Insecticidal and Synergistic Activities of Two Essential Oils from *Pistacia lentiscus* and *Mentha pulegium* Against the Green Peach Aphid *Myzus persicae*

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ABSTRACT

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Chemical composition of two essential oils (EOs) extracted from *Mentha pulegium* and *Pistacia lentiscus* was investigated. Volatile compounds were characterized. Major ones were pulegone (45.89%), cis-menthone (23.25 %) and trans-menthone (14.73 %) for *M. pulegium* and α-pinene (28.57%), β-myrcene (21.03%) and L-limonene (6.97%) for *P. lentiscus*. Then, the insecticidal and synergistic activities of the EOs were studied against *Myzus persicae*. The results showed that both EOs were toxic against the target pest. Aphid mortality caused by *M. pulegium* and *P. lentiscus* Eos was 86 ± 11.4 and 76 ± 11.4%, respectively. LC_{50} of the latest EO was lower than that of *P. lentiscus* with 596 and 876 ppm, respectively. In addition, no synergism was observed when both oils were mixed and used against the same aphid. Interestingly, there are no differences between toxicity of both EOs and that of the chemical insecticide leading to 70 ± 10% mortality. This study suggested that the EOs have a great potential to be used in agriculture against *M. persicae*.

Keywords: Contact toxicity, essential oils, *Mentha pulegium*, *Myzus persicae*, *Pistacia lentiscus*

The green peach aphid *Myzus persicae* (Hemiptera: Aphididae) is one of the most polyphagous and harmful insect pests of various crops (Blackman and Eastop 2000). It has a cosmopolitan distribution and can be a vector of more than 100 plant viruses (Blackman et al. 2007; Kennedy et al. 1962). The control of this species is becoming more and more problematic because of the insecticide resistance which now extends to most classes of insecticides, including organophosphates, carbamates and pyrethroids (Bass et al. 2014). This is due to the extensive and repeated use, since several decades, of chemical insecticides leading to a frequent risk of emergence of new resistances. In Tunisia, *M. persicae* is well distributed particularly in the north and the center of the country and cause

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serious damage to various crops such as peach, potato, pepper, citrus, etc. (Boukhris et al. 2007). Moreover, as in the rest of the world, it is proved that the insecticide resistance is well established in Tunisia (Charaabi et al. 2016). This situation has stimulated interest in developing eco-friendly alternative methods to control this aphid and to promote Integrated Pest Management (IPM). In this context, some studies had reported the insecticidal activities of essential oils (EOs) and plant extracts to control aphids. Digilio et al. (2008) found that several Mediterranean Eos are able to cause mortality of *Acyrthosiphon pisum* and *M. persicae*. Other studies also underlined the toxic effect of *Illicium verum* fruit extracts against *M. persicae* and its ability to inhibit the acetylcholinesterase and glutathione S-transferase activities (Li et al. 2016). The present work was performed to investigate the EO composition and the insecticidal and synergistic activities of two Tunisian medicinal and aromatic plants: mastic *Pistacia lentiscus* (Sapindales: Anacardiaceae) and pennyroyal *Mentha Pulegium* (Lamiales: Lamiaceae) against *M. persicae*. These plant species were chosen because of their abundance in the Tunisian mountain and the Mediterranean area (Bonnier and Douin 1990; Pottier-Alapetite 1981). They also are cited in the literature for their insecticidal potential (Bachrouch et al. 2010a, 2010b; Petrakis et al. 2014).

MATERIALS AND METHODS

Plant material.

M. pulegium and *P. lentiscus* leaves were collected at flowering stage in September 2014 from natural forestry populations. *M. pulegium* were collected in Marja Lekbouch site (36°11′10″N8°42′00″E) in the locality of Kef (North-West, Tunisia) and *P. lentiscus* in Korbous (36°48′59″N10°34′07″E) in the site of Nabeul (North-East, Tunisia). Samples were air-dried at ambient temperature. EOs were extracted from 70 g of leaves by hydrodistillation for 90 min using modified Clevenger-type apparatus (Craveiro et al. 1976). Anhydrous sodium sulfate was used to remove water after extraction. The obtained EO were quantified to calculate the EO yields using the folowing formula: Y= (Wo/Wp) × 100, where Y: EO yield, Wo: weight of EO and Wp: dry weight of plant (Akrout 2004). Three replicates were adopted to calculate the average of EO yield. The oils were then conserved at 4°C.

Essential oil composition.

EO analysis by GC-MS was performed on an Agilent 7890A GC system, coupled to an Agilent 5972C mass spectroscopy detector with electron impact ionization (70 eV). A HP-5 MS capillary column was used (30 m × 0.25 mm, coated with 5% phenyl methyl silicone, 95% dimethylpolysiloxane, 0.25 mm film thickness; Hewlett-Packard, CA, USA). The column temperature was programmed to rise from 40 to 240°C with a 5°C/min rate, the carrier gas was helium N60 with a 0.9 ml/min flow rate; split ratio was 100:1. Scan time and mass range were 1 s and 50-550 m/z, respectively. The identification of compounds was based on mass spectra (compared with Wiley Registry 9th Edition/NIST 2011 edition mass spectral library) and by comparison of their Kovats retention indices (Ri) with either those in the literature (Papachristos and Stamopoulos 2002; Pavela 2006) or with those of authentic compounds available in our laboratories. Kovats retention indices were determined in relation to a homologous series of n-alkanes (C8-C40) under the same conditions.

Insect rearing.

M. persicae individuals were collected at different stages (larvae, winged and wingless adults) from citrus orchards in Cap Bon region (North-East, Tunisia). Rearing was performed on young radish plants in cages under controlled conditions of a growth chamber (22°C ± 1; 60% ± 10 RH; 16:8 h photoperiod).

Bioassay.

Contact insecticidal activity. The insecticidal activities of *P. lentiscus* and *M. pulegium* EOs were tested on apterous adult aphids of 2-3 day-old age. This stage is known to be the most harmful for plants. A preliminary test was conducted in order to select the doses to be used. The adopted doses for both extracted oils were 400, 500, 600, 800, 900 and 1100 ppm (corresponding to 0.4, 0.5, 0.6, 0.8, 0.9 and 1.1 µl/ml of water with 2% tween 20 and in practical application to 40, 50, 60, 80, 90, 110 ml/hl). Distilled water with 2% tween 20 was used for dilution. Whatman filter paper discs (9 cm in diameter) were placed in Petri dishes before being impregnated afterward by 1 ml of each tested dose of EO. Ten adults of *M. persicae* were placed carefully using a fine brushin the Petri dishes containing the treated filter papers to perform the contact toxicity assays. During the experiment, fresh leaves of *R. sativus* were given as a food resource for aphids. Treatment with water solution mixed with 2% tween 20 was considered as control. A chemical insecticide namely imidacloprid as active molecule, was used as control and tested at the manufactory recommended dose (60 ml/hl). Incubation of the different Petri dishes was carried out in a growth chamber under the same conditions cited above. Five replications were used for each individual treatment. Mortality of aphids was observed at 2, 4, 6, 8 and 24 h after aphid exposure to EOs. The corrected mortality (Mc) was calculated using the modified Abbott formula (Abott 1925) considering the mortality in the treated Petri dishes (Mo) and the natural mortality in control ones (Mt): $Mc = [(Mo – Mt) / (100 – Mt)] \times 100$. An aphid was considered dead when no leg or antennal movements were observed.

Spray assays and synergistic effect. The synergism between both oils was checked as a complementary assay. Five test groups were conducted: *M. pulegium* EO, *P. lentiscus* EO and three binary mixtures of these oils applied at three ratios (1:1, 1:2 and 2:1 (w/w) ratios). The doses used were based on the previously obtained LC_{50}. Aphid sprays were performed in Petri dishes. Incubation conditions were same as cited above. Five replications were used for each individual treatment. Aphid's mortality was observed at 2, 8 and 24 h after aphid exposure to EOs. Abbott formula (Abott 1925) was used to calculate the mortality.

Statistical analysis.

Data were analyzed with SPSS software (version 20). The lethal concentrations LC_{50} and LC_{95} were calculated using the mortality rates obtained after 24 h in the bioassay with PROBIT analysis (Finney 1971). The mortalities of aphids induced by both EO were compared by ANOVA test at $\alpha = 0.05$.

RESULTS

Yields of tested essential oils and their chemical composition.

The average EO yield was estimated at 1.76% for *M. pulegium* and at 0.19% for *P. lentiscus*. GC-MS analysis revealed a total of 27 compounds from *M. pulegium* (Table1). The major compounds were pulegone (45.89%), cis-menthone (23.25 %) and trans-menthone (14.73%). Concerning *P. lentiscus* EO, the chemical analysis revealed the presence of 32 compounds (Table1). The most abundant ones were α-pinene (28.57%), β-myrcene (21.03%) and L-limonene (6.97%). Five compounds were detected in both oils namely camphene, sabinene, trans-caryophyllene, α-pinene, and β-myrcene.

Table 1. Chemical composition of *Mentha pulegium* and *Pistacia lentiscus* essential oils

Volatile compounds	*Mentha pulegium*		*Pistacia lentiscus*	
	Rate (%)	Quantity (mg/100 g dry weight)	Rate (%)	Quantity (mg/100 g dry weight)
(+)-Neoisomenthol	0.35	5.73	-	-
1.8-(P-Menthadienone)	0.07	1.10	-	-
1.8-Cineole	0.91	14.93	-	-
1-Menthene	0.56	9.28	-	-
1r-Menthyl Acetate	2.01	33.00	-	-
2- B-Pinene	-	-	1.88	3.65
3-Cyclohexen-1-Carboxaldehyde.3.4-Dimethyl	0.03	0.49	-	-
3-Octanol	0.37	6.01	-	-
3-Octanone	0.10	1.72	-	-
3-Phenylbutyraldehyde	0.16	2.59	-	-
4-Terpineol	-	-	4.60	8.92
Alloaromadendrene	-	-	0.16	0.30
A-Terpinene	-	-	2.12	4.12
Bornyl Acetate	-	-	1.26	2.44
Cadina-1.4-Diene	-	-	0.18	0.35
Camphene	0.06	0.95	3.41	6.62
Camphre	0.26	4.29	-	-
Caryophyllene Oxide			0.16	0.31
Chrysanthenone	0.09	1.54	-	-
Cis-Isopulegone	0.88	14.38	-	-
Cis-Menthone	**23.25**	**381.92**	**-**	**-**
Cymene	-	-	0.79	1.52
D-Limonene	0.89	14.55	-	-
Eucarvone	4.62	75.87	-	-

Germacrene-D	-	-	2.39	4.64
Hexahydrofarnesyl Aceton	0.07	1.14	-	-
L-Limonene	**-**	**-**	**6.97**	**13.52**
L-Phellandrene	-	-	1.10	2.14
N-Butyl Isovalerate	-	-	0.12	0.24
Piperitone	3.25	53.39	-	-
Pulegone	**45.89**	**753.77**	**-**	**-**
Sabinene	0.08	1.36	1.75	3.40
Tau-Cadinol		--	0.50	0.96
Trans-Caryophyllene	0.09	1.43	3.19	6.19
Trans-Menthone	**14.73**	**241.97**	**-**	**-**
Tricyclene	-	-	0.83	1.61
A -Amorphene	-	-	0.69	1.34
α -Humulene	0.13	2.14	-	-
α -Terpineol	0.07	1.12	-	-
A-Amorphene	-	-	0.54	1.05
A-Copaene	-	-	0.27	0.52
A-Eudesmol	-	-	0.82	1.60
A-Muurolene	-	-	0.56	1.08
α-Pinene	**0.61**	**10.10**	**28.57**	**55.43**
A-Terpineol	-	-	2.16	4.20
A-Terpinolene	-	-	0.92	1.79
A-Thujene	-	-	0.54	1.05
B-Cis-Ocimene	-	-	4.76	9.24
β-Myrcene	**0.16**	**2.59**	**21.03**	**40.81**
β-Pinene	0.31	5.14	-	-
β-Selinene	-	-	0.61	1.19
B-Trans-Ocimene	-	-	1.79	3.47
γ-Terpinene	-	-	2.70	5.24
δ-Cadinene	-	-	2.61	5.06
Total	**100**	**1642.5**	**100**	**194**

Insecticidal and synergistic activities.

Eos extracted from *P. lentiscus* and *M. pulegium* were found to be toxic against *M. persicae* but no synergistic interaction has been noticed between them. Aphid mortality varied depending on exposure time and concentrations of tested EOs.

Insecticidal activity. Only two hours of exposure to *M. pulegium* EO were sufficient to observe an important mortality in *M. persicae* individuals ranging between 40 ± 25.49% at 600 ppm and 60 ± 14.14% at 1100 ppm. This clearly shows the rapid action of *M. pulegium* EO on aphids. A mortality of 86 ± 11.4% was recorded after 24 h of exposure using the highest dose i.e. 1100 ppm (Fig. 1).

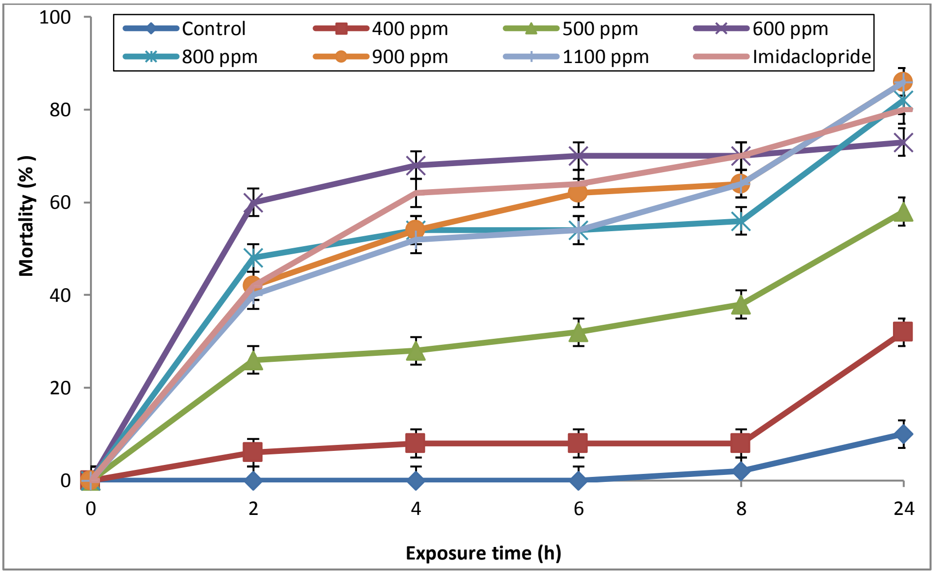

Fig. 1. Effect of *Mentha pulegium* essential oil on *Myzus persicae* mortality noted at different concentrations and exposure times. Error bars represent standard deviations.

P. lentiscus EO-based treatment applied to *M. persicae* has also led to an important aphid mortality which was positively correlated to the increase of tested concentrations. After exposure for 2 h, mortality was 2 ± 0.44% for 400 ppm and 32 ± 10.95% for 1100 ppm. After 24 h, the mortality reached 76±11.4% using *P. lentiscus* EO at the highest concentration (1100 ppm) (Fig. 2).

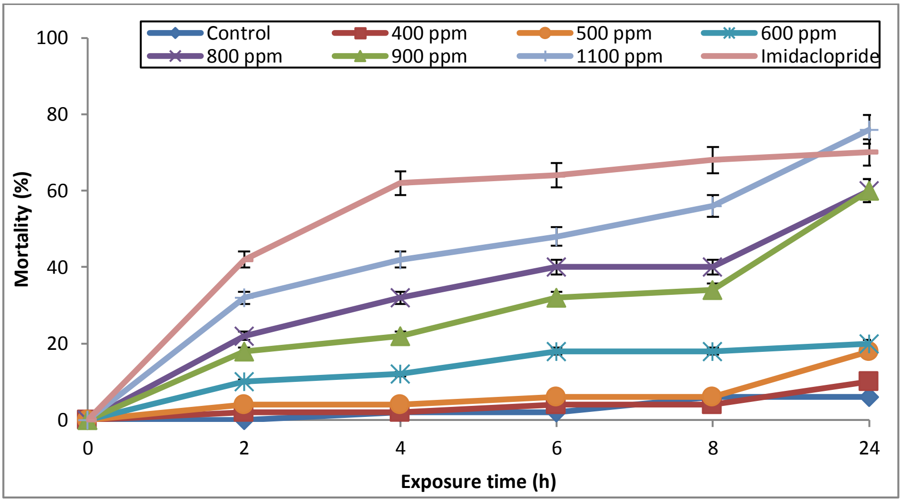

Fig. 2. Effect of *Pistacia lentiscus* essential oil on *Myzus persicae* mortality noted at different concentrations and exposure times. Error bars represent standard deviations.

After 24 h exposure to *M. pulegium* EO, aphid mortality was significantly different from the control. At concentrations varying from 600 to 1100 ppm, no significant differences were observed in aphid mortality (73 ± 8.36 to 86 ± 11.4%, respectively) neither between concentrations nor compared to the reference insecticide imidacloprid. However, after 24 h of exposure to *P. lentiscus* EO, the observed aphid mortality was low and statistically equal to the control at concentrations ranging between 600 and 1100 ppm. The recorded mortality varied between 60 ± 18.7 and 76 ± 11.4% (Fig. 3). However, in the same conditions the mortality caused by *M. pulegium* was always higher than *P. lentiscus*.

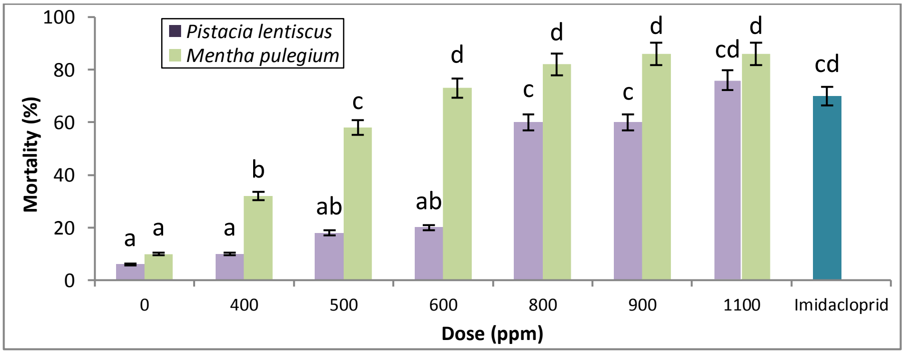

Fig. 3. Effect of *Mentha pulegium* and *Pistacia lentiscus* essential oils applied at different concentrations on *Myzus persicae* mortality noted after 24 h of exposure. Error bars represent standard deviations. For each essential oil tested, bars sharing the same letters are not significantly different based on Duncan's Multiple Range test (at $P < 0.05$).

This higher efficiency of *M. pulegium* EO is confirmed by its LC_{50} and LC_{95} which are much lower than those of *P. lentiscus*. The lethal concentrations of *M. pulegium* EO for 50 and 95% of treated aphids are 596 and 1264 ppm, respectively, whereas those of *P. lentiscus* EO's are 876 and 1405 ppm, respectively (Table 2).

Table 2. Lethal concentrations of *Mentha pulegium* and *Pistacia lentiscus* essential oils against *Myzys persicae* noted after 24 h of exposure

Source of EO	LC_{50} (ppm)	LC_{95} (ppm)	χ^2	ddl
Mentha pulegium	596 (427 - 736)	1264 (1036 - 1852)	5.087	5
Pistacia lentiscus	876 (760 - 1062)	1405 (1174 - 2032)	1.393	5

The estimated lethal concentrations values (ppm) were given using probit analysis.

Synergistic effect. Based on the common detection of five compounds in the both tested EOs, the combination of *M. pulegium* and *P. lentiscus* EOs is supposed to improve the mortality of aphids. However, the results of the synergism test showed that the mortality of *M. persicae* varied from 60 ± 2.58% to 66 ± 3.27% using *P. lentiscus* and *M. pulegium* EOs, respectively. The used concentrations corresponded to LC_{50} of both EOs. Those combined induced around 50% of aphid mortality with the spraying test which showed similar results as the contact test with a treated surface. This indicates that both application methods induce the same mortality for the same dose. No synergism was noticed between both oils in all the mixtures. According to the statistical analysis, there is no significant difference between the recorded mortalities caused by the individual oils and their mixtures (Fig. 4).

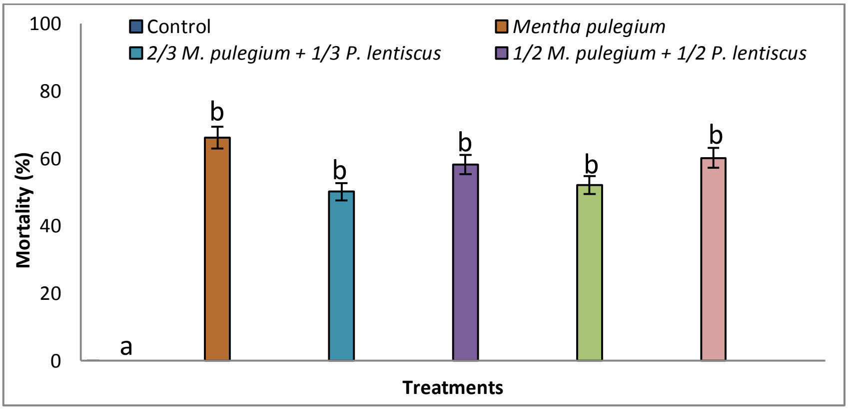

Fig. 4. Effect of different combinations of *Mentha pulegium* and *Pistacia lentiscus* essential oils on *Myzus persicae* mortality noted after 24 h of exposure. Error bars represent standard deviations. Bars sharing the same letters are not significantly different based on Duncan's Multiple Range test (at $P < 0.05$).

DISCUSSION

Essential oils extracted from *M. pulegium* and *P. lentiscus* were investigated for their yield, chemical composition and insecticidal activities against *M. persicae* with contact and spray methods.

The oil extraction yield of *M. pulegium* (1.76%) was higher than that of *P. lentiscus* (0.19%). For the chemical composition, the major compounds identified in both oils are monoterpenoïds. This fact is in accordance with previous studies (Duru et al. 2003; Gradeli et al. 2008; Işcan et al. 2002; Yadegarinia et al. 2006). Tunisian *M. pulegium* EOs are characterized by their abundance of pulegone (45.89%) compared to those from Turkey, India, Washington State, Oregon which are rich in menthol (28-42%) and menthone (18-28%) (Işcan et al. 2002). However, *M. pulegium* EOs from Iran are rich with α-terpinene (19.7%), isomenthone (10.3%) and trans-carveol (14.5%) (Yadegarinia et al. 2006).

P. lentiscus EO was characterized by the abundance of limonene (6.97%), β-myrcene (21.03%) and α-pinene (28.57%) while Turkish *P. lentiscus* EO was more rich in terpinene-4-ol (29.9%) and limonene (10.6%) (Duru et al., 2003). Morocco EO from this plant contained germanicol (12.8%), thunbergol (8.8%), himachalene (7.4%), trans-squalene (6.7%), terpinyl propionate (6.7%), 3,3-dimenthol (6.2%), and cadina-1.4-diene (5.1%) (Mharti et al. 2011). This composition variability with remarkable quantitative and qualitative differences in relation with sampling sites was previously reported by Barra et al. (2007) and Mkaddem et al. (2007) for *P. lentiscus* and *M. pulegium*, respectively. The major compounds detected in both Eos are known for their insecticidal activities (Koul et al. 2008). Several studies have proved that they interfere with the insect physiological functions by a rapid cuticule penetration (Lee et al. 2002; Papachristo and Stamopoulos 2002). Furthermore, it has been shown that some of them have an effect on stomach tissues (Sauvion 1995) and can disturb growth, fecundity and molting process of several insects. In the same context, Chiasson and Beloin (2007) have proved the relation between octopamine (a neurotransmitter responsible of insect metabolism and flight) and some monoterpenoic essential oil compounds.

Based on bioassay results, both tested Eos were found to be toxic to *M. persicae* with some variability in the induced mortality depending on concentrations and exposure times. Moreover, the obtained LC_{50} and LC_{95} confirm the efficiency of both oils against the target aphid with about four times less than the LC_{50} obtained with camphor *Eucalyptus globules* (4070 ppm), cinnamon *Cinnamomum zeylanicum* (3307 ppm), clove *Syzygium aromaticum* (5469 ppm) and mustard *Brassica rapa* (4261 ppm) against*Bruchidius incarnatus* adults (Fouad 2013).The contact toxicity has probably affected the aphid nervous system via a penetration of EO's toxic compounds through the ventral surface as cited by Lee et al. (2002) and Papachristos and Stamoupolos (2002).

After exposure to 500 ppm of *M. pulegium* EO, the aphicidal efficiency was as high as the chemical insecticide used as control (Imidaclopride) where mortality reached 86 ± 11.4%. The toxic oil effect recorded is probably attributed to the major compounds pulegone and (Cis and Trans) menthone which are known for their insecticidal properties (Koul et al. 2008). Gabris et al. (2005) and Dancewikz et al. (2008) also found that pulegone deterred aphid probing and feeding and influenced their growth and reproduction. In addition, it has been shown that the essential oil of *M. pulegium* reduced the longevity and fecundity of *M. persicae* adults (Petrakis et al. 2014). Furthermore, this EO displayed a strong antimicrobial activity (Oraby and El Borollosy 2013).

P. lentiscus EO showed toxicity against *M. persicae* leading to high morality level (76 ± 11.4%) and exhibited similar efficiency as the chemical insecticide used as control but an activity less than that of *M. pulegium* EOs. The experimental toxicity is in accordance with previous reports on other insect pests such as *Tribolium castaneum*, *Lasioderma serricorne*, *Ectomyelois ceratoniae* and *Ephestia kuehniella* (Bachrouch et al. 2010a, 2010b).

The synergism assay with the tested mixtures of EOs revealed the absence of interaction (neither negative nor positive) between their main compounds against *M. persicae*. However, Liu et al. (2006) found that repellent activity of the mixture of EOs from *Artemisia princeps* and *Cinnamomum camphora* against *Sitophillus oryzae* and *Bruchus rugimanus* adults was significantly higher than that elicited by individual oils. Nevertheless, the mechanisms involved in how the interactions between the components of each EO improve the repellent activities, need further investigations (Nerio at al. 2010).

In conclusion, this study showed a better aphicidal activity of *M. pulegium* EO compared to that of *P. lentiscus* in controlling adult form of *M. persicae*. However, both of them showed the same efficiency as the chemical insecticide used as control. Moreover, it is established that both EOs have a potential as a biopesticide in integrated pest management against this polyphagous aphid species. However, the effect of EO on non-target insects and natural enemies needs to be further elucidated. This work should be completed with the stable formulation of those EOs for practical use in agriculture once their safety toward non-target insects confirmed.

RESUME

Behi F., Bachrouch O., Ben FekihI. et Boukhris-Bouhachem, S. 2017. Effet insecticide et synergique de deux huiles essentielles *Pistacia lentiscus* et *Mentha pulegium* sur le puceron vert du pêcher *Myzus persicae*. Tunisian Journal of Plant Protection 12: 53-65.

La composition chimique de deux huiles essentielles extraites à partir de la menthe pouliot *Mentha pulegium* et du pistachier lentisque *Pistacia lentiscus* a été étudiée. Les composés volatils ont été caractérisés. Les composés majeurs détectés ont été pulégone (45,89%), cis-menthone (23,25 %) et trans-menthone (14,73 %) pour *M. pulegium* et α-pinène (28,57%), β-myrcène (21,03%) et L-limonène (6,97%) pour *P. lentiscus.* Ensuite, les activités insecticides et la synergie des huiles essentielles ont été étudiées contre *Myzus persicae*. Les résultats ont montré que les deux huiles essentielles sont toxiques au puceron cité. La mortalité causée par *M. pulegium* et *P. lentiscus* a été de 86 ± 11,4% et 76 ± 11,4%, respectivement. La LC_{50} de *M. pulegium* a été plus faible que celle de *P. lentiscus* avec des valeurs respectives de 596 et 876 ppm. Aucune synergie n'a été détectée entre les deux huiles lorsqu'elles ont été mixées et testées contre *M. persicae.* Néanmoins, elles ont montré une efficacité équivalente à celle du produit chimique : l'imidaclopride, qui a causé une mortalité de 70 ± 10%. Cette étude a prouvé que les deux huiles essentielles ont un potentiel intéressant avec une efficacité supérieure de *M. pulegium* et peuvent être utilisées en agriculture pour la lutte contre *M. persicae.*

Mots clés: Huiles essentielles, *Mentha pulegium*, *Myzus persicae*, *Pistacia lentiscus*, toxicité de contact

ملخص

الباهي، فاطمة وألفة بشروش وابتسام بن فقيه وسنية بوخريص-بوهاشم. 2017. فعالية وأنشطة التآزر للزيوت الأساسية لنبتتيْ *Mentha pulegium* و *Pistacia lentiscus* ضد حشرة منّ الخوخ الأخضر *Myzus persicae*. Tunisian Journal of Plant Protection 12: 53-65.

تمت دراسة التركيبة الكيميائية لإثنين من الزيوت الأساسية للنعناع (*Mentha pulegium*) والمستكة. (*Pistacia lentiscus*). تم الكشف عن مركبات متبخرة. كانت المركبات الأكثر تواجد من بينهم هي pulegone (45.89%) و cis-menthone (23.25%) و trans-menthone (14.73%) بالنسبة لزيت النعناع و α-pinene (28.57%) و β-myrcene (21.03%) و L-limonene (6.97%) بالنسبة لزيت المستكة. تم اختبار هذه الزيوت ضد حشرة المن الأخضر (*Myzus persicae*). أظهرت النتائج أن كلا الزيتين سام لحشرات المن وتبين أن زيت النعناع أكثر فعالية من زيت المستكة. تسبب زيت النعناع في مقتل 86 ± 11.4% من الحشرات بينما تسبب زيت المستكة في مقتل 76 ± 11.4% من الحشرات. وصلت الجرعة القاتلة لـ 50% من الحشرات إلى 596 ppm بالنسبة لزيت النعناع و 876 ppm لزيت المستكة. لم يظهر اي تآزر بين الزيتين عندما تم خلطهما. تبين أيضا أنه لهما نفس سمية المبيدر الكيمياءئ الحشري Imidaclopride الذي تسبب في قتل 70 ±10%. تظهر نتائج هذه الدراسة أن كلا الزيتين لهما نجاعة جيدة، ويمكن استخدامهما في مكافحة المن الأخضر في مختلف الزراعات.

كلمات مفتاحية: زيوت أساسية، سمية التلامس، *Pistacia lentiscus*، *Myzus persicae*، *Mentha pulegium*

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