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GROWTH AND OIL PRODUCTION OF *Foeniculum vulgare*, MILL.:
2:THE EFFECT OF NUMBER OF IRRIGATIONS AND ORGANIC FERTILIZERS

Abdou, M.A. and M. A-H. Mahmoud
Dept. of Horticulture, Faculty of Agriculture, Minia University, Egypt

ABSTRACT

Seeds of aromatic plants *Foeniculum vulgare*, Mill. were sown in sandy soil with 0 or 2.5 kg/m^{2}of 3 sources of air dried organic fertilizers (OF); chicken manure (ChM), cattle manure (CaM) or plant compost (PC). Plants were subjected to 3, 4, 5 or 6 times of irrigation after 21 days of emergence till harvesting. Number of irrigations and organic fertilizers had significant effects on harvesting date, plant height, branch number and fruit weight and volatile oil yield. Number of days till harvesting was significantly increased when number of irrigations increased or/and adding organic fertilizers. Plants irrigated 3 times had 41.4 g fruits/plant whereas 6-times irrigated plants yielded 67.7 g/plant. However, there was insignificant difference in volatile oil yield between 5- and 6-times irrigated plants (1.75 and 1.76 ml/plant volatile oil respectively). Percentage of N, P and k of plants were significantly reduced with the reduction in number of irrigations. The minimum N and P %;were 2.36 and 0.303 respectively, being in 3-times-irrigated plants. Whereas K% increased by decreasing number of irrigations, plants irrigated 3 times had the highest % of K; 1.65%. Organic fertilizers significantly increased fruit yield over the control plants especially when number of irrigations decreased. Plants, which did not fertilize with organic fertilizers, had significantly the lowest plant height, branch number and fruit and oil yield. ChM-fertilized plants had the highest volatile oil yield 1.92 ml/plant followed by PC-fertilized plants (1.78 ml/plant). Organic-fertilized plants had significantly higher percentage of NPK.

INTRODUCTION

Foeniculum vulgare, Mill (fennel) which belongs to family Umbelliferae (Apiaceae) is an annual plant. Vegetative parts of the plant are used as a green salad while fruits, which is the economical part, have a pleasant, spicy odour and burning sweet taste are used in pharmaceutical, perfumery and as a flavor of different foods product. Fennel fruits contain 1-3% volatile oils, which exerts disinfectant and anti-inflammatory action, primarily on the respiratory and digestive organs and has antispasmodic effect on smooth muscle (Stary and Jirasek, 1975). The antioxidant and antimacrobial activity of fennel has been also reported (Ruberto *et al.*, 2000).

Drought stress is a major environmental stress factor that affects plant morphology, physiology and biochemistry, causing a significant reduction in agricultural production (Hsiao, 1973; Tyree and Karamanos,

1981). Although effects of drought on many plants have been widely investigated, not much is known about the biosynthesis and accumulation of oil in aromatic plants under water deficit conditions (Sangwan *et al.*, 1993). *Origanum majorana* had higher oil content and leaf dry weight with increasing the soil moisture deficit (Rhizopoulou and Diamantoglou., 1991). Sangwan *et al.*, (1994) exposed lemongrasses, *Cymbopogon nardus* var. *confertiflorus* and *C. pendulus*, to water stress. They found that water deficit reduced plant height, leaf length, leaf area, fresh and dry weight and moisture content. Percentage of oil content was significantly affected depending on the water stress treatment. Letchamo *et al.*, (1995) found that there was a significant reduction in dry matter and relative growth rate of *Thymus vulgaris* grown under drought stress. Growth and oil content of fennel plants had been affected by irrigation schedule (Patel *et al.*, 2000).

Natural recycling of farm-waste organic matter through composting is a procedure aimed to minimize losses of nutrients, accumulation of wastes and limit greenhouse gas emission. So that, compost enhances the environmental sustainability of agriculture through decreasing chemical inputs and increasing soil organic matter (Mathur *et al.*, 1993). Manure mineralized by microorganisms after incorporating into the soil increasing mineral content of the soil, as well as, its water-holding capacity, and cation exchange capacity (Karmer and Boyer, 1995). Hence, organic fertilizers produce multiple effects on agronomical properties of the soil and serve as source of macro-and micronutrients, which improve plant growth and productivity.

So, this experiment amid to study the effect of number of irrigations and three different types of organic fertilizers; chicken manure (ChM), cattle manure (CaM) and commercial available plant compost (PC) on growth and volatile oil contents of fennel growing in new reclaimed sandy soil.

MATERIAL AND METHODS

A field experiment was carried out during two consecutive seasons of 2000/2001 and 2001/2002 in a new reclaimed sandy soil (West Samalout, Minia governorate, Egypt). Physical and chemical properties of the experimental soil are shown in Table 1. Fennel seeds were sown on November 1st of both seasons. Seedlings were thinned for one plant and irrigated after 21 days of emergence. The experimental unit consisted of three rows; 2 m in length with 60 cm apart and a distance of 30 cm between plants in the row. The experiment was carried out in 3 replicates in a randomized split plot design where irrigation frequency treatments were the main plot and the type of organic fertilizers was the sub-plot treatment. A border of 1 meter wide was constructed to separate between each two-irrigation treatment. Irrigation frequency treatment was 3, 4, 5 or 6 times after emergence.

Calcium superphosphate (15.5 % P_2O_5) at 50 kg/fed and 0 (as a control) or 2.5 kg/m^2. of air dried of ChM, CaM or PC were added during the preparation of the experimental soil. Percentages of moisture content of organic fertilizers were assessed in air-dried sample to calculate the required

weight of organic fertilizers. Table 2 shows the chemical composition of these different types of organic fertilizers. All plants were fertilized with 50 kg/fed ammonium sulphate (20.6% N) and 25 kg/fed potassium sulphate 48.5 % divided into three equal doses and added at the first three times of irrigation.

At flowering stage, leaves of the middle part of plant have been taken from plants of the middle row. Leaves were dried at 60 °C and used to determine N, P, K (Page *et al.*, 1982) and total carbohydrates as described by Smith *et al.*, (1956). At maturity stage, plants were harvested and number of days from sowing till harvesting was calculated. Plant height and number of main branches were recorded. Fruits were collected and air-dried to estimate fruit dry weight. Volatile oil percentage was determined in 10 g of sample fruits according to Guenthere (1961).

Table (1): Some physical and chemical analysis of the used soil in the two seasons

Character		Value	Character	Value
Particale size distribution	sand	90.67%	% $CaCo_3$	12.69
silt		6.28%	% total N	0.03
clay		3.05%	Available K mg/kg	22.1
texture grade		sandy soil	DTPA- Extractable P mg/kg	1.15
Organic matter		0.08%	Fe mg/kg	1.13
PH 1:2.5		8.14	Mn mg/kg	0.38
EC dSm^{-1}		1.07	Zn mg/kg	0.21

Table (2): Chemical analysis of the used organic fertilizers in the two seasons

organic fertilizers	season	C/N ratio	N%	P %	K%	Fe ppm	Mn ppm	Zn ppm
Chicken manure	1 st	10.69	3.35	0.64	1.25	1508	320	120
	2 nd	10.96	3.80	0.93	1.20	1408	370	117
Cattle manure	1 st	19.18	1.22	0.65	1.19	4256	600	60
	2 nd	19.00	1.36	0.66	1.12	6390	610	61
Plant compost	1 st	17.81	0.64	0.31	0.68	320	118	44
	2 nd	17.65	0.68	0.30	0.75	310	121	48

Experimental results were submitted to an analysis of variance (ANOVA) and means were compared using LSD test ($p<0.05$) between any pair of data (Zar, 1996). ANOVA was performed using SPSS Version 6 for Windows.

RESULTS AND DISCUSSION

1- Vegetative growth

Irrigation schedule had noticeable effects on fennel vegetative growth characters in both seasons (Table 3). Basis leaves of fennel plants, which had been irrigated 3 or 4 times were dried out, and flowered and commenced maturity stage earlier than plants had more frequency irrigation. Number of irrigations had a significant effect on harvesting date in both seasons Plants, which irrigated 3 times, were harvested after 142 days but those irrigated 6 times were harvested after 197 days of sowing.

Table (3): Effect of number of irrigations and organic fertilizers on some growth characters of fennel plants grown in sandy soil in the two seasons

Organic fertilizers (B)	number of irrigations (A)									
	1 st season					2 nd season				
	3	4	5	6	Mean B	3	4	5	6	Mean B
days from sowing till harvesting										
Control	135	155	166	184	160	133	151	168	182	159
CaM[1]	139	161	171	192	166	137	156	174	193	165
ChM[2]	148	165	183	212	177	146	166	185	205	176
PC[3]	145	168	178	200	173	143	163	181	201	172
Mean A	142	162	174	197		139	159	177	195	
LSD 0.05	A 16		B 4		AB 8	A 18		B 7		AB ns
plant height (cm)										
Control	82.5	93.4	104.0	113.7	98.4	84.0	93.1	105.5	115.6	99.6
CaM[1]	91.9	103.7	116.0	127.3	109.7	94.8	104.7	118.7	130.1	111.9
ChM[2]	99.3	110.8	123.2	135.7	117.3	102.4	113.2	125.7	138.7	120.0
PC[3]	97.8	110.2	122.5	134.3	116.2	100.9	110.8	125.0	137.8	118.6
Mean A	92.8	104.5	116.4	127.7		95.5	105.6	118.6	130.6	
LSD 0.05	A 7.8		B 2.8		AB ns	A 2.8		B 2.8		AB ns
number of main branches / plant										
Control	3.33	3.87	4.37	4.77	4.08	3.53	3.97	4.43	4.93	4.22
CaM[1]	3.90	4.70	5.00	5.23	4.71	4.60	5.13	5.67	6.07	5.37
ChM[2]	4.43	5.23	5.90	6.33	5.47	4.97	5.47	5.93	6.47	5.71
PC[3]	4.23	4.97	5.60	5.77	5.14	4.80	5.30	5.77	6.27	5.54
Mean A	3.97	4.69	5.21	5.52		4.47	4.96	5.45	5.93	
LSD 0.05	A 0.69		B 0.11		AB 0.21	A 0.40		B 0.40		AB 0.79

[1]CaM: cattle manure; [2]ChM: chicken manure; [3]PC: plant compost, [4] ns; not significant

Organic fertilizers significantly increased number of days till harvesting over the control plants which were harvested after 160 days, followed by CaM-fertilized plants; 166 days. However, ChM-fertilized plants harvested after 177 days. The interaction between number of irrigations and organic fertilizers was significant in harvesting date in both seasons. Control plants were harvested after 135 days however the latest harvested date (212 days of sowing) being when plants were fertilized with ChM and irrigated 6 times. There was insignificant difference between 5- and 6-times irrigated plants in number of days till harvesting. In the second season the same effects had been recorded with a slight difference in number of days till harvesting.

Table 3 shows that both of irrigation number and organic fertilizers significantly affect plant height and main branch number of fennel plants in both seasons. Reducing number of irrigations from 6 to 3 times significantly reduced plant height from 127.7 cm to 92.8 cm. Also, There was a significant difference in plant height among plants had different number of irrigations. Organic fertilizers had a significant effect on plant height, control plant had the lowest plant height, 98.4 cm., Whereas the tallest plant ; 117.3 cm was estimated when plants were fertilized with ChM with insignificant difference between ChM- and PC-fertilized plants. There was insignificant interaction between the two studied factors on plant height. Overall, the tallest plant: 135.7 cm being when plants were irrigated 6 times and fertilized with ChM.

Main branch number was gradually reduced from 5.52 to 3.97 branch/plant when irrigation times reduced from 6 to 3 times in the first season. There was no significant difference in main branch number between plants irrigated 4 and 5 times or plants 5 and 6 times. However, plants irrigated 4, 5 or 6 times had main branch number significantly higher than 3-times irrigated plants. Control plants produced the lowest number of branches (4.08 branch/plant). Organic fertilizer treatments significantly produced higher number of branches compared with the control treatment. Also, there was a significant difference among the different types of organic fertilizers. Among these treatments ChM had the highest number of main branches (5.4 branch/plant).

There was a significant interaction between number of irrigations and organic fertilizers in number of main branches of fennel plants. The minimum branch number (3.33) being obtained when plants irrigated 3 times and did not fertilize with organic fertilizers. The highest number of branches 6.33 recorded on ChM-fertilized plants and irrigated 6 times in the first season (Table 3). Similar results were recorded in the second season.

Results show that water stress significantly reduced number of days till harvesting, plant height, and main branch number. The diverse effects of water stress on physiological and metabolic response in plant growth have been investigated (Karmer and Boyer, 1995). Early maturity of plants as a result of water deficit consider as a plant escape mechanism to cope with drought (Thomas, 1997). Patel *et al.*,. (2000) showed that fennel plants grown in sandy-loam soil had better growth parameters by increasing number of irrigations to ten times. Similar results about effects of water stress on other aromatic plants were found; Sangwan *et al.*, (1994) on lemongrasses and Letchamo *et al.*, (1995) on *Thymus vulgaris*.

Soil holds water according to its texture however, the levels of organic matter also determine how much water a soil can held. In a specific type of soil Hudson, (1994) estimated that every 1% of organic matter increased water-holding capacity by 1.5 per cubic-foot. Add to that the addition of organic matter improves aggregation, which improve infiltration. The study had shown a significant difference in plant height and main branch number of fennel plants, which were fertilized with different types of organic fertilizers and a significant difference among different types of organic fertilizers. This could be due to the differences in physical and chemical character of organic fertilizers, which affect water, holding capacity, infiltration, as well as, the nutrition availability. Poultry manure is a valuable, more concentrated and quick-acting organic fertilizers as all its nutrients are in an available form (Yagodin, 1984). Similar improving effect on plant growth under drought stress due to organic fertilizer have been reported (Badran, 2002).

Aly (1999) found that plant height, as well as, number of branches of *Nigella sativa* plants significantly increased when plants were fertilized with farm yard manure at 8, 16 and 24 t/fed. Mohamed and Matter (2001) added poultry and farm yard manure at 4 or 8 t/fed to *Tagetes minuta* and observed a significant increase in plant height and branch number over the control plants.

1- Fruit and Volatile oil yield

In the first season fennel fruit yield significantly increased by 63.6% when plants were irrigated 6 times instead of 3 times, this had 41.40 g/plant. But there was insignificant difference in the yield between 5- and 6-time-irrigated plants. However, both of them have significantly higher yield than 3 or 4-time irrigated plants in both seasons. All organic fertilized plants had a fruit yield significantly higher than the control plants, which had the lowest yield (45.18 g/plant). A significant difference in fruit yield among plants fertilized with organic fertilizers has been recorded. Among these treatments ChM-fertilized plants had the highest fruit yield 64 g/plant; this yield was 41.7% higher than that of control plants. In the first season, the interaction between number of irrigations and types of organic fertilizers was significant in fennel fruit yield. Control plants, which were irrigated 3 times, had the lowest fruit yield 32.13 g/plant, whereas 6-times-irrigated plants which were fertilized with ChM had the highest yield 76.13 g/plant (Table 4). No significant difference in fruit yield had been found between plants irrigated 5 or 6 times when they were fertilized with the same organic fertilizer.

Percentages of volatile oil of fennel fruits were significantly affected by number of irrigations and organic fertilizers in both seasons. Volatile oil percentage was decreased gradually by increasing number of irrigations. The differences in percentage of volatile oil among different water treatments were significant. Plants that were irrigated 6 times had the lowest volatile oil percentage (2.58) but 3-times-irrigated plants had the highest percentage of volatile oil (3.17%). All plants that were fertilized with organic fertilizers had volatile oil percentage significantly higher than control plants. However, there was a significant difference among plants fertilized with different types of organic fertilizers. ChM-fertilized plants had the highest percentage of volatile oil (3.04%), which was significantly higher than all other treatments (Table 4). The interaction between the two studied factors in % of volatile oil was significant in the second season.

Table 4 indicates that both of fruit yield and percentage of volatile oil percentage were significantly affected with the number of irrigations and organic fertilizers. As a result, volatile oil yield/plant had been significantly affected with these treatments (Table 4). Also, Table 4 shows that volatile oil percentage decreased as the number of irrigations decreased. Although 3-times-irrigated plants had a higher percentage of volatile oil, the volatile oil yield of these plants was significantly lower than volatile oil of any other treatment. This reduction in volatile oil yield was a result of decreasing fruit yield. Plants irrigated 5- or 6-times had insignificant difference in volatile oil yield (1.75 and 1.76 ml/plant, respectively) in the first season. However, the difference between any of these values and 3 or 4-time irrigated plants was significant.

Table (4): Effect of number of irrigations and organic fertilizers on fruit yield and volatile oil percentage and yield of fennel plants grown in sandy soil in the two seasons

Fertilizer (B)	number of irrigations (A)									
	1 st season					2 nd season				
	3	4	5	6	Mean B	3	4	5	6	Mean B
	fruit yield g/plant									
Control	32.13	42.53	51.67	54.40	45.18	36.47	45.60	54.07	58.67	48.70
CaM[1]	45.40	55.80	69.40	73.07	60.92	46.00	57.87	67.93	68.80	60.15
ChM[2]	48.20	59.07	72.60	76.13	64.00	50.73	61.60	70.87	78.60	65.45
PC[3]	39.87	49.93	63.73	67.33	55.22	41.67	51.47	62.33	68.53	56.00
Mean A	41.40	51.83	64.35	67.73		43.72	54.14	63.80	68.65	
LSD 0.05	A 10.49		B 4.49		AB 9.07	A 7.12		B 3.06		AB ns[4]
	volatile oil %									
Control	2.86	2.63	2.39	2.30	2.55	2.95	2.80	2.64	2.39	2.70
CaM[1]	3.30	3.08	2.81	2.69	2.97	3.42	3.25	3.05	2.78	3.13
ChM[2]	3.39	3.15	2.86	2.75	3.04	3.53	3.35	3.17	2.87	3.23
PC[3]	3.14	2.96	2.70	2.59	2.85	3.22	3.06	2.80	2.60	2.92
Mean A	3.17	2.96	2.69	2.58		3.28	3.11	2.92		2.66
LSD 0.05	A 0.08		B 0.05		AB 0.10	A 0.08		B 0.05		AB 0.10
	oil yield ml/plant									
Control	0.92	1.12	1.24	1.25	1.13	1.08	1.28	1.43	1.40	1.30
CaM[1]	1.50	1.72	1.95	1.97	1.78	1.57	1.88	2.07	1.91	1.86
ChM[2]	1.63	1.86	2.08	2.09	1.92	1.79	2.06	2.25	2.26	2.09
PC[3]	1.25	1.48	1.72	1.74	1.55	1.34	1.58	1.75	1.78	1.61
Mean A	1.33	1.55	1.75	1.76		1.45	1.70	1.88		1.84
LSD 0.05	A 0.17		B 0.07		AB 0.14	A 0.2		B 0.08		AB ns[4]

[1]CaM: cattle manure; [2]ChM: chicken manure; [3]PC: plant compost, [4]ns; not significant

Organic fertilized plants had significantly higher volatile oil than non-organic fertilized plants, which had 1.13 ml/plant. ChM-fertilized plants had significantly the highest volatile oil yield, 1.92 ml/plant followed by plants fertilized with CaM. The interaction between number of irrigations and organic fertilizers was significant. It is noticeable that non-organic fertilized plants which were, irrigated 3, 4, 5 or 6 times had significantly the lowest volatile oil yield than any other treatment. Similar results have been observed in the second season.

Results showed that volatile oils of fennel plants had significantly affected with number of irrigations and organic fertilizers. Rhizopoulou and Diamentoglou, (1991) found that *Origanum majorana* had higher oil content with increasing the soil moisture deficit. Patel *et al*,. (2000) showed that fennel plants grown in sandy-loam soil had higher volatile oils percentage by increasing number of irrigations. Results indicated that fennel fruits had higher percentages of volatile oil but lower volatile oil yield when subjected to low number of irrigations. Mohamed *et al.*, (2002) found that percentage of volatile oil content of *Tagetes minuta* was increased when plants grow in soil at 40% field capacity compared to plants grown in soil at 100% field capacity. But, the volatile oil yield of plants grown in soil at 40 % filed capacity was significantly higher.

Organic fertilisers had a dramatic affect on volatile oil percentage and yield of fennel plants. These affects could be attributed to the nutrient elements of the organic matter as well as improving physical condition of the

soil. Volatile oil percentage and yield of marjoram, peppermint, caraway and basil were higher when plants were fertilised with manure rather than chemical fertiliser (Aflatuni, 1993). Aly (1999) applied farm yard manure at 0, 8, 16 or 24 t/fed and observed a significant increment of total lipid of *Nigellia sativa* with 8 t/fed farm yard manure than other treatments. Saker (2001) found that 20 m^3/fed of poultry manure, 40 m^3/fed cattle manure and 30 m^3/fed sheep manure significantly increased volatile oil percentage and yield in fresh mint herb.

2- N, P and K %

Table 5 shows the significant effect of number of irrigations and organic fertilizers on percentage of N, P and K of fennel plants. Increasing number of irrigations significantly increase the percentage of N and P of dry leaves of fennel plants. In the first season, the minimum N and P % of dry leaves (2.36 and 0.303%, respectively) was obtained when plants irrigated 3 times. But % of K significantly decreased with increasing number of irrigations.

Table (5): Effect of number of irrigations and organic fertilizers on percentage of N, P and K of dry leaves of fennel plants grown in sandy soil in the two seasons

fertilizer (B)	number of irrigations (A)									
	1 st season					2 nd season				
	3	4	5	6	Mean B	3	4	5	6	Mean B
					N%					
Control	1.95	2.06	2.12	2.17	2.07	1.87	1.91	2.01	2.03	2.00
CaM[1]	2.5	2.43	2.50	2.57	2.50	2.18	2.17	2.43	2.38	2.29
ChM[2]	2.57	2.71	2.81	2.87	2.74	2.45	2.48	2.61	2.64	2.55
PC[3]	2.52	2.62	2.71	2.73	2.62	2.31	2.45	2.38	2.50	2.41
Mean A	2.36	2.45	2.53	2.59		2.20	2.25	2.36	2.39	
LSD 0.05	A 0.08		B 0.05	AB 0.11		A 0.11		B 0.04	AB 0.08	
					P%					
Control	0.270	0.293	0.327	0.350	0.310	0.273	0.283	0.293	0.310	0.290
CaM[1]	0.317	0.323	0.373	0.400	0.353	0.333	0.336	0.367	0.383	0.355
ChM[2]	0.330	0.357	0.393	0.417	0.374	0.350	0.343	0.387	0.403	0.371
PC[3]	0.297	0.323	0.370	0.373	0.341	0.317	0.327	0.345	0.363	0.338
Mean A	0.303	0.324	0.366	0.385		0.318	0.322	0.348	0.365	
LSD 0.05	A 0.011		B 0.089	AB ns[4]		A 0.075		B 0.042	AB ns[4]	
					K%					
Control	1.650	1.580	1.423	1.330	1.496	1.397	1.467	1.633	1.717	1.553
CaM[1]	1.727	1.620	1.460	1.270	1.519	1.433	1.507	1.677	1.777	1.598
ChM[2]	1.783	1.707	1.540	1.333	1.591	1.503	1.583	1.763	1.883	1.683
PC[3]	1.641	1.537	1.390	1.220	1.447	1.357	1.434	1.590	1.727	1.527
Mean A	1.700	1.611	1.453	1.288		1.423	1.498	1.666	1.776	
LSD 0.05	A 0.075		B 0.036	AB 0.072		A 0.0.75		B 0.036	AB ns[4]	

[1]CaM: cattle manure; [2]ChM: chicken manure; [3]PC: plant compost, [4]ns; not significant

The highest % of K in fennel leaves (1.700%) was in plants irrigated 3 times however, the lowest K % (1.288%) was in plants irrigated 6 times (Table 5).

Organic fertilisers significantly increased N, P and K % over dry leaves of control plants, which had 2.07, 0.310 and 1.496 %, respectively. There were significant differences among the different types of the organic fertilisers on % of N and P on fennel dry leaves. In the first season, ChM-fertilised plants had the highest N, P and K % (2.74, 0.374 and 1.591%, respectively). There was significant interaction between number of irrigations and organic fertilisers in N, P and K% in the first season. Control plants, which were irrigated 3 times, had the lowest % of N and P (1.95 and 0.27 respectively). Whereas ChM-fertilized plants, which were irrigated 6 times, had the highest content of these elements (Table 5). Control plants that irrigated 6 times had the lowest K% (1.330) which was significantly lower than K% when plants were irrigated 3 times. Similar results were observed in the second season.

The increment in percentages of NPK of fennel dry leaves following the application of organic fertilisers could be due to the increments in NPK availability following the mineralzation of manure in the soil. Mansour *et al.*, (1999) added different types of organic fertilizers at different rates to spearmint and marjoram plants and observed that N, P and K contents significantly increased. Also, they found that the highest content of these elements was in plants fertilized with ChM. Similar results about the increments of N, P and K in medicinal plants as a result of adding organic fertilizer have been found in *Calendula officinalis* (Matter and Mohamed, 2001) and *Tagetes minuta* (Mohamed and Matter, 2001).

3- Total carbohydrates content

Both of number of irrigations and organic fertilizers had a significant effect on total carbohydrates of fennel plants (Table 6). Total carbohydrates were significantly increased when number of irrigations decreased. Also, Table 5 shows a significant difference in total carbohydrates content among plants had 3, 4, 5 or 6 times of irrigation. Three-times-irrigated plants had the highest content of total carbohydrates (215.2 mg/g dry leaves) whereas 6-times-irrigated plants had the lowest content (184.2 mg/g) in the first season.

Table 6 shows that all OF-fertilized plants had significantly higher total carbohydrates than control plants, which had the minimum, content (173.6 mg/g, leaves dry weight). ChM-fertilized plants had the highest content of total carbohydrates 223.4 mg/g.

A significant interaction between irrigation treatment and organic fertilizers has been observed, in the first season. Control plants that irrigated 6 times had 153.2 mg/g total carbohydrates. The highest concentration of total carbohydrates 238.3 mg/g dry weight being when plants fertilized with ChM and irrigated 3 times. Similar results were observed in the second season (Table 6).

Results showed that reducing number of irrigations increased total carbohydrates content of fennel plants. This is in agreement with (Thomas, 1997) who reported that photosynthesis is less sensitive to water stress. So that, the reduction of photosynthesis under water stress is less than the

reduction in the growth. Therefore, sugars and other metabolites will accumulate at least during the early stage of the drought condition. The changes in soluble sugar content during stress conditions have been reported in *Tagetes* (Mohamed *et al.*, 2001), pea (Sanchez *et al.*, 1998) and brassica (Sinniah *et al.*, 1998). The increments in total carbohydrates of fennel dry leaves, which were attributed with the application of organic fertilizers was similar to results obtained by Mansur *et al.*, 1999 in mentha and Matter and Mohamed, 2001 in *Calendula officinalis*.

Table (6): Effect of number of irrigations and organic fertilizers on total carbohydrates of fennel plants grown in sandy soil in the two seasons

Fertilizer (B)	number of irrigations (A)									
	1 st season					2 nd season				
	3	4	5	6	MeanB	3	4	5	6	Mean B
	Carbohydrates content (mg/g dry weight)									
Control	190.2	180.8	170.2	153.2	173.6	201.6	193.5	181.9	163.8	185.2
CaM[1]	204.7	201.7	194.3	192.1	198.1	224.7	215.7	207.7	186.2	208.6
ChM[2]	238.3	235.0	221.0	199.3	223.4	254.0	243.8	229.2	206.2	233.3
PC[3]	227.6	223.7	213.7	192.2	214.3	246.2	236.6	224.5	201.3	227.2
Mean A	215.2	210.3	199.8	184.2		231.6	222.4	210.8	189.4	
LSD 0.05	A 6.5		B 1.8		AB 3.5	A 5.5		B 2.6		AB 5.2

[1]CaM: cattle manure; [2]ChM: chicken manure; [3]PC: plant compost, [4] ns; not significant

As conclusion, it is recommended to irrigate fennel plants grown under sandy soil conditions 5 times as there was no significant difference in the yield between 5 and 6-time-irrigated plants. In addition to the fact that to that these plants harvested earlier than 6-time-irrigated plants. Under water shortage conditions it is recommended to add organic fertilizers to relief the diverse effect of water stress. All types of organic fertilizers especially Ch-M had improved plant productivity especially when number of irrigation was reduced.

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النمو و إنتاج الزيت لنباتات الشمر
٢- تأثير عدد الريات والأسمدة العضويه

محمود عبد الهادى حسن عبدة ، محمود عبد الحكيم محمود
قسم البساتين بكلية الزراعة – جامعة المنيا

تم إجراء هذه التجربة فى موسمين زراعيين ٢٠٠٠/٢٠٠١ و ٢٠٠١/٢٠٠٢ لدراسة اثـر عـدد الريات والتسميد العضوى على النمو ومحتويات الزيت الطيار لنباتات الشمر النامية فـى ارض رمليـه٠ زرعت بذور الشمر فى تربه رمليه مضاف إليها صفر –٢,٥ كجم/م٢ سماد عضـوى جـاف مـن أسـمدة مخلفات الدواجن – مخلفات الأبقار – كمبوست نباتى وتم رى النباتات ٣-٤-٥ أو ٦مرات بعـد الإنبـات. أوضحت النتائج أن لكل من عدد الريات و الأسمدة العضوية تأثير معنوى على ميعاد الحصاد ارتفاع النباتات –و عدد الأفرع الرئيسية ومحصول الثمار والزيت٠ أدت زيادة عدد الريات والأسمدة العضوية إلى تـأخير ميعاد الحصاد فالنباتات التى رويت ثلاث مرات أعطت أقل محصول ثمرى٤,٤١ جم/نبات بينما تلك التـى رويت ست مرات أعطت ٧,٦٧ جم/نبات. لكن لم يكن هناك فرق معنوى فى محصول الثمار والزيت بيـن النباتات التى رويت ٥ او ٦ مرات (١,٧٥ ، ١,٧٦ مل/نبات على التوالي) كما حدثت زيادة معنويـة فـى نسبه النتروجين والفوسفور بزيادة عدد الريات وكانت اقـل نسـبه مـن النـتروجين والفوسـفور (٢,٣٦ و٠,٣٠٣% على التوالى) عندما رويت النباتات ثلاث مرات لكن كانت أعلى نسبة من البوتاسـيوم (١,٦٥%) عندما رويت النباتات ثلاث مرات٠ النباتات التى لم تسمد بالا سمده العضوية كانت اقل ارتفاعا وبها عدد اقل من الأفرع الاساسيه كذلك أعطت محصول منخفض من الثمار والزيت ٤٥ جم/ نبات و ١,١٣ مل / نبـات على التوالى. النباتات التى سمدت بمخلفات الدواجن أعطت أعلى محصول للزيت ١,٩٢مل / نبات وتليـها النباتات التى سمدت بالكمبوست النباتى١,٧٨مل / نبات ٠ادت الأسمدة العضويه إلى زيادة نسبه النـتروجين و الفوسفور و البوتاسيوم فى أوراق النبات. وعموما أوضحت النتائج أن الا سمده العضوية أدت الى تحسـين إنتاجية النباتات خصوصا تحت ظروف نقص عدد الريات.