Journal of Medicinal Plants Studies
www.PlantsJournal.com

ISSN (E): 2320-3862
ISSN (P): 2394-0530
NAAS Rating 2017: 3.53
JMPS 2017; 5(3): 327-334

Received: 01-03-2017
Accepted: 02-04-2017

Abd El-Aleem Wafaa
Department of Medicinal and Aromatic Plants, Desert Research Center, El-Matareya, Cairo, Egypt

Hendawy SF
Department of Cultivation and Production of Medicinal and Aromatic Plants, National Research Center, Dokki, Cairo, Egypt

Hamed ES
Department of Medicinal and Aromatic Plants, Desert Research Center, El-Matareya, Cairo, Egypt

Toaima WIM
Department of Medicinal and Aromatic Plants, Desert Research Center, El-Matareya, Cairo, Egypt

Correspondence
Abd El-Aleem Wafaa
Department of Medicinal and Aromatic Plants, Desert Research Center, El-Matareya, Cairo, Egypt

Effect of planting dates, organic fertilization and foliar spray of algae extract on productivity of Dutch fennel plants under Sinai conditions

Abd El-Aleem Wafaa, Hendawy SF, Hamed ES and Toaima WIM

Abstract
The present work was conducted on Dutch fennel plant strains during the two successive seasons of 2014/2015 and 2015/2016 in El-Maghara region, North Sinai Governorate, Egypt to detect the effect of sowing dates, organic fertilization, foliar spray of *Spirulina platensis* algae extract and the interaction among treatments on fruits and essential oil productivity. The experiment was planned in split split plot design. The interaction results showed that the significantly maximum increments in growth, fruits and oil yields were obtained when plants were sown in the early sowing date (15th of October) and received the higher level of compost manure (20 m^3/fed.) combined with foliar spray of *Spirulina platensis* extract. The major chemical constituents of extracted essential oils were trans-anethole, estragole, l-fenchone and d-limonene.

Keywords: Dutch fennel, sowing date, compost, algae, fruits, essential oil

Introduction
Fennel (*Foeniculum vulgare* Mill, Family: Apiaceae) is a strong aromatic and medicinal plant native to North Africa, Mediterranean Region, southern Europe and Asia. The fruits of the plant are used in folk medicine for its antispasmodic and stomachic, sedative, balsamic, cardiotonic, digestive, lactogogue and tonic properties. Also, are considered as a spice due to terpenoid compounds isolated from fruits volatile oil. The essential oil is used in cosmetics and pharmaceutical products. It was mentioned that the constituents of fennel volatile oil were anethole, limonene, fenchone, estragole, safrole, α-pinene, camphene, β-pinene, β-myrcene and p-cymene [1-5].

In Egypt, fennel fruits are considered an important export spice, the country cultivates about 11000 feddans of fennel, mostly in Assiut and Qena Governorates but the Egyptian bitter fennel type (*Foeniculum vulgare* var. *vulgare*) is inferior in the anethole content which is about 15.75%. Furthermore, Egyptian type has another major drawback due to high content of estragole which reaches 87.98%. Estragole is among the substances banned for use in infant formulae and drugs. Some countries such as Germany ban the use of Egyptian fennel in drug manufacturing at large. Therefore, there was an urgent need for introducing new fennel varieties for cultivation in our country.

Dutch fennel (*Foeniculum vulgare* spp *vulgare*) is a new sweet fennel genotype introduced to Egypt by Sekem Company in the last few years. The seeds were imported from the Netherlands. The new fennel type is characterized by higher yields of fruits and oil, a higher percentage of anethole and a lower percentage of estragole than the local fennel type [6-8].

The Egyptian Government‘s policy is concerned to reclaim new lands for increasing the production of medicinal and aromatic plants. Up to now, very rare information are known on the effect of agriculture practices on productivity and quality of Dutch fennel plants under the ecosystem conditions of El-Maghara region, North Sinai Governorate as newly reclaimed lands. So, the aim of the present work was to study the effect of sowing dates, organic farming practices i.e. compost manure requirements, foliar spray of blue green algae extract and the interaction among treatments on quantitative and qualitative parameters of Dutch fennel fruits.

Materials and methods
The present investigation was carried out during the two successive seasons of 2014/2015 and 2015/2016 in newly reclaimed arid land in the Agricultural Experimental Station of the Desert

Research Center at El-Maghara village (30.71º N and 33.33º E), North Sinai Governorate.

Seeds of Dutch fennel (*Foeniculum vulgare* spp *vulgare*) type were imported from Euro Herb Company, Netherlands by Sekem Company. The experiment was planned in a split split plot design with three replicates. The main plots were consisted of three different sowing dates as October15th, November 1st and November 15th for both seasons. The subplots included applying of two levels of compost manure before sowing as 10 and 20 m^3 per feddan. The sub-subplot involved foliar spray of *Spirulina platensis* algae extract as without and with, respectively.

Fennel seeds were sown directly in the sandy soil under drip irrigation system in rows 75 cm apart and 50 cm within hills. Drip irrigation was used with drippers (4 liter / hour /hill) for only one hour every two days. Fennel plants were thinned after germination at three plants per hill (33600 plants/fed.). The blue-green algae extract was obtained from Algae Production Unit at the National Research Center, Egypt. It was an extract of *Spirulina platensis*. The algae extract was applied as foliar spray twice per season after 60 and 90 days of sowing dates at concentration of 1 liter extract/200 liter water/feddan. Fennel plants were harvested at the fruits mature stage according to the dates of sowing as follows:- on May 6th for the first sowing date, May 15th for the second sowing date and May 24th for the third sowing date. L.S.D. test at 0.05 was used to compare the means of treatments according to [9]. The following data were recorded:-

A- Growth and yield parameters

Plant height (cm), herb fresh weight (g/plant), umbel number per plant, fruits yield (g/plant and kg/feddan).

B- Chemical active constituents parameters

1. Determination of essential oil percentage: Essential oil percentage was determined in the air dried fruits by hydrodistillation for 3 hours using a Clevenger type apparatus [10].
2. Determination of volatile oil yield per plant (ml) as follows: Oil percentage x fruits dry weight per plant /100.
3. Determination of essential oil yield per feddan (l) as follows: Oil yield per plant x number of plants/feddan.
4. Determination of essential oil components: The essential oil samples of the second season were analyzed by using Gas Chromatography-Mass Spectrometry instrument (GC-MS analysis) at the Laboratory of Medicinal and Aromatic Plants, National Research Center, Egypt with the following specifications. Instrument: a TRACE GC Ultra Gas Chromatographs (THERMO Scientific Corp., USA), coupled with a THERMO mass spectrometer detector (ISQ Single Quadrupole Mass Spectrometer). The GC-MS system was equipped with a TR-5MS column (30 m x 0.32 mm i.d., 0.25 μm film thickness). Analyses were carried out using helium as carrier gas at a flow rate of 1.3 ml/min at a split ratio of 1:10 and the following temperature program: 80 ºC for 1 min; rising at 4 ºC/min to 300 ºC and held for 1min. The injector and detector were held at 220 and 200 ºC, respectively. Diluted samples (1:10 hexane, v/v) of 1 μL of the mixtures were always injected. Mass spectra were obtained by electron ionization (EI) at 70 eV, using a spectral range of m/z 40-450. The separated components of the essential oil were identified by matching with the National Institute of Standards and Technology (NIST) published.

The soil, water, compost manure and *Spirulina platensis* extract samples were analyzed at the laboratories of Desert Research Center and Soils, Water and Environment Research Institute, as shown in Tables (A, B, C, D and E). The analyses were carried out as described by [11, 12].

Table (A): Mechanical analysis of the experimental soil.

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Soil texture
0-30	95.00	4.00	1.00	Sandy

Table (B): Chemical analysis of the experimental soil.

pH	E.C.(ds/m)	O.M.(%)	Soluble anions (meq/l)				Soluble cations (meq/l)			
			CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
7.9	2.8	0.5	-	1.0	20.0	7.0	6.0	8.0	12.6	1.4

Table (C): Chemical analysis of irrigation water.

pH	E.C.	Soluble anions (meq/l)				Soluble cations (meq/l)			
	ppm	CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^+	K^+
7.32	2547.15	-	4.26	23.59	11.44	11.45	9.64	17.31	0.89

Table (D): Chemical analysis of the used compost manure.

pH	EC (ds/m)	O.M. (%)	C/N ratio (%)	N (%)	P (%)	K(%)	Fe(%)	Mn (mg/kg)	Zn (mg/kg)	Cu (mg/kg)
8.8	4.6	20.5	11.85	1.03	0.22	2.04	3.43	606.8	85.65	43.60

Table (E): Chemical analysis of the used *Spirulina platensis* algae extract.

Macro elements (%)			Micro elements (%)			
N	P	K	Fe	Zn	Mn	Cu
4.30	2.15	0.10	2.11	2.42	3.04	0.75

Table (F): Means of the meteorological data of El-Maghara region during the seasons of 2014/2015 and 2015/2016.*

Months	Average air temperature (°C)		Solar (MJ/m²)	Precipitation (mm)	Relative humidity (fraction)	Wind (m/s)
	Max.	Min.				
October	28.16	14.68	18.23	0.10	0.68	1.98
November	21.45	9.87	13.60	0.33	0.70	1.85
December	19.46	8.08	12.27	0.03	0.69	1.82
January	19.39	7.43	12.16	0.13	0.69	1.84
February	20.51	9.47	15.92	0.61	0.62	2.28
March	22.23	7.75	21.30	0.13	0.64	2.33
April	26.74	11.42	23.95	0.00	0.54	2.24
May	29.28	13.94	26.95	0.04	0.56	2.29

*****EMA, Egyptian Meteorological Authority [13].

Results and discussion

I- Effect of sowing dates

Generally, the cultivation area of El-Maghara, North Sinai Governorate is characterized by extremely arid climatic conditions. It has mild winter, hot summer with relatively low precipitation and high evaporation [14]. So, choosing of the suitable sowing date is very important for successful agricultural productivity.

Concerning the effect of sowing dates on growth and yield parameters, it was appeared from presented data in Table (1) that the different sowing dates affected significantly plant height, fresh weight per plant, umbel number per plant, fruit yield per plant as well as per feddan. The results showed significant variations among the different sowing dates in both seasons. The maximum values were detected in the early sowing date of 15th of October whereas the lowest parameters were detected in the late sowing date of 15th of November. Similar results were obtained by many investigators who reported that early sowing date increased fennel growth and productivity. These effects might be due to the higher temperature and longer photoperiod during early sowing date that can give the plants a chance to build up more stored foods than the later sowing dates and this may be reflected on faster growing of plants with more number of umbels per hill and consequently a higher fruit yield per plant than under the colder conditions (Table, F) [15-20].

As for, the effect of sowing dates on essential oil productivity, it was clear from Table (1) that the different sowing dates significantly affected essential oil percentage, oil yield per plant and per feddan. The results showed significant differences among sowing dates in both seasons, in which the early and middle dates were on one side and late date was only, on the other side. The maximum values were recorded as a result of sowing date at 15th of October whereas the lowest values were recorded from plants cultivated in the late sowing date of 15th of November. The increment of oil percentage during the early date more than in the late one may be due to the rise in temperature and day length in 15th of October and its decrease in 15th of November in both seasons [18, 20].

II- Effect of organic fertilization

Data present in Table (2) emphasized that plant height, fresh weight per plant, umbel number per plant, fruits yield per plant as well as per feddan were enhanced by increasing compost fertilizer rates from 10 to 20 m^3/ fed. On the other hand, data demonstrated that organic fertilization had a non-significant effect on essential oil yield per feddan in the first season while proved significant effect in the second one. The results were coincided with those obtained by [21] on fennel plants. These findings may be attributed to the role of compost as an organic material influences agricultural sustainability by improving chemical, physical, biological properties of soils, the fertility and structure of the soil and the moisture holding capacity which could finally led to a significant effect on improving of plant growth and yield productivity and quality [22-24].

III- Effect of foliar spray of blue-green algae extract:

Data presented in Table (3) indicated that foliar spray of *Spirulina platensis* extract had a significant marked effect on the average plant height, fresh weight per plant, number of umbels per plant, fruit yield per plant as well as per feddan in both seasons over untreated plants. Also, data revealed that, there were significant differences in essential oil percentage, oil yield per plant and per feddan between the treated plants with algae extract on one side and the plants non-treated with algae extract on the other side. The stimulatory effect of foliar spray with *Spirulina platensis* extract could be due to its high content of macro and micro elements (Table E), as well as its high content of free amino acids. Also, it contains the whole spectrum of natural mixed carotene and xanthophyll phytopigments which are considered as the richest natural source of vitamin B-12. In addition to the presence of high levels of various plant hormones such as auxins and cytokinins, which are considered an important and vital for raising the plant production and increasing the capacity of plant to withstand various stress conditions [25-28].

IV-Effect of the interaction among treatments

Data presented in Table (4) showed that the significantly tallest plant, heaviest fresh weight per plant, maximum number of umbels per plant, highest fruit yield per plant as well as per feddan were recorded by the interaction among early sowing date of 15th of October and the highest compost manure rate (20 m^3/fed.) combined with foliar spray of *Spirulina platensis* extract. On the contrary, the lowest mean values of these parameters were detected by the late sowing date of 15th of November and the lowest compost manure level (10 m^3/fed.) without foliar spray of *Spirulina platensis* extract. Likewise, the achieved results revealed that the interaction within early sowing date and the highest level of compost manure combined with foliar application of blue-green algae extract recorded high significant increments in essential oil yield per plant and per feddan in both seasons. These results were coincided with those found by [15, 21, 29-32].

The increases in all previous parameters by sowing in early date and applying of the highest compost manure level combined with foliar spray of *Spirulina* extract may be due to the effect of the warm weather of the earliest sowing date which hastens the process of mineralization of organic matter and increasing microbial activity in addition, using both of compost manure and algae extract provided plants with macro and micro nutrients, amino acids, vitamins and auxins which promote plant photosynthesis activity [33].

The GC-MS analysis proved that the chemical constituents of

essential oils were affected by the different farming practices (Table 5 and Fig. 1), however, its dominant components were trans-anethole, estragole, l-fenchone and d-limonene as follows:-

For the treatment of sowing on October15th + applying 10 m^3 compost/fed. + without foliar spray of algae extract, its oil main components were trans-anethole 45.60%, estragole 20.02%, l-fenchone 19.85% and d-limonene 10.52%. Concerning the treatment of sowing on October 15th + applying 20 m^3 compost/fed. + foliar spray of algae extract, its oil major components were trans-anethole 37.65%, estragole 31.39%, l-fenchone 15.39% and d-limonene 12.86%. Respecting the treatment of sowing on November 1st + applying 10 m^3 compost/fed. + without foliar spray of algae extract, its oil dominant components were trans-anethole 48.51%, estragole 11.17%, l-fenchone 26.31% and d-limonene 10.04%, while dealing with the treatment of sowing on November 1st + applying 20 m^3 compost/fed. + foliar spray of algae extract, its oil chief components were trans-anethole 48.56%, estragole 9.42%, l-fenchone 15.41% and d-limonene 18.31%. As regard to the treatment of sowing on November 15th + applying of 10 m^3 compost/fed. + without foliar spray of algae extract, its highest components were trans-anethole 70.22%, estragole 5.61%, l-fenchone 12.05% and d-limonene 7.03% and for the treatment of sowing on November15th + applying 20 m^3 compost/fed. + foliar spray of algae extract, its oil main components were trans-anethole 71.85%, estragole 9.76%, l-fenchone 5.99% and d-limonene 9.58%. The observed constituents of Dutch fennel oils were in harmony with the findings of [6, 8].

The above mentioned results showed that the highest anethole concentration was found by the late sowing date whereas the lowest anethole content was recorded by the early sowing date. These findings may be attributed to the fact that cultivated plants of the later sowing date were under environmental stresses and under stress conditions the amount of trans-anethole in the essential oil increases, because in such conditions the plants produce more secondary metabolites, the substances that prevent oxidation processes in the cells [34].

Finally, the foregoing oil analyses indicated the superiority of new Hollander fennel strain as its oil trans-anethole contents were 37.65-71.85% and its estragole contents were 5.61-31.39% in comparison to the Egyptian fennel type as mentioned by [35] who found that in the Egyptian fennel plants cultivated under El-Maghara region conditions, the main oil components were anethole (3.54-22.21%) and estragole (29.30-50.65%).

Table 1: Effect of sowing dates on growth, yield and active constituents parameters of Dutch fennel plants under El-Maghara region conditions during the two successive seasons of 2014/2015and 2015/2016.

Treatments	Plant height (cm)		Herb fresh weight (g/plant)		Umbel number per plant		Fruits yield (g/plant)		Fruits yield (kg/feddan)		Essential oil (%)		Essential oil yield (ml/plant)		Essential oil yield (l/feddan)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
15th of October	72.56	76.79	112.32	117.16	20.75	22.04	16.09	16.97	540.54	570.20	1.15	1.22	0.18	0.21	6.05	6.81
1st of November	65.20	65.70	69.64	70.85	14.67	15.34	10.81	11.49	363.14	385.90	0.98	1.04	0.11	0.12	3.53	3.95
15th of November	59.20	60.52	52.16	55.76	10.74	11.36	6.47	7.05	217.31	236.89	0.96	0.96	0.07	0.07	2.02	2.27
LSD at 0.05	4.598	4.829	24.480	11.540	1.677	1.337	2.331	1.329	66.670	33.640	0.063	0.072	0.001	0.036	0.742	0.420

Table 2: Effect of organic fertilization on growth, yield and active constituents parameters of Dutch fennel plants under El-Maghara region conditions during the two successive seasons of 2014/2015and 2015/2016.

Treatments	Plant height (cm)		Herb fresh weight (g/plant)		Umbel number per plant		Fruits yield (g/plant)		Fruits yield (kg/feddan)		Essential oil (%)		Essential oil yield (ml/plant)		Essential oil yield (l/feddan)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
10m^{3}compost/fed.	58.58	60.29	54.16	55.92	12.06	13.17	9.18	9.71	308.34	326.26	1.18	1.21	0.11	0.12	3.76	4.09
20m^{3}compost/fed.	72.71	75.05	101.92	106.58	18.70	19.31	13.07	13.96	438.98	469.06	0.88	0.93	0.12	0.14	3.98	4.60
LSD at 0.05	3.754	3.496	22.680	14.400	5.267	3.765	1.256	1.024	49.490	31.530	0.045	0.073	0.001	0.037	0.695	0.473

Table 3: Effect of foliar spray with blue green algae extract on growth, yield and active constituents parameters of Dutch fennel plants under El-Maghara region conditions during the two successive seasons of 2014/2015and 2015/2016.

Treatments	Plant height (cm)		Herb fresh weight (g/plant)		Umbel number per plant		Fruits yield (g/plant)		Fruits yield (kg/feddan)		Essential oil (%)		Essential oil yield (ml/plant)		Essential oil yield (l/feddan)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Without algae	62.52	64.72	64.12	68.59	13.67	14.79	9.92	10.42	333.15	349.95	0.99	1.01	0.10	0.11	3.30	3.59
With algae	68.77	70.61	91.95	93.92	17.09	17.69	12.33	13.26	414.18	445.37	1.07	1.12	0.13	0.15	4.43	5.10
LSD at 0.05	2.411	3.922	11.460	13.730	3.009	1.859	1.115	1.112	30.850	40.480	0.033	0.033	0.001	0.023	0.502	0.231

Table 4: Effect of the interaction among treatments on growth, yield and active constituents parameters of Dutch fennel plants under El-Maghara region conditions during the two successive seasons of 2014/2015and 2015/2016.

Treatments			Plant height (cm)		Herb fresh Weight (g/plant)		Umbel number per plant		Fruits yield (g/plant)		Fruits yield (kg/feddan)		Essential Oil (%)		Essential oil yield (ml/plant)		Essential oil yield (l/feddan)	
			1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
15th of October	10 m^3 compost /fed.	Without algae	61.00	65.44	61.79	63.33	16.15	17.49	11.67	12.33	392.11	414.29	1.30	1.33	0.15	0.16	5.04	5.38
		With algae	68.00	68.75	72.33	77.55	18.23	20.11	14.25	15.25	478.80	512.40	1.39	1.42	0.20	0.22	6.72	7.39
	20 m^3 compost /fed.	Without algae	79.39	81.67	121.53	130.64	22.09	23.42	16.14	16.91	542.30	568.18	0.96	1.00	0.16	0.17	5.38	5.71
		With algae	81.82	91.28	193.61	197.09	26.50	27.11	22.29	23.39	748.94	785.90	0.95	1.09	0.21	0.26	7.06	8.74
1st of November	10 m^3 compost /fed.	Without algae	56.61	60.13	53.20	50.00	9.97	10.39	9.00	9.23	302.40	310.13	1.03	1.11	0.09	0.10	3.02	3.36
		With algae	59.67	59.00	60.83	59.33	12.42	13.00	10.00	10.33	336.00	347.09	1.17	1.24	0.12	0.13	4.03	4.37
	20 m^3 compost /fed.	Without algae	67.33	68.08	62.50	69.61	15.42	17.00	11.33	11.58	380.68	389.09	0.81	0.83	0.09	0.10	3.02	3.36
		With algae	77.17	75.57	102.00	104.44	20.83	20.93	12.90	14.80	433.44	497.28	0.90	0.95	0.12	0.14	4.03	4.70

15th of November	10 m3 compost /fed.	Without algae	50.31	51.17	35.19	40.00	6.67	8.00	4.58	5.11	153.89	171.70	1.06	1.00	0.05	0.05	1.68	1.68
		With algae	55.89	57.22	41.61	45.30	8.92	10.00	5.56	6.01	186.82	201.94	1.12	1.12	0.06	0.07	2.02	2.35
	20 m3 compost /fed.	Without algae	60.50	61.83	50.50	57.94	11.67	12.41	6.77	7.33	227.47	246.29	0.78	0.80	0.05	0.06	1.68	2.02
		With algae	70.06	71.83	81.33	79.78	15.66	15.00	8.96	9.75	301.06	327.60	0.86	0.90	0.08	0.09	2.69	3.02
LSD at 0.05			5.905	9.606	28.060	33.620	9.819	4.553	2.732	2.7224	75.560	99.170	0.080	0.080	0.002	0.056	1.229	0.565

Table 5: Effect of the interaction among treatments on volatile oils chemical constituents (%).

NO	Compound	Sowing on October15th + applying 10 m3 compost/fed. + Without foliar spray of algae extract	Sowing on October15th + applying 20 m3 compost/fed. + foliar spray of algae extract	Sowing on November 1st + Applying 10 m3 compost/fed. + Without foliar spray of algae extract	Sowing on November 1st + Applying 20 m3 compost/fed. + foliar spray of algae extract	Sowing on November 15th + Applying 10 m3 compost/fed. + without foliar spray of algae extract	Sowing on November 15th + Applying 20 m3 compost/fed. + foliar spray of algae extract
1	α-Thujene	-	-	-	-	0.19	-
2	2-Myristynoyl pantetheine	0.22	-	-	-	0.13	-
3	l-Phellandrene	0.20	-	0.18	-	-	-
4	α-Pinene	2.47	1.70	2.57	5.41	3.64	1.23
5	Z,Z,Z-1,4,6,9-Nonadecatetraene	0.25	-	-	-	-	
6	p-Mentha-1,3,8-triene	-	-	-	-	-	0.18
7	Camphene	-	0.17	0.20	0.47	0.40	-
8	ç-Terpinene	-	-	-	-	-	0.27
9	5-Tetradecen-3-yne	-	-	0.20	-	0.22	-
10	Sabinene	-	0.24	-	-	-	0.26
11	Cineole	-	-	-	-	-	0.15
12	Dihexyl terephthalate	-	-	-	0.62	-	-
13	d-limonene	10.52	12.86	10.04	18.31	7.03	9.58
14	4-Terpineol	-	-	-	-	-	0.15
15	Linalyl acetate	-	-	0.18	-	-	-
16	l-Fenchone	19.85	15.39	26.31	15.41	12.05	5.99
17	Camphor	0.36	0.29	0.47	0.45	0.51	0.19
18	α-Fenchyl acetate	-	-	-	1.35	-	0.29
19	Limonene oxide	-	0.31	-	-	-	0.10
20	Estragole	20.02	31.39	11.17	9.42	5.61	9.76
21	Trans-anethole	45.60	37.65	48.51	48.56	70.22	71.85
22	7-Acetoxy-6-nitrobenzo[a]pyrene	0.31	-	-	-	-	-
23	3-Isopropoxyphthalide	-	-	0.17	-	-	-
24	Colchiceine	0.20	-	-	-	-	-
Total Identified Compounds		100	100	100	100	100	100
Total Hydrocarbon Compounds		14.17	14.97	13.19	24.19	11.61	11.52
Total Oxygenated Compounds		85.83	85.03	86.81	75.81	88.39	88.48

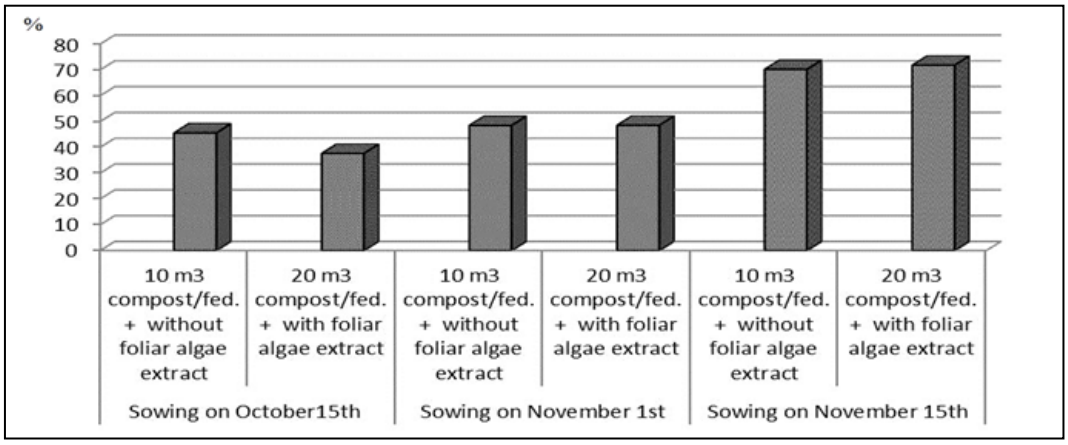

Fig 1: Effect of the interaction among treatments on trans-anethole concentration of the Dutch fennel essential oil under El-Maghara region conditions, North Sinai Governorate.

Conclusión

For organic production of Holland fennel fruits under El-Maghara region conditions, North Sinai Governorate it is recommended to sow on October 15th, apply of 20 m^3 compost manure per feddan before sowing and plants should be foliar sprayed with blue green algae extract of *Spirulina platensis* after 60 and 90 days of sowing date at concentration of 1 liter extract/200 liter water/feddan.

References

1. Wichtl M, Bisset, NG. Herbal Drugs and Phytopharmaceuticals (ed), Medpharm Scientific Publ. Stuttgart, 1994, 107-108.
2. Al-Kordy MAA. Mother plant selection in local germplasm of fennel *Foeniculum vulgare* Mill. Annals of Agric. Sci. Moshtohor 2000; 38(4):2199-2215.
3. Patra M, Shahi SK, Midgely G, Dikshit A. Utilization of essential oil as natural antifungal against nail infective fungi. Flavor and Fragrance J. 2002; 17:91-94.
4. Saleha, YMA. Investigation of the genetic toxicology of dill and fennel extracts and cyclophosphamide in male rats by RAPD-PCR assay. Journal of American Science. 2011; 7(9):398-408.
5. Saravanaperumal SA, Terza AL. Polyphenolics free DNA isolation and optimization of PCRRAPD for fennel (*Foeniculum vulgare* Mill.) from mature and young leaves. African Journal of Biotechnology 2012; 11(35):8622-8631.
6. Shalaby AS, Hendawy SF, Khalil MY. Evaluation of some types of fennel (*Foeniculum vulgare* Mill.) newly introduced and adapted in Egypt. Journal of Essential Oil Research. 2011; 23(4):35-42.
7. Abou El-Nasr THS, Mahfouze SA, Al-Kordy MAA. Assessing phenotypic and molecular variability in fennel (*Foeniculum vulgare*) varieties. Australian Journal of Basic and Applied Sciences. 2013; 7(2):715-722.
8. Yousef RMM, Abu El-Leel OF. Growth, essential oil production and genetic study of some fennel varieties under different compost levels in sandy soil. J. Agric. Chem. and Biotechn. Mansoura Univ. 2014; 5(12):331-356.
9. Snedecor GW, Cochran WG. Statistical Methods. The Iowa State Univ., Press, Ames, Iowa, U.S.A. 1982, 507.
10. British Pharmacopoeia. Determination of Volatile Oil in Drugs. The Pharmaceutical Press, London, 1963.
11. Jackson ML. In Soil Chemical Analysis. Constable. Co. Lt., London, 1976.
12. AOAC. Association of Official Analytical Chemists. In Official Methods of Analysis. Published by AOAC International 17th ed. Washington, D.C. 2002.
13. EMA. Egyptian Meteorological Authority. Arab Millennium Ecosystem Assessment, Sinai Subglobal Assessment, El-Maghara, North Sinai, Egypt. http://www.millenniumassessment.org/documents_sga/Egypt%20Copy%20of%20Progress%20Report%20October%2006.pdf. Progress Report, October, 2006.
14. Ibrahem Zahira TZ. Effect of some cultural practices on growth and chemical composition of some medicinal plants under conditions of northern Sinai. Ph.D. Thesis, Fac. Agric. Kafr El-Sheikh, Tanta Univ., Egypt, 2000.
15. Yadav BD, Khurana SC, Thakral KK, Malik YS. Effect of sowing dates and planting methods on quality of seed produced by different order umbels in fennel. Haryana-Journal-of-Horticultural-Sciences. 2000; 29(1/2):108-110.
16. Abou El-Magd MM, El-Abagy HMH. Vegetative growth and green yield of sweet fennel plants as affected by date of sowing, mineral and organic fertilization. Egypt. J. Appl. Sci. 2003; 18(12B):717-728.
17. Tunio SD, Majeedano HI, Jogi MS, Jarwar AD. Effect of different sowing dates on growth and yield of fennel. Pakistan Journal of Agriculture, Agricultural Engineering, Veterinary Sciences. 2005; 21(2):7-10.
18. Sudeep S, Buttar GS, Singh SP. Growth, yield and heat unit requirement of fennel (*Foeniculum vulgare*) as influenced by date of sowing and row spacings under semi-arid region of Punjab. Journal of Medicinal and Aromatic Plant Sciences. 2006; 28(3):363-365.
19. Abd El-Wahab MA, Mehasen HR. Effect of locations and sowing date on (*Foeniculum vulgare* Mill.) Indian fennel type under Upper Egypt conditions. Journal of Applied Sciences Research. 2009; 5(6):677-685.
20. Abou El-Ghait EM, Gomaa AO, Youssef ASM, Atiea EM, Abd-Allah WH. Effect of sowing dates, bio, organic and chemical fertilization treatments on growth and production of Indian fennel under North Sinai conditions. Bull. Fac., Cairo Univ. 2012; 63:52-68.
21. Ryckeboer J, Mergaert J, Vaes K, Klammer S, De Clercq D, Coosemans J *et al*. A survey of bacteria and fungi occurring during composting and self-heating processes. Ann. Microbiol. 2003; 53: 349-410.
22. Rivero C, Chirenje T, Ma LQ, Martinez G. Influence of compost on soil organic matter quality under tropical conditions. Geoderma. 2004; 123:355-361.
23. Saha S, Mina BL, Gopinath KL, Kundu S, Gupta HS. Relative changes in phosphatase activities as influenced by source and application rate of organic composts in

field crops. Biores. Technol. 2008; 99:1750-1757.
24. Aly MS, Esawy MA. Evaluation *of Spirulina platensis* as bio. stimulator for organic farming systems, J. Gen. Eng. Biotechnol. 2008; 6(2):1-7.
25. Anitha L, Bramari GS, Kalpana P. Effect of supplementation of *Spirulina platensis* to enhance the zinc status in plants of *Amaranthus gangeticus*, *Phaseolus aureus* and tomato. Advances in Bioscience and Biotechnology. 2016; 7:289-299.
26. Khater RMR. Effect of sowing dates and foliar spray with algae extract on cluster bean (*Cyamopsis tetragonoloba* L.). International Journal of PharmTech Research. 2016; 9(9):75-84.
27. Moghith WMA. Effect of organic and biofertilization on the growth, production and the chemical constituents of *Origanum vulgare* L. plants, M.Sc. Thesis, Fac. Agric., Tanta Univ., Egypt, 2016.
28. Guerrero TM, Johnson CB. Season has a major effect on the essential oil yield response to nutrient supply in *Origanum majorana*. J. Hort. Sci. and Biotech. 2000; 75(5):520-527.
29. Osman YAH. Possibility of production of coriander (*Coriander sativum* L.) under Sinai conditions. Ph. D. Thesis, Fac. Agric., Cairo Univ. 2000.
30. Rai SK, Katiyar RS, Singh SP. Effect of nitrogen and phosphorus on the growth and yield of *Foeniculum vulgare*, L. on the sodic soil. J. of Medicinal and Aromatic Plant Sciences. 2002; 24(1):65-67.
31. Kandeel AM, Sharaf MS. Productivity of *Majorana hortensis*, Moench. plants as influenced by the interactions between mineral and biological fertilization. J. Agric., Sci., Mansoura Univ. 2003; 28(2):1373-1389.
32. Ahmed YM, Shalaby EA. Effect of different seaweed extracts and compost on vegetative growth, yield and fruit quality of cucumber. J. Hortic. Sci. Ornam. Plants. 2012; 4:235-240.
33. Acimovic MG, Korac J, Jacimovic G, Oljaca S, Djukanovic L, Vuga-Janjatov V. Influence of ecological conditions on seeds traits and essential oil contents in anise (*Pimpinella anisum* L.). Not. Bot. Horti. Agrobo. 2014; 42(1):232-238.
34. Badawy MYM. Effect of mycorrhiza and mineral fertilization on growth and oil productivity of *Foeniculum vulgare*, Mill. plant under Sinai conditions. Bull. Fac. Agric., Cairo Univ. 2016; 67:245-255.