

EFFECT OF SOME ESSENTIAL OILS ON *Acanthoscelides obtectus* SAY (COLEOPTERA: BRUCHIDAE) AND *Tetranychus urticae* KOCH, (ACARI: TETRANYCHIDAE) ADULTS

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Summary. In search of new and safe pesticides, the toxicity of volatile oils obtained from three plant species against *Acanthoscelides obtectus* and *Tetranychus urticae* adults was studied. The essential oils of peppermint (*Mentha piperita* L), rosemary (*Rosmarinus officinalis* L) and coriander (*Coriandrum sativum* L) showed higher toxicity on mites than on weevils. The peppermint and rosemary essential oils demonstrated efficacy against *A. obtectus* in both fumigant and acute contact toxicity tests. The peppermint and coriander essential oils had the most pronounced fumigant toxicity to mites, with LT₅₀ of 2.5 and 3.7 h, respectively, at 5 µg/cm³ air and are the most promising sources of natural substances with acaricidal properties.

Keywords: insecticidal and acaricidal effects, essential oils, *Acanthoscelides obtectus*, *Tetranychus urticae*.

Introduction

The bean weevil, *Acanthoscelides obtectus*, and the two-spotted spider mite, *Tetranychus urticae*, are two dangerous pests causing a great economic damage to agricultural crops in the Republic of Moldova. The larvae of *A. obtectus* cause damage by continuous cyclic feeding both in storage and in legume seeds in the field. *T. urticae* is a polyphagous that causes severe damage to various crops in greenhouses.

The bean weevils and mites control is still based primarily on the use of synthetic contact insectoacaricides (ANSA, 2023). However, these chemicals pose a risk of rapid development of insecticide and acaricide resistance in the pests. They are highly toxic to the environment and human health. So, there is a need for new insecticides and acaricides for use in both greenhouse crops and stored products. Some plant essential oils are known as natural pesticides which degrade rapidly in nature and are virtually non-toxic to warm-blooded organisms (Regnault-Roger et al, 2012). Therefore, much attention is paid to the toxicological evaluation of plant essential oils with high pesticidal activity in the context of developing new environmentally safe pest control agents.

The aim of the work was to study the insecticidal and acaricidal effect of essential oils from *Mentha piperita* L., *Rosmarinus officinalis* L. (the family Lamiaceae), and *Coriandrum sativum* L. (the family Apiaceae) on adults of *A. obtectus* and *T. urticae* under laboratory conditions.

Materials and methods

Essential oils *Mentha piperita* L. (EO_{MP}) and *Rosmarinus officinalis* L. (EO_{RO}) essential oils were purchased from “Dullberg Konzentra”, and “Sigma-Aldrich”, (Germany), respectively. *Coriandrum sativum* L. (EO_{CS}) essential oil was obtained industrially in the Republic of Moldova.

Insect and mite cultures Laboratory cultures of bean weevil (*Acanthoscelides obtectus*, Say) and two spotted spider mite, (*Tetranychus urticae* Koch.) were maintained in the laboratory at 28 ± 1 °C, 80% relative humidity and 16:8 h light:dark photoregime without insecticides exposure. The weevils were reared in 0.6 L glass jars containing bean grain (seeds). *T. urticae* adults were reared on bean plants. *A. obtectus* and *T. urticae* adults, 1–3 days old, were used for evaluation fumigant and contact toxicity of essential oils.

Fumigant toxicity of essential oils To determine the fumigant toxicity of essential oils and the thionated form of coriander oil on adult individuals of *A. obtectus*, low-density "White Ribbon" paper filters (4.5 cm diameter) were impregnated with samples of EO_{Cs} and S-EO_{Cs} dissolved in acetone at precalculated doses to obtain an equivalent fumigant concentration of 100-550 µg/cm³ air. The treated filters were held in the open air for 1 min before being clamped to the bottom of the glass jar lid (volume 0.27 L). In the control sample, only acetone was applied to the filter. To prevent direct insect contact with the substances, the filters were protected with a wire mesh. Twenty to thirty adults were placed in glass jars, which were covered with lids and incubated for 48 hours. Each experiment was performed in triplicate. After exposure to test substance vapors, the insects were transferred to clean jars (volume 0.5 L) with bean seeds (one bean seed per two individuals of *A. obtectus*), water, and covered with a cotton cloth. Mortality was determined 3-5-7 days after treatment. If, when touched with a brush, the insects showed no signs of life, i.e. no movement of limbs or antennae, the individuals were considered dead.

To determine the fumigant effect of essential oils on *T. urticae*, 20-25 females were transferred to bean leaves placed on moist cotton disks in glass Petri dishes 6 cm in diameter 24 hours prior to the experiment. White Ribbon paper filters (5.5 cm diameter) were impregnated with a solution of essential oil in acetone at doses calculated to obtain equivalent fumigant concentrations of 5 µg/cm³ for EO_{Mp} and EO_{Cs} and 30 µg/cm³ of air for EO_{Ro}. The solvent was allowed to evaporate for 30 s, after which the treated filters were attached to the underside of the lid of a 1.5 L glass desiccator. Petri dishes containing females of *T. urticae* were placed in the desiccators, tightly covered, and incubated for 24 hours at 28 ± 1 °C. Control groups of mites were kept under the same conditions, but the filters were treated with acetone. Death of adult mites was recorded after 1, 3, 6 and 24 hours. Mites were considered to be dead if they did not move when touched with fine hairbrush. All experiments were performed in four replications for each concentration of essential oils.

Acute contact toxicity of essential oils To evaluate the contact toxicity of essential oils and the thionated form of coriander oil, twenty adult *A. obtectus* specimens were immersed for 30 sec in 0.375-3.0% solutions of the test substances dissolved in dimethyl sulfoxide (DMSO, 10%). The insects were then transferred to 0.5 L glass jars with beans. Mortality was determined 3-5-7 days after treatment.

Data analysis The data on pest mortality were processed in consideration of the mortality of individuals in the control group and were analyzed by ANOVA. The mean lethal time of action of essential oils (LT₅₀) on mites was calculated using the Finney-Miller-Tainter probit analysis (Gar, 1963).

Results and discussion

Fumigation is the primary method of controlling insect pests of stocks and is acknowledged as the most effective method of applying acaricides in greenhouses.

Fumigant toxicity of essential oils on *A. obtectus* As evidenced by comparative research, the rapid death of adults (within four hours) occurs at a vapor concentration of the peppermint and rosemary oils <200 µg/cm³ air. The coriander essential oil was found to be significantly less toxic to adult *A. obtectus* than the other oils tested. A higher concentration of volatile oil vapors of at least 400 µg/cm³ air and a longer treatment time of 48 hours were required to achieve 50% mortality of the pests (Figure 1).

Sulfur-containing compounds are widely known for their biological activity. It is demonstrated that the thionation can enhance the insecticidal efficacy of certain essential oils. To

illustrate, the insecticidal activity of essential oil derived from *Ruta montana* plants to be markedly elevated (up to 8-fold) following thionation, when tested against *Sitophilus oryzae* (Fekhar et al., 2017). However, our research has shown that the vapour toxicity of EO_{Cs} to bean weevils did not increase after oil thionation (Figure 1). After fumigation with S-EO_{Cs}, individuals were actively moving, flying, mating and laying eggs and their lifespan was similar to that of the control group.

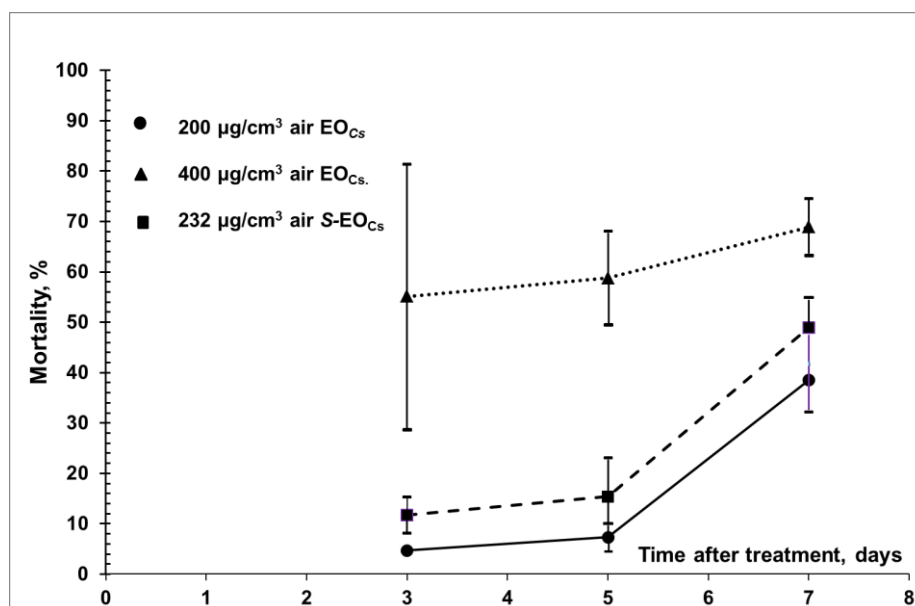


Figure 1. Dynamics of adult mortality of *A. obtectus* after fumigation with coriander essential oil for 48 hours

Acute contact toxicity of essential oils on *A. obtectus* In order to determine the insecticidal properties of essential oils as contact insecticides, the acute direct toxicity of these substances against the bean beetle was studied. Mortality rates of *A. obtectus* individuals exposed to different vapor concentrations of EO_{Ro} and EO_{Cs} in 10% DMSO solution are shown in Figure 2. After treatment of adulte beetles with 0.75-1.5% solutions of EO_{Ro}, the pests did not emerge from the nokdaun state and died within two days. Pest mortality rate increases significantly with increasing concentrations of EO_{Cs}. But it should be noted that EO_{Cs} showed lower insecticidal toxicity compared to EO_{Ro} (Figure 2). A 3.73% S-EO_{Cs} solution in DMSO had no insecticidal contact activity against bean weevils.

Fumigant toxicity of essential oils on *T. urticae* Volatile components of peppermint, rosemary and coriander had a significant toxic effect on adults of *T. urticae*. The oils toxicity was contingent upon the duration of contact of mites with oils vapours as evidenced by the data represented in Figure 3. LT₅₀ values of EO_{Ro}, EO_{Mp}, EO_{Cs} were 2.2, 2.5 and 3.7 h, respectively, indicating that these oils have rapid acaricidal action. The rapid lethal effect of oil vapours on spider mites indicates a neurotoxic mechanism of action. Nevertheless, vapours of peppermint and coriander were the most toxic for mites, because the acaricidal properties of these oils appeared at a lower concentration (5 µg/cm³ air) compared to rosemary oil (30 µg/cm³ air) vapour concentration. The biological activity of essential oils depends on the chemical constitution of these oils, which are composed of a variety of hydrocarbon and belong to disparate chemical classes, and the ratio of these components and their relationship to one another are of particular importance. The results obtained are consistent with the relative fumigant toxicity of essential oils obtained from different plants and are attributed to the different chemical composition of these oils. According to available literature data, the greatest acaricidal activity is possessed by essential oils of plants from the Lamiaceae family (various species of mint, *Rosmarinus officinalis*), which are enriched with terpene hydrocarbons and especially monoterpenoids: menthol, α -pinene, 1,8-cineole, α -terpineole

(Rincon et al., 2019; Ebadollahi et al., 2014; Amizadeh et al., 2013; Regnault-Roger et al., 2012).
 Acaricidal properties

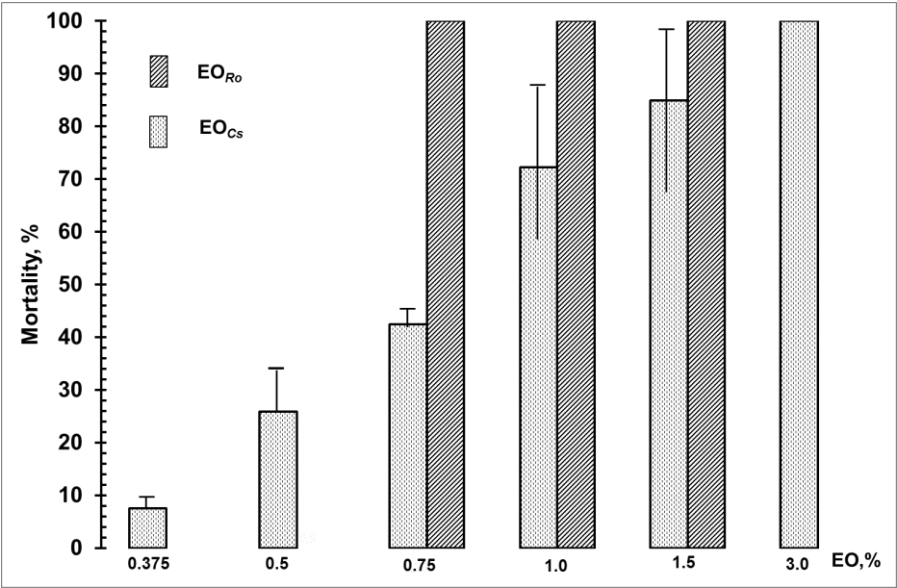


Figure 2. Mortality of *A. obtectus* adults following direct contact exposure to EO_{Ro} and EO_{Cs} (after 48 hours)

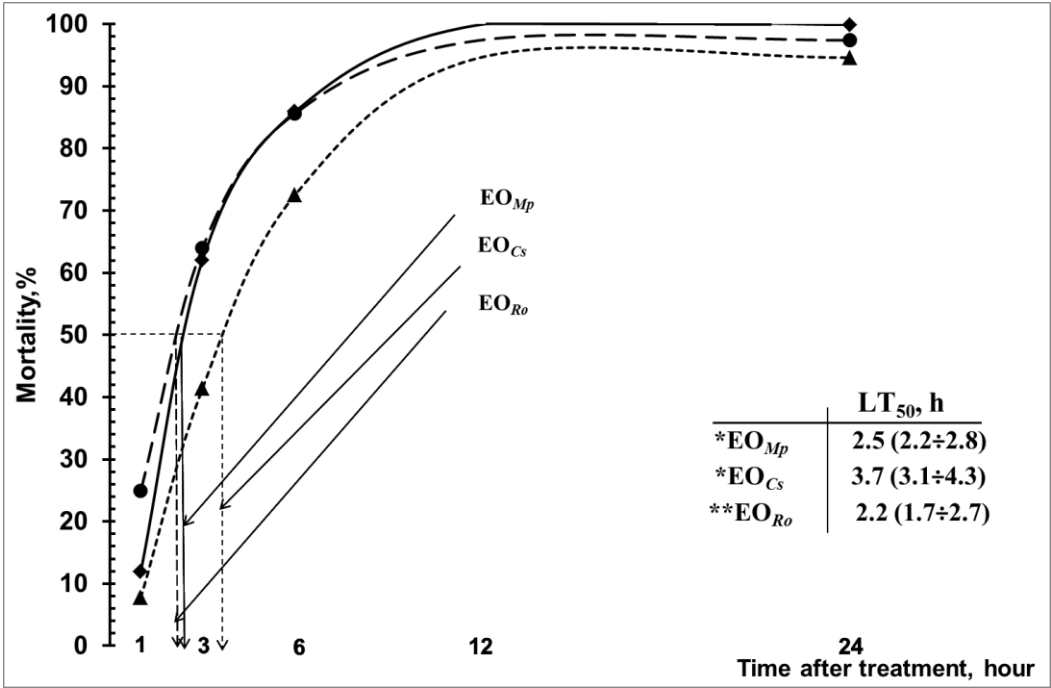


Figure 3. Mean lethal time (LT₅₀) of the effect of essential oils on *T. urticae* females
 Note: *5µg /cm³ air, **30 µg/cm³

of essential oils of plants of the Apiaceae family (fennel, cumin, coriander) are determined by such components of these oils as anetol, limonene, linalool, camphor and others (Al-Khayri, 2023).

Conclusion

The present results suggest that all tested essential oils have the pesticides activity against *A. obtectus* and *T. urticae* adults.

The peppermint and rosemary essential oils vapors have high toxicity against bean weevils because within four hours occurred 100% *A. obtectus* adults' death. The coriander essential oil was significantly less toxic to *A. obtectus* adult, when it was used as fumigant or contact insecticide. The sulphur-derivative of coriander essential oil obtained as a result of the thionation procedure is not toxic to beetles. These data suggest that ketones play a prominent role in the insecticidal properties of the oil.

Toxicological indices show that essential oils are more toxic to mites compared to adults of bean weevil. Among the oils, peppermint and coriander essential oil vapours were the most toxic to *T. urticae* adults. However, coriander essential oil was less effective ($LT_{50}=3.7$ h) compared to peppermint essential oil ($LT_{50}=2.5$ h) in terms of the rate of lethal effect on mites. Rapid mite eradication, based on the $LT_{50}=2.2$ h value, is also possible with rosemary essential oil vapours. However, the vapour concentration of rosemary essential oil must be six times higher than for peppermint or coriander oils.

Thus, peppermint essential oil can be used to develop potentially new insecticides against *A. obtectus*, and peppermint and coriander oils - a new acaricides. However, more research is needed to evaluate the cost-effectiveness of these essential oils for a wider range of greenhouse and storage pests.

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