INSECTICIDAL ACTIVITIES OF ESSENTIAL OILS FROM SOME CULTIVATED AROMATIC PLANTS AGAINST SPODOPTERA LITTORALIS (BOISD)

Salaheddine Souguir*, Ikbal Chaieb, Zohra Ben Cheikh, Asma Laarif

Entomological Laboratory, Regional Research Center in Horticulture and Organic Agriculture, Chott Mariem 4042, Sousse, Tunisia

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Abstract: Medicinal plant species were tested for their fumigant activity against Spodoptera littoralis third instar larvae. Responses varied according to plant species and parts used. For the present investigation, volatile oils were obtained from: Foeniculum vulgare (flowers and seeds), Coriandrum sativum (seeds), Daucus carota (flowers), Pelargonium graveolens (leaves and flowers), Origanum majorana (leaves and flowers), and Salvia officinalis (leaves). Fumigant activity was observed after 24 hours of exposure. All essential oils were proved to be toxic to the third instar larvae. However, the highest mortality was observed in the essential oil of S. officinalis leaves, C. sativum seeds, F. vulgare seeds, D. carota flowers, and O. majorana leaves with LC50 = 23.050 µl/l air, 68.925 µl/l air, 95.075 µl/l air, 99.300 µl/l air, and 100.925 µl/l air, respectively. Other oils showed an LC50 between 101 and 183 µl/l air.

Key words: Coriandrum sativum, Daucus carota, essential oils, Foeniculum vulgare, Fumigant activity, LC50, Origanum majorana, Pelargonium graveolens, Salvia officinalis, Spodoptera littoralis

INTRODUCTION

Insect pests are a major constraint on crop production, especially in developing countries. Due to the growing concerns over health hazards, environmental pollution, and negative effects on non-target organisms, essential oils have begun to play an increasingly prominent role as alternatives to synthetic pesticides (Sharma et al. 2006). Many floral volatiles have anti-microbial or anti-herbivore activity (De Moraes et al. 2001; Friedman et al. 2002; Hammer et al. 2003). Such activity acts to protect valuable reproductive parts of plants from damage (Dudareva et al. 2004).

However, intensive screening is necessary to select compounds with pesticidal properties, which are harmless to the environment and ecosystem. Research is urgently needed on potential botanical extracts which are safe and which leave little or no residues, and which are naturally derived with minimal technology. There are more than 2400 plant species belonging to 189 plant families which are said to be rich sources of bioactive organic compounds (Rao et al. 2005).

The Spodoptera littoralis (Boisd) adult lays between 300 and 500 eggs. The larva attacks the foliage of plants. This is the most serious pest of various crops such as cotton, chilli, and tobacco. Those crops are economically important. This pest has already developed resistance to many chemical pesticides (Niranjankumar and Regupathy 2001).

The aim of our study was to assess the insecticide activity of the essential oils obtained by six Mediterranean plants and their different parts, against the third instar larvae of S. littoralis, using the fumigant bioassay.

MATERIALS AND METHODS

Plant material and essential oils extraction

Origanum majorana L., Foeniculum vulgare L., Coriandrum sativum L., Daucus carota L., Pelargonium graveolens L’Hér., and Salvia officinalis L. were cultivated on the biological fields of the Regional Center for Research on Horticulture and Organic Agriculture (RCRHOA).

Essential oils were extracted from the used plant parts using a Clevenger-type water steam distillation apparatus (Papachristos and Stamopoulos 2004). The distilled essential oils were stored in the refrigerator at 4°C until being used in the bioassay.

Insect rearing

Spodoptera littoralis (Lepidoptera: Noctuidae) were reared on an artificial diet in the laboratory. Rearing conditions were: a 12 h photo regime at 28±2°C and 75±5% relative humidity (RH). Insect cultures were continuously refreshed with wild moths captures from the RCRHOA organic farm (El-Minshawy et al. 2009).
Insecticidal activity: Fumigant Test

The insecticidal activity of the essential oils against the third instar larvae of *S. littoralis*, was determined by fumigant bioassay using the closed container method. A group of 10 larvae were put into the bottom of a 40 ml plastic container. Paper discs were treated with different concentrations of essential oils: 0, 25, 50, 100, and 200 µl/l air. The discs were then attached to the inside top of the container and the container was then closed.

Mortality was determined after 24 h of the treatments. All bioassays were performed in 5 repetitions. All of the treated larvae were held in the same rearing conditions. An insect was considered dead if it did not move when observed outside of the container.

**Statistical analysis**

The data were corrected using Abbott’s formula (Abbott 1925) for the mortalities then subjected to probit analyses using SPSS (v. 2011) to estimate LC₅₀ and LC₉₀ the values of each of the essential oils against the third instar larvae of *S. littoralis* (Finney 1971). Means were separated at the 5% significance level by Duncan’s test.

**RESULTS**

**Rates of oil production**

The oil production yields of the different parts of the tested plants are given in Table 1. The results showed that seeds and leaves of *F. vulgare*, and the leaves and flowers of *O. majorana* produced the highest rate of oil, with a yield > 1%.

**Insecticidal activity of essential oils against *S. littoralis* larvae (Third instar)**

All the essential oils tested were active towards third instar larvae of *S. littoralis*. All of them caused mortality: a dose of 200 µl/l air was required to obtain over 80% of mortalities for essential oils of *O. majorana* (flowers), and *F. vulgare* (flowers and seeds).

The essential oils of *C. sativum* (seeds) and *D. carota* (flowers) at the lowest tested dose of 100 µl/l air, caused 72% and 70% mortality, respectively. While a dose of 50 µl/l air was required to obtain over 92.5% mortality for essential oils of *S. officinalis* (Table 2).

Among the nine tested essential oils, the most potent insecticidal oil was extracted from *S. officinalis* leaves LC₅₀ = 23.050 µl/l air (LC₉₀ = 41.625 µl/l air). The next most potent insecticidal oil was extracted from *C. sativum* seeds LC₅₀ = 68.925 µl/l air (LC₉₀ = 125.475 µl/l air), followed by *D. carota* essential oils from the flowers (EO) by LC₅₀ = 99.300 µl/l air (LC₉₀ = 170.350 µl/l air), leaves of *O. majorana* EO by LC₅₀ = 100.925 µl/l air (LC₉₀ = 250.425 µl/l air), and *F. vulgare* seeds EO by LC₅₀ = 101.050 µl/l air (LC₉₀ = 199.825 µl/l air). The flowers of *O. majorana* essential oils had an LC₅₀ = 140.725 µl/l air (LC₉₀ = 216.350 µl/l air). The least potent essential oils were those of the flowers and leaves of *P. graveolens* by LC₅₀ = 179.300 µl/l air (LC₉₀ = 299.750 µl/l air) and LC₅₀ = 182.350 µl/l air (LC₉₀ = 287.975 µl/l air), respectively (Table 3).

**Table 1. Investigated plant material**

<table>
<thead>
<tr>
<th>Botanical name</th>
<th>Family</th>
<th>Part used</th>
<th>Yield [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>F. vulgare</em></td>
<td>Umbelliferae</td>
<td>flowers</td>
<td>2.7±0.308</td>
</tr>
<tr>
<td><em>O. majorana</em></td>
<td>Lamiaceae</td>
<td>leaves</td>
<td>1.2±0.300</td>
</tr>
<tr>
<td><em>P. graveolens</em></td>
<td>Geraniaceae</td>
<td>leaves</td>
<td>0.18±0.080</td>
</tr>
<tr>
<td><em>C. sativum</em></td>
<td>Umbelliferae</td>
<td>flowers</td>
<td>0.24±0.100</td>
</tr>
<tr>
<td><em>D. carota</em></td>
<td>Umbelliferae</td>
<td>flowers</td>
<td>0.15±0.025</td>
</tr>
<tr>
<td><em>S. officinalis</em></td>
<td>Lamiaceae</td>
<td>leaves</td>
<td>0.43±0.050</td>
</tr>
</tbody>
</table>

Small letters – comparison between yields of essential oil in the same plant part (Duncan’s test p < 0.005)

**Table 2. Mortality in percent of *S. littoralis* larvae, after 24 h of exposure to different concentrations of essential oils**

<table>
<thead>
<tr>
<th>Parts of plant</th>
<th>Concentration of EO’s [µl/l air]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td><em>F. vulgare</em> flowers</td>
<td>0±0.00</td>
</tr>
<tr>
<td><em>F. vulgare</em> seeds</td>
<td>0±0.00</td>
</tr>
<tr>
<td><em>O. majorana</em> leaves</td>
<td>0±0.00</td>
</tr>
<tr>
<td><em>O. majorana</em> flowers</td>
<td>0±0.00</td>
</tr>
<tr>
<td><em>C. sativum</em> seeds</td>
<td>0±0.00</td>
</tr>
<tr>
<td><em>D. carota</em> flowers</td>
<td>0±0.00</td>
</tr>
<tr>
<td><em>P. graveolens</em> leaves</td>
<td>0±0.00</td>
</tr>
<tr>
<td><em>P. graveolens</em> flowers</td>
<td>0±0.00</td>
</tr>
<tr>
<td><em>S. officinalis</em> leaves</td>
<td>0±0.00</td>
</tr>
</tbody>
</table>

Small letters – comparison between doses of same essential oil (Duncan’s test p < 0.005)

Capital letters – comparison between essential oils in the same concentrations (Duncan’s test p < 0.005)
Table 3. Calculated lethal concentrations (LC\textsubscript{50} and LC\textsubscript{90}) of third instar larvae of S. littoralis exposed to different essential oils

<table>
<thead>
<tr>
<th>Parts of plants</th>
<th>Lethal concentrations [µl/l air]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LC\textsubscript{50}</td>
</tr>
<tr>
<td>O. majorana leaves</td>
<td>100.925 (30–510.75)</td>
</tr>
<tr>
<td>O. majorana flowers</td>
<td>104.725 (47.225–248.875)</td>
</tr>
<tr>
<td>F. vulgare flowers</td>
<td>101.050 (27–502.65)</td>
</tr>
<tr>
<td>F. vulgare seeds</td>
<td>95.075 (50.200–177.800)</td>
</tr>
<tr>
<td>C. sativum seeds</td>
<td>68.925 (47.600–105.050)</td>
</tr>
<tr>
<td>P. graveolens leaves</td>
<td>182.350 (166.825–202.125)</td>
</tr>
<tr>
<td>P. graveolens flowers</td>
<td>179.300 (123.800–421.425)</td>
</tr>
<tr>
<td>S. officinalis leaves</td>
<td>23.050 (17.050–31.475)</td>
</tr>
</tbody>
</table>

DISCUSSION

Essential oils (EO) from plants may be an alternative source of S. littoralis third instar larvae control. The reason for this is because EO are a source of bioactive compounds that are safe for human health and the environment.

The first reason we chose these particular plant parts was because they were available during the season of the year when we decided to do our research. The second reason was for the yields of essential oils extracted from these parts.

Many researches have reported on the effectiveness of plant essential oils against insects, especially stored-products insects. In our study, we are concentrated on S. littoralis. Pavela (2004) reported that some medicinal plants essential oils are larvicidal to the third instar larvae of S. littoralis. Krishnappa et al. (2010) tested oils obtained from Thymus persicus L. also on S. littoralis larvae.

Results showed that 100 µl/l of air, toxic enough to obtain 100% mortality of S. littoralis third instar larvae, using the S. officinalis essential oils. We needed 200 µl/l air from C. sativum (seeds), and D. carota (flowers) essential oils to obtain 100% mortality. But to realize 100% mortality for the others essential oils used in this study, we needed a little bit more than 200 µl/l air.

Compared with other researches, de Sousa et al. (2005) reported that C. sativum essential oils kill 53.99% of Callosobruchus maculatus (Fabricius) at a concentration of 2.5% (w/w). Hazrat and Soaib (2012) also showed that those essential oils from C. sativum are effective against Mosquito larvae.

Rana et al. (2012) found that EO from F. vulgare kills 100% of Culex quinquefasciatus (Linnaeus) larvae at 250 ppm after 40 min. In addition, Pavela (2004) tested oils from O. majorana and S. officinalis against S. littoralis larvae. He showed that when using 10% (w/v) from each oil, he was able to obtain a 77.8% mortality with the use of O. majorana, and 97.7% with the use of S. officinalis.

Based on the Probit analysis, EO from the leaves of S. officinalis revealed that LC\textsubscript{50} = 23.050 µl/l air. Oils obtained from F. vulgare seeds, C. sativum seeds, and D. carota flowers, showed an LC\textsubscript{50} < 100 µl/l air. But with other oils extracted from O. majorana (leaves and flowers), F. vulgare flowers, and P. graveolens (leaves and flowers), we obtained an LC\textsubscript{50} > 100 µl/l air.

Likewise, a lethal dose (LC\textsubscript{50}) has been determined by many authors. Rana and Rana (2012) tested F. vulgare EO against C. quinquefasciatus and found an LC\textsubscript{50} = 24.69 ppm. Ebadollahi (2011) evaluated oils from F. vulgare against Sitophilus granarius (Linnaeus) (LC\textsubscript{50} = 27.30 µl/l air) and against S. oryzae (Linnaeus) (LC\textsubscript{50} = 44.16 µl/l air). Sedagh et al. (2011) studied the effect of C. sativum essential oils against Anopheles stephensi, and determined an LC\textsubscript{50} = 120.95 ppm. Pavela and Cheremenskaya (2004) tested oils of S. officinalis against the third instar larvae of S. littoralis, LC\textsubscript{50} = 4.7 µg/ml.

These results demonstrate that the essential oils of S. officinalis leaves, C. sativum seeds, D. carota flowers, and F. vulgare seeds, may be serving as a lepidopteran agricultural pest control of S. littoralis.

The possible sites of action of essential oil toxicity are acetylcholinesterase and the octopamingeric system in insects (Kostyukovsky et al. 2002; Evans 1981).

CONCLUSION

The increasing number of investigations on plant-insect chemical interactions revealed that plant secondary metabolites, like essential oils, can be used as a pest control agent. This study could also contribute toward
preserving the agroecological systems that are in danger because of excessive use of synthetic insecticides.

Essential oils can be mixed with some water. It is important to be careful with the concentrations to be used on those hothouse plants that need to be protected from attacks of *S. littoralis* larvae. There is also a need to develop extraction methods which are easy, understandable for users, and can be used at the farm level.

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**REFERENCES**


