vary with ECi in any tissue.

The results in Table (8) present proline content in bulbs of plants treated with the diverse levels of saltiness. It shows up from data that proline content under saltiness conditions was raised more than the control plants. In any case, it gradually increments as salt concentrations in irrigation water expanded. The accumulation of free proline in plant tissues might be due to other soluble compounds, because of the reduction of the oxidation enzymes (Stewart *et al.*, 1977).

C. Effect of the interaction:

The results in Table (9) revealed that nitrogen, phosphorus and potassium content of sweet fennel leaves and bulbs were not statistically affected by the interaction of organic manuring and salinity. These results were true and similar in the two seasons. The results in Table (9) revealed that proline content of sweet fennel bulbs was not statistically affected by the interaction of organic manuring and salinity. These results were true and similar in the two seasons.

III) - Total green yield, essential oil yield and chemical bulb quality

A. Effect of organic fertilization:

1. Total green yield:

Data introduced in Table (10) demonstrated that total green yield of sweet fennel took after a similar pattern of vegetative growth. The increase in the total green yield due to application of organic fertilization amounted to 38.75 and 28.82% in the two seasons, respectively. These increments were statistical and comparative in the two seasons. Comparable results were acquired on sweet fennel by El-Kassas (1999); El-Desuki *et al.* (2001); Ali (2002); El-Ghawwas *et al*. (2002); Kandil (2002); Abou El-Magd *et al*. (2008) and Zaki *et al*. (2009a) .

Organic matter may influence plant growth as a source of growth promoters, axins, vitamins and amino acids which follow up on the vegetative growth, yield and quality of the plant product (Melo and De- Oliveira, 1999).The increment in the total green yield was the sum of the increments in the vegetative growth characteristics.

2. Essential oil content:

The essential oil rate in leaves and bulbs was not statistically affected by utilizing natural organic fertilizer compared with without treatment (Table, 10). Oil yield per plant was the highest in plants which treated using organic manure because of their heavy and dense vegetative growth. This pattern was seen in the leaves and bulbs. Results were similar and true in the two seasons of the experiment. Similar results were obtained on sweet fennel by Zaki *et al*. (2009a).

3. Chemical bulb quality:

Data presented in Table (10) indicated that application of organic manure treatment to the soil which irrigated with saline water increased the values of TSS total acidity and vitamin C, and

decreased crude fiber in bulbs of sweet fennel plants compared with plants did not treated. These findings were similar and true in both seasons of this study.

B. Effect of irrigation water salinity:

1. Green yield:

Data showed in Table (11) demonstrate that total green yield of sweet fennel plants was statistically diminished by increasing irrigation water saltiness. As saltiness of irrigation water increased bulb green yield were diminished. Linear decrement was recorded in total green yield by increasing saltiness of irrigation water up to the highest level (5000 ppm). These results were comparative and measurable in the two periods of the investigation. Irrigation by well water (control) and 1000 ppm treatment gave the highest green bulb yield and the heaviest mean fresh weight of total plant and its organs, i. e. leaves and bulbs. While, the thinnest plants resulted from the highest saltiness level (5000 ppm) in the two seasons.

Many investigators reported that salinity caused decreases in the yield of fennel plant. Pascale and Barbieri (1995) and Graifenberg *et al*. (1996). Comparative and related crops reflected abatements in total green yield when it was irrigated by saline water. Saleh *et al*. (2003) reported that using saline water to irrigate onion plants significantly decreased the yield due to its effects on increasing soil salinity.

2. Essential oil content:

The essential oil content was linearly and significantly decreased salinity increased (Table, 11). Increasing salinity concentration in irrigation water decreased essential oil content expressed as V/W or mg/ plant. Data show that higher essential oil content was obtained by well water and the lower salinity concentration in irrigation water. Higher essential oil content of leaves was obtained by diluting sea water up to its lower concentration (1000 ppm). The highest content of essential oil of bulbs was recorded by irrigation by 1000 ppm sea water followed by the low concentrations of irrigation water.

The lowest values of essential oil were obtained by the highest salinity concentration of irrigation water. Lower values of essential oil were obtained by the higher salinity concentration in irrigation water. The lowest essential oil content was obtained by irrigation with sea water at 5000 ppm. Results of essential oil content were similar in the two seasons of the experiment. Similar results were obtained on sweet fennel by Zaki *et al*. (2009a) and Semiza *et al*. (2012).

3. Chemical bulb quality:

Data presented in Table (11) cleared that TSS, total acidity, vitamin C and crude fiber in bulbs of sweet fennel plants were significantly affected by irrigation water salinity. There was positive effect in chemical bulb quality due to salinity increase. TSS in bulbs of sweet fennel plants was increased by increasing salinity concentrations in irrigation water until 4000 ppm compared with plants did not irrigate with saline water (control). Values of total acidity, vitamin C and crude fiber in bulbs were increased negatively until 3000 ppm concentration of irrigation water salinity and then decreased after that. These findings were true and similar in the two periods of this study. Zaki *et al*. (2009a) was obtained the similar results on sweet fennel.

C. Effect of the interaction:

1. Green yield:

The recorded data in Table (12) demonstrated that the highest green yield was gotten by the interaction effect of organic fertilization and irrigation by well water. It is obvious from the results that applying of organic manuring decreased the adverse effect of salinity on the green yield of sweet fennel plants. The most reduced green yield was recorded when the plants fertilized by doses of

Table 9: Effect of the interaction between organic manure with Salinity concentrations on N, P, K, Na, Ca, K: Na and free proline content in bulbs of sweet fennel at120 days from transplanting during two seasons (2013/2014 and 2014/2015).

Organic manure	Salinity conc.	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Ca (%)	Na (%)	K : Na (%)	Free proline (µ mole/g F. w)
		Leaves	Bulbs	Leaves	Bulbs	Leaves	Bulbs	Bulbs	Bulbs	Bulbs	Bulbs
						First season (2013/2014)					
	Control	4.47	4.16	0.19	0.48	3.15	3.63	0.52	0.78	4.66	14.14
	1000	4.09	3.10	0.26	0.42	3.13	3.45	0.58	1.32	2.62	15.85
Without	2000	4.01	2.98	0.32	0.39	2.94	3.17	0.52	1.60	1.98	26.38
	3000	3.60	2.59	0.30	0.35	2.76	3.11	0.54	1.81	1.72	32.12
	4000	3.58	1.82	0.53	0.24	2.62	3.02	0.50	1.89	1.60	37.86
	5000	3.12	1.63	0.44	0.19	2.61	2.53	0.54	1.66	1.53	43.62
	Control	4.63	5.11	0.31	0.60	3.71	3.98	0.55	0.77	5.21	11.54
	1000	4.35	4.87	0.38	0.59	3.35	3.60	0.58	1.25	2.88	19.95
With	2000	4.17	4.70	0.43	0.58	3.24	3.27	0.57	1.46	2.24	32.76
	3000	3.95	4.16	0.51	0.44	2.97	3.22	0.57	1.42	2.27	41.00
	4000	3.52	2.18	0.59	0.42	2.89	3.19	0.57	2.22	1.44	46.92
	5000	3.47	2.11	0.71	0.26	2.77	3.08	0.48	1.57	1.96	52.83
L.S.D. at 0.05		N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
						Second season (2014/2015)					
	Control	4.47	4.67	0.32	0.45	3.27	3.68	0.49	0.70	5.30	13.86
	1000	4.41	4.12	0.36	0.43	3.17	3.21	0.54	0.77	4.21	15.83
Without	2000	4.22	3.70	0.36	0.41	3.24	3.17	0.49	1.17	2.71	31.30
	3000	3.63	3.37	0.40	0.37	3.10	3.15	0.49	1.38	2.29	35.44
	4000	3.28	3.01	0.42	0.35	2.99	3.11	0.47	2.65	1.18	37.75
	5000	2.95	2.90	0.45	0.24	2.86	2.67	0.50	1.70	1.58	39.29
	Control	5.85	6.14	0.49	0.62	4.39	3.87	0.57	0.58	6.63	15.47
	1000	5.27	5.26	0.53	0.57	3.91	3.85	0.59	0.93	4.13	27.50
With	2000	4.95	4.56	0.58	0.51	3.61	3.78	0.58	1.23	3.10	33.33
	3000	4.01	3.99	0.63	0.44	3.54	3.75	0.57	1.49	2.52	42.70
	4000	3.88	3.58	0.65	0.36	3.28	3.71	0.58	1.88	1.97	52.46
	5000	3.83	3.56	0.63	0.32	2.82	2.78	0.53	1.87	1.49	55.27
L.S.D. at 0.05		N.S.	N.S.	N.S.	N.S.	0.07	N.S.	N.S.	0.07	N.S.	N.S.

Table 10: Effect of organic manure on total green yield, essential oil yield and chemical quality of sweet fennel plants at 120 days from transplanting during two seasons (2013/2014 and 2014/2015).

Organic manure	Total green yield (kg/pot)	Essential oil yield				Chemical quality			
		% (V/W)		per plant (ml.)		T.S.S	Total Acidity	Ascorbic acid	Crude fiber
		Leaves	Bulbs	Leaves	Bulbs	(%)	(g/100 g* F. w)	(mg/100 g*F. w)	(mg/100 g*F. w)
First season (2013/2014)									
Without	1.031	0.09	0.06	0.232	0.102	9.92	0.31	25.96	4.618
With	1.597	0.09	0.06	0.360	0.181	10.74	0.33	28.45	4.306
L.S.D. at 0.05	0.266	N.S.	N.S.	0.028	0.011	0.10	0.00	0.51	0.004
Second season (2014/2015)									
Without	1.008	0.08	0.05	0.141	0.105	9.63	0.305	26.96	4.751
With	1.521	0.08	0.05	0.203	0.149	10.67	0.319	29.16	4.440
L.S.D. at 0.05	0.091	N.S.	N.S.	0.020	0.012	0.35	0.004	0.47	0.004

Table (11): Effect of salinity concentrations on total green yield, essential oil yield and chemical quality of sweet fennel at 120 days from transplanting during two seasons (2013/2014 and 2014/2015).

Salinity conc.	Green yield (Kg/pot)	Essential oil yield				Chemical quality			
		% (V/W)		per plant (ml.)		T.S.S	Total Acidity	Ascorbic acid	Crude fiber
		Leaves	Bulbs	Leaves	Bulbs	(%)	(g/100 g* F. w)	(mg/100 g*F. w)	(mg/100 g*F. w)
First season (2013/2014)									
Control	2.345	0.12	0.04	0.589	0.168	8.02	0.29	29.12	4.615
1000	2.030	0.11	0.06	0.473	0.216	8.48	0.33	30.86	4.330
2000	1.354	0.10	0.07	0.274	0.177	10.67	0.32	30.18	4.479
3000	0.951	0.09	0.08	0.209	0.142	11.18	0.34	27.96	4.525
4000	0.665	0.07	0.06	0.145	0.094	11.68	0.33	24.38	4.380
5000	0.540	0.06	0.05	0.088	0.051	11.93	0.31	20.75	4.443
L.S.D. at 0.05	0.063	0.01	0.01	0.049	0.020	0.42	0.01	0.88	0.008
Second season (2014/2015)									
Control	2.099	0.11	0.03	0.392	0.113	8.08	0.28	29.74	4.748
1000	1.694	0.09	0.05	0.295	0.164	9.12	0.32	31.85	4.463
2000	1.564	0.08	0.06	0.181	0.178	9.85	0.32	31.64	4.613
3000	0.922	0.07	0.07	0.085	0.154	10.92	0.34	28.74	4.658
4000	0.697	0.06	0.05	0.046	0.096	11.48	0.32	24.83	4.514
5000	0.610	0.05	0.04	0.032	0.058	11.43	0.30	21.57	4.576
L.S.D. at 0.05	0.048	0.01	0.01	0.035	0.021	0.38	0.01	0.81	0.008

Table 12: Effect of the interaction between organic manure with salinity concentrations on total green yield , essential oil yield and chemical quality of sweet fennel plants at 120 days from transplanting during two seasons (2013/2014 and 2014/2015).

Organic manure	Salinity conc.	Green yield	Essential oil yield				Chemical quality			
			% (V/W)		per plant (ml.)		T.S.S	Total Acidity	Ascorbic acid	Crude fiber
		(Kg/pot)	Leaves	Bulbs	Leaves	Bulbs	(%)	(g/100 g* F. w)	(mg/100 g*F. w)	(mg/100 g*F. w)
First season (2013/2014)										
	Control	1.727	0.13	0.04	0.457	0.148	7.53	0.26	26.67	4.694
	1000	1.494	0.11	0.05	0.359	0.133	8.50	0.30	28.65	4.510
Without	**2000**	1.318	0.10	0.07	0.224	0.127	10.04	0.32	29.10	4.582
	3000	0.711	0.09	0.08	0.168	0.105	10.83	0.34	26.58	4.841
	4000	0.565	0.08	0.06	0.127	0.067	11.26	0.33	24.00	4.552
	5000	0.372	0.06	0.05	0.060	0.030	11.33	0.31	20.79	4.529
	Control	2.964	0.12	0.03	0.721	0.187	8.50	0.31	31.57	4.536
	1000	2.565	0.11	0.06	0.587	0.299	8.47	0.35	33.07	4.150
With	**2000**	1.389	0.10	0.07	0.323	0.226	11.30	0.33	31.27	4.377
	3000	1.191	0.09	0.08	0.250	0.179	11.53	0.34	29.34	4.209
	4000	0.765	0.07	0.07	0.163	0.121	12.10	0.32	24.75	4.208
	5000	0.708	0.06	0.05	0.116	0.072	12.52	0.31	20.70	4.357
L.S.D. at $_{0.05}$		0.089	N.S.	N.S.	0.069	0.028	N.S.	0.01	1.24	0.011
Second season (2014/2015)										
	Control	1.614	0.04	0.03	0.358	0.115	7.23	0.26	27.28	4.827
	1000	1.380	0.05	0.04	0.232	0.115	8.40	0.30	29.27	4.644
Without	**2000**	1.200	0.07	0.06	0.137	0.135	9.13	0.31	31.83	4.715
	3000	0.787	0.08	0.07	0.064	0.138	10.50	0.34	27.39	4.974
	4000	0.565	0.06	0.05	0.032	0.080	11.13	0.32	24.57	4.686
	5000	0.499	0.05	0.04	0.020	0.048	11.37	0.31	21.43	4.662
	Control	2.585	0.03	0.02	0.427	0.110	8.93	0.31	32.20	4.670
	1000	2.007	0.06	0.05	0.357	0.213	9.83	0.34	34.42	4.283
With	**2000**	1.928	0.07	0.06	0.226	0.221	10.57	0.32	31.46	4.510
	3000	1.056	0.08	0.07	0.106	0.170	11.33	0.33	30.09	4.342
	4000	0.829	0.07	0.06	0.060	0.111	11.83	0.32	25.10	4.341
	5000	0.721	0.05	0.04	0.043	0.069	11.50	0.30	21.72	4.491
L.S.D. at $_{0.05}$		0.068	N.S.	N.S.	0.050	0.029	N.S.	0.01	1.14	0.011

mineral fertilization with irrigation by the highest concentration of diluted sea water. These results were true and similar in the two periods of this experiment.

These results were agreement with those obtained by Zaki *et al*. (2009a) and Amer (1999) who reported that supplementing fertilizer N with organic matter alleviated the adverse effect of salinity on nitrogen transformation in soil. Whereas, Saleh *et al*. (2003) revealed that using water salinity in irrigation of onion plants decreased the yield, and the reduction increased with increasing the salt concentration in irrigation water without organic manure. On the other hand, application of organic manure significantly increased onion yield.

2. Essential oil content:

Essential oil content of leaves and bulbs of sweet fennel plants expressed as ml/ plant was widely affected by the interaction between organic fertilization and salinity concentrations (Table, 12). Plants were fertilized and irrigated with well water or the low salinity concentration (1000 ppm) gave the highest values of essential oil content in leaves and bulbs. On the other hands, the lowest values of essential oil content were obtained by plants which non-fertilized organically and irrigated with the high concentration of salinity (5000 ppm). Other interaction treatment recorded values of essential oil ranged in between these two interactions. Essential oil percentage in leaves and bulbs of sweet fennel plants was not statistically affected by salinity concentrations of irrigation water. Results of the two seasons were similar and agreement with those obtained by Zaki *et al*. (2009a) on sweet fennel.

3. Chemical bulb quality:

The recorded data in Table (12) show that the good bulb quality was obtained by the interaction effect of organic fertilization and irrigation of well water. It is obvious from the data that utilization of natural organic fertilizer decreased the adverse effect of saltiness on bulb quality of sweet fennel plants.TSS, total acidity, vitamin C and crude fiber in bulbs of sweet fennel plants were significantly affected by irrigation water salinity. There was a positive effect in chemical bulb quality due to salinity increase. TSS in bulbs of sweet fennel plants was increased by increasing salinity concentrations in irrigation water until 4000 ppm compared with (control).
Values of total acidity, and crude fiber in bulbs were increased negatively until 3000 ppm concentration of irrigation water salinity and then decreased after that. Ascorbic acid values were increased also until 2000 ppm and then decreased after that. These results were similar and true in both seasons of this study. Similar results were obtained on sweet fennel by Zaki *et al*. (2009a) on sweet fennel. On the other hand, lower values of ascorbic acid were obtained by plants which non-fertilized with organic manure and irrigated with the highest salinity concentration of irrigation water (5000 ppm). The results of both seasons showed the same trend.

Conclusion

From the results of this investigation it might be recommended to add natural organic fertilizer at the rate of (5.0 ton/ fed.) during preparation the land to cultivation of sweet fennel, when water irrigation contains salinity levels up to 1000 ppm, in order to overcome or reduce the toxic effect of salinity and to obtain relatively good plant growth, good bulb quality and high yield, as well as good quality.

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