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APHICIDAL AND REPELLENT ACTIVITIES OF PLANT EXTRACTS FROM *Hertia cheirifolia* L. AND *Marrubium deserti* de Noé

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Abstract

The black bean aphid Aphis fabae constitutes a dangerous pest. The use of pesticides provokes undesirable effect on the environment and the human health. Thus, the research for methods with low negative secondary effect becomes very important. The purpose of this study is the screening of the aphicidal activity of extracts from Marrubium deserti and Hertia cheirifolia. Moreover, the effect of the same treatments was tested on the orientation of A. fabae.
Through our study, ANOVA revealed significant differences between the studied essential oils. Those of H. cheirifolia with a concentration of 10000 ppm were the most effective with 96.67% of corrected mortality rate after 6 hours. Whereas for aqueous extracts, the mortality rate were less important and it reached only 30% after 24 h for H. cheirifolia 30% extracted by maceration. For the test of orientation, the results showed that after 24 hours, the essential oils of H. cheirifolia with a concentration of 10000 ppm and the extracts obtained by maceration of the two plants had an important repellency rate superior than 70%.

Key words*: Aphis fabae, aqueous extracts, essential oil, aphid mortalities, repellency percentage.*

INTRODUCTION

Aphids are economically important insect pests of agriculture and forest crops (Guerrieri & Digilio, 2008; Chaieb et al., 2018). Chemical pesticides are the main tool used to control aphid populations. Nevertheless, the extensive and unscientific use of insecticides has resulted in a universal zooming insecticide resistance among aphids across regions and substantial detrimental influences on the environment (Yan et al., 2018; Kumar et al., 2019). In Africa, it is estimated that 10% of products used are extremely hazardous (Class 1a) and highly hazardous (1b) (Pretty & Bharucha, 2014).
Therefore, there is a need to develop biopesticides for effective control that minimizes environmental hazards (Barzman et al., 2015).
The term "Green pesticides" include all natural materials that can reduce the pest population and increase food production (Mossa, 2016).
There is a common notion that natural products with unique bioactive structures have been playing a vital role in developing new types of insecticides with glaring advantages of low residual, easy biodegradation and high security to non-target organisms, like the application of pyrethrin, rotenone, nicotine and neonicotine in the control of pests (Yan et al., 2018).
Furthermore, the combination of non-chemical methods that may be individually less efficient than pesticides can generate valuable synergies (Barzman et al., 2015).
Literature survey on the potential use of essential oils as bio-pesticides indicated that essential oils obtained from different plant families, including Asteraceae and Lamiaceae have insecticidal activity and they are active as a repellent, fumigant, larvicidal and adulticidal against insects (Mossa, 2016).
In Algeria, several plants endowed with insecticidal and repellent activities are rarely used (Arab et al., 2018). *Hertia cheirifolia* and *Marrubium deserti* are two plants widespread in Algeria. However, no study has been performed on the evaluation of its repellency and aphicidal effect against the black bean

aphid. Thus, the aim of our study is the screening of the aphicidal and repellency activities of plant extracts from these two plants against *A. fabae* under laboratory conditions.

MATERIALS AND METHODS

Plant collection and tested treatments

Two plant species were chosen to obtain aqueous extracts and essential oils: *Hertia cheirifolia* L. (belonging to the Asteraceae family) and *Marrubium deserti* de Noé (belongs to the family of Lamiaceae).

The choice of these plants is justified on the one hand by their availability at the time of experimentation and on the other hand they are not known as hosts for the black bean aphid (*Aphis fabae*).

H. cheirifolia, also known as *Othonnopsis cheirifolia* Jaub. (Segueni et al., 2017), is a very popular plant in Algeria (Chermat & Gharzouli, 2015). It is an endemic medicinal species of the Tunisian and Algerian flora (Rahali et al., 2017).

In addition, *M. deserti*, an Algerian endemic species, has several applications in traditional medicine (Zaabat et al., 2010), as a remedy for asthma, diabetes and as a diuretic (Edziri et al., 2012).

The parts collected from the selected plants (leaves and stems) were air-dried and cleared of dust. Then, they were crushed electrically to obtain a fine powder.

The aqueous extraction was made using two methods: maceration and infusion.

As regards maceration, a quantity of plant powder was mixed with cold distilled water at a ratio of 1/10 (w/v). Each of the two obtained solutions was agitated for a few minutes and left for 24 h. The solutions were then filtered and later diluted with distilled water to obtain two doses (10 and 30%).

For infusion, a quantity of plant powder was mixed with warm distilled water at a ratio of 1/10 (w/v). Each of the two obtained solutions was agitated for a few minutes and then left for 2 h. The solutions were then filtered and later diluted with distilled water to obtain two doses (5 and 10%).

The obtained aqueous extracts were kept in the refrigerator until use.

Concerning the essential oils of *H. cheirifolia*, they were obtained using the technique of hydro-distillation. Afterwards, the resulted solution was diluted using distilled water and 2% Tween 20, to obtain three doses 1000, 5000 and 10000 ppm.

Test of aphicidal activity

The test of the toxicity effect was performed under laboratory conditions. Adults of the black bean aphid *Aphis fabae* were selected as target pests.

Toxicity tests are focused in the treated insect mortality counting after a period of time from the beginning of the experiment. Treatment can be applied with different manner, including contact toxicity (Chaieb, 2011).

A total of 39 Petri dishes were prepared with three repetitions for each treatment. 13 treatments were tested: four by infusion, four obtained by maceration, three of essential oils, one with distilled water (control 1) and one with distilled water and Tween 20 (control 2).

Each Petri dish contains one faba bean leaflet, imbibed with the corresponding treatment. Then, ten adults were placed on the treated leaflet. Dead aphids were counted 3, 6 and 24 h after the artificial infestation for each dish.

The corrected percentage of mortality was then calculated basing on Abott formula (1925):

Corrected mortality rate = [(Tmp - Cmp)/ (100 - Cmp)] × 100

Knowing that:

Tmp: Treatment mortality percentage;

Cmp: Control mortality percentage.

Test of repellency

The repellent effect of essential oils and aqueous extracts (obtained by maceration and infusion) on the aphids *A. fabae* was evaluated using a standard method. The Petri dishes were divided into two equal areas: one occupied by a treated faba bean leaflet and the other by a control (treated either by distilled water for aqueous extracts or by distilled water and Tween 20 for essential oils).

Ten aphids were placed in the center of each dish. The procedure is repeated three times for each of five examined treatments. After 3, 6 and 24 hours, the number of insects present on each part was noted, and then the percentage of

repellency (PR) for each treatment was calculated as follow:

PR = [(NC - NT) / (NC + NT)] × 100 (Singh et al., 2012)

Where:

NC represents the number of aphids oriented towards the control;

NT represents the number of aphids oriented towards the treated leaflet.

Statistical analysis

Analysis of variance (ANOVA) combined with a Student-Newman-Keuls test were performed, using the 10th version of SPSS software, to compare the corrected percentage of mortalities.

RESULTS AND DISCUSSIONS

Concerning the test of aphicidal activity, the ANOVA analysis revealed a significant difference between aqueous extracts during the inspection after 6 hours only (P = 0.024); whereas after 3 and 24 h, there were no significant differences (P = 0.084 and 0.064, respectively).

In general, the aqueous treatments caused weak mortality rates, which did not exceed 30% (Figure 1). Similarly, previous studies revealed a low insecticidal activity of the aqueous extracts from *M. vulgare* (Lebbal et al., 2018a), *Artemisia herba-alba, Myrtus communis* and *Ruta montana* against *A. fabae* (Lebbal et al., 2018b).

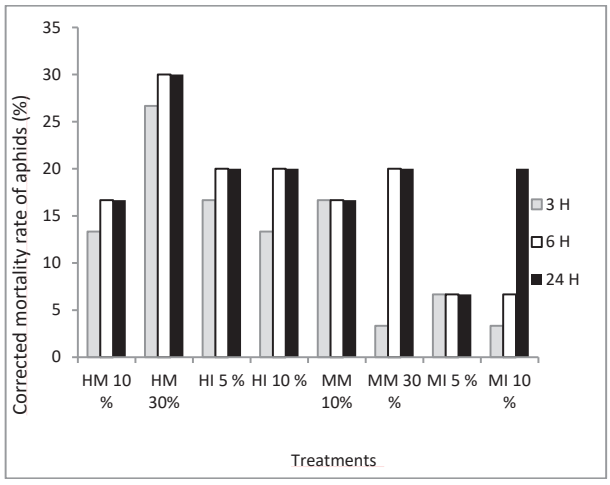


Figure 1. Corrected mortality rate of aphids on different aqueous treatments
(HM: *H. cheirifolia* by maceration; HI: *H. cheirifolia* by infusion; MM: *M. deserti* by maceration; MI: *M. deserti* by infusion)

However, there were highly significant differences of aphid mortality between the different concentrations of the essential oils of *H. cheirifolia* (P = 0.000), where the most efficient was 10000 ppm (Table 1). Likewise, Oulebsir-Mohandkaci et al. (2015) mentioned that essential oils of *Eucalyptus globulus* proved very toxic towards green peach aphid *Myzus persicae* (Sulzer) either by contact or by inhalation.

Table 1. Corrected mortality percentages of aphids on different essential oil treatments

Treatments	**3 H**	**6 H**	**24 H**
Essential oils *H. cheirifolia* 10000 ppm	76.67 c	96.67 c	78,47 b
Essential oils *H. cheirifolia* 5000 ppm	46.67 b	66.67 b	78,47 b
Essential oils *H. cheirifolia* 1000 ppm	00 a	06.67 a	-13,69 a
Signification	0.000*	0.000*	0.000*

*Significant at P < 0.05

Plants are very rich in allelochemical molecules, of structural diversity, reacting as a bio-insecticide according to various mechanisms (Bourmita et al., 2013). For instance, the results of aphicidal bioassay against *Aphis citricola* (van der Goot) aphids showed that some compounds, particularly *N*-Allylnorgalanthamine (alkaloids), exhibited considerable aphicidal activity (Yan et al., 2018).

Botanical insecticides are generally complex mixtures of several, often closely related secondary metabolites that may or may not have an important role in the toxicity of the mixture (Miresmailli & Isman, 2014).

Segueni et al. (2017) indicated that GC-MS analysis of *H. cheirifolia* oil has resulted in the identification of 62 compounds representing 78.29% of the total oil, where the compounds belonging to the class of monoterpenoids and sesquiterpenoids represented 33.64% of the total identified compounds.

Previous studies have noticed a correlation between insecticidal activity against different insects and monoterpenoids (Lee et al., 1997; Papachristos et al., 2004) or sesquiterpenoids (Collins et al., 2000).

Nevertheless, it can be assumed that mortality was mainly due to the various active molecules containing in those oils and of a synergism of all compounds (Hakimi et al., 2015). A better

understanding of the behavior and bioactivity of individual components of botanical insecticides coupled with more advanced methods of compartmentalization and formulation will allow greater degrees of control over the availability and activity of individual components of complex botanical mixtures and, consequently, should enhance the efficacy of botanical insecticides (Miresmailli & Isman, 2014).

On the other hand, the results revealed that after 24 hours, the essential oils of *H. cheirifolia* with a concentration of 10000 ppm and the extracts obtained by maceration of the two plants had a repellency rate superior than 73% (Table 2). In the same way, Oulebsir-Mohandkaci et al. (2015) found that percentages of repulsion against green peach aphid vary between 37.59% and 63% for the essential oils of thyme, and 50 to 72.4% for those of eucalyptus after three hours. Besides, rosemary oil was shown to have a repellency effect against aphids and repelled them even in the presence of host plant odor (Hori & Komatsu, 1997).

Table 2. Percentage of repellency (PR) of different plant extracts against black bean aphids

Treatments	Time of count (H)	PR (%)
Essential oils *H. cheirifolia* 10000 ppm	3	53.3
	6	66.7
	24	80
H. cheirifolia 30% by maceration	3	60
	6	66.7
	24	73.3
H. cheirifolia 10% by infusion	3	33.3
	6	20
	24	26.7
M. deserti 30% by maceration	3	73.3
	6	80
	24	80
M. deserti 10% by infusion	3	13.3
	6	6.7
	24	13.3

The extracts obtained by infusion showed a very weak repulsive effect comparatively to those obtained by maceration. For the same plant species, the efficiency of extracts may differ depending on the extraction method and the organ used. For example, entrainment extracts from uninfested *Prunus padus* L. had no effect on emigrants in the olfactometer, whereas those from twigs infested with nymphal emigrants were repellent against bird cherry–oat aphid, *Rhopalosiphum padi* (Linnaeus, 1758) (Glinwood & Pettersson, 2000). The repellency effectiveness of the examined extracts may be attributed to their composition, including their contents in terpenoids. Schultz et al. (2004) mentioned that the mature leaf essential oil samples of *Nepta cataria* L. (Lamiaceae) exhibited significant repellency to German cockroaches, *Blattella germanica* L., and nepetalactone (a terpenoid) was the major constituent of catnip essential oil.

CONCLUSIONS

Our results suggest that the extract of the essential oils extracted from *H. cheirifolia* may be a potential alternative to chemical insecticides. They expressed aphicidal and repulsive effects. It would be interesting to carry out more investigations on this plant by identifying molecules responsible for these activities and by testing these essential oils in natural conditions.

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