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Research Article

Insecticidal activity of five medicinal plant essential oils against the cabbage aphid, *Brevicoryne brassicae*

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Abstract: Essential oils are volatile mixtures of hydrocarbons with diverse functional groups. In the current study the effect of essential oils from five medicinal plants including *Zataria multiflora* and *Nepeta cataria* (Lamiaceae), *Tagetes minuta* and *Artemisia sieberi* (Asteraceae), and *Trachyspermum ammi* (Apiaceae) were analyzed using GC-mass spectrometry. The toxicity of these plant essential oils against the adult stage of the cabbage aphid, *Brevicoryne brassicae* L. (Hemiptera: Aphididae) was studied using a fumigant assay.GC/Mass analysis revealed that the main essential oils varied between species. The most abundant components in *N. cataria, Z. multiflora, T. ammi, T. minuta and A. sieberi were* 4a-α, 7-β, 7a-α-nepetalactone (76.8%), carvacrol (62.1%), γ-terpinene (27.1%), limonene (13.0%) and artemisia ketone (48.0%) respectively. The fumigant assays showed that all of these essential oils were toxic to *B.brassicae* in a dose-dependent manner. The essential oils of *N. cataria* at 126, 63, 31, 16, 8, and 3 µl L^{-1} air caused 94, 76, 52, 46, 36, and 24% mortality within 24 hours, respectively. The same trend was seen when essential oils of the other plants were tested against *B. brassicae*. These plant essential oils have great potential to be used in integrated pest management especially in greenhouses or other closed systems.

Keywords: Essential oils, GC/Mass analysis, Fumigant toxicity, *Brevicoryne brassicae*

Introduction

The Cabbage aphid (*Brevicoryne brassicae* L.) is widely distributed and it is a severe pest of oil-seed and horticultural brassicaceous crops. This aphid was identified in Europe for the first time and later on it has been reported worldwide in most countries with a temperate climate (Ellis and Singh, 1993; Singh and Ellis, 1993). The aphid feeds exclusively on cultivated and wild cruciferous plants. The aphid's major plant hosts are Broccoli, Brussels sprouts, cauliflower, and head cabbage. It also feeds on other species of the family Cruciferae, however, its damage is usually less severe than on cabbage hosts. Cabbage aphid populations, if not controlled, often build high densities. Thus, heavily infested plants acquire a grayish appearance due to the mass of aphid bodies on the foliage (Amin and ElDefray, 1981; Trumble, 1982; Pickel *et al.*, 1983).

In addition to the direct damage, damage is caused by aphid contamination of foliage. The cabbage aphid can also be a vector of plant viruses which over 30 viruses are known to be transmitted by *B. brassica*. Amongst them *cauliflower mosaic* and *cabbage ring spot virus* are two destructive viruses that are transmitted

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by this aphid. More importantly cabbage aphid transmits cauliflower mosaic more effectively because this virus concentrates in the young tissues of the plant, which is the preferred feeding site of the aphid (Broadbent, 1956; Miles, 1989; Khattab, 2007).

The main method of *B. brassicae* control is pesticide use. However, development of resistance to pesticides is an important issue (Yan-ping *et al.,* 2006). Increasing number of resistant insect and mite species to synthetic pesticides is associated with the use of chemicals that indiscriminately affect both natural enemies and pest itself. In addition, environmental pollution and food contamination by synthetic pesticides are other scenarios that should be considered seriously. Thus, it is necessary to develop new alternatives and explore safe control methods with no residual activity or adverse effects on the non-target animals. Many plants produce secondary metabolites with diverse structures (Barenbaum 1995). These chemicals especially in the form of essential oils act as a plant protection agent against micro-organisms and insect herbivores (Choi *et al.,* 2004; Kazana *et al.,* 2007). The essential oils are the complex mixture of 20-60 organic compounds that give characteristic odor and flavor to leaves, flowers, fruits, seeds, barks and rhizomes. Several essential oils have been known to show bactericidal, fungicidal, virucidal and insecticidal properties (Bakkali *et al.,* 2008). Essential oils generally are safer to mammals, birds and fish than commercial pesticides (Isman, 2006). These compounds have been known to have different mode of action including repellency and antifeedant activities, disruption of molting and cuticle, retardation of growth and fecundity, inhibition of oviposition and disruption of embryonic development (Cosimi *et al.,* 2009; Sertkaya *et al.,* 2010). Because of rapid action of these natural chemicals against insects and mites, it has been concluded that these compounds possess neurotoxic effects especially affecting octopamine pathways and GABA-Gated chloride ion channels (Isman, 2006). Different methods including fumigant toxicity, repellency activity and antifeedant activity have been used to test the effects of plant essential oils on different insects and mites (Trigg and Hill, 1996; Chou *et al.,* 1997; Lee *et al.,* 2004; Ceferino *et al.,* 2006; Cosimi *et al.,* 2009; Nerio *et al.,* 2009).

Although some studies have been done regarding the effect of essential oils against *B. brassicae* (Moharramipour and Sahaf, 2006; Pavela, 2006; Isik and Gorur, 2009), the current study was undertaken to evaluate the effect of essential oils from five different plant species including *Zataria multiflora* and *Nepeta cataria* from Lamiaceae, *Tagetes minuta* and *Artemisia sieberi* from Asteraceae and *Trachyspermum ammi* from Apiaceae against *B. brassicae*. Also, the constituents of these plants essential oils were analyzed using gas chromatography/mass spectrometry.

Materials and Methods

Insect's cultures

The insect, *B. brassicae* was obtained from department of Plant Protection, Faculty of Agriculture, University of Shiraz. *B. brassicae* were reared on *Brassica napus* at 25 ± 2 °C and 55 ± 5% Relative Humidity, and a photoperiod of 16: 8 L: D in greenhose.

Plant species

Five medicinal plant species including *Z. multiflora*, *N. cataria*, *T. minuta*, *A. sieberi*, and *T. ammi* were collected in 2010 from Fars Province, Iran, mainly at flowering stage.

Essential oil extraction

Plant leaves and stems were air dried in shade, at room temperature and chopped into small pieces. Then, essential oils were extracted based on Motazedian *et al*., (2012). Plant materials were submitted for 3h to water-distillation using a Clevenger- type apparatus (Papachristos and Stamopoulos, 2004). Anhydrous sodium sulphate was used for water removal, and oils were stored in sealed vials at 4 °C before using in assays.

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Essential oil analysis

The constituents of essential oils was determined using GC/MS based on Ayvaz *et al*. (2010) method. The oils were analyzed using a Shimadzu QP 5050 system fitted with a Free Fatty Acid Phase (50 m × 0.32 mm i.d.) (0.25 µm df) capillary column. Then, the oven temperature was programmed at 6 °C/min from 120 °C to 230 °C and held at 230 °C for 30 min. Other operating conditions were: carrier gas, He with a flow rate of 1.1 ml/min; injector and detector temperatures were 250 and 280 ºC, respectively; split ratio, 1: 10.The carrier gas was helium GC/MS analysis was performed on a GC mentioned above coupled with a Thermoquest-Finnigan Trace GC-MS Mass system. The other operating conditions were the same conditions as described above, mass spectra were taken at 70 eV. Mass range was from m/z 35–465 amu and an ionization current of 150 mA. The compounds were identified by comparison of their mass spectra with those of Wiley and Nilst Tutore Libraries (Adams, 2001).

Insecticidal activity

Toxicity of essential oils on the *B. brassicae* was essentially done based on Pascual-Villalobos and Robledo (1998). Briefly, glass Petri plates (90 × 10 mm) were used as a chamber for the determination of test materials on the insect. To test essential oil toxicity, ten adults of the same age (1-48 hour of age) from the stock colonies were transferred onto excised *B. napus* leaves (2 cm diam.) placed with its dorsal side on four layers of wet (saturated with distilled water) filter paper in a Petri dish using a soft paint brush. The insects were allowed to settle for half an hour before being exposed to the essential oil. The application of the essential oil was based on Soylu *et al.,* (2006). To prevent a direct contact between the insects and oils, the desired oil quantities were applied on filter paper (5 × 2 cm) fixed on the inner surface of the Petri dish. Preliminary tests were done to choose the right doses. Each filter paper received 0.25, 0.5, 1, 2, and 4 µl of essential oils using micropipette (Eppendorf®, 0.1-2.5 µl) which corresponds to 3.9, 7.9, 15.7, 31.5, 62.9, and 125.8 µl L^{-1} air. Plates were then sealed with parafilm to prevent any loss of essential oils. Each concentration (treatment) was replicated five times with each replicate consisting of 10 adult insect. The control consisted of a similar setup but without essential oils. Mortality was recorded after 24 hours of exposure. Aphid incapable of moving after a slight touch with a fine brush was considered as dead.

Data analysis

Data were corrected using Abbot's formula (Abbot 1925).The lethal concentration was obtained using probit analysis (Robertson *et al.,* 2007) and Polo Pc software (LeOra software, 1987). Percentage of mortality values for different doses were subjected to analysis of variance (by one way of ANOVA) fallowed by LSD test when significant differences were shown at α = 0.05 (SAS institute 1997).

Results

Essential oils constituents

The GC-Mass analysis of essential oils of *N. cataria*, *Z. multiflora*, *T. ammi*, *T. minuta*, and *A. sieberi* are presented in table 1. The main constituents of *N. Cataria* main essential oils were 4a-α,7-β,7a-α-nepetalactone (76.8%), 4a-α,7-β,7a-β-nepetalactone (18.6%), and Thymole (1.1%). The main constituents of *Z. multiflora* essential oils were Carvacrol (62.1%), Thymol (7.4%), α-Pinene (2.8%) and Myrcene (2.0%). Composition of *T. ammi* essential oils were thymol (45%), Y-Terpinene (27.1%), P-Cymene (15.1%), and myrcene (13%).

T. minuta main essential oils compositions were Limonene (13.0%), Piperitenone (12.2%), α-Terpineol (11%), z-ocimenone (5.1%), Docosane (5.0%), Z-Tagetone (5.7%), Tricosane (4.2%), Verbenone (3.7%), and Caryophyllene oxide (3%). *A. sieberi* main essential oils constituents were Artemisia ketone (48.0%), 1,8 Cineol (20%), Selin-11en-4-a-ol (4.6%), yomogi alcohol (3.8%), and lavandulol (2.8%).

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Table 1 Chemical composition of the essential oils obtained from five medicinal plants, *N cataria*, *Z. multiflora*, *T. ammi*, *T. minuta*, and *A. Sieberi* using GC/Mass.

Compounds	*N. cataria*	*Z. multiflora*	*T. ammi*	*T. minuta*	*A. Sieberi*
4a-α,7-β,7a-β-nepetalactone	76.8	-	-	-	-
4a-α,7-β,7a-α-nepetalactone	18.6	-	-	-	-
carvacrol	-	62.1	-	-	-
thymol	1.1	7.4	45.0	-	-
γ-terpinene	-	-	27.1	-	-
ρ- cymene	-	0.1	15.3	-	0.9
Myrcene	-	2.0	1.3	-	-
11- dodecenol	0.7	-	-	-	-
Trans caryophyllene	0.7	-	-	-	-
α- Pinene	-	2.8	0.2	0.5	0.2
Cis-linalool oxide	-	1.2	-	-	-
Trans-linalool oxide	-	1.2	-	-	-
3-octyl acetate	-	1.2	-	-	-
α- humulene	0.5	1.1	-	-	-
Carvacrol acetate	-	0.7	-	-	-
E-isocitral	-	0.6	-	-	-
β-pinene	0.4	0.4	0.1	-	0.3
1,8-cineole	-	0.1	-	-	-
Triplaol	0.3	-	-	-	-
Terpinen-4-ol	-	-	0.2	-	1.5
linalol	-	-	0.2	-	-
Chavicol	-	-	-	-	-
α-terpinene	-	-	0.2	-	-
α-thujene	-	0.2	0.2	-	-
1-cyclohexan-1-yl-methyl ketone	0.2	-	-	-	-
camphene	-	0.1	-	-	-
1-octene-3-one	-	0.1	-	-	-
Sabinene	-	0.1	-	-	-
α-phellandrene	-	0.3	-	-	-
Delta-3-carene	-	0.1	-	-	-
Octyl acetate	-	0.3	-	-	-
Geranyl acetate	-	0.2	-	-	-
Alleo-aromadendrene	-	0.2	-	-	-
bicyclogermacrene	-	0.1	-	-	-
Limonene	-	-	-	13.0	-
Piperitenone	-	-	-	12.2	-

Table 1 Continued

Compounds	*N. cataria*	*Z. multiflora*	*T. ammi*	*T. minuta*	*A. Sieberi*
α-terpineol	-	0.2	-	11.0	0.90
Z-ocimenone	-	-	-	5.1	-
Docosane	-	-	-	5.0	-
Z-tagetone	-	-	-	5.7	-
Tricosane	-	-	-	4.2	-
Verbenone	-	-	-	3.7	-
Caryophyllene oxide	0.50	0.2	-	3.0	0.09
dihydrotagetone	-	-	-	1.2	-
1-methyle1-4-isopropenylbenzene	-	-	-	1.0	-
Cis- epoxy ocimene	-	-	-	2.6	-
Trans-epoxy ocimene	-	-	-	1.2	-
β-Bisabolone	-	-	-	2.0	-
E- tagetone	-	-	-	2.0	-
Linalyl propionate	-	-	-	0.9	-
Piperitone	-	-	-	6.0	-
Piperitone oxide	-	-	-	1.2	-
β- Caryophyllene	0.06	-	-	2.5	-
Spathulenol	-	-	-	0.7	-
Heptadecane	-	-	-	0.7	-
Neophytadiene	-	-	-	0.6	-
Octadecane	-	-	-	0.9	-
Nonadecane	-	-	-	1.2	-
Heneicosane	-	-	-	2.5	-
Artemisia ketone	-	-	-	-	48
1,8-cineol	-			-	20
Selin-11-en-4-a-ol	-	-	-	-	4.6
Yomogi alkohol	-	-	-	-	3.8
lavandulol	-	-	-	-	2.8
Cadium-4-en-7-ol	-	-	-	-	2.5
Artemisia alcohol	-	-	-	-	1.2
Trans verbenol	-	-	-	-	0.8
Santoline teriene	-	-	-	-	0.3
Lavandulol acetate	-	-	-	-	1.3
Geranyl acetate	-	-	-	-	0.8
Lavandulol isovalerate	-	-	-	-	1.5
Lavandulol 2- methyl butyvate	-	-	-	-	1.5
Caryophyllene 4 (14), 8 (15)-diexe-5-a-ol	-	-	-	-	1.2
B- eudesmol	-	-	-	-	1.4
Total	99.86	83	89.8	90.6	94.19

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Toxicity assay

As shown in Table 2, the vapors of the essential oils from five medicinal plant species were toxic to *B. brassicae*. In all plant species when high dose (125.8 µlL^{-1} air) was used the insect mortality was more than 90% (Table 2). Also, it was found that the effect of all plant species essential oils on the aphid was in a dose dependant manner. For example essential oils of *N. cataria* at 125.8, 62.9, 31.5, 15.7, 7.9, and 3.0 µlL^{-1}air produced 94, 76, 52, 46, 36, and 24 % mortality within 24 hours, respectively (Table 2). The same trend was seen when essential oils from the other plant species including *Z. multiflora*, *T. minuta*, *A. sieberi*, and *T. ammi* were tested against the aphid (Table 2). LC_{10}, LC_{50} and LC_{90} of *N. cataria* against the aphid was 2(0.00- 3), 21(14-34), and 297(150-710) µlL^{-1}air, respectively (Table 3). Toxicity of the other plant species is given in Tabel 3. Six different doses were employed for each essential oil and differences between doses were found to be significant ($P < 0.001$) in all five essential oils used in the assays (Table 4). Figure 1 compares percentage mortality of *B. brassicae* caused by six different concentrations of each plant species. As seen in Figure 1 when low dose (3.0 µl L-1 air) of essential oil was used *Z. multiflors* caused low mortality (less than 20%) whereas *T. minuta* caused high (more than 30%) mortality. Figure 2 shows regression lines of the five plant essential oils against the aphid. As seen in the Figure 2 line slopes of different essential oils are quite different showing different toxicity rate against the aphid. For example the lowest and the highest slopes belongs to *T. minuta* and *T. ammi*, respectively (Fig. 2). The results showing the effectiveness of *T. ammi* essential oil against *B. Brassicae* was high. *T. minuta* has the lowest slope showing that its effectiveness on the aphid is not as pronounced as *T. ammi* (Fig. 2).

Table 2 The mortality percentage of the essential oils from five medicinal plants, *Z. multiflora, N. cataria, T. minuta, A. sieberi, T, ammi*, against *B. brassicae*.

Concentration (µlL^{-1} air)	**Mean mortality (%)[1]**				
	N. cataria	***T. minuta***	***A. sieberi***	***T. ammi***	***Z. multiflora***
125.8	94.0a	98.0a	96.0a	96.0a	94.0a
62.9	76.0b	84.0ab	72.0b	78.0b	70.0b
31.5	52.0c	74.0b	50.0bc	48.0c	54.0bc
15.7	46.0c	56.0c	40.0dc	40.0cd	46.0cd
7.9	36.0cd	40.0cd	32.0dc	34.0ed	34.0de
3.0	24.0d	34.0d	26.0d	22.0e	18.0e
0.0 (control)	4.0e	4.0e	2.0e	2.0f	0.0 f
LC_{10}[2]	2 (0.00- 3)	1 (0.00- 2)	1 (0.00- 3)	2 (0.00-5)	2 (0.00- 3)
LC_{50}	21 (14-34)	12 (8-16)	25 (16- 42)	23 (11- 32)	21 (15-32)
LC_{90}	297 (150-710)	117 (66-343)	472 (172- 796)	286 (86- 639)	289 (131- 696)
Slope ± S.E	1.124 ± 0.219	1.277 ± 0.219	1.000 ± 0.208	1.168 ± 0.214	1.130 ± 0.201
df	4	4	4	4	4
χ^2	1.7052	0.8723	1.7601	3.8192	0.871

1. Mean values (n = 5 replicates with ten adults aphid per replicate) followed by different letters in the same column differ significantly at $\alpha = 0.05$ according to LSD test. The estimated lethal concentration values (µl L^{-1} air) for each essential oil was given using probit analysis.
2. Values in parentheses indicate 95% confidence limits.

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Table 3 LC_{10}, LC_{50}, and LC_{90} of five essential oils *Z. multiflora, N. cataria, T. minuta, A. sieberi, T, ammi* against *Brevicoryne brassicae*.

Essential oils	N	LC_{10}[1]	LC_{50}[1]	LC_{90}[1]	Slope ± S. E	χ^2
T. ammi	350	2 (0.00-5)	23 (11-32)	286 (86- 639)	1.168 ± 0.214	3.8192
Z. multiflora	350	2 (0.00- 3)	21 (15-32)	289 (131- 696)	1.130 ± 0.201	0.871
T. minuta	350	1 (0.00- 2)	12 (8-16)	117 (66- 343)	1.277 ± 0.219	0.8723
A. sieberi	350	1 (0.00- 3)	25 (16- 42)	472 (172- 796)	1.000 ± 0.208	1.7601
N. cataria	350	2 (0.00- 3)	21 (14-34)	297 (150-710)	1.124 ± 0.219	1.7052

1. Values of LC_{10}, LC_{50} and LC_{90} μlL^{-1}air estimated 24 h post application using probit analysis.

Table 4 Effects of essential oils of *Z. multiflora, N. cataria, T. minuta, A. sieberi, T, ammi* against *Brevicoryne brassicae*.

Source of variation		*N. cataria*		*T. minuta*		*A. sieberi*		*T. ammi*		*Z. multiflora*	
	df	MS	F	MS	F	MS	F	MS	F	MS	F
Dose (μlL^{-1}air)	6	46.447	24.08**	51.247	26.97**	47.98	16.63**	53.53	55.11**	51.51	31.63**
Error	28	1.92		1.90		2.88		0.97		1.62	
Total	34										

For each plant essential oil, six doses and one control were used. M. S. = Mean Square, $P < 0.001$.

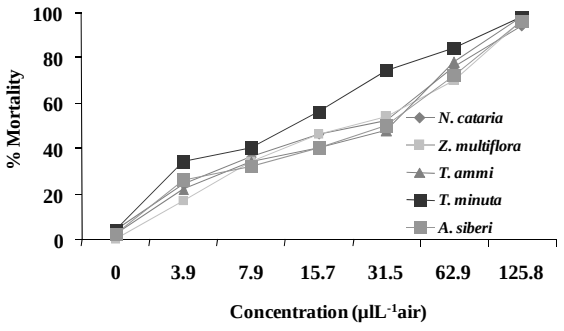

Figure 1 Comparison of mortality percentage of five essential oils *Z. multiflora, N. cataria, T. minuta, A. sieberi, T, ammi* against *B. brassicae.*

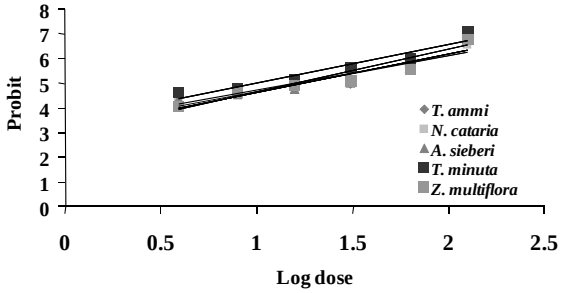

Figure 2 Regression lines of the effect of five essential oils including *Z. multiflora, N. cataria, T. minuta, A. sieberi, T, ammi* against *B. brassicae.*

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Discussion

In the current study essential oils of five plant species from three different plant families were evaluated using GC/Mass spectroscopy and bioassays. GC/Mass analysis showed that each plant species contains a wide range of essential oil components. For example total number of essential oil compound in *N. cataria*, *Z. multiflora*, *T.* ammi, *T. minuta* and *A. sieberi* were 11, 25, 9, 26, and 21 compounds, respectively. However, only a limited number of compounds constitute the major components. The major compounds which constitute more than 10% of essential oil of *C. cataria* were two compounds of 4a-α,7-β,7a-α-nepetalactone (18.6%) and 4a-α,7-β,7a-β-nepetalactone (76.8%). In *Z. multiflora* only one compound exists in its essential oil with a quantity of higher than 10% which is Crvacrol (62.1%). In *T. minuta* only two compounds including Limonene (13%) and Piperitenone (12.2 %) were major constituents of essential oils while in *A. sieberi* had only one compound including 1,8-Cineol (20%) which was the major constituent of essential oil. The number of compounds, their amounts and the yield of essential oils amongst different and even the same species vary considerably in different studies. The variation between studies may be due to the method of isolation, plant location, plant varieties and time of harvest (Bakkali *et al.,* 2008).

Studies showed that plant essential oil components including γ- terpinene (fumigant toxicity against adults of *Tribolium castaneum*, Moravej *et al.,* 2009), pulegone (against *Sitoplzilus oryzae*,*Tribolium castaneum*, *Musca domestica* and *Blattella germanica*, Lee *et al.,* 2002a), (E)- anethole (Adulticidal against *Plodia interpunctella*, Ebadollahi and Ashori, 2011), carvacrol, thymol (Toxicity against the workers of the *Odontotermes obesus* termite, Gupta *et al.,* 2011 and Contact and fumigant toxicity against adult male and female of *Blattella germanica*, Yeom *et al.,* 2012) and α-terpinene (against adults of *Sitophilus zeamais* and *Acanthoscelides obtectus*, Bittner *et al.,* 2008) linalool (Fumigant toxicity on adult of *Sitophilus granarius* and *Tribolium castaneum*. Ebadollahi & Mahboubi, 2011), eugenol (against *Sitophilus granarius*, *S. zeamais*, *Tribolium castaneum* and *Prostephanus truncates* were investigated in the laboratory by Obeng-ofori and Reichmuth, 1997; Isman, 2006).

Current study showed that tested plant species essential oils had fumigant toxicity toward the cabbage aphid but with varying degrees. However, since there are overlaps between obtained upper and lower limits it seems that there was not significant differences in the obtained values.

Toxicity of Citronella (*Cymbopogon winterianus*) and Alfazema (*Hyptis suaveolens* (L.)) oils was studied against *Hyadaphis foeniculi* Passerini (Hemiptera; aphidae) and its predator *Cyloneda sangninea.* The experiment showed the high toxicity of alfazama against aphid and attractive effect to the predator (Abramason 2006). Also, studies on the effect of seven essential oils on poultry red mite *Dermanyssus gallinae* and non target invertebrates *Tenebro molitor* revealed that while the oils were toxic to *D. gallinae*, they had less toxicity to *T. molitor* (George *et al.,* 2009).

In conclusion, as seen in the current study and in the other studies, plant essential oils in addition to being toxic against postembryonic stages of insect and mite herbivores, they have ovipostion- and feeding deterring activities (Topuz and Erler 2007; Motazedian *et al.,* 2012). Thus it could be mentioned, based on the current study, that plant essential oils possess a great potential compounds that could be used in the integrated pest management program in order to control insect pests both in field and especially in the greenhouses or other closed systems.

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فعالیت حشره‌کشی اسانس پنج گونه گیاه دارویی روی شته کلم، *Brevicoryne brassicae*

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چکیده: اسانس‌ها مخلوطی از ترکیبات هیدروکربن فرار با گروه‌های عاملی متفاوت هستند. در مطالعه حاضر اثراسانس‌های پنج گیاه دارویی شامل *Zataria multiflora* and *Nepeta cataria* (Lamiaceae), *Tagetes minuta* and *Artemisia sieberi* (Asteraceae), and *Trachyspermum ammi* (Apiaceae) با استفاده از GC-Mass آنالیز شدند. سمیت این اسانس‌ها علیه حشرات کامل شته کلم *Brevicoryne brassicae* L. (Hemiptera: Aphididae) با استفاده از زیست‌سنجی تدخینی بررسی شدند. آنالیز GC-Mass نشان داد که ترکیبات اصلی اسانس در بین گونه‌های مختلف متفاوت می‌باشد. فراوان‌ترین ترکیب در *N. cataria*، *Z. multiflora*، *T. ammi*، T. minuta و A. seiberi به‌ترتیب 4a-α, 7-β, 7a-α- nepetalactone (۷۶,۸ درصد)، Carvacrol (۶۲,۱ درصد)، γ-terpinene (۲۷,۱ درصد)، limonene (۱۳ درصد)، و Artemisia ketone (۴۸ درصد) بودند. سمیت تدخینی نشان داد که همه این اسانس‌ها برای شته مومی کلم به‌صورت وابسته به غلظت سمی بودند. اسانس گیاه N. cataria در غلظت‌های ۳، ۸، ۱۶، ۳۱، ۶۳ و ۱۲۶ میکرولیتر در لیتر هوا به‌ترتیب باعث ۲۴، ۳۶، ۴۶، ۵۲، ۷۶، و ۹۴ درصد مرگ و میر در مدت ۲۴ ساعت شدند. روند یکسانی در مورد سایر اسانس‌های گیاهی بر علیه شته کلم دیده شد. این اسانس‌های گیاهی دارای پتانسیل قوی جهت کاربرد در مدیریت تلفیقی آفات مخصوصاً در گلخانه‌ها و محیط‌های بسته دارند.

واژگان کلیدی: اسانس، آنالیز Gc-Mass، سمیت تدخینی، *Brevicoryne brassicae*

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