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EVALUATION OF ESSENTIAL OILS OF SOME UMBELLIFEROUS PLANTS AS NATURAL NEMATICIDES AGAINST *Meloidogyne javanica.*

BY

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ABSTRACT

Hydrodistillation of seeds of some umbelliferous plants, i.e., anise (*Pimpinella ansium* L.), caraway (*Carum carvi* L.), celery (*Apium graveolens* L.), coriander (*Coriandum satvium* L.), dill (*Anethum graveolens* L.) and fennel (*Foeniculum vulgare* L.), were under taken. The main identified constituents were essential oils containing anethole (85.36 %), carvone (22.82 %), limonene (20.13%), linalool (19.31%), limonene (45.47%) and anethole (56.03%) in respect to the umbelliferous plants. Nematicidal activity of the resulting essential oils were evaluated against the root-knot nematode, *Meloidogyne javanica* infecting Okra plants at concentrations rates of 0.50, 0.75 and 1.0 µl/ml. All the applied oils showed highly nematicidal activity at all concentrations. The essential oils succeeded in reducing numbers of galls, counts of egg laying females, number of eggs/egg mass, juveniles in soil, the nematode final population and its rate of reproduction. The nematicidal effects of the oils were proportionally increased by successive increase of concentration rate. Application of such essential oils resulted in improving growth of Okra plants. Ethanol as solvent did not affect plant growth or nematode populations. Essential oil of anise achieved the highest nematicidal effect on the nematode development and reproduction followed by fennel, coriander, caraway, celery and dill essential oils compared with that of the check.

Key words: Essential oils, *Meloidogyne javanica, Pimpinella ansium, Carum carvi, Apium graveolens, Coriandum satvium, Anethum graveolens, Foeniculum vulgare*, Umbelliferae.

INTRODUCTION

Many Umbelliferous plants as anise, celery, caraway, coriander, dill and fennel as well as their essential oils are popularly used as spices and condiments in cosmetic, medical and food industries. Plant volatile oils have been recognized since antiquity to possess biological activities namely, antimicrobial, antifungal (Janssen *et al.*, 1987 and Müller-Riebau *et al.*, 1995) insecticidal (Isman, 1999) and nematicidal activities (Oka *et al.*, 2000). Plant-parasitic nematodes are generally controlled by several means including cultural practices, chemical nematicides and resistant cultivars. However, usage of nematicides today tends to

be minimized due to environmental problems and hazardous conflicts to human and animals health. For example, Aldicarb, the highly toxic and widely used non-fumigant to control insects and nematodes, has been detected in ground water (Aspeline and Grubbe, 1998). However, the commonly used nematicides of the short-chain halogenat alkylating agents, cholinesterase inhibiting carbamates and organophosphates pose severe problems of mammalian toxicity. The former class of nematicides are also associated with phytotoxicity and residual effects (Salgado,1997). In recent years, alternative nematode control methods or less toxic nematicides of plant origin have shown encouraging results (Bauske *et al.*, 1994; Amin, 1999 and Stephan *et al.*, 2001). Several compounds, e.g. alkaloids, phenols, sesquiterpenes, diterpens and polyacetyllenes have nematicidal activity. Utilization of essential oils and their components have been evaluated for their nematicidal effects (Sangwan *et al.* 1990; Leela *et al.* 1992; Walker & Melin 1996; Oka *et al.* 2000 and Al-Shalaby and Ali 2001). In this study hydrodistillation of seeds related to six plant species belonging to family Umbelliferae; i.e., anise (*Pimpinella ansium* L.), caraway (*Carum carvi* L.), celery (*Apium graveolens* L.), coriander (*Coriandum satvium* L.), dill (*Anethum graveolens* L.) and fennel (*Foeniculum vulgare* L.) was under taken. The resultant essential oils were analyzed by Gas Chromatography Mass Spectroscopy and evaluated for their nematicidal effects on the root-knot nematode *Meloidogyne javanica* infecting okra plants.

MATERIALS AND METHODS

Plant materials:

Dried seeds of anise, caraway, celery, coriander, dill and fennel were purchased from the local market. The essential oils were obtained by water distillation using Clevenger-type apparatus. The volatile oils were separated and dried over anhydrous sodium sulphate (ASTA, 1968).

GC-MS analysis:

Essential oils were analyzed by GC-MS using a Hewlett Packard GC-MS Model 6890 series equipped with selective detector Mass spectroscopy Model 5973. This equipment interfaced via HP chemstation version A 02.12 software (Hewlett Packard, Avondale, PA). The gas chromatography was equipped with Carbowax 20 M capillary column, 50 m x 0.53 mm i.d, 1.5 µm thickness (J &W Company, CA, USA). The operating conditions for gas chromatography were as follows: injector temperature 250 °C; Carrier gas: helium at 30 cm/sec, measured at 130 °C. Oven temperature was kept at 50 °C for 5 min programmed to 250 at rate 2 °C/min and held at 250 °C until the chromatogram was completed, detector temperature; 300 °C (Adams,1995). Mass spectroscopy operating parameters were: electron ionization at 70 eV, accelerating voltage 10 KV and Scan M/Z range from 40 to 650. The identification of oil constituents was carried out by comparing retention times with those of available authentic reference compounds, as well as peak-matching library (NIST standard mass library, version 2.0) and in the previously published data of available literature.

Biological activity:

a. Nematode source:

Egg masses of *M. javanica* were collected from eggplant infected roots and incubated in distilled water at room temperature for hatching. Second stage juveniles (J_2) were collected daily for a week, and the hatched juveniles were used as inocula at the proper time.

b. Effects of essential oils:

Efficacy of essential oils in controlling *M. javanica* infecting okra plants was tested in a greenhouse experiment. Plastic pots 16 cm diameter, filled with 2 kg sandy clay soil (2:1, v:v) were seeded with okra seeds. After germination, seedlings were thinned to one plant/pot. Two weeks later, plants in pots were inoculated with 2000 newly hatched juveniles of *M. javanica* per pot. One ml of the concentrations at the rates of 0.50, 0.75 or 1.00 µl/ml of each essential oil dissolving in ethanol 95%, was separately pipetted to soil of the pots. Ethanol only was mixed with soil as a solvent check treatment. Other comparable check pots were inoculated with the nematode without receiving any essential oils. Another group of non-nematode inoculated pots were received the different concentrations of the tested essential oils to investigate the possible effect of such oils on okra plant growth. Each treatment was replicated four times and pots were kept on a green house bench. After 55 days, plants were uprooted, in which lengths and weights of shoots and roots were recorded. Number of galls, nematode counts in soil and roots were counted.

Statistical analysis:

Data of all experiments were subjected to analysis of variance (ANOVA), and means were separated according to LSD (P= 0.05).

RESULTS AND DISCUSSION

1. GC.MS analysis of the essential oils:-

The GC-MS analyses of anise, caraway, celery, coriander, dill and fennel essential oils are shown in table (1). As shown in the table (1), twelve volatile components (98.42%) were identified and five volatile components were unknowns (1.58 %) in anise essential oil. Anethole (cis-anethol, 75.13% and trans-anethol, 10.23%) was the most abundant component identified comprising 85.36% of total anise oil. Masada (1976), Formacek and Kubeozk (1982), Karaali and Basogiu (1995) and Duke (1997) reported that anise essential oil contains 80 to 90% anethole.

Results in table (1) indicate that eighteen constituents were identified (94.15 %) and five components (5.85 %) were unknowns in caraway essential oil. Carvone (22.82%)was identified as the most abundant components followed by limonene (18.46%). Kallio and Kerrola, (1994) and Zowirska and Wasowicz (2000) reported that limonene and carvone were identified as the major constituents of caraway essential oil. Carvone (19.60 - 27.11%) and Carvecol (16.05 - 22.40%)were the major characteristic constituents of caraway oil as reported by Kallio and Kerrola (1994) and Braun and Schwarz (2000).

Based on the results of the GC-MS investigation (table, 1) fourteen components (95.72%) were identified while six components were unknowns (4.38 %) in celery essential oil. The major constituents were limonene (20.13 %), Elemicin (13.30 %), myristicin (12.70 %), α-pinene (10.67%) and β-selinene (10.26 %).These results are largely in agreement with those reported by Masada (1976), Thomann *et al.*, (1993), Tang *et al.*, (1994), Vernin and Parkanyi (1994) and Ali, (2000).

As shown in table (1), *nineteen* components (92.98 %) were identified and four components were unknowns (7.02%) in the coriander essential oil. Linalool (19.31 %) was the most abundant constituent followed by limonene (10.54%). Linalool (59.6-71.60%) has been reported by Borges *et al.*, (1990) and Budavari, (1996) as the main constituent in the coriander essential oil. Linalool (67-78.10%) was also characterized as a main component by Kerrola and Kallio (1993) and Rahman *et al.*, (1999).

The presented data in table (1) indicate that dill essential oil contained fifteen identified compounds (97.68 %) and three unknowns (2.32%). Limonene (45.47 %) was the most abundant identified component in the oil. α-phellandrene (10.12 %) was the second major identified volatile compound. Maharan *et al.*, (1992), Thomann *et al.*, (1993) and Charles *et al.*, (1995) reported that dill essential oil contained limonene as a major constituent at the percentage of 40, 50 and 70%, respectively. Pino *et al.*, (1995) and Ali, (2000) emphasized that α-phellendrene was identified as a major volatile constituent in dill essential oil.

The results in table (1) indicate that fennel essential oil contained sixteen identified components (96.62%) and five ones (3.38 %) were unknowns . *Cis*-anethole (56.03%) was the main component, while estragole (12.16 %) and limonene (10.16 %) were found in relatively high amounts. Fennel essential oil was previously reported by Charles *et al.*, (1993) to have anethole and limonene as main constituents as they represented more than 80% of the oil. Lamarti *et al.*, (1993) and Venskutonis *et al.*, (1996) Marotti *et al.*, (1994) and; Bernath *et al.*, (1996) emphasized that the fennel oil contained anethole and estragole as major constituents . While, Badoc *et al.*, (1994) and Ali, (2000) reported that fennel essential oil contained liomnene as a main constituent at the percentage of 52.40% and 45.64%, respectively.

In general, anethole was identified as a major volatile constituent in both anise and fennel essential oils, accounting 85.36% and 56.03%, respectively. Limonene was detected as a major volatile constituent in both celery and dill essential oils at the percentage rates of 20.13 and 45.17 %, respectively. Carvone (22.82%) and linalool (19.31%) were identified as two major constituents in caraway and coriander essential oils, respectively.

Table (1): Chemical composition of essential oils of six Umblliferous plants.

Identified Constituent	M^+ (m/e)	Base peak	Area percentage					
			1	2	3	4	5	6
Myercene	136	93	---	0.30	6.58	---	---	1.06
Ethanonone	148	117	---	5.46	---	---	---	---
α -Fenchene	136	93	---	---	---	6.06	---	---
α -Thujene	136	91	---	---	---	3.72	0.63	---
α -pinene	136	93	0.51	---	10.67	3.6	---	---
β -pinene	136	93	---	---	1.67	0.72	0.56	1.06
Iso-limonene	136	79	---	6.39	---	---	---	---
Sabinene	136	91	---	6.60	1.45	---	---	---
α - phellandrene	136	91	---	---	---	---	10.12	---
β - phellandrene	136	98	---	---	---	---	4.18	---
α -Terpenine	136	120	---	4.68	---	---	---	---
Limonene	136	93	0.22	18.46	20.13	10.54	45.47	10.16
Limonyl alcohol	154	94	---	4.83	---	---	---	---
γ-terpinene	154	108	---	---	---	1.86	---	---
€-carene	204	119	---	---	---	2.16	---	---
cis-ocimene	136	105	---	---	5.07	5.04	---	1.07
Fenchone	152	110	---	---	---	---	---	1.5
Nonanal	144	41	---	---	---	0.24	---	---
p- cymene	136	93	---	---	---	---	0.18	---
p- menthene	130	123	---	---	---	---	0.79	---
Carveol	152	109	---	7.89	---	---	---	0.67
Carvecol	152	137	---	---	---	---	2.08	---
Epoxy decane	135	107	---	---	---	1.14	---	---
Fenchyl acetate	196	136	---	---	---	---	---	1.45
Carvone	150	108	---	22.82	---	---	2.68	1.54
cis-anethole	148	121	75.13	---	---	---	6.19	56.03
trans-anethole	148	117	10.23	1.50	---	---	0.98	---
Linalool	154	108	1.07	---	---	19.31	---	---
Lavandulyl actate	194	41	---	---	---	2.58	---	---
1,8- nonadiene	124	41	---	---	---	5.28	---	---
p-cymene- 8- ol	150	135	---	---	---	---	1.45	---
Myrtanal	150	121	---	---	---	3.24	---	---
Linyl acetate	186	139	---	---	---	5.52	---	---
Decanol	158	111	---	---	---	7.02	---	---
p-menthe-2-en-1-ol	154	139	---	0.28	---	---	---	---
Verbenol	222	139	---	1.65	---	---	---	---
Borneol	154	138	---	1.53	---	---	---	---
cis-caryophyllene	204	105	---	---	---	0.66	---	---
Estragole	148	117	5.16	---	6.12	---	---	12.16
Elmatrienol	222	59	---	2.34	---	---	---	---
Methyl bornene	108	66	---	7.92	---	---	---	---
β - selinene	204	119	---	---	10.26	---	---	---

Table (1): (continue)

Citral	152	137	—	1.23	—	—	—	—
Geraniol	154	134	—	0.90	—	—	—	—
Naphthalene	128	102	0.63	—	—	—	—	—
Limonene oxide	152	135	0.37	—	0.87	—	—	—
Nonadecanol	144	45	—	0.97	—	—	—	—
Geranyl acetate	196	121	—	—	—	0.96	—	—
Cadinene	204	161	2.33	—	—	—	—	—
Anis aldehyde	135	77	0.65	—	—	—	—	1.27
Isopulegol	154	41	—	—	—	7.86	—	—
Piperetonene	204	151	—	—	—	—	—	3.5
Methyl eugenol	178	163	1.03	—	—	—	—	—
Anisyl acetate	180	121	—	—	—	—	—	0.65
Bergamotene	204	119	1.09	—	—	—	—	—
α -copaene	204	160	—	—	—	—	—	0.58
Farnesene	204	162	—	—	—	—	3.15	—
Myristicin	192	161	—	—	12.70	—	9.68	8.1
Elemicin	208	208	—	—	13.30	—	—	—
Dill apiole	222	177	—	—	5.05	—	7.78	—
Menthofuran	150	108	—	—	—	—	—	2.16
Sedanolide	194	108	—	—	0.98	—	—	—
Sedanonic anhydride	192	107	—	—	0.68	—	—	—
Unknown	—	—	1.58	5.85	4.38	7.02	2.32	3.38

1: Anise oil. 2: caraway oil, 3: celery oil, 4: coriander oil, 5: Dill oil, 6: fennel oil

2. Biological activity of the essential oils:

a. Effect of the essential oils on the nematode development:

The nematicidal activity of six essential oils on development and reproduction *of M. javanica* is presented in table (2). Data indicated that most of such essential oils were effective in controlling *M. javanica*. All the tested concentrations of such essential oils caused significant reduction in the total number of galls on okra roots comparing with those of the check; and such reduction was positively correlated with the concentration rates of oils. All concentration rates of the oils significantly reduced the total number of immature stages, egg masses in roots, the total number of nematode in soil in addition to the nematode final population when compared with those of the check treatment or even with those of the ethanol check one. Accordingly, the rate of nematode reproduction was drastically affected by such oils concentrations. At high concentration rate (1.0 µl/ml per pot) the essential oil of anise was the most effective on nematode development and reproduction followed by fennel, coriander, caraway, celery and then dill. Consequently, rates of reproduction of the nematode were 0.29, 0.34, 0.51, 0.56, 0.64 and 1.22, respectively when compared with those of non-treated or ethanol treated check plants as they were 6.03 and 5.46, respectively. The rest treatments performed, however, pronounced reduction in the rate of nematode reproduction.

Table (2): Effect of different essential oils on development and reproduction of *Meloidogyne javanica* infecting okra.

Concentration (µl/ml.)	No.of galls/root	Immature stages	No. of egg masses	Average eggs/egg mass	No. of J_2 in soil	Final pop.(Pf)	Rate of reproduction
Non-treated (check1)	450 ^{a}	1070 ^{a}	380 ^{a}	410 ^{a}	10600 ^{a}	12050 ^{a}	6.025 ^{a}
Caraway							
0.5	176 ^{def}	302 ^{f}	98 ^{de}	212 ^{d}	1680 ^{ghi}	2080 ^{fg}	1.04
0.75	123 ^{ghij}	250 ^{i}	62 ^{ghijk}	163 ^{ef}	1200 ^{ghijkl}	1512 ^{ijk}	0.76
1.0	79 ^{l}	120 ^{l}	20 ^{l}	81 ^{l}	980 ^{ijkl}	1120 ^{jk}	0.56
Celery							
0.5	209 ^{c}	342 ^{e}	140 ^{c}	242 ^{c}	3000 ^{d}	3482 ^{c}	1.741
0.75	142 ^{gh}	270 ^{h}	83 ^{efghi}	170 ^{e}	1700 ^{fghi}	2053 ^{fg}	1.027
1.0	112 ^{ij}	200 ^{j}	61 ^{hijk}	126 ^{hi}	1010 ^{ghijkl}	1271 ^{ijk}	0.636
Coriander							
0.5	198 ^{cd}	410 ^{c}	138 ^{c}	221 ^{d}	2904 ^{de}	3452 ^{c}	1.726
0.75	160 ^{fg}	281 ^{gh}	91 ^{ef}	162 ^{ef}	1902 ^{fgh}	2274 ^{ef}	1.137
1.0	100 ^{jkl}	219 ^{j}	44 ^{jkl}	110 ^{ij}	750 ^{jkl}	1013 ^{kl}	0.507
Fennel							
0.5	187 ^{cde}	380 ^{d}	105 ^{de}	210 ^{d}	3000 ^{cf}	3485 ^{d}	1.743
0.75	111 ^{jk}	207 ^{j}	58 ^{ijk}	129 ^{h}	1207 ^{ghijkl}	1472 ^{ijk}	0.736
1.0	87 ^{l}	148 ^{k}	24 ^{l}	86 ^{kl}	502 ^{kl}	674 ^{m}	0.337
Dill							
0.5	200 ^{c}	402 ^{c}	117 ^{cd}	152 ^{efg}	1197 ^{fg}	1716 ^{e}	0.858
0.75	159 ^{fg}	271 ^{gh}	85 ^{efgh}	140 ^{gh}	1131 ^{ghijk}	1487 ^{gh}	0.744
1.0	132 ^{hi}	266 ^{hi}	65 ^{ghij}	89 ^{kl}	2117 ^{hijkl}	2448 ^{jk}	1.224
Anise							
0.5	167 ^{ef}	290 ^{fg}	90 ^{efg}	149 ^{fg}	1000 ^{ghij}	1380 ^{fg}	0.690
0.75	132 ^{hi}	250 ^{i}	70 ^{fghi}	123 ^{hi}	796 ^{ghijkl}	1116 ^{ijk}	0.558
1.0	88 ^{kl}	132 ^{kl}	37 ^{kl}	101 ^{jk}	400 ^{jkl}	569 ^{lm}	0.285
Solvent (check 2)	408 ^{b}	1002 ^{b}	352 ^{b}	389 ^{b}	9560 ^{b}	10914 ^{b}	5.457

Values in each column followed by the same letter(s) are not significantly different according to new L.S.D. (P = 0.05).

b. Effect of the essential oils on the growth of okra plants:

Data presented in table (3) show that most concentrations of the essential oils significantly increased the plant growth as compared to the check plants. All tested concentrations of fennel and coriander except the smallest one significantly caused some improvement in the plant growth, specially in shoot length. Although, the essential oils of anise and celery, at all concentrations, significantly increased the lengths and weights of the plant shoots, they did not affect root parameters. Also, the essential oil of dill increased the growth parameters of shoots at all concentrations rates. Lengths and weights of okra roots were decreased by the concentration rates of 0.50 or 0.75 µl/ml per pot of such essential oil, while they were increased by the higher concentration rate (1.0 µl/ml per pot).

Table(3) : Effect of different essential oils on growth of okra plants infected with *Meloidogyne javanica*.

Concentrations (µl/ml)	Shoot Length (cm)			Shoot weight (gm)			Root Length (cm)			Root weight (gm)		
	Non-infected	Infected	Increase (%)	Non-infected	Infected	Increase (%)	Non-infected	Infected	Increase (%)	Non-infected	Infected	Increase (%)
Non-treated (check 1)	34.25^{bcd}	26.25^{gh}	---	26^{abc}	20.5^{e}	---	25.25^{cde}	22.5^{bcde}	---	13^{ab}	11^{bc}	---
Caraway												
0.5	31.5^{defg}	27^{fgh}	2..86	27^{abc}	25.5^{ab}	24.39	25^{cde}	20^{e}	--	14^{ab}	10.5^{bc}	---
0.75	30^{efgh}	28^{defg}	6.67	29^{ab}	24^{abcd}	17.03	26^{bcde}	22.75^{abcde}	1.11	13.5^{ab}	11^{bc}	0
1.0	30^{efgh}	28.5^{defg}	8.57	31^{a}	23^{bcde}	12.2	26.5^{bcde}	23^{abcde}	2.22	13^{ab}	12^{abc}	9.09
Celery												
0.5	36^{abc}	30^{defg}	14.29	25^{bc}	21.75^{cde}	6.1	31.75^{a}	22^{cde}	---	14^{ab}	12^{abc}	9.09
0.75	34^{bcde}	28.25^{defg}	7.62	26.5^{abc}	23.5^{bcde}	14.63	28^{abcde}	23.5^{abcde}	4.44	13.75^{ab}	12.5^{abc}	13.64
1.0	31.5^{defg}	27.5^{efg}	4.76	27^{abc}	24^{abcd}	17.07	27.5^{bcde}	24.75^{abcd}	10	13^{ab}	12.75^{abc}	15.91
Coriander												
0.5	26.75^{hij}	24^{hi}	---	24.75^{e}	20.75^{de}	1.22	28^{abcde}	23^{abcde}	2.22	12^{b}	11^{bc}	0
0.75	28.5^{ghi}	26.75^{fgh}	1.90	25^{bc}	21.5^{de}	4.88	29^{abc}	25.75^{abc}	14.44	12.75^{ab}	11.25^{abc}	2.27
1.0	25^{ij}	28^{defg}	6.67	27.5^{abc}	23^{bcde}	12.2	30^{ab}	27^{a}	20	13.5^{ab}	11.75	6.82
Fennel												
0.5	24^{j}	22^{i}	--	27^{abc}	24^{abcd}	17.07	24.25^{e}	23^{abcde}	2.22	14.75^{ab}	13^{abc}	18.18
0.75	28^{ghij}	26.75^{fgh}	1.9	28^{abc}	24^{abcd}	17.07	26.25^{bcde}	26.5^{ab}	17.78	15^{ab}	13.5^{abc}	22.73
1.0	36^{abc}	32^{bc}	21.9	29^{ab}	25^{abc}	21.95	28.5^{abcd}	27^{a}	20	15.75^{a}	14^{ab}	27.27
Dill												
0.5	30^{efgh}	28^{defg}	6.67	27.75^{abc}	26^{ab}	26.83	24^{e}	20^{e}	---	13.5^{ab}	10^{c}	---
0.75	32^{cdefg}	30.5^{cde}	6.19	28^{abc}	24^{abcd}	17.07	26^{bcde}	21de	----	14^{ab}	10.75^{bc}	---
1.0	37^{ab}	31^{cd}	18.1	30^{a}	22^{cde}	7.32	25.5^{cde}	22.75^{abcde}	1.11	14^{ab}	12^{abc}	9.09
Anise												
0.5	34.75^{bcd}	32^{bc}	21.9	26.75^{abc}	24^{abcd}	17.07	24^{e}	23^{abcde}	2.22	11.75^{b}	11^{bc}	0
0.75	38^{ab}	34.5^{ab}	31.43	27.75^{abc}	25^{abc}	21.95	26^{bcde}	24.75^{abcd}	10	12^{b}	12.5^{abc}	13.64
1.0	40^{a}	35.75^{a}	36.19	28.5^{abc}	26.5^{a}	29.27	28.5^{abcd}	26^{abc}	15.56	14.5^{ab}	14.75^{a}	34.09
Solvent (check 2)	32.5^{cdef}	27^{fgh}	2.86	25^{bc}	21.75^{cde}	6.1	24.75^{de}	23^{abcde}	2.22	12.75^{ab}	11.75^{abc}	6.82

Values in each column followed by the same letter(s) are not significantly different according to new L.S.D. (p=0.05)

Essential oils confer upon the plants its fragrance and protect them from diseases and infections by parasites (Duke, 1997). Essential oils are widely used throughout the world to import flavor to food, cosmetics, and medicine (Masada, 1976) since they are usually safe for human, animals and environment (Tisserand and Balacs, 1995). In the present study the essential oil of anise showed an excellent nematicidal activity against *M. javanica* followed by fennel, coriander, caraway, celery and then dill oils. Among the chemotypes of umbelliferous plants, higher nematicidal activity was found in anise and fennel, this may be due to the presence of anethole at relatively higher percentages (85.36 and 56.03%, respectively). Essential oils of coriander and caraway caused also remarkable effectiveness as linalool and carvone were found in percentages of 19.31 % and 22.84%, respectively. Whereas the lowest nematicidal activity was found in the celery and dill oils in which limonene was present in high percentages (17.20 and 45.17 %, respectively).

It seems that there is a relationship between chemical structure of the most abundant oil components and nematicidal activity . It is well-known that the oxygenated components such as phenol (anethole), aliphatic alcohol (linalool), ketone (carvone) possess remarkable disinfectant properties (Kim *et al.*, 1995). In addition, it is well established that hydroxyl and carbonyl groups are much more reactive and can easily form hydrogen bonds with the active sites of enzymes (Kim *et al.*,1 995). Accordingly, anise and fennel essential oils which contain phenolic group (anethole) possessed higher inhibitory effect. Coriander essential oil, which contains aliphatic alcohol (linalool) and caraway essential oil which contains ketone (carvone) possessed mediate inhibitory effect. On the other hand, celery and dill essential oils which contain aliphatic hydrocarbon (limonene) caused the least inhibitory effect. Similar results were obtained by Sangwan *et al.* 1990; Oka *et al.*, 2000 and Al-Shalaby and Ali, 2001.

The mode of action of essential oils against nematode is unclear, but in insects, several essential oils inhibit acetyl cholin esterase activity and are antagonists of octopamine which is a neurotransmitter in insects (Ryan and Byrne, 1988 and Isman 1999). It is interesting to note that most of the essential oils used in this study have been also reported to have insecticidal activity (Isman 1999). In the involvement of essential oils in interrupting the nematode nervous system is unclear; however, essential oils may disrupt the nematode cell membrane and change permeability (Oka *et al.*, 2000). The essential oils used in this study were reported to have low toxicity to mammals with LD_{50} values ranging from 2.5 to 5 g /Kg (Tisserand and Balacs, 1995), whereas, the chemical nematicides are classified as toxic substances, e.g. the LD_{50} value of aldicarb in male rats was reported to be 0.93 mg/kg (Thomposon and Watts, 1978).

In conclusion, the promising nematicidal activity of these essential oils may be profitably utilized leading to develop safer nematicides by further chemical transformations. However, further studies are needed to elucidate the mechanism of their action and evaluate economic aspects under field conditions

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تقييم الزيوت الطيارة لبعض نباتات العائلة الخيمية كمبيدات نيماتودية طبيعية في مكافحة نيماتودا تعقد الجذور " ميلودوجين جافانيكا "

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تم استخلاص الزيوت الطيارة لبذور نباتات الينسون والكراوية والكرفس والكسبرة والشبت والشمر وتم التعرف على التركيب الكيميائى لها باستخدام جهاز التحليل الكروماتوجرافى الغازى لمرتبط بجهاز تحليل الكتلة، وقد وجد أن المركب لأساسى في كل منهم هو الانيثول ٨٥,٣ %) وكرفون (٢٢,٨٢%) والليمونين (١٧,٢٠%) ولينالول (١٩,٣١%) والليمونين (٤٥,٤٧%) والانيثول (٦٥,٠٦%) على التوالى وقد استخدم ثلاث تركيزات من كل زيت على حده وهى ٠,٥٠ ، ٠,٧٥ ، ١,٠٠ ميكروليتر/ مل مذابه في كحول ايثايل ٩٥% و تم اختبارها في مكافحة نيماتودا تعقد الجذور (ميلودوجين جافانيكا) على نبات البامية، وأوضحت النتائج إن كل هذه الزيوت عند هذه التركيزات أدت إلى خفض عدد العقد الجذرية وعدد كتل البيض وعدد البيض في كتلة البيض وتعداد النيماتودا في التربة وكذلك التعداد النهائى وبالتالى معدل تكاثر النيماتودا على جذور نباتات البامية مما انعكس على النمو الخضرى والجذرى فتحسنا مقارنة بالنباتات الغير معاملة (المقارنة) هذا وقد وجد أن بزيادة تركيز الزيت تزداد فاعليته في خفض الكثافة العددية للنيماتودا. والكحول كوسط مذاب فيه الزيت لا يؤثر تأثيرا معنويا على نمو النباتات أو النيماتودا وقد خلصت النتائج إلى إن الزيوت الطيارة لنباتات الينسون والشمر والكراوية أعطت أعلى تأثير في مكافحة النيماتودا بمقارنة التعداد النهائى للنيماتودا عند المعاملة بهذه الزيوت ومثيلتها الغير معاملة.