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EFFECT OF HUMIC ACID AND FERTILIZERS TYPES ON VEGETATIVE GROWTH, FRUIT YIELD, ESSENTIAL OIL QUALITY OF FENNEL (*Foeniculum Vulgare* Mill.) PLANTS.

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ABSTRACT

The present investigation was carried out in the Experimental Station of the Medicinal and Aromatic Plants, Fac. Agric., Mansoura Univ., during the two seasons of 2008 / 2009 and 2009 / 2010 to study the effect of foliar humic acid application and fertilizers types; $N_{200}P_{200}K_{50}$ (kg / fed) recommended dose (RD), compost and cattle manure at rates of (10, 15 and 20 m^3 / fed) in addition to their interaction on vegetative growth, fruits yield and essential oil quality of fennel (*Foeniculum Vulgare* Mill.*)* plants.

The results indicated that, foliar humic acid application at 10 cm / L had a positive effect on vegetative growth, expressed as plant height, plant dry weight, number of days till harvesting, essential oil percentage, oil yield and the main component estragole was increased significantly in comparison with treatment plants without humic acid.

The best results were of fennel plants which received $N_{200}P_{200}K_{50}$ kg / fed (RD) followed by compost at rate of 20 m^3 / fed, when compared with other plants treated by fertilizers separately.

The combined treatment of NPK (RD) followed by the medium compost dose (15 m^3/ fed) and foliar humic acid application were more effective on all traits studied than each individual or combination treatments with humic acid in both seasons.

The G.L.C. of the essential oil revealed a total of 7 compounds which represent from 92.73 to 99.05 %. These components are α-pinene, myrcene, limonene, fenchone, 1.8- cineole, estragole and anethole. The major component is estragole which represent from 65.72 % to 91.46 %.

INTRODCTION

Fennel (*Foeniculum Vulgare* Mill.*)* is one of the important crops grown in Egypt, belong to Fam. Umbellifera (Apiaceae). Its export value amounts to 10 million US $ from Egypt. Fruits is the economical part contain 2 to 6 % essential oil according to different varieties. It occupies an important position among the medicinal and aromatic crops due to its multifarious use in folk medicine as a antispasmodic, diuretic, stimulant and sedative. Fennel fruits are said to be particularly helpful in digesting fat. The constituents of oil are α-pinene, p-cymene, limonene, estragole, anethole, fenchon and campher. In addition, the essential oil is used as aromatic carminative, expectorant, condiment and in perfumery industries (Keville, 1999).

Application of humic acids (HA) has several benefits and agriculturists all over the world are accepting humic acids as an integral part of their fertilizer program and change physical properties of soil, (Fortun *et al*., 1989). Enhancement of plant growth using humic acid had been due to increasing nutrients uptake such as N, P, K, Mg, Fe, Zn and Cu, (Adani *et al*., 1998).

Using soil organic matter leads to a significant and direct impact on the availability of micronutrients as Zn, Fe and Mn, (Zhang *et al*., 2001).

Municipal solid waste compost had a high water holding capacity because of its organic matter content, which in turn improved the water holding capacity of the soil (Soumare *et al*., 2003).

Essential oil production has direct influenced with fertilization materials, (Moradi *et al*., 2010).

The objective of the present work was to study the effect of humic acid application and fertilizers types; $N_{200}P_{200}K_{50}$ kg / fed recommended dose (RD), compost and cattle manure at rates of (10, 15 and 20 m^3 / fed) in addition to their interaction on vegetative growth, fruits yield, essential oil content and compositions of fennel (*Foeniculum Vulgare* Mill.) plants. For improving the production and investigate the performance growth with fertilization sources accepted in organic farming and compare it with mineral fertilization.

MATERIALS AND METHODS

The present study was conducted during the two successive winter seasons of 2008/2009 and 2009/2010 at the Experimental Station of the Medicinal and Aromatic Plants, Fac. Agric., Mansoura Univ.

Seeds of fennel (*Foeniculum Vulgare* Mill.) were obtained from Medicinal and Aromatic Plants Section of Agricultural Research Center, El-Dokky, Cairo, and sown on 5th November in both winter seasons. Seeds were sown in hills 35 cm apart on one side of ridge of 2 meters in length and 60 cm in width. The plot area was 3m^2 (2m in length x 1.5 m in width) included 12 plants. Thinning took place after complete germination, i.e., two weeks after seed sowing, leaving one plant per hill. Three weeks before sowing the experimental farm was prepared, in each growing season as usually recommended. The soil is clay loam in texture. Some physical and chemical properties of the studied soil are shown in Table (A).

Table (A): Some physical and chemical analysis of experimental soil before the application of any fertilizers (mineral and organic).

Physical properties	1st season	Chemical properties	1st season
Coarse sand (%)	1.66	$CaCO_3$	2.53
Fine sand (%)	19.99	Organic matter (%)	1.96
Silt (%)	28.72	Nitrogen (ppm)	48
Clay (%)	49.63	Phosphorus (ppm)	3.88
Textural class	Clay loam	Potassium (ppm)	315
		pH	8.17

The layout of the experiment was split plot design with three replicates. The main plots were fertilization types while the sub plot assigned to the two foliar applications (with and without humic acid).

Humic foliar spray treatments were applied as 1 % (10 cm^3 actesol / L fresh water). Commercial liquid organic fertilizer (actosol®) contains 2.9 % humic acid, 10 % from each of N, P and K, 0.1 % Fe plus 0.01 % from each of Zn, Mn and Cu. Half experimental treatments received humic acid as

spraying until drop-off by using a hand-sprayer at two times after 60 and 105 days from sowing and the another treatments was only sprayed with tap water.

Three commercial mineral fertilizers were used; calcium super phosphate (15.5 % P_2O_5) was added during preparation of the soil, ammonium sulfate (15.5 % N) and potassium sulfate (48 % K_2O) were added after thinning of the plants in both seasons.

Straw rice compost was obtained from Research Department., Gemiza, Gharbia Governorate. Cattle manure was obtained from Farm, Fac. Agric. Mansoura Univ. and were added during the preparation of the experimental soil. The chemical properties of compost and cattle manure are presented in Tables (B and C).

Table (B): Chemical and physical properties of the used straw rice compost in (2008 / 2009) and (2009 / 2010) seasons.

PH (1:10)	E.C (1:10) mohs /cm	O.M %	C %	C / N	Humidity %	Density (g / cm^3)	Available nutrients (%)		
							N	P	K
7.33	2.33	45	26.11	12:1	30.7	0.66	2.2	0.76	0.7

Table (C): Chemical analysis of cattle manure in the two seasons of (2008 / 2009) and (2009 / 2010).

Properties	1st season	2nd season
Ph (in 1:5)	8.03	8.01
E.C (1:10) mohs/cm	5.33	5.14
N %	0.74	0.78
P %	0.28	0.41
K %	1.81	1.72
O.M %	26.66	29.21
C %	15.5	16.9
C/N	20.95	21.66
Humidity %	18.63	18.65
Density g/cm^3	0.72	0.69

Treatments :

1- Control (N_{200} P_{200} K_{50} kg / fed, recommended dose).
2- Compost at 10, 15 and 20 m^3 / fed.
3- Cattle manure at 10, 15 and 20 m^3 / fed.
4- Mineral fertilization + humic acid (10 cm / L).
5- 10 m^3 / fed compost + humic acid (10 cm / L).
6- 15 m^3 / fed compost + humic acid (10 cm / L).
7- 20 m^3 / fed compost + humic acid (10 cm / L).
8- 10 m^3 / fed cattle manure + humic acid (10 cm / L).
9- 15 m^3 / fed cattle manure + humic acid (10 cm / L).
10- 20 m^3 / fed cattle manure + humic acid (10 cm / L).

A random sample of nine plants from each treatment were taken at the harvesting stage for determination of vegetative growth, i.e., plant height, herb dry weight. The harvesting date was recorded (at the first of May to the beginning of June). All fruits harvested from each treatment through

harvesting period were weighted to calculate the total yield per plant and per fed and weight of 1000 seeds.

Essential oil percentage was determined in the dried fruits samples (100g) by subjecting to hydro distillation using modified Clevenger traps in British Pharmacopeia (2000). The oil content was determined at harvest in both seasons. Oil yield (L/ fed) was calculated by multiplying the essential oil percentage per plant by number of plants per feddan (16.800 plants).

Gas liquid chromatography technique (GLC) was used to separate and identify the components of essential oil constituents according to Guenther and Joseph (1978) at the Medicinal and Aromatic Plants Section, Agriculture Research Centre, Giza.

Statistical analysis:

The obtained data were statistically analyzed and means separation were compared with the least significant differences (L.S.D) test at 0.05 % according to the method described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Vegetative growth characteristics :

Data presented in Table (1) show that humic acid foliar application treatments had a significant effect on growth parameters (plant height, plant dry weight, time of harvesting) in both seasons.

Spraying fennel plants with humic acid produced the highest values of growth parameters; when compared with the treatment (without humic) which gave the lowest values of these characters in both seasons.

The superiority of plant growth with addition of humic acid might be attributed to the role in protein synthesis, nutrients translocation, and foliar growth as reported by (Chen *et al*., 2004). The role of humic acid in stimulating plant growth is by the assimilation of major and minor elements, enzyme activation, changes in membrane permeability, protein synthesis and the activation of biomass production (Ulukan, 2008). In addition, foliar spray with humic acid reduces the transpiration rate, and this in turn leads to keep higher water content in the plant tissues and hence might favor the plant metabolism, the physiological processes, photosynthetic rate and many other important functions that directly affect the plant growth, (Ezzat *et al*., 2009).

Decrease in the days essential for harvesting may be due to a direct positive effect of humic acid on plant growth include those changes in plant metabolism that occur following uptake of organic macromolecules. These compounds caused several biochemical changes which caused the plants grow rapidly to flowering and harvesting, (Stevenson, 1994).

Herein results are in harmony with those obtained by Khalil and El-Sherbeny (2003) on *Mentha spp*. and Arancon *et al*. (2006) on marigold.

Regarding fertilization treatments, a significant effect on growth parameters were recorded with the recommended dose of NPK when compared with either cattle manure or compost treatments in both seasons.

The obtained results indicated that the important role of mineral fertilization on plant growth, may be due to the physiological functions of each

element in plant growth and development as well as biochemical functions on structure of photosynthetic pigments, metabolism of carbohydrates.

Table (1): Vegetative growth of fennel plants as affected by humic acid and fertilization types during the two seasons of (2008/2009) and (2009/2010).

Treatments			Plant height (cm)		Plant DW (g)		Harvesting time (day)	
			1st season	2nd season	1st season	2nd season	1st season	2nd season
Effect of Humic acid application (cm / fed)								
With			153.9	157.0	119.9	125.1	189.3	195.0
Without			134.0	136.7	98.3	102.7	198.1	204.1
L.S.D at 5%			**1.44**	**1.16**	**0.83**	**0.79**	**0.93**	**0.92**
Effect of fertilization types								
$N_{200}P_{200}K_{50}$		**Kg / fed**	157.6	160.8	123.8	129.5	205.3	211.4
Compost		**10 m^3 / fed**	135.4	138.1	103.4	106.8	186.0	191.5
		15 m^3 / fed	149.6	152.6	115.7	119.9	201.3	207.3
		20 m^3 / fed	152.3	155.3	117.1	122.1	203.2	209.3
Cattle		**10 m^3 / fed**	129.7	132.3	89.9	94.7	179.0	184.4
		15 m^3 / fed	139.3	142.1	102.3	107.9	183.3	188.7
		20 m^3 / fed	143.8	146.8	111.6	116.3	198.2	204.1
L.S.D at 5%			**2.69**	**2.17**	**1.55**	**1.49**	**1.73**	**1.73**
Effect of the interaction								
With humic	$N_{200}P_{200}K_{50}$	**Kg / fed**	167.6	171.0	136.1	142.4	200.3	206.3
	Compost	**10 m^3 / fed**	141.3	144.1	108.6	112.3	180.7	186.1
		15 m^3 / fed	162.7	166.0	128.7	133.5	197.1	203.0
		20 m^3 / fed	159.6	162.8	124.3	129.3	199.3	205.3
	Cattle	**10 m^3 / fed**	139.9	142.7	103.5	109.4	174.2	179.4
		15 m^3 / fed	151.3	154.3	116.4	121.1	179.3	188.7
		20 m^3 / fed	155.1	158.2	121.5	127.4	194.3	200.1
Without humic	$N_{200}P_{200}K_{50}$	**Kg / fed**	147.7	150.7	111.4	116.6	210.2	216.4
	Compost	**10 m^3 / fed**	129.4	132.0	98.2	101.3	191.2	196.9
		15 m^3 / fed	136.4	139.1	102.7	106.2	205.4	211.6
		20 m^3 / fed	145.0	147.9	109.8	114.8	207.1	213.3
	Cattle	**10 m^3 / fed**	119.6	122.0	76.3	79.9	183.8	189.3
		15 m^3 / fed	127.3	129.8	88.1	94.6	187.2	192.8
		20 m^3 / fed	132.6	135.3	101.7	105.1	202.0	208.1
L.S.D at 5%			**3.10**	**3.06**	**2.20**	**2.10**	**2.45**	**2.45**

Concerning the increasing in vegetative growth due to receiving NPK fertilizers may be also attributed to improved availability of nutrientst exudates that have triggered the growth of newly emerged leaves. The better growth regarding to the increase of plant photosynthetic potentiality which resulted higher dry matter production as mentioned by (Longnecker, 1994).

Moreover, mineral fertilizer plays a major role in many physiological and biochemical processes such as cell division and elongation and metabolism of carbohydrates and protein compounds (Marschener, 1995). Our obtained results are in a good accordance with Ashorabadi *et al*. (2003), Gomaa and youssef (2007) on fennel plants.

Increasing the number of days for harvesting in plants treated with mineral fertilization may be due to the increase in N led to prolonged vegetative

phase and delayed harvesting stage. These results are in agreement with Jagdale and Dalve (2010) on fenugreek plants.

El-Ghawwas *et al*. (2002) applied three levels of FYM (14, 21 and 28 m^3 / fed) on fennel plant, they found that 28 m^3 / fed FYM significantly produced the tallest plants. The level 21 m^3 / fed FYM significantly produced the highest number of branches, the highest value of fruit yield per plant and plot. These results are in the same line with many researchers on different plants such as Kandil *et al*. (2002), Abdou and Mahmoud (2003) on fennel plants, since they reported that compost at different levels significantly increased the vegetative growth characters.

As a bird´s eye view, the interaction in Table (1) showed that significant effects on growth parameters in both seasons. The highest values of plant height (167.6 cm), herb dry weighty per plant (136.1 g), time of harvesting (200.3 day) were recorded by using NPK (RD) with foliar application of humic acid in the first season. These findings were true in both seasons. Significant increase in the plant height by chemical fertilizer plus humic acid might be due to optimum supply and availability of nutrients through inorganic and organic source which helped in better uptake of nutrients which increased growth of plants in these treatments.

Increasing in growth of fennel herb when treated plants with mineral fertilization plus humic acid may be due to the effect of humic acid in producing materials that may affect plant growth such as substances acting as plant hormone analogues or growth regulators, (Frankenberger and Arshad, 1995).

These results coincided with Gomaa and Youssef (2008) on caraway plants. From another view, plants were treated by different types of fertilization (NPK, compost and cattle manure) and foliar humic acid had lower number of days till harvesting of fennel than the same plants which were untreated with humic acid in both seasons. The reason for the enhancing harvesting when NPK or compost plus humic acid was used, may be due to the properties of humic acids that have a direct positive effect on plant growth. These results are in agreement with Ahmed *et al*. (2011) on roselle plants.

Fruit yield and its components :

Foliar application of humic acid had a significant effect on all yield parameters as compared with the treatment (without humic) in both seasons, (Table, 2). This increment in spraying fennel plants with humic acid may be due to that humic acid increase vegetative growth through availability of nutrients for plants which reflected on increasing in number of umbels per plant (58.4), weight of 1000 seeds (8.0 g), fruit yield (64.6 g / plant and 1085.0 kg / fed). The results are supported by Kandil *et al*. (2002) on fennel.

Moreover, The increase of seed yield per plant and per feddan may be due to the increase in the number of umbels formed by plant. Such effects of NPK fertilization on fruit yield may be attributed to the important role these on the synthesis of metabolites used in fruit formation. Also, the obtained results were in accordance with those obtained by Ibrahim (2000), Kandil *et al*. (2002), Abdou *et al.* (2004), Badran and Safwat (2004) on fennel.

Table (2): Fruits yield of fennel plants as affected by humic acid, fertilization types during (2008 / 2009) and (2009 / 2010) seasons.

Treatments			Number of umbels / plant		Weight of 1000 seeds (g)		Fruit yield (g / plant)		Fruit yield (kg / fed)	
			1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Effect of Humic acid application										
With			58.4	63.0	8.0	8.5	64.6	68.5	1085.0	1150.3
without			42.4	45.8	6.5	6.9	45.6	48.3	765.4	811.2
L.S.D at 5%			**1.24**	**0.99**	**0.11**	**0.10**	**0.95**	**0.83**	**15.97**	**13.88**
Effect of fertilization types										
$N_{200}P_{200}K_{50}$		**Kg / fed**	61.7	66.7	8.3	8.8	69.3	73.4	1163.4	1233.1
Compost		**10 m^3/ fed**	43.9	47.4	6.8	7.1	46.4	49.2	778.7	825.7
		15 m^3/ fed	55.5	59.9	7.7	8.3	60.7	64.4	1019.8	1081.1
		20 m^3/ fed	57.3	61.8	8.1	8.4	63.5	67.3	1066.8	1130.6
Cattle		**10 m^3/ fed**	38.5	41.6	6.3	6.7	39.5	41.9	663.6	703.9
		15 m^3/ fed	45.7	49.3	6.8	7.3	50.7	53.8	851.8	903.0
		20 m^3/ fed	50.2	54.2	7.3	7.7	55.5	58.8	932.4	987.8
L.S.D at 5%			**2.31**	**1.85**	**0.20**	**0.17**	**1.78**	**1.55**	**29.88**	**25.97**
Effect of the interaction										
With humic	**$N_{200}P_{200}K_{50}$**	**Kg / fed**	69.8	75.4	8.9	9.4	78.2	82.9	1313.8	1392.7
	Compost	**10 m^3/ f ed**	49.1	53.0	7.3	7.7	53.3	56.5	895.4	949.2
		15 m^3/ fed	66.3	71.6	8.7	9.3	73.0	77.4	1226.4	1300.3
		20 m^3/ fed	62.9	67.9	8.7	9.1	68.0	72.1	1142.4	1211.3
	Cattle	**10 m^3/ fed**	45.7	49.4	7.0	7.4	49.2	52.2	826.6	876.1
		15 m^3/ fed	55.6	60.0	7.8	8.3	63.1	66.9	643.4	1123.9
		20 m^3/ fed	59.1	63.8	8.2	8.6	67.3	71.3	734.2	1197.8
without hmic	**$N_{200}P_{200}K_{50}$**	**Kg / fed**	53.7	58.0	7.7	8.1	60.3	63.9	1013.0	1073.5
	Compost	**10 m^3/ fed**	38.7	41.8	6.2	6.5	39.4	41.8	661.9	702.2
		15 m^3/ fed	44.7	48.3	6.7	7.3	48.4	51.3	813.1	861.8
		20 m^3/ fed	51.7	55.8	7.4	7.7	59.0	62.5	991.2	1050.0
	Cattle	**10 m^3/ fed**	31.3	33.8	5.6	6.0	29.8	31.6	500.6	530.9
		15 m^3/ fed	35.8	38.7	5.8	6.2	38.3	40.6	643.4	682.1
		20 m^3/ fed	41.3	44.6	6.3	6.8	43.7	46.3	734.2	777.8
L.S.D at 5%			**3.27**	**2.61**	**0.20**	**0.25**	**1.78**	**1.55**	**29.88**	**25.97**

The interaction between humic acid as a foliar application and fertilization treatments had significant effects on all fruit yield parameters when compared with the treatments (without humic). The highest values of number of umbels (69.8 and 66.3), weight of 1000 seeds (8.9 and 8.7 g), fruit yield (78.2 and 73.0 g / plant) and (1313.8 and 1226.4 kg / fed) were recorded by using NPK (RD) followed by compost at 15 m^3/ fed with foliar humic acid application, respectively in the first season.

The beneficial effect of those interactions (chemical, compost fertilizer plus humic acid) on fennel fruits yield may be attributed to the enhancing of easily nutrients release into soil solution and to encourage their penetration through plant roots, as well as to develop antagonistic impacts toward pests and plant diseases (Ho and Hwan, 2000). The positive effect of compost with humic acid were in harmony with those obtained by Gomaa and Youssef (2008) on caraway plants.

Essential oil content :

Studying essential oil (Table, 3), it was obvious that the highest percentage and yield were 2.81%, 1.82 ml/ plant and 30.53 L/fed respectively, of plants sprayed with foliar humic acid application, while the lowest values were of plants without humic application in the first season.

Table (3): Essential oil (%), content (ml / plant) and yield (kg / fed) of fennel plants as affected by humic acid and fertilization types during (2008 / 2009) and (2009 / 2010) seasons.

Treatments			Essential oil content					
			(%)		(ml / plant)		(L / fed)	
			1st season	2nd season	1st season	2nd season	1st season	2nd season
Effect of Humic acid application								
With			2.81	3.08	1.82	2.11	30.53	35.52
without			2.69	2.95	1.23	1.42	20.71	23.98
L.S.D at 5%			**0.015**	**0.012**	**0.029**	**0.037**	**0.484**	**0.434**
Effect of fertilization types								
$N_{200}P_{200}K_{50}$		**Kg / fed**	2.84	3.11	1.97	2.29	33.10	38.48
Compost		**10 m^3/ fed**	2.71	2.96	1.26	1.46	21.09	24.45
		15 m^3/ fed	2.78	3.05	1.69	1.97	28.40	33.02
		20 m^3/ fed	2.79	3.05	1.77	2.06	29.74	34.61
Cattle		**10 m^3/ fed**	2.68	2.93	1.06	1.19	17.81	20.67
		15 m^3/ fed	2.73	2.99	1.39	1.62	23.44	27.13
		20 m^3/ fed	2.75	3.01	1.53	1.78	25.79	29.91
L.S.D at 5%			**0.028**	**0.023**	**0.054**	**0.068**	**0.905**	**0.812**
Effect of the interaction								
With humic	$N_{200}P_{200}K_{50}$	**Kg / fed**	2.92	3.21	2.28	2.66	38.30	44.69
	Compost	**10 m^3/ ed**	2.74	2.99	1.46	1.69	24.53	28.39
		15 m^3/ fed	2.84	3.12	2.07	2.41	34.78	40.49
		20 m^3/ fed	2.83	3.10	1.92	2.24	32.26	37.63
	Cattle	**10 m^3/ fed**	2.71	2.97	1.33	1.55	22.34	26.04
		15 m^3/ fed	2.80	3.07	1.77	2.05	29.74	34.44
		20 m^3/ fed	2.81	3.08	1.89	2.2	31.75	36.96
without hmic	$N_{200}P_{200}K_{50}$	**Kg / fed**	2.75	3.01	1.66	1.92	27.89	32.26
	Compost	**10 m^3/ fed**	2.67	2.92	1.05	1.22	17.64	20.5
		15 m^3/ fed	2.71	2.97	1.31	1.52	22.01	25.54
		20 m^3/ fed	2.74	3.00	1.62	1.88	27.22	31.58
	Cattle	**10 m^3/ fed**	2.64	2.89	0.79	0.91	13.27	15.29
		15 m^3/ fed	2.66	2.91	1.02	1.18	17.14	19.82
		20 m^3/ fed	2.69	2.94	1.18	1.36	19.82	22.85
L.S.D at 5%			**0.039**	**0.032**	**0.076**	**0.097**	**1.280**	**1.148**

The positive effect of foliar humic acid on oil quality may be due to humic acid (HA) containing auxins, which influence cell division and stem that gave the cell walls the ability to expand. These results in accordance with those obtained by Said-Al Ahl *et al*. (2009) on oregano plants, they indicated that increasing growth compared with control plants due to the direct effect of humic acid on solubilization and transport of nutrient.

The highest significantly essential oil percentage and yield were 2.84 %, 1.97 ml/ plant and 33.10 L/ fed respectively, of plants which received the recommended dose of $N_{200}P_{200}K_{50}$ kg /fed followed by the plants fertilized

with compost at rate of 20 m^3/ fed were 2.79 %, 1.77 ml/plant and 29.74 L/ fed respectively. The lowest values were 2.68 %, 1.06 ml/ plant and 17.81 L/ fed respectively, from plants fertilized with cattle manure at rate of 10 m^3 / fed in the first season compared with other fertilizers treatments separately. The results of the second season followed the same trend. These results might be due to the important role of macro elements which plays an important role in synthesis of plant constituents such as in essential oil. The sufficient availability of these elements might have led to higher seed yield and resulting in higher essential oil yield (Wagner and Micheal, 1971).

The increase in oil yield has been reported with increase in NPK level alone as mentioned by Mukesh (1996). These results are in accordance with the previous results of Ashorabadi *et al*. (2003), Gomaa and Youssef (2007) and Azzaz *et al.* (2009) on fennel plant.

The primitive effect of compost on increasing essential oil percentage, content and yield of fennel plant might be attributed to their enhancing effect on vegetative growth characteristics and plant chemical composition. In addition, this favorable effect could be related to increasing the number of glands. These results coincide with those obtained by Abdou and Mahamoud (2003) on fennel plant.

Data in Table (3) showed that the essential oil content and yield of fennel plant were significantly affected by the interaction treatments between different types of fertilization (NPK recommended dose (RD), compost and cattle manure) plus spraying humic acid application.

The highest values were 2.92 %, 2.28 ml / fed and 38.30 L / fed obtained from plants fertilized with the recommended dose of NPK plus spraying humic acid followed by plants fertilized with the medium dose of compost at 15 m^3/ fed plus humic acid (2.84 %, 2.07 ml / plant and 34.78 L/fed) respectively, compared with other combination of fertilizers with humic. Therefore, using organic fertilizers improved quality and quantity of medicinal plants. The favorable effect treating fennel plants with mineral fertilization plus humic acid are in harmony with those of Gomaa and Youssef (2008) on caraway plants and Said-Al Ahl *et al*. (2009) on oregano plants.

Essential oil components (%):-

The results in Table (4) and illustrated in Figures (1 and 2) showed the different components separated and identified from oil samples produced from the plants treated with interaction between fertilizers types and humic acid during the second season of 2009 / 2010.

The obtained chromatograms revealed and identified 7 components represented from 92.73 to 99.05 % of essential oil are α-pinene, p-myrcene, limonene, fenchone, 1.8-cineole, estragole and anethole. The main component estragole was 91.46 % produced by the NPK (RD) with humic acid.

All treated plants with humic acid produced highest percentage of the main components (estragole) compared with untreated ones. Estragole is a major oil component of many common herbs such as fennel up to 65 % (Barazani *et al*., 2002).

Generally, it could be concluded that, foliar application of humic acid twice after sowing at rate of 10 cm / L and fertilization plants with compost at rate of 15 m^3 / fed gave a higher values of fruit yield and essential oil with good quality from natural source of fertilizers established efficiency on safety manner for soil fertility and more economic as well as unpolluted environment

Table (4): Essential oil components (%) of fennel plants affected by fertilization types and humic acid application in the second season of (2009 / 2010).

Treatments		Essential oil components (%)							
		Monoterpenic ydrocarbons			Oxygenated compounds				known
		α-pinene	p-myrcene	limonene	fenchone	1.8-cineole	estragole	anethole	
		With humic acid (10 cm / L)							
$N_{200}P_{200}K_{50}$	Kg / fed	0.41	0.24	2.32	3.11	0.35	91.46	-	97.89
Compost	10 m^3 / fed	0.47	0.54	6.39	2.55	0.65	82.05	2.31	94.96
	15 m^3 / fed	0.32	0.52	6.14	2.77	-	88.81	-	98.56
	20 m^3 / fed	0.42	0.40	6.15	3.05	0.52	87.49	-	98.03
Cattle	10 m^3 / fed	1.59	-	5.99	5.19	2.35	77.61	-	92.73
	15 m^3 / fed	0.30	-	2.60	3.38	0.41	85.07	3.48	95.24
	20 m^3 / fed	0.26	0.15	1.85	2.88	0.37	88.29	0.39	94.19
Without humic acid (0 cm / L)									
$N_{200}P_{200}K_{50}$	Kg / fed	0.49	0.28	3.92	6.76	0.81	86.52	-	98.78
Compost	10 m^3 / fed	-	2.07	11.68	4.04	2.29	77.05	1.92	99.05
	15 m^3 / fed	0.72	0.55	6.19	4.45	0.80	85.91	0.21	98.83
	20 m^3 / fed	0.49	0.56	7.65	3.19	0.46	86.30	-	98.65
Cattle	10 m^3 / fed	2.09	0.91	6.25	8.47	5.89	65.72	5.89	95.22
	15 m^3 / fed	0.52	-	4.16	3.52	1.00	84.70	3.54	97.44
	20 m^3 / fed	1.24	0.55	5.23	3.69	0.84	86.04	-	97.59

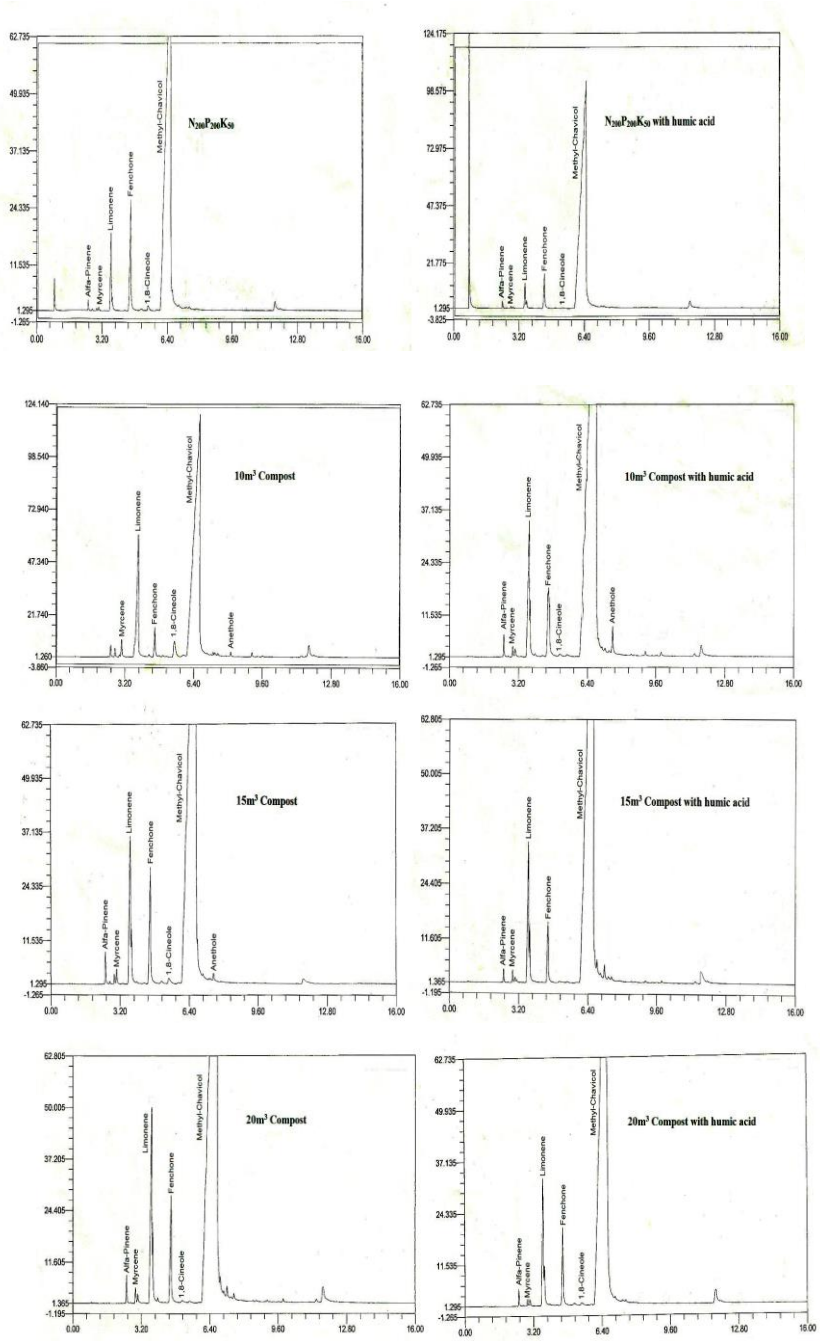

Fig. (1): G.L.C. chromatographic analysis of fennel oil components % from $N_{200}P_{200}K_{50}$ kg / fed and compost at (10, 15 and 20 m^3 / fed) with or without humic acid application.

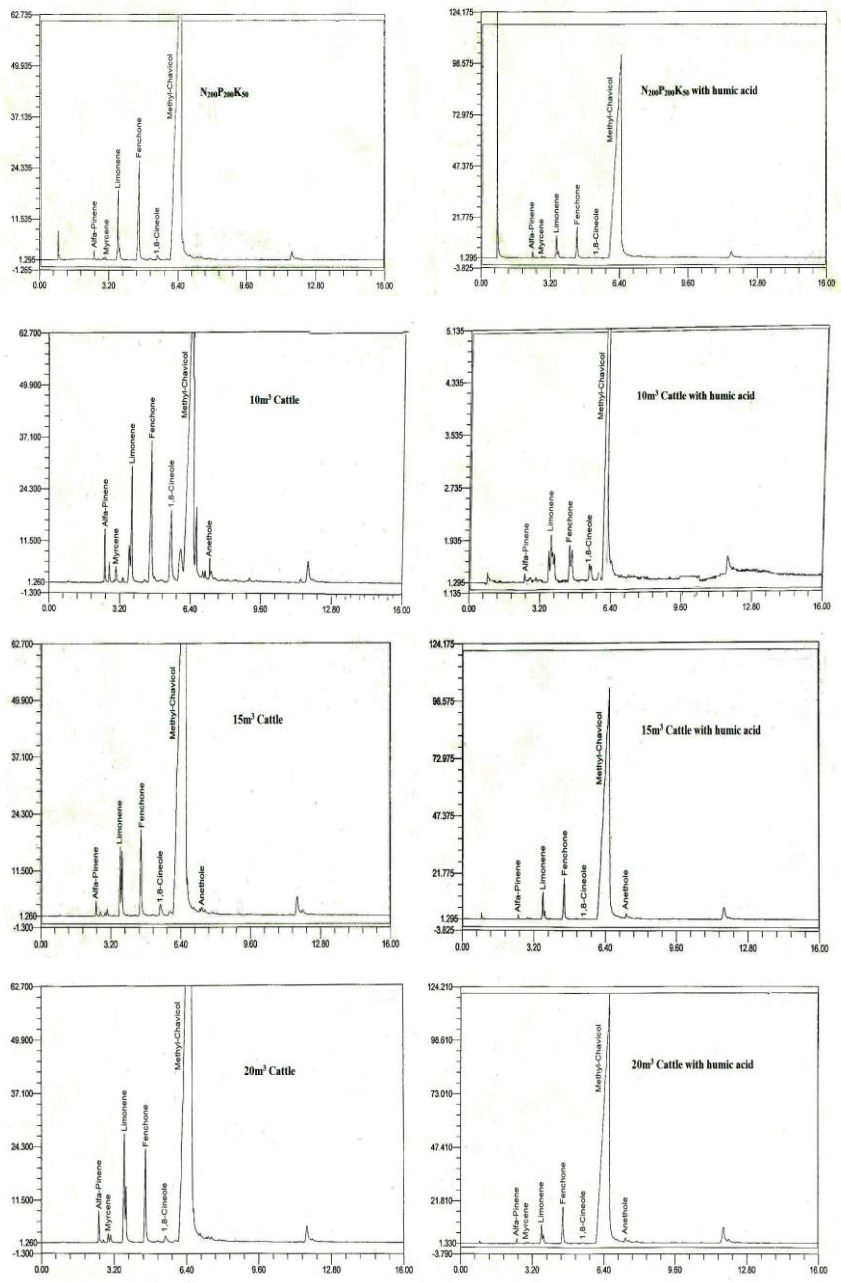

Fig. (2): G.L.C. chromatographic analysis of fennel oil components % from $N_{200}P_{200}K_{50}$ kg/fed and cattle manure at (10, 15 and 20 m^3 / fed) with or without humic acid application.

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تأثير حمض الهيوميك ومستويات من الكمبوست وسماد الماشية على نبات الشمر وعلاقة ذلك بالنمو الخضرى والمحصول والزيت الطيار

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تم تنفيذ تجربتين حقليتين خلال الموسمين ٢٠٠٨/٢٠٠٩ م و ٢٠٠٩/ ٢٠١٠ م على نبات الشمر في مزرعة النباتات الطبية والعطرية بكلية الزراعة - جامعة المنصورة ، لدراسة تأثير حمض الهيوميك (رش ورقى – بدون رش) وكذلك التسميد بمستويات مختلفة من الكمبوست و وسماد الماشية بمعدل (١٠-١٥-٢٠ م٣ / فدان) بالإضافة الى استخدام الجرعة الموصى بها من السماد الكيماوى (٢٠٠-٢٠٠-٥٠ كج ن فوبو/ فدان) وتأثير ذلك على النمو الخضرى ومحصول الثمار وكذلك الزيت الطياروم‌كوناته الفعالة.

ويمكن تلخيص النتائج المتحصل عليها فيما يلي : -

اولا :أدي الرش الورقى بحمض الهيوميك بتركيز ١% للنبات بمعدل مرتين بعد ٦٠ و١٠٥ يوم من الزراعة الى زيادة النمو الخضرى ومحصول الثمار وأيضا الزيت الطيار زيادة معنوية فى كلا الموسمين

ثانيا :أوضحت النتائج أن تسميد نباتات الشمر بالجرعة الموصى بها من السماد الكيماوى أعطى أعلى القيم لجميع الصفات المدروسة تلاه التسميد بسماد الكمبوست (٢٠ م٣ للفدان).

ثالثا :أعطت معاملة التفاعل بين الرش الورقى بحمض الهيوميك والتسميد بالجرعة الموصى بها من السماد الكيماوى يليها سماد الكمبوست بمعدل ١٥م٣/ فدان تأثيرا معنويا على جميع الصفات المدروسة .

رابعا :حدثت زيادة فى النسبة المئوية للزيت العطرى الطيار والمكون الرئيسى (استراجول) عند معاملة النباتات بسماد الكمبوست بمعدل ١٥م٣/ فدان مع الرش بحمض الهيوميك.

خامسا :التحليل الكروماتوجرافى للزيت الناتج من ثمار الشمر تعرف على ٧ مركبات بلغ مجموع نسبتهم من ٩٢.٧٣ % الى ٩٩.٠٥ % من المكونات.

التوصية :يمكن إضافة حمض الهيوميك كرش ورقى بتركيز ١% للنبات بعد ٦٠ و ١٠٥ يوم من الزراعة بالإضافة إلى تسميد النباتات ب ١٥ م٣ /فدان من سماد الكمبوست وذلك لتحسين النمو الخضرى والحصول على أعلى محصول من الثمار و الزيت الطيار ذو صفات جيدة وأكثر أقتصاديه بالاضافه الى انه غير ملوث للبيئه.

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