

The Chemical Constituent and Vegetative and Yielding Characteristics of Fennel Plants Treated with Organic and Bio-fertilizer Instead of Mineral Fertilizer

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Abstract: This experiment was conducted at the Experimental Farm, Faculty of Agriculture, Al-Azhar University, Assiut branch to investigate the possibility of organic and bio-fertilizers utilization instead of mineral fertilizers and the subsequent effects on vegetative growth, yielding, volatile and crude oils as well as the secondary metabolites on fennel plants. The obtained results indicated that vegetative growth, yield, essential oil and crude oil were augmented when application of different mineral and organic fertilizers. The interaction between recommended NPK x bio-fertilizer treatment and the combined of 40 m³ organic manure and bio-fertilizer treatment were the most effective on previous parameters.

Key word: Fennel, organic, bio-fertilizer, yield, flavonoid and saponin.

INTRODUCTION

Fennel (*Foeniculum vulgare* L.) belongs to Family Apiaceae, which is an annual, biennial or perennial aromatic herb, depending on the variety (Farrell 1988, Wichtl and Bisset, 1994). It contains phytochemical hormones (saponins), flavonoids, lipids, proteins and essential oils. Medicinal and aromatic plants are important economic products which represent significant sources of economic revenue and foreign exchange and are among the most important agricultural export products (Watt and Breyer, 1962). The Egyptian government in collaboration with the WHO seeks to protect fennel plants that serve as sources for pharmaceutical compounds and who might increase the export of these plants from Egypt to all over the world (Egypt Magazine, 2000). Botanically, the seeds are defined as fruits (Bhati *et al.* 1988 and Buntain and Chung, 1994). Fennel is used in folk medicine as a stimulant, diuretic, carminative and sedative (Charles *et al.* 1993) and galactagogic, emmenagogic, expectorant and antispasmodic (Chiej, 1984). It is also considered as a spice due to terpenoid compounds isolated from its fruits volatile oil (Masada, 1976). Also, fennel fruits are widely used in the preparation of various dishes like soups, sauces, pastries, confectioneries, pickles and meat dishes etc. (Bhati *et al.* 1988). The leaf stalks and the tender shoots are also used in salads. Fennel is used in cooking for liqueurs (Bhati *et al.* 1988). The essential oil of fennel is used to flavor different food preparations and in perfumery industries. The oil contains fenchone which plays an important role in pharmaceutical and other industries as well as in confectionery (Abdallah *et al.* 1978). To increase the crops quality especially medicinal and aromatic plants, organic fertilization is more acceptable than chemical fertilizers and organic farming is a quality standard to be matched well by small farmers in Egypt (Abou El-Fadl *et al.* 1990).

It is recommend that completely or partial substitution of mineral fertilization (NPK) by using of organic and bio-fertilizers which are safe and economic to farmer. Many researchers have pointed out efficacy of organic manures on increasing the growth, yield and essential oil production of celery (Mahajan *et al.* 1977), Achilla (Sayed,1993) groundnut (Mehta *et al.* 1995), roselle (Ezz-Eldin and Abd-Elmoaz,1998) anise (Safwat *et al.* 2001), cumin (Safwat and Badran 2002), and fennel (Badran and Safwat 2004). Meanwhile, bio-fertilizers (N fixing and P dissolving bacteria) had an effective role in partial replacement of N and P mineral fertilization. This role was revealed by Ibrahim (2002) and (Badran and Safwat 2004) on fennel, Safwat *et al.* (2001) and Soliman (2002) on anise, Safwat and Badran (2002) on Cumin and (Badran *et al.* 2002) on black cumin. This experiment was conducted to study the effect of NPK fertilizer and organic manure separately or in combination with bio-fertilizers on vegetative aspects, seed yield, crude oil, essential oil % and yield, saponins, flavonoids, N, P and K% of fennel plant.

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MATERIALS AND METHODS

The present study was carried out at the Experimental farm, Faculty of Agriculture, AL-Azhar University, (Assiut branch) during two successive seasons, (2005/2006 and 2006/2007) to study the influence of NPK and organic manure with or without bio-fertilizers mixture growth, yield, crude oil, and volatile oil. Organic manure (cattle) was provided from the animal production Farm Faculty of Agriculture, AL-Azhar University, (Assiut branch), while the bio-fertilizers were brought from Faculty of Agriculture, Ain-Shams University, to be used as seed inoculants in this study before sowing. Seeds were sown on Nov. 15th of the both seasons. The experimental plot was 3 × 3 m in hills 50 cm apart, each plot contained 6 rows (60 cm apart) and each row contained 5 hills. Four weeks from planting, plants were thinned to two plants/ hill. The experimental treatments were layed out in a randomized complete block design with 3 replicates. All agricultural practices were performed as usual.

The ten treatments were as follows:

- 1) -Control (no additions)
- 2) -Bio-fertilizer mixtures (*Azotobacter sp.*, *Bacillus megatherium var Phosphaticum*, and *Bacillus circulans*).
- 3) -N P K recommended fertilizers.
- 4) -N P K (recommended) + bio-fertilizer mixtures.
- 5) -20 m³/fed cattle manure. (organic1)
- 6) -20 m³/fed cattle manure (organic1) + bio-fertilizer mixtures.
- 7) - 30 m³/fed cattle manure. (organic 2)
- 8) - 30 m³/fed cattle manure (organic2) + bio-fertilizer mixtures.
- 9) -40 m³/fed cattle manure. (organic3)
- 10) -40 m³/fed cattle manure (organic3) + bio-fertilizer mixtures.

The organic manure was added during soil preparation, meanwhile, seeds was inoculated by the bio-fertilizer mixture.

The following data were recorded: plant height, number of branches / plant, herb dry weight g/plant, number of umbels / plant, fruit yield g /plant and the fruit yield kg/fed. was calculated. Essential oil% and essential oil yield /plant and / fed. were calculated. Also, crude oil %, saponins, flavonoids in fruits, N, P, and K in dry herb were determined at the end of the experiment (April 25th) in both seasons.

Fatty acid methyl esters, essential oil constituents, chemical properties of fixed oil, flavonoids and saponins contents were estimated.

Statistical analysis was carried out according to the method of Snedecor and Cochran (1982).

The physical and chemical characteristics of the soil used are presented in Table (1) and chemical analysis of the organic manure are shown in Table (2)

Table 1: Physical and chemical characteristics of the used soil.

Texture	pH	E.Ce (ds/m)	CaCO ₃ %	Available nutrients (ppm)			Water soluble Ions (meq/L) in the soil paste				
				N	P	K	Ca	Mg	CO ₃ +HCO ₃	CL	SO ₄
Loamy	7.9	1.2	2.7	62.4	9.2	356	3.4	1.9	2.9	2.2	6.6

Table 2: Chemical analysis of organic manure used in Al-Azhar Farm.

Organic fertilizer	C%	OM %	C/N ratio	Macro elements (%)					Micro elements	
				N %	P %	K %	Ca %	Mg %	Fe %	Mn ppm
Cattle manure	18.71	37.41	11.62	1.61	0.7325	1.2706	0.1667	0.6965	0.6499	190.217

Chemical analysis:

Volatile oil percentage in fennel fruits was extracted by steam distillation, while, crude fat extracted by petroleum ether using Soxhlet apparatus. N, P, and K were determined according to A.O.A.C. (1990). Crude oil were methylated according to the method of Kates (1972). GC was carried out on the sampled that represent the highest percentage of crude and essential oil of the second season.

Fatty acid methyl esters derived from crude oil were analyzed with Hewlett Packard (HP) 6890 series GC system with capillary column (BP-70), length =60 m, diameter = 320 μm and film thickness = 0.25 μm equipped with (FID) detector and the detector temperature was 300°C. Temperature program was 70°C with initial time 2 min. Separation rate was (40 and 4 min.) with final temperature at (120 and 220°C) and final

time at (2 and 10 min.), respectively. The inlet temperature was 250°C (splitless), with flow rate 2 ml/ min. Carrier gases were N₂ with 30 ml/min., H₂ at 30 ml/min. and air at 300 ml/min. Fatty acids percentage were expressed as percentage of total fatty acid methyl esters. The authentic samples of fatty acids methyl esters were also injected under the same condition for the identification of fatty acids.

Essential oil constituents were analyzed with Agilent Technologies 6890 N Network GC System (HP) with capillary column (HP-5) phenyl methyl siloxane, length =30 m, diameter = 320 µm and film thickness = 0.25 µm equipped with (FID) detector and the detector temperature was 280°C. Temperature program was 70°C with initial time 2 min. Separation rate was 4 min. with final temperature at 190°C and final time at 25 min. The inlet temperature was 250°C (split = 15 sec.), with flow rate 3 ml/ min. carrier gases were N₂ with 30 ml/min., H₂ at 30 ml/min. and air at 300 ml/min. The authentic samples of fenchone, cis-anethol, trans-anethol, limonene, cineol, α- pinene, β-pinene, and farnesone were also injected under the same conditions for identification of constituents of anise essential oil.

Chemical properties of fixed oil:

The chemical properties of fennel fixed oil were determined according to A.O.A.C. (1990).

Analysis of Flavonoids and Saponins:

The analysis of flavonoid and saponins from seeds of fennel were carried out by using silica gel column chromatography. The columns were washed with various solvents (Diethyl ether, n-propanol, ethanol and methanol) on the basis of their polarity order (Aritomi and Kawaski, 1984; Gulfranz *et al.* 2004).

RESULTS AND DISCUSSION

Vegetative growth:

Plant height (cm).

Data presented in Table (3) reveal that the main effect of NPK and organic manure fertilizers separately or in combination with bio-fertilizers on plant height of fennel plants was statistically significant in both seasons. From the obtained results, it is clear that all chemical and organic manure mixture with or without addition of bio-fertilizers treatments were significantly augmented the plant height compared to un-fertilized plants in the two experimental seasons. Fertilizing fennel plants with NPK + bio-fertilizer or the recommended doses of NPK or the high rate of organic manure + bio-fertilizer treatment gave the tallest plants in the first season in comparison with other combination treatments. It was found that the differences between NPK and NPK + bio-fertilizer were not significant similar observation was noticed between the high level of organic fertilizer and the high level of organic manure + bio-fertilizers. The same trends were obtained in the second seasons.

The beneficial effect of NPK, organic manure and bio-fertilizer on plant height was emphasized by Mohamed and Ahmed (2003), Abdou and Mahmoud(2003), Badran and Safwat(2004) on fennel plant, Somida *et. al.*,(2001) on black cumin plant, and Swaefy *et. al.*,(2007) on peppermint plant.

Table 3: Effect of mineral and organic with or without bio-fertilizer mixture on vegetative growth characters of fennel plants during 2005/2006 and 2006/2007 seasons.

Treatment	Plant height (cm)		Branch number/plant		Herb dry weight (g)	
	2005/2006 season	2006/2007 season	2005/2006 season	2006/2007 season	2005/2006 season	2006/2007 season
Control	156.70 f	161.0 e	8.67 f	12.00 e	84.93 i	87.53 h
Bio.	170.0 e	174 d	11.00 e	15.33 abc	86.50 h	89.92 g
N P K	193.0 ab	200.0 a	14.00 bc	16.00 a	103.67 c	107.43 c
N P K + Bio	195.7 a	201.7 a	15.33 a	12.67 de	108.20 a	112.07 a
Organic (1)	169.0 e	177.0 d	11.33 e	13.67 cde	92.00 g	94.67 f
Organic(1)+ Bio	181.0 d	180.0 cd	12.33 de	14.00 bcd	94.00 f	94.17 E
Organic (2)	181.0 cd	185.3 bc	13.33 bcd	15.00 abc	93.67 f	96.73 e
Organic(2)+Bio	188.70 bc	190.0 b	13.00 cd	15.00 abc	101.83 d	100.20 d
Organic(3)	190.3 abc	196.7 a	13.67 cd	8.67 f	9.67 f	106.27 c
Organic(3)+Bio	193.0 ab	198.7 a	14.67 ab	15.67 ab	106.77 b	109.83 b

Branch number/plant:

Branch number of fennel plants had significant effect by using NPK, organic manure and bio-fertilizers compared to the check treatment in the two seasons. It seems that all fertilizer treatments led to a significant increase in number of branches/plant in comparison with untreated control plants in the two consecutive

seasons. Treating fennel plants with NPK+ bio-fertilizers or the high level of organic manure + bio-fertilizers recorded that tallest plants compared to other treatments in the two growing seasons. Furthermore, the differences between the two mentioned treatments were insignificant in the two experimental seasons, as clearly shown in Table (3). The promoting effect of NPK, organic manure and bio-fertilizer treatments was studied on fennel plant by Mohamed and Ahmed (2003), Heikal (2005) on *Thymus vulgaris* L., Abd EL-Latif (2006) on *Salvia officinalis* L. and Swaefy *et al.* (2007) on peppermint plant.

Herb dry weight:

Table (3) shows that herb dry weight of fennel plant was significantly affected when fertilized the plans with chemical, organic and bio-fertilizer treatments in both seasons. From the obtained data it could be noticed that all fertilizer treatments significantly increased herb dry weight compared to unfertilized once for the two successive seasons. It is obvious that adding NPK+ bio-fertilizer followed by organic manure at 40 m³/fed.+ bio-fertilizers gave the best results concerning herb dry weight in comparison with other treatments in the two seasons.

The efficiency of NPK, organic manures and bio-fertilizers was mentioned by many authors such as. Badran and Safwat (2004) on fennel plant, Abou-Aly and Gomaa (2002) on coriander plant, Shaalan (2005) on *Nigella sativa* L. plant and Swaefy *et al.* (2007) on peppermint plant.

The yield parameters:

Number of umbels/plants:

Data recorded in Table (4) pointed out that the main effect of NPK, organic manure and bio-fertilizer treatments on the number of umbels of fennel plant was significant in the two experimental seasons. It is cleared that all fertilizer ones significantly augmented umbels number compared to control plants in the two consecutive seasons. The maximum number of umbels was obtained due to fertilizing the plants with NPK+ bio-fertilizer combination for organic manure at the high level + bio-fertilizers treatment comparing to other combination ones in both seasons. From the obtained data it is clear that the differences between NPK and NPK + bio-fertilizers treatment have not significant in the firs season. Observation was noticed between the treatments of 30m³/fed. organic manure + bio-fertilizers with organic manure 40m³/fed.+bio-fertilizers in the same season.

The positive effect of NPK, organic manure and bio-fertilizers was declared by Badran and Safwat (2004) on fennel plant, Yuonis *et al.* (2004) on *Ammi visnaga* L and Salem and Awad (2005) on coriander plant.

Table 4: Effect of mineral and organic manure with or without Bio-fertilizer mixture on yield characters of fennel plants during 2005 / 2006 and 2006 / 2007 season.

Treatment	Number of umbels / Plant		Seed yield (kg) / fed.		Seed yield (g) / plant	
	2005/2006 season	2006/2007 season	2005/2006 season	2006/2007 season	2005/2006 season	2006/2007 season
Control	64.67 e	69.67 f	50.37 e	53.17 e	994.9 e	1005.2 e
Bio.	72.00 d	76.00 e	55.27 d	57.60 d	1091.7 d	1137.8 d
N P K	91.67 a	96.67 ab	64.99 ab	57.60 d	1283.8ab	1386.0 a
N P K + Bio	93.33 a	98.67 a	68.00 a	70.95 a	1339.3 a	1401.5 a
Organic (1)	80.00 c	83.00 d	67.80 a	61.60 cd	1171.4cd	1216.8 cd
Organic(1)+Bio	83.33 b	86.33 cd	59.30 cd	64.65 bc	128.5 bc	1277.0 bc
Organic (2)	84.00 b	89.00 c	62.70 bc	64.13 bc	1210.4bc	1266.8 bc
Organic(2)+Bio	90.67 a	94.00 b	61.28 bc	65.67 bc	1255.6abc	1297.0 bc
Organic(3)	90.67 a	95.00 b	63.80abc	67.37 ab	1260.2abc	1330.7 ab
Organic(3)+Bio	92.33 a	97.67 ab	68.20 a	71.07 a	1374.2 a	1403.8 a

Seed yield per plant and per fed:

The effect of NPK, organic manure, bio-fertilizer treatments on seed yield/plant and/ fed was statistically significant in the two experimental seasons. The data reveal that receiving fennel plants with the high level of organic manure + bio-fertilizers or NPK + bio-fertilizers treatment produced the highest values of seed yield / plant and / fed in comparison with other combination ones in the two successive seasons. These mentioned treatments yielded 1374.2, 1403.8, 1339.3 and 1401.5 kg/ fed fennel seed compared to unfertilized control (994.9 and 1005.2 kg / fed) fennel seed in the first and the second seasons, respectively, as illustrated in table (4). The stimulating effect of NPK, organic manure and bio-fertilizer treatments was investigated by. Mohamed and Ahmed (2003), Abdou and Mahmoud(2003), Sharaf and Khattab (2004) on fennel plant and Radwan and Farahat(2002) on coriander plant

Chemical constituents:**N, P and K percent:**

The obtained data in Table (5) indicate that NPK, organic and bio-fertilizer treatments separately or in combination with them led to a significant augment in N% comparing to unfertilized plants in the two seasons. Supplying fennel plants with NPK+ bio-fertilizer followed by NPK or the high level of organic manure + bio-fertilizer compared to other treatments in the first season gave the highest values of N%. In the second season, NPK + bio- fertilizer application followed by NPK treatment recorded the best results of N % in comparison with other combination ones.

Concerning the effect of NPK, organic manure and bio- fertilizers, data in Table (5) shows that all of them significantly increased P% compared to the check control in the two growing seasons. From the obtained data, it was found that receiving fennel plants NPK + bio-fertilizers followed by organic manure at 40 m³/fed. resulted the maximum values of P% in both seasons compared to other treatments.

In regard to K%, the data show that all fertilizer treatments used, except bio-fertilizers alone significantly increased K% in comparison with control for the two seasons. It is obvious that fertilizing fennel plants with NPK + bio- fertilizers followed organic manure at 40 m³ / fed + bio-fertilizers gave the maximum values of K% compared to other ones in the first season. Treating the plants with NPK + bio- fertilizers or NPK rather than the high level of organic manure + bio- fertilizer recorded the highest K% in comparison with other treatments for the second season. Moreover, it is noticed that the differences between the three previous treatments were not significant, as clearly shown in Table (5). The augmentation of N, P and K% as a result of NPK, organic manure and bio- fertilizer utilization was studied by Yuonis *et. al.*,(2004) on *Ammi visnaga*, L, Kandeel and Sharaf (2003) on marjoram plant, Al-Qadasi (2004) on *Ocimum basilicum* plant and Ahmed & Saad (2007) on *Borago officinalis* L. plant.

Table 5: NPK contained of fennel plant treated with mineral, organic and bio-fertilizers.

Treatment	% N		% P		%K	
	2005/2006 season	2006/2007 season	2005/2006 season	2006/2007 season	2005/2006 season	2006/2007 season
Control	2.063 h	1.937 j	0.250 i	0.300 h	2.200 g	2.263 f
Bio.	2.137 g	2.037 i	0.273 h	0.337 g	2.217 g	2.347 f
N P K	2.680 b	2.593 b	0.433 bc	0.553 b	3.320 ab	3.413 a
N P K + Bio	2.760 a	2.653 a	0.463 a	0.577 a	3.390 a	3.463 a
Organic (1)	2.150 g	2.093 h	0.300 g	0.577 a	2.620 f	2.670 e
Organic(1)+Bio	2.200 f	2.180 g	0.300 f	0.410 e	2.653 f	2.717 e
Organic (2)	2.337 e	2.293 f	0.363 e	0.423 d	2.803 f	2.893 d
Organic(2)+Bio	2.457 d	2.357 e	0.400 d	0.460 d	3.013 d	3.047 c
Organic(3)	2.573 c	2.460 d	0.417 cd	0.500 c	3.170 c	3.260 b
Organic(3)+Bio	2.680 b	2.567 c	0.450 ab	0.553 b	3.307 b	3.413 a

Indeed, phosphorus became known as the master key to agriculture because lack of available P in soils limited the growth of both cultivated and uncultivated plants (Foth and Ellis, 1997). Potassium is a macronutrient which's essential for plant growth is known since the work of von Liebig, published in 1840 (Foth and Ellias, 1997). Potassium is associated with many enzymes involved in photosynthesis, organic compound synthesis and translocation of organic compounds.

Crude oil percent:

Data presented in Table (6) reveal that the main effect of NPK, organic manure and bio-fertilizer treatments on crude oil% was significant in the two growing seasons. From the obtained, it is noted that all fertilizers ones, except bio-fertilizer treatment alone, significantly augmented crude oil % compared to control in both seasons. Moreover, receiving fennel plants 40 m³/fed. organic manure + bio-fertilizer followed by 40 m³/fed. organic manure treatment resulted the highest value of crude oil% in comparison with other combination treatments in the two seasons.

The positive effect of NPK, organic manure and bio-fertilizer application was noticed on black cumin by Shaalan (2005) Ahmed *et al.* (1998) on *Hibiscus sabdariffa* L and Edris *et al.* (2003) on marjoram plant.

Essential oil percent:

From the obtained results, it could notice that the effect of NPK, organic manure and bio-fertilizer treatments separately or in combination with them on essential oil % was significant in both seasons.

All of fertilizer ones used, except supplying the plants with the low level of organic manure in the second season significantly increased essential oil% comparing to the check treatment in the two experimental seasons. Furthermore, the highest essential oil% were obtained due to treating fennel plants with organic manure at 40

m³/fed. followed by fertilized the plants with NPK in comparison with other treatments in the first season. The data show that organic manure at 40 m³ /fed + bio-fertilizer followed by NPK + bio-fertilizer treatments gave the maximum values of essential oil% compared to other ones used in the second season. It is noticed from the obtained results that the differences between these above treatments were not significant, as clearly declared in Table (6).

The promoting effect of NPK, organic manure and bio-fertilizer treatments was emphasized by Mohamed and Ahmed (2003), Abdou and Mahmoud (2003), Badran and Safwat (2004) on fennel plant, Somida *et al.* (2001) on black cumin plant, and Swaefy *et al.* (2007) on peppermint plant.

Essential oil yield per plant and per fed:

Table (6) reveals that the main effect of all fertilizer treatments on essential oil yield/plant and/fed. was statistically significantly in both seasons. These fertilized ones significantly augmented essential oil yield/plant and/fed. compared to control in the two seasons. It is concluded that fertilizing fennel plants with the high level of organic manure + bio-fertilizer or organic manure at the high level produced the maximum essential oil yield/plant and/fed. These previous treatments recorded 50.24, 52.94, 46.28 and 49.58 L of essential oil/fed. compared to untreated ones (33.12 and 35.62 L of essential oil/fed.) in the first and the second seasons, respectively. The positive role of NPK, organic manure and bio-fertilizer treatments on essential oil yield was studied by by Mohamed and Ahmed (2003), Abdou and Mahmoud (2003), Badran and Safwat (2004) on fennel plant, Somida *et al.* (2001) on black cumin plant, and Swaefy *et al.* (2007) on peppermint plant.

Table 6: Effect of mineral and organic with/without bio-fertilizers on crude oil and essential oil yield of fennel seeds.

Treatment	Crude oil %		Essential oil % in the fruits		Essential oil yield (ml) /plant		Essential oil yield (L) /fed	
	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007	2005/2006	2006/2007
	season	season	season	season	season	season	season	season
Control	8.20 fg	8.293 g	3.330 e	3.387 d	1.677 g	1.803 g	33.12 g	35.62 g
Bio.	8.187 g	8.280 g	3.513 c	3.537 bc	1.947 f	2.037 f	38.45 f	40.23 f
N P K	8.217 f	8.317 f	3.697 b	3.693 a	3.693 a	2.583 ab	47.08abc	51.03 ab
N P K + Bio	8.120 h	8.230 h	3.697 ab	3.713 a	3.713 a	2.637 ab	47.08abc	52.08 ab
Organic (1)	8.300 e	8.403 e	3.343 de	3.443 d	3.443 d	2.123 ef	39.31 ef	41.94 ef
Organic(1)+Bio	8.350 d	8.447 d	3.393 d	3.467 cd	3.467 cd	2.243 de	41.94 de	44.31 de
Organic (2)	8.400 c	8.493 c	3.547 c	3.590 b	3.590 b	2.300 d	42.86 d	45.43 d
Organic(2)+Bio	8.410 bc	8.517 b	3.570 c	3.590 b	3.590 b	2.373 cd	44.71 cd	45.88 cd
Organic(3)	8.420 b	8.530 b	3.673 ab	3.730 a	3.730 a	2.510 bc	46.28 bc	49.58 bc
Organic(3)+Bio	9.200 a	9.317 a	3.730 a	3.773 a	3.773 a	2.680 a	50.24 a	52.94 a

Table (7) indicated the fractionated fatty methyl esters of the four treatments. Lauric acid and Stearic acid contents were high in control and NPK treatments, but reduced in the others. Oleic acid content represents the major percentage of fatty acid methyl esters, but the plants received 40 m³ of organic manure x bacterial bio-fertilizer mixture, 40 m³ of organic manure and recommended NPK x bacterial bio-fertilizer mixture have the highest ratio of oleic acid (57.98, 57.23 and 57.02 respectively) and the all treatments gave high records than the control treatment. Linoleic acid was the second highest ratio of FAME of all treatments, but fennel plants received recommended NPK x bacterial bio-fertilizer mixture, 40 m³ of organic manure and 40 m³ of organic manure x bacterial bio-fertilizer mixture have the highest ratios (34.48, 32.12 and 31.76%).

Table 7: Relative amount of fennel fixed oil constituents from GC of control and treated plants with mineral, organic manure and with or without Bio-fertilizers mixture of second season (2006 / 2007).

Components	Control	NPK	NPK + Bio	Organic (3)	Organic(3)+Bio
Lauric acid	5.82 %	5.94	2.12	2.13	2.16
Stearic acid	11.98 %	10.99	3.38	3.25	3.06
Oleic acid	30.28 %	48.52	57.02	57.23	57.98
Linoleic acid	19.65 %	25.68	34.48	32.12	31.76
linolenic acid	1.41 %	1.84	1.51	1.50	1.50
Unknown (b)	18.43 %		1.45		

The data in Table (8) represent the fractionated volatile oil constituents as a result of treating fennel plants with different kinds and levels of fertilizations. The major constituent is fenchone that the characterized smell odor of fennel. Plants received 40 m³ of organic manure x bacterial bio-fertilizer mixture represent the highest content of fenchone more than all treatments (88.80%) and recommended NPK x bacterial bio-fertilizer mixture (88.37%). On the other hand, the recommended mineral NPK treatment had significantly reduced the fenchone content (73.47%) than control treatment (84.51%).

The chemical properties of fennel fixed oil revealed that no significant differences between all tested of treated seeds oil. All of acid, ester, saponification, iodine and peroxide values were approximately around the trusted factors (Table 9)

Table 8: Relative amount of fennel volatile oil constituents from GC of control and treated plants with mineral, organic manure and with / without Bio-fertilizers mixture of second season (2006 / 2007).

Component	Control	NPK	NPK + Bio	Organic(3)	Organic(3)+Bio
α - pinine	4.02	5.11	4.01	3.84	3.94
β - pinene	0.37	0.58	0.43	0.22	0.12
d-Limonine	2.63	2.11	1.85	2.10	0.43
Cineol	0.36	1.96	1.40	0.91	1.91
Fenchone	84.51	73.47	88.37	85.30	88.80
Cis-anethol	1.21	0.67	0.90	0.81	0.22
Trans-anethol	0.36	1.25	1.30	1.42	1.79
Farnsone	0.43	2.11	0.38	0.98	0.10
Unknown	0.42	3.77	0.56	0.58	0.32
Unknown	1.13	3.28	0.76	1.53	0.31
Unknown	0.71	1.19	0.41	0.92	0.71
Unknown	3.29	4.43	1.30	1.39	0.35

Table 9: Chemical properties of fennel fixed oil.

Treatment	Acid Value	Ester Value	Sap. value	Iodine value	Peroxide value
Control	1.1	172.9	174.0	89	8.2
Bio.	1.1	173.1	174.2	90	8.0
N P K	1.1	173.0	174.1	89	7.9
N P K + Bio	1.2	172.9	174.1	88	8.1
Organic (1)	1.2	172.7	173.9	89	8.2
Organic (1)+ Bio	1.1	172.9	174.0	88	8.1
Organic (2)	1.1	173.0	174.1	87	7.9
Organic(2)+Bio	1.2	172.8	174.0	89	8.2
Organic(3)	1.1	173.0	174.1	88	8.0
Organic(3)+Bio	1.1	173.1	174.2	87	7.9

Table (10) illustrates the saponins percentages of the treated fennel plants in the experiment. The plants received 40 m³ of organic manure x bacterial bio-fertilizer mixture and 20 m³ of organic manure x bacterial bio-fertilizer mixture showed the highest content (38.23 and 38.16%) of saponins overall. The lowest content was obtained from the plants treated 20 m³ of organic manure treatment. All of the other treatments gave the average percentage as well as control treatment.

Table 10: The Saponin percentage (%) of *Foeniculum vulgare* fruits.

Sample	Control	Bio.	N P K	N P K + Bio	Organic (1)	Organic (1) + Bio	Organic (2)	Organic(2)+Bio	Organic(3)	Organic(3)+Bio
Sap.%	31.10	33.12	30.10	29.50	19.20	38.16	30.50	36.12	27.58	38.23

Table (11) demonstrates flavonoid content of treated fennel plants in the experiment. All of the treatments showed an average content of flavonoid. The lowest content was of the plants treated with recommended mineral NPK and 20 m³ of organic manure x bacterial bio-fertilizer mixture (24.16% of the two). The flavonoid highest content was found on the recommended mineral NPK x 20 m³ of organic manure x bacterial bio-fertilizer mixture treatment (26.20%) but not significantly high than control treatment.

Table 11: The Flavonoid percentage (%) of *Foeniculum vulgare* fruits.

Sample	Control	Bio.	N P K	N P K + Bio	Organic (1)	Organic (1) + Bio	Organic (2)	Organic(2)+Bio	Organic(3)	Organic(3)+Bio
fla.%	26.17	25.10	24.16	26.20	25.25	24.16	24.90	25.09	26.00	25.50

The extensive use of manufactured chemical fertilizers on the Egyptian soils has increased crops productivity but compromised quality especially for medicinal and aromatic plants which therefore are not acceptable for export. Organic fertilizers are excellent sources of nutrients for crop production and improving physical and chemical properties of soil (Eghaball and Power, 1994).

Organic matter is essential for plant growth, because it has been suggested that humic substances can have a direct effect on plant growth, assuming a hormonal action of humic substances (Varanini and Pinton, 1995). Soil organic matter is the component of mineral soils that makes it possible for successful growth of most plants. Soil organic matter can increase water holding capacity and cation exchange capacity in sandy soil. Soil organic matter supplies nutrients, it is a buffer against pH change, it protects against plant diseases, protects against heavy metal and salt toxicity, detoxifies pesticides and prevents their leaching, promotes microbial breakdown of toxic substances and supports micro-organisms that recycle nutrients and soil formation (Varanini and Pinton, 1995).

REFERENCES

- Abdallah, N., S. El-Gengaihi and E. Sedrak, 1978. The effect of fertilizer treatments on yield of seed and volatile oil of fennel (*Foeniculum vulgare* Mill.). Pharmazie, 33(9): 607-608.
- Abd El-Latif, E.S., 2006. Effect of chemical, organic and spraying with active dry yeast on growth, oil production and plant constituents of sage (*Salvia officinalis*, L.) plants. M. Sc. Thesis, Fac. Agric., Cairo Univ., Egypt.
- Abdou, M.A. and A.H. Mahmoud, 2003. Growth and oil production of *Foeniculum vulgare*, Mill. 2: The effect of number of irrigation and organic fertilizers. J. Agric. Sci. Mansoura Univ., 28 (5): 3857-3868.
- Abou-Aly, H.E. and A.O. Gomaa, 2002. Influence of combined inoculation with diazotrophs and phosphate solubilizers on growth, yield and volatile oil content of coriander plants (*Coriandrum sativum*, L.). Bull. Fac. Agric., Cairo Univ., 53: 99-113.
- Abou El-Fadl, I.A., M. Abou-Baker and A.M. El-Gamal, 1990. Effect of different organic manure composts on roselle (*Hibiscus sabdariffa* L.) plants and soil characteristics. Agric. Res. Review, 68 (5): 1077-1087.
- Ahmed, S.K., E.O. El-Ghawas and A.F. Aly, 1998. Effect of active dry yeast and organic manure on roselle plant. Egypt. J. Agric. Res., 76 (3): 1115-1143.
- Ahmed, E.T. and O.A. Saad, 2007. Response of *Borago officinalis*, L. plants to phosphorus, organic and Biofertilization. The 1st Inter. Conf. on Desert Cultivation, Minia, Egypt, March, 27-29, under press.
- AOAC Method, 1990. In Official Methods of Analysis, 15th Edition. Association of Official Analytical Chemists, Washington, DC.
- Al-Qadasi, A.S., 2004. Effect of biofertilization on *Ocimum basilicum*, L. plant. M.Sc. Thesis, Fac. Agric., Cairo Univ., Egypt.
- Aritomi, M and T. Kawaskaki, 1984. Three highly oxygenated Flavonone Glucuronides in Leaves of Spinacia Oleracea. Phytochemist, 23, 2043-47.
- Badran, F.S., F.A. Attia and H.S. Soliman, 2002. Effect of combining phosphorene with superphosphate and rock phosphate on seed and oil productivity of *Nigella sativa*, L. plants. 2nd International Conf. Hort. Sci., kafr El-sheikh, Tanta Univ., Egypt, pp: 846-855.
- Badran, F.S. and M.S. Safwat, 2004. Response of fennel plants to organic manure and bio-fertilizers in replacement of chemical fertilization. Egypt. J. Agric. Res., 82(2): 247- 256.
- Bhati, D.S., M.S. Shaktawat, L.L. Somani and H.R. Agarwal, 1988. Response of fennel (*Foeniculum vulgare* Mill.) to nitrogen and phosphorus. Transactions of Indian Society of Desert Technology, No. 2: 79-83.
- Buntain, M. and B. Chung, 1994. Effects of irrigation and nitrogen on the yield components of fennel (*Foeniculum vulgare* Mill.). Australian J. of Experimental Agriculture, 34(6): 845-849.
- Charles, D.J., M.R. Morales and J.E. Simon, 1993. Essential oil content and chemical composition of finocchio fennel. In: Janick, J. and J. E. Simon (eds.), New crops. Wiley New York, pp: 570-573.
- Chiej, R., 1984. The Macdonald Encyclopedia of Medicinal Plants. Macdonald & Co., London.
- Edris, A.E., A. Shalaby and H.M. Fadel, 2003. Effect of organic agriculture practices on the volatile aroma components of some essential oil plants grown in Egypt II: Sweet marjoram (*Origanum marjorana*, L.) essential oil. Flavour and Fragrance J., 18(4): 345-351.
- Eghaball, B. and J.F. Power, 1994. Beef cattle feedlot manure management. J. Soil Water Conserv, 49: 113-122.
- Egypt Magazine, 2000: www.sis.gov.eg/public/magazine/iss023e/html/mag11.htm
- Ezz-Eldin, A. and M.R. Abd-Elmoaz, 1998. Productivity of riselle (*Hibiscus sabdariffa*, L.) plants under organic fertilization treatments. Sec. Conf. Ornam. Hort. Ismailia, Egypt.
- Farrell, K.T., 1988. Spices, Condiments and Seasonings. AVI Publ. Westport, CT., pp: 106-109.
- Foth, D.H. and B.G. Ellias, 1997. Soil fertility. Lewis publishers is an imprint of CRC, USA.
- Gulfraz, M., M. Arshad, k.N. Nayyar, N. Kanwalj and U. Naisr, 2004. Investigation of Bio active compounds of *Berberis lyceum* Royal and *Justicia Adhatoda* L. Ethanbotanical. Leaflet. world wide web., 1-10
- Heikal, A.M., 2005. Effect of organic and bio-fertilization on the growth, production and composition of thyme (*Thymus vulgaris*, L.) plants. M. Sci. Thesis, Fac. Agric., Cairo Univ., Egypt.
- Ibrahim, S.M., 2002. Effect of seeding rate and bio-fertilization on fennel (*Foeniculum vulgare*, Miller) plants. M.Sc. Thesis, Fac. Of agric., Minia Univ.
- Kandeel, A.M. and M.S. Sharaf, 2003. Productivity of *Majorana hortensis*, L. plants as influenced by the interaction between mineral and biological fertilization. J. Agric. Sci. Mansoura Univ., 28: 1373-1389.
- Kates, M., 1972. Techniques, of lipidology, isolation, analysis and identifications of lipids, North Holland Publishers, Co. Amsterdam.

- Mahajan, V.P., G.S. Randahawa and D.S. Bains, 1977. Effect of row spacing and nitrogen levels on the seed yield of celery (*Apium graveolens*, L.). *J. Rwes India*, 14(1): 15-17. (C.F Hot. Abst., 48, 6).
- Masada, Y., 1976. Analysis of essential oils by gas chromatography and mass spectrometry. Copyright by the Hirokawa Publishing company, INC printed in Japan.
- Mehta, A.C., D.D. Malavia, B.B. Kaneria and V.D. Khanpara, 1995. Effect of phosphatic bio-fertilizer in conjunction with organic and inorganic fertilizers, on growth and yield of groundnut *Arachis hypogaea*. (Biographic Citation): *Indian-journal of Agronomy*, 40: 709-710.
- Mohamed, A.A. and M.E. Ahmed, 2003. A comparative study on the effect of sugarcane filter mud, sheep and chicken manures used for fertilization of sweet fennel (*Foeniculum vulgare*, L.) *Minia J. Agric. Res. & Dev.*, 22(3): 221-234.
- Radwan, S.M.A. and M.M. Farahat, 2002. Growth and yield of coriander plants as affected by bio-organic fertilization and pix application. *Egypt. J. Appl.*, 17: 268-286.
- Safwat, M.S., F.S. Badran and G.A. Zayed, 2001. Response of anise plants to different organic and bio-fertilization treatments. The 10th Conf. of Medicinal and Aromatic plants, Cairo, Egypt.
- Safwat, M.S. and F.S. Badran, 2002. Efficiency of organic – and bio-fertilizers, in comparison with chemical fertilization, on growth yield and essential oil of cumin plants. The 9th Conf. of Medicinal and Aromatic Plants, Cairo, Egypt.
- Salem, A.G. and A.M. Awad, 2005. Response of coriander plants to organic and mineral fertilizers in sandy soils. *Egyptian Journal of Agricultural Research*, 83(2): 829-858.
- Sayed, R.M., 1993. Effect of some growth media and microelements on growth, flowering and oil content of *Achillea millefolium*, L. plants. M.Sc. Thesis, Fac. Of Agric., Minia Univ.,
- Shaalán, M.N., 2005. Influence of bio-fertilization and chicken manure on growth, yield and seeds quality of *Nigella sativa*, L. plants. *Egypt, J. Agric. Res.*, 83(2): 811-828.
- Sharaf, M.S. and M.E. khattab, 2004. Effect of fertilization with inorganic and bio-fertilizers on growth, yield and volatile constituents of fennel (*Foeniculum vulgare*, Mill.). *J. Agric. Sci., Mans. Univ.*, 29(9): 5245-5264.
- Snedecor, G.W. and W.G. Cochran, 1982 *Statistical Methods*. The Iowa State Univ., Press, Ames., Iowa, U.S.A., pp: 507.
- Soliman, H.S., 2002. Effect of chemical and biological fertilization on growth, yield and oil production of anise (*pimpinella anism*, L.) plants. Ph.D. Disser., Fac. Of Agric., Minia Univ.
- Somida, E.G., F.A. Attia, F.S. Badran and A.A. El-Sayed, 2001. Response of *Nigella sativa*, L. plant, grown in sandy soil, to some nitrogen and potassium fertilization treatments. *Proc. 5th Arabian Hort. Conf.*, Ismailia, Egypt, March, 24-28: 179-194.
- Swaefy Hend, M.F., Weaam R.A. Sakr, A.Z. Sabh and A.A. Ragab, 2007. Effect of some chemical and bio-fertilizers on peppermint plants grown in sandy soil. , *Annals. , Agric. Sci. , Ain Shams Univ. , Cairo*, 52(2): 451-463.
- Varanini, Z. and R. Pinton, 1995. Humic substances and plant nutrition. *Progress in Botany*, (56): 79-117.
- Watt, A. and B. Breyer, 1962. *The medicinal and poisonous plants of southern and eastern Africa*. Edinburgh: Livingstone.
- Wichtl, M. and N.G. Bisset, 1994. *Herbal drugs and phytopharmaceuticals* (ed), Med. Pharm scientific Publ Stuttgart, pp: 107-108.
- Yuonis, S.I., N.G. Ghaly and S.K. Ahmed, 2004. Effect of FYM and planting space on the vegetative growth, active ingredient and chemical composition of *Ammi visnaga*, L. *J. Agric. Sci. Mansoura Univ.*, 29(4): 1985-1993.