

TESTING THE EFFICACY OF ESSENTIAL OILS AGAINST *Drosophila suzukii* (Matsumura)

Stefan RASHEV¹, Nedyalka PALAGACHEVA², Ivan ARABADJIEV², Stoyan GEORGIEV¹

¹Agricultural Academy, Field Crops Institute, 2 Georgi Dimitrov Blvd, Chirpan, Bulgaria

²Agricultural University of Plovdiv, 12 Mendelev Blvd, Plovdiv, Bulgaria

Corresponding author email: stgeorgiev@abv.bg

Abstract

Drosophila suzukii (Matsumura) is an economically important pest of berry species. It is characterized by high reproductive potential and wide food specialization. For control of *Drosophila suzukii*, insecticides are mainly used, which lead to the development of resistance, therefore other alternatives are sought. In this regard, the efficacy of essential oils of lavender (*Lavandula angustifolia* Mill.), rosemary (*Rosmarinus officinalis* L.) and peppermint (*Mentha piperita* L.) against adults of *Drosophila suzukii* was tested in two concentrations 0.1% and 0.2%. The study was carried out under laboratory conditions. The processing of the obtained data was carried out with a package of statistical programs Statistika 7 V. The highest efficacy was reported for rosemary, followed by mint and lavender. A gradual increase in efficacy was observed for all essential oils. Regression analysis of the results shows functional relationships between the concentration of the working solution and efficacy. As the concentration of the essential oil increases, efficacy increases and death occurs earlier.

Key words: *Drosophila suzukii* (Matsumura), essential oils, *Lavandula angustifolia*, *Rosmarinus officinalis*, *Mentha piperita*.

INTRODUCTION

The repeated use of insecticides to control pests on crops leads to environmental pollution, disruption of the ecological balance, destruction of pollinators and beneficial entomofauna, and very often to the development of resistance. Therefore, alternative solutions are sought (Dam et al., 2019; Tait et al., 2021).

Plant insecticides have been used to control pests for centuries (Isman, 2006). The majority of plant products are biodegradable, therefore there is increasing interest in the use of plant extracts or essential oils for pest control (De Groot and Schmidt, 2016).

It is known that some chemical constituents of essential oils have insecticidal properties, their toxic effect is due to bioactive components such as mono- and sesquiterpenoids (Spitzer, 2004; Isman, 2020a; Chaudhari et al., 2021), which is why they can be used in both conventional and integrated plant protection.

Secondary compounds from plants, including alkaloids, terpenoids, phenols and flavonoids, can cause death of insects and act as attractants, detergents, phagostimulants, antifeedants or

affect their reproductive processes (Smet et al., 1986; Houghton, 1996).

The effectiveness of essential oils depends on environmental conditions, photodegradation and evaporation (Pavela, 2014; Isman, 2020b). Economic losses caused by *D. suzukii* reach \$511 million per year in the United States alone, with additional costs associated with monitoring and control required to prevent attacks by this pest (Goodhue et al., 2011; Lee et al., 2011). Plant-based insecticides, essential oils and their compounds, can be used as alternative means to control *D. suzukii* (Isman and Grieneisen, 2014; Bernardi, 2017; Amoabeng et al., 2019; Souza et al., 2022; de Albuquerque et al., 2024; Dos Santos et al., 2024). They contain chemical compounds that cause death or delay the development of resistance (Isman, 2020b). Essential oils are toxic to *D. suzukii* larvae and adults (Jang et al., 2017). Furthermore, many essential oils disrupt the sense of smell of *D. suzukii* and act as repellents (Souza et al., 2022). Rosemary (*Rosmarinus officinalis* L.) is one of the plants from which essential oils are extracted that have insecticidal activity. Chromatographic analyses of rosemary essential oil have shown

the presence of the following compounds: α -pinene, 1,8-cineole, borneol, bornyl acetate, camphor and verbenone (Isman et al., 2008; Sayorwan et al., 2013).

According to Renkema et al. (2016) most essential oils repel *D. sukukii*. Peppermint oil consists of two monoterpenoids menthol and menthone and is particularly effective. It acts as a repellent for up to 6 days.

Lavender oil contains the monoterpene components 1,8-cineole, carene and linalool, which act as fumigants for *D. sukukii* (Erland et al., 2015).

In this regard, essential oils have been tested for the control of *D. sukukii*.

MATERIALS AND METHODS

The studies were conducted under laboratory conditions (temperature 22-23°C, relative humidity 40-50% and photoperiod 16:8 - L:D). Essential oils of lavender, rosemary and mint were tested against adults of *Drosophila sukukii*. The experiment was set up in seven variants and three replicates: Variant I. Lavender - 0.1%, Variant II. Lavender - 0.2%, Variant III. Rosemary - 0.1%, Variant IV. Rosemary - 0.2%, Variant V. Mint - 0.1%, Variant VI. Mint - 0.2%, Variant VII. Control.

Blueberry fruits were placed in plastic containers, treated with the essential oils in the corresponding concentration. After that, 10 adults of *D. sukukii* were released into each container. Readings were made after 24 hours, on the 3rd and 5th days.

The efficiency is calculated using the Henderson-Tilton formula:

$$E\% = \left(1 - \frac{TaxCb}{TbxCa}\right) \cdot 100$$

Ta - number of live in the variant after spraying;
Tb - number of live in the variant before spraying;

Ca - number of live in the control after spraying;
Cb - number of live in the control before spraying.

The processing of the obtained data was carried out with a package of statistical programs Statistika 7 V.

RESULTS AND DISCUSSIONS

In the first readings of the 24th hour, there are statistically proven differences between the efficacy of lavender 0.1% and mint 0.1% essential oils, with mint being higher (Figure 1). On the third day, there is only a statistically proven difference between rosemary 0.1%, lavender 0.1% and mint 0.1%. The highest efficacy is demonstrated by rosemary essential oil at a concentration of 0.1% (Figure 2).

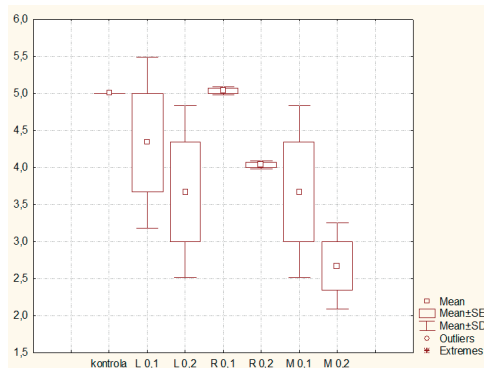


Figure 1. Comparing 24-hour averages

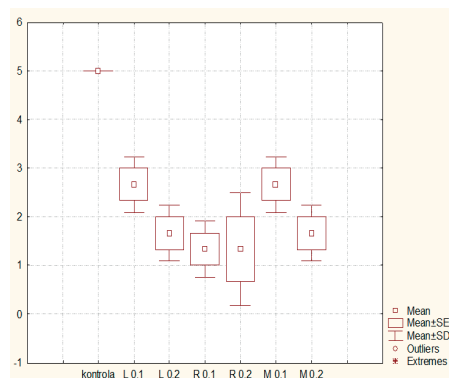


Figure 2. Comparison of average values on day 3

On the fifth day, there was a statistically significant difference between rosemary 0.2% and mint 0.1% (Figure 3).

The highest efficacy was demonstrated by rosemary at a concentration of 0.2%. These data are confirmed by studies by other authors Renkema et al. (2016).

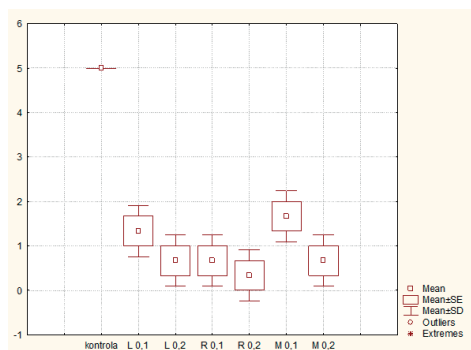


Figure 3. Comparison of average values on day 5

Table 1. Duration of action and amount of lavender oil in the working solution on *D.suzukii* adults

Regression Summary for Dependent Variable: z (lavender) R = ,89846037 R ² = ,80723104 Adjusted R ² = ,74297472 F(3,9) = 12,563 p						
	Beta	Std. Err.	B	Std. Err.	t(9)	p-level
x	1,31475	0,358487	0,471429	0,128542	3,66751	0,005175
y	1,29195	0,306116	1,155556	0,273799	4,22046	0,002238
xy	-1,96396	0,448108	-0,514286	0,117342	-4,38278	0,001764

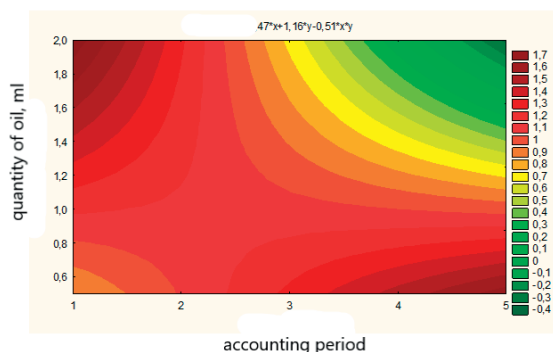


Figure 4. Flies counted after treatment with lavender oil

Table 2. Duration of action and amount of rosemary oil in the working solution on adults of *D.suzukii*

Regression Summary for Dependent Variable: z (rozmarin) R = ,94515842 R ² = ,89332443 Adjusted R ² = ,86961875 F(2,9) = 37,684 p						
	Beta	Std. Err.	B	Std. Err.	t(9)	p-level
Intercept			3,43229	0,254726	13,47446	0,000000
y	-0,734974	0,108871	-1,13333	0,167879	-6,75089	0,000084
x2	-0,594254	0,108871	-0,05134	0,009406	-5,45834	0,000401

When using rosemary oil, it is seen from the proposed model and graph that the number of flies decreases dramatically when the amount of oil in the solution is 2.0 ml on the second day (Figure 5). With a smaller amount of essential

A regression analysis was conducted with the results of the research. Functional dependencies between the concentration of the working solution and the flies were obtained.

The obtained models are adequate at a significance level of $p = 0.001$.

In the case of lavender, the proposed model and graph show that the number of flies decreases at an essential oil concentration of 2.0 ml on the second day. At a lower amount of essential oil of 1.2 ml, the density of flies decreases on the 3rd day, and at a concentration of 1.0 ml, their number decreases only on the 5th day (Figure 4).

oil, the duration of action is extended. At 1.4 ml, the number of flies decreases on the 4th day, and at 1.0 ml after the 5th day. With increasing the concentration of the essential oil, the duration of the destruction of the enemy is reduced.

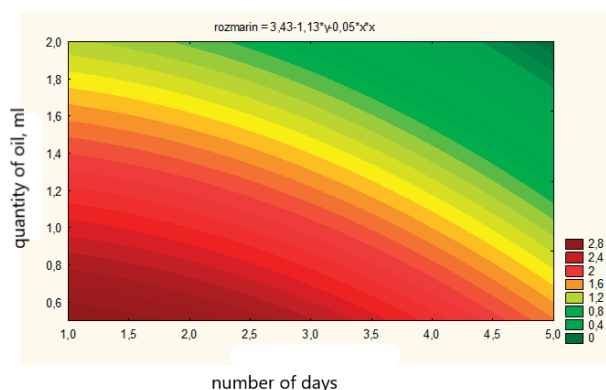


Figure 5. Flies counted after treatment with rosemary oil

Table 3. Duration of action and amount of peppermint oil in the working solution on *D.suzukii* adults

Regression Summary for Dependent Variable: z (menta) R = ,92867066 R ² = ,86242920 Adjusted R ² = ,81084015 F(3,8) = 16,717 p						
Intercept	Beta	Std. Err.	B	Std. Err.	t(8)	p-level
y	-2,47850	0,744703	-5,56667	1,672591	-3,32817	0,010413
x ²	-0,60312	0,131135	-0,07589	0,016501	-4,59922	0,001757
y ²	1,88461	0,744703	1,66667	0,658582	2,53069	0,035218

With the mint from the proposed model, it is seen that at a concentration of the essential oil in

the solution of 1.2-2 ml, the density of flies decreases after the fourth day (Figure 6).

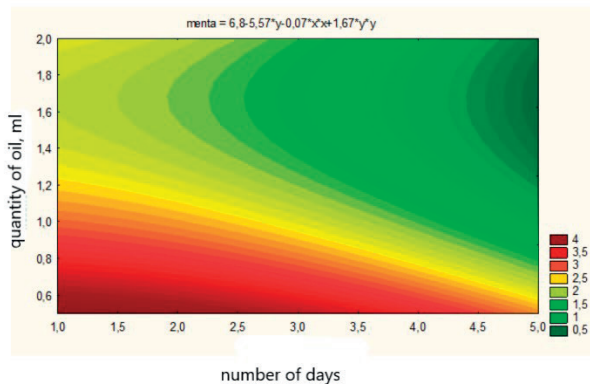


Figure 6. Flies counted after treatment with peppermint oil

According to Erland et al. (2015) lavender oil acts as a fumigant for *D. suzukii*, due to the presence of monoterpene components - 1,8-cineole, carene and linalool.

The toxic effect of peppermint oil is associated with the presence of menthol (monoterpene type), menthofuran, menthone, menthol esters - menthol acetate and valerate, phellandrene, pinene, cineole, menthofuran, piperitone, jasmone, tannins, flavonoids (luteolin, apigenin, diosmetin), as well as mustard, phenolic acids

and mineral salts (İşcan et al., 2002; Kumar et al., 2011; Renkema et al., 2016). This oil also acts as a repellent.

According to Souza et al. (2022) rosemary oil shows better efficacy of 50% and 90% against adults compared to spinetoram. The compounds contained in rosemary essential oil - pinene, 1,8-cineole and camphor act as repellents against adults of *D. suzukii*. Females prefer to lay their eggs in untreated fruits compared to those treated with rosemary essential oil.

Botanical products are an alternative for controlling crop pests. They can be applied in organic farming and reduce the risk of developing resistance.

CONCLUSIONS

As a result of the conducted research, the following conclusions can be drawn:

- Against adult forms of *Drosophila suzukii* (Matsumura), the highest efficacy was reported for rosemary essential oil (*Rosmarinus officinalis* L.), followed by peppermint (*Mentha piperita* L.) and lavender (*Lavandula angustifolia* Mill.).
- With increasing concentration of essential oils, efficacy increases and death occurs in a shorter time.

REFERENCES

- Amoabeng, B. W., A. C. Johnson and G. M. Gurr. (2019). Natural enemy enhancement and botanical insecticide source: a review of dual use companion plants. *Appl. Entomol. Zool.* 54: 1–19.
- Bernardi, D. (2017). Essential oils as a source of ecofriendly insecticides for *Drosophila suzukii* (Diptera: Drosophilidae) and their potential non-target effects. *Molecules*, 27, 6215.
- Chaudhari, A.K., Singh, V.K., Kedia, A., Das, S., Dubey, N.K. (2021). Essential oils and their bioactive compounds as eco-friendly novel green pesticides for management of storage insect pests: Prospects and retrospects. *Environ. Sci. Pollut. R.* 28, 18918–18940.
- Dam, D., Molitor, D., Beyer, M. (2019). Natural compounds for controlling *Drosophila suzukii*. A review. *Agron. Sustain. Dev.*, 39, 53.
- de Albuquerque, M.X.J., de Jesus, A.M.A., dos Santos, S.B.S., da Rocha, C.Q., da Silva, L.A. (2024). Neotropical flora's contribution to the development of biorational products for *Drosophila suzukii* control. *Neotrop. Entomol.*, 53, 400–414.
- De Groot and Schmidt, (2016). Essential oils, part III: Chemical composition. *Dermatitis*, 27, 161–169.
- Dos Santos, V.F., Abeijon, L.M., da Cruz, A.S.H., Garcia, F.R.M., de Oliveira, E.E. (2024). The Potential of Plant-Based Biorational Products for the *Drosophila suzukii* Control: Current Status, Opportunities, and Limitations. *Neotrop. Entomol.*, 53, 236–243. *Insects* 2024, 15, 733 11 of 12.
- Erland L.A.E., M. R. Rheault, S. S. Mahmoud. (2015). Insecticidal and oviposition deterrent effects of essential oils and their constituents against the invasive pest *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae). *Crop Protection*, Vol. 78, 20–26.
- Goodhue RE, Bolda M, Farnsworth D, Williams JC and Zalom FG. (2011). Spotted wing drosophila infestation of California strawberries and raspberries: economic analysis of potential revenue losses and control costs. *Pest Manag Sci* 67:1396–1402.
- Houghton, P.J. (1996). Compounds with anti-HIV activity from plants. *Trans R Soc Trop Med Hyg* 90: 601–604.
- İşcan, G., Kirimer, N., Kırkcıoğlu, M., Başer, K.H.C., Demirci, F. (2002). Antimicrobial Screening of *Mentha piperita* Essential Oils. *J. Agric. Food Chem.* 2002, 50, 3943–3946.
- Isman, M.B. (2006). Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. *Annu Rev Entomol.* 51: 45–66. <http://doi.org/10.1146/annurev.ento.51.110104.151146>.
- Isman, M. B., J. A. Wilson and R. Bradbury. (2008). Insecticidal activities of commercial rosemary oils (*Rosmarinus officinalis*) against larvae of *Pseudaletia unipuncta* and *Trichoplusia ni* in relation to their chemical compositions. *Pharm. Biol.* 46: 82–87.
- Isman, M. B. and M. L. Grieneisen. (2014). Botanical insecticide research: many publications, limited useful data. *Trends Plant Sci.* 19: 140–145.
- Isman M. (2020a). Botanical insecticides in the twenty-first century – fulfilling their promise? *Annual Review of Entomology*, 65: 233–249.
- Isman, M. (2020b). Commercial development of plant essential oils and their constituents as active ingredients in bioinsecticides. *Phytochem. Rev.*, 19, 235–241.
- Jang, M., Kim, J., Yoon, K.A., Lee, S.H., Park, C.G. (2017). Biological activity of Myrtaceae plant essential oils and their major components against *Drosophila suzukii* (Diptera: Drosophilidae). *Pest Manag. Sci.*, 73, 404–409.
- Kumar, P., Mishra, S., Malik, A., Satya, S. (2011). Insecticidal Properties of *Mentha* Species: A Review. *Ind. Crop. Prod.* 34, 802–817.
- Lee JC, Bruck DJ, Dreves AJ, Ioriatti C, Vogt H and Baufeld P. (2011). In focus: spotted wing drosophila, *Drosophila suzukii*, across perspectives. *Pest Manag Sci* 67:1349-1351.
- Pavela R. (2014). Limitation of plant biopesticides. In: Singh D. (ed.): *Advances in Plant Biopesticides*. Springer, New Delhi.
- Renkema, J., Wright, D., Buitenhuis, R. (2016). Plant essential oils and potassium metabisulfite as repellents for *Drosophila suzukii* (Diptera: Drosophilidae). *Sci Rep* 6, 21432. <https://doi.org/10.1038/srep21432>.
- Sayorwan, W., N. Ruangrunsi, T. Piriyapunyorn, T. Hongratanaworakit, N. Kotchabhakdi and V. Siripornpanich (2013). Effects of inhaled rosemary oil on subjective feelings and activities of the nervous system. *Sci. Pharm.* 81: 531–542.
- Smet H., Van-Mellaert H., Rans M., De-Loof A. (1986). The effect of mortality and reproduction of beta-asarone vapours on two insect species of stored grain: *Ephestia kuehniella* (Lepidoptera) and *Tribolium confusum* Duval (Coleoptera). *Mededeligen Van de Faculteit Landbouwwetenschappen Rijksuniversiteit Gent*, 51: 1197-1204.
- Souza, Michele Trombin de, Mireli Trombin de Souza, Máira Chagas Morais, Daiana da Costa Oliveira, Douglas José de Melo, Leonardo Figueiredo, Paulo Henrique Gorgatti Zarbin, Maria Aparecida Cassilha Zawadneak and Daniel Bernardi. (2022). Essential Oils as a Source of Ecofriendly Insecticides

- for *Drosophila suzukii* (Diptera: Drosophilidae) and Their Potential Non-Target Effects. *Molecules*, 27, no. 19: 6215. <https://doi.org/10.3390/molecules27196215>
- Spitzer C. (2004). *Oleos volateis*. In *Farmacognosia: da planta ao medicamento Porto Alegre*. Edited by Simoes CMO, Schenkel EP, Gosmann G, Mello JCP, Mentz LA, Petrovick PR 467–495.
- Tait, G., Mermer, S., Stockton, D., Lee, J., Avosani, S., Abrieux, A., Anfora, G., Beers, E., Biondi, A., Burrack, H. (2021). *Drosophila suzukii* (Diptera: Drosophilidae): A Decade of Research Towards a Sustainable Integrated Pest Management Program. *J. Econ. Entomol.*, 114, 1950–1974.