Efficiency of different types of traps in mass trapping *Drosophila suzukii* (Diptera, Drosophilidae) in raspberry plantings

Miloš Marjanović, Snežana Tanasković

University of Kragujevac, Faculty of Agronomy in Čačak, Cara Dušana 34, 32000 Čačak, Serbia
Corresponding author: stanasko@kg.ac.rs

Abstract: *Drosophila suzukii* (Matsumura, 1931) is an invasive oligophagous pest native to southeastern Asia. The first documented report of this pest in Serbia was in 2014. The insect is a pest of healthy and physiologically mature (ripening) soft fruits. The aim of the study was to determine the efficiency of different types of baited traps in mass trapping specimens of this species in raspberry plantings. Five types of blends (attractants) were used for mass trapping. The experiment was set up on May 27th, 2017. Inspection and sample collections were carried out at 7-10 day intervals from June 4th to July 31st, 2017.

Based on the analysed field data, we confirmed that standard trap S was the most efficient, with 8099 specimens caught in the experimental period. The number of caught specimens decreased in the deployed traps, as follows: trap T4 (695), trap T3 (682), trap T2 (643), and trap T1 (482) as the least efficient. Statistical analyses showed very significant differences between the standard trap and trap T1, and significant differences between the standard trap and the other trap types in the average number of caught specimens. No significant differences in trapping were found between the other trap types.

Keywords: *Drosophila suzukii,* trap, efficiency, raspberry.

Introduction

The spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura, 1931) (Diptera, Drosophilidae) is an invasive oligophagous pest native to southeastern Asia (Asplen *et al*., 2015). The first report in Europe came in 2009 from Spain, France and Italy (Calabria *et al*., 2012). Ecological plasticity and a wide range of host plants enabled survival and spread in the territory of introduction (Zerulla *et al*., 2015). European countries, such as Italy (2009), Spain (2010) and France (2010), have established pest monitoring and control programmes (Cini *et al*., 2012).

The first documented and confirmed report of SWD presence in Serbia was in 2014 (Toševski *et al*., 2014). The species was probably introduced to Serbia through fresh fruit imports at the Horgoš border crossing. In Serbia, SWD is a very important pest of small fruits, primarily raspberry (Toševski *et al*., 2014), as still one threat in this production behind newer identified (Tanasković and Milenković, 2009). The harmful effects of this insect are observed during purchase or later during proccessing, and this is the main reason for justified concerns of raspberry producers, purchasers and processors.

This insect is on the EPPO A2 (EPPO, 2011) quarantine list, which requires mandatory surveillance for early detection and monitoring of pest populations, given the economically important damages caused to the host plants' healthy and ripening (mature) fruits. The main difference between this insect and other fruit flies is that SWG lays eggs in healthy fruits in the ripening phase (Pajač and Barić, 2010) by a large serrated ovipositor. Infested fruits are susceptible to infection by rot pathogens (Hauser et. al., 2011), and within a few days after infection fruits and the entire crop can completely decay.

Setting up traps is the only way to record the presence of pests in fruit and vine orchards, as well as to implement population number control measures (EPPO, 2010). Regular monitoring in orchards is necessary to keep population numbers below the economic threshold (www.pisvojvodina.com).

The aim of this study was to determine the pest presence and efficiency of traps i.e. volatile attractants according to the number of specimens caught. Based on the obtained results, the most efficient trap will be recommended for deployment in different types of orchards for mass trapping of SWD and to decrease population numbers.

Material and method

Field experimental design

The trail was set up at the Gornja Kravarica locality, Lučani municipality during 2017, in a 31-year-old open-field orchard of raspberry 'Willamette', covering an area of 0.1 ha (N 43º 45' 55, 4" E 20º 10' 33, 6", 471 m a.s.l.).

Hand-made plastic bottle traps were used for SWD mass trapping (Figure 1). Nine round holes 4 mm in diameter were made in the bottle trap to allow SWD to enter. A rectangular opening was cut in the top portion of the bottle and covered with gauze to spread volatile blends (chemicals) i.e. attractants or baits.

In the experiment, five types of traps were used:

1.   Trap T1 – an olfactory attractant mixture of 300 mL apple cider vinegar and 5 g dry yeast.

2.   Trap T2 – an olfactory attractant mixture of 300 mL apple cider vinegar, 5 g dry yeast, and 1 g white sugar.

3.   Trap T3 – an olfactory attractant mixture of 300 mL apple cider vinegar, 5 g dry yeast, and 1 g white sugar, and a red-black plastic (PVC) stripe used as a visual attractant.

4.   Trap T4 – an olfactory attractant mixture of 300 mL apple cider vinegar, 5 g dry yeast, and 1 g white sugar, and a yellow plastic (PVC) stripe used as a visual attractant.

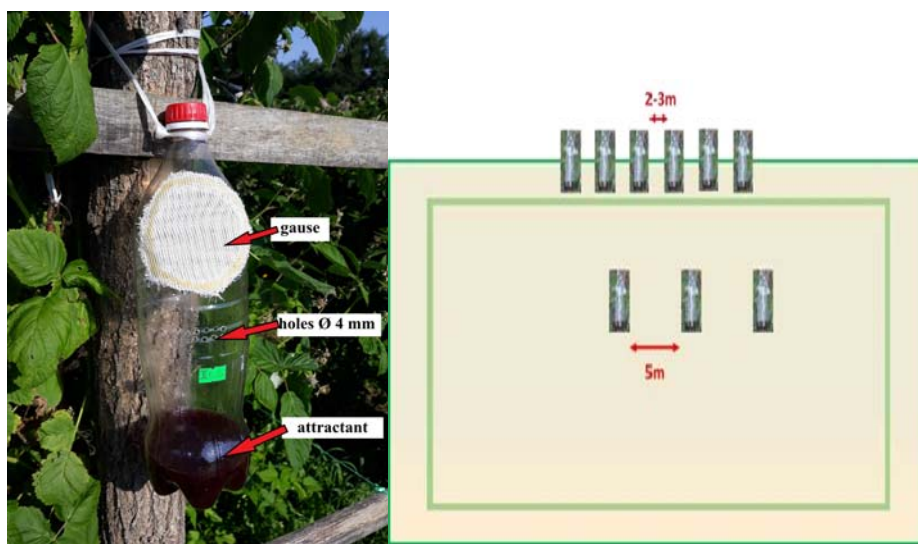5.   Trap S – an olfactory attractant mixture of 150 mL red wine and 150 mL apple cider vinegar.

Figure 1. A hand-made trap used for *D. suzukii* mass trapping (photo: M. Marjanović and PISS)

A small drop of dish soap was added as a surfactant to each bait to increase SWD capture.

The trail was set up on May 27th, 2017. The raspberry planting was at the phenological growth stage BBCH 73 – 30% of fruits formed (Meier, 2018).

Field inspectione were performed at 7-10 day intervals, i.e. on June 4th, 12th, 22th, and July 2nd, 11th and 31st, 2017. During the inspection, specimens were filtered and transferred into plastic self-lock tubes. After sample collection, the tubes were carried to the laboratory at the Faculty of Agronomy, where insects were identified and specimens counted for further analyses.

Data analyses

Adults were identified by a Leica M 125 binocular, equipped with LAS software.

Statistical analyses were performed by one- and two-sample t tests at $p < 0.05$ using GenStat 12th Edition, and $\bar{x}$ t test single sample at $p < 0.05$ using STATISTICA 7 StatSoft.

Results and discussion

The highest efficiency in the first examination was shown by attractant S, with an average catch of 53.85 adults per trap, followed by the attractants T4, T2, and T1 as the least effective (Figure 2).

In the second examination, the highest efficacy was found for attractant S, as in the first inspection, whereas the second highest efficacy was shown by attractant T3, unlike the previous examination (Figure 2).

Unlike the first two inspections, the highest efficiency in the third inspection was shown by attractant T3. However, the other attractants did not show significantly lower efficiency, and their average catches ranged from 31.00 to 36.67 adults (Figure 2).

The fourth inspection differed from the rest in having the extremely low efficiency of the four types of attractants T1, T2, T3 and T4. The attractant efficiency of S was very high, as in the first two inspections (Figure 3).

The fifth inspection was conducted on the July, 11th. As in the fourth inspection, the 4 types of attractants T1, T2, T3 and T4 showed a very low efficiency. The efficiency of attractant S was high i.e. on average 43.21 adults were caught (Figure 3).
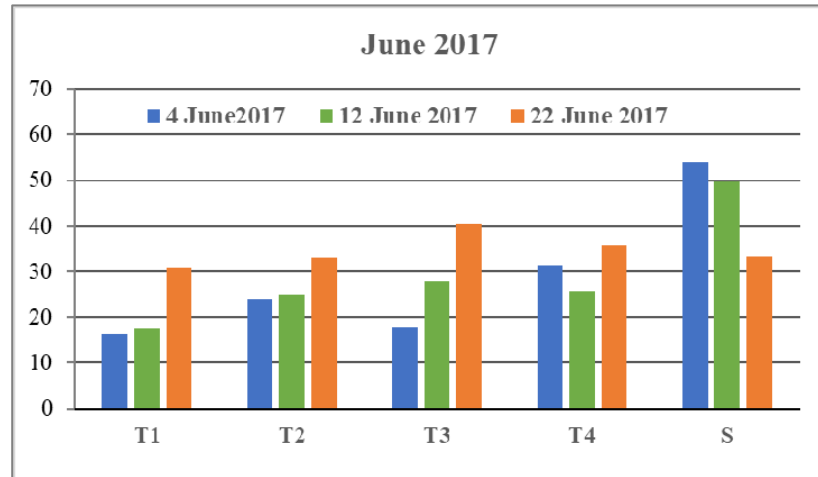
Figure 2. Number of specimens caught per trap in June

The last inspection was carried out on 31 July. During the period from 11 to 31 July, extremely high air temperatures caused reduced pest activity and a decrease in pest abundance (Figure 3). Very low efficiency of all types of attractants was reported. But again, attractant S stood out as having the highest efficiency.
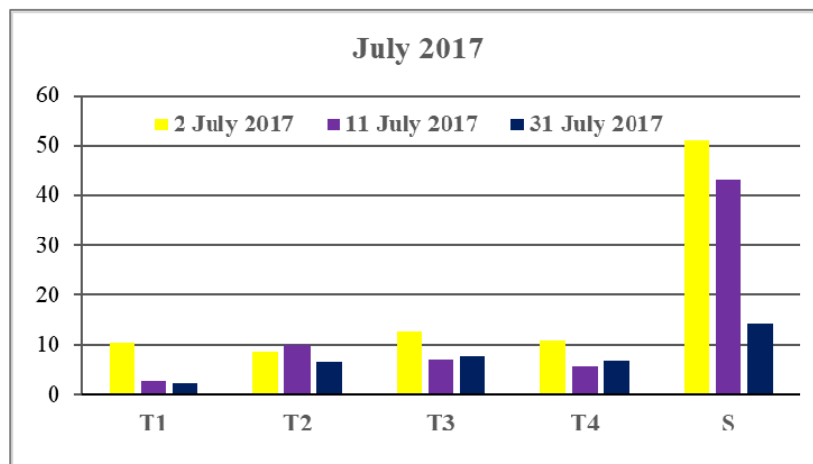

Figure 3. Number of specimens caught per trap in July

The low trap efficiency, i.e. the low number of caught specimens was probably the consequence of the end of the raspberry harvest (around 20 July

2017). Also, extremely high air temperatures over 35°C were recorded during this period, and contributed to the decline in SWD numbers in the planting.

Monitoring results of the total and average numbers of specimens caught per bait/trap are shown in Table 1.

Table 1. Total and average numbers of specimens caught per trap in the trial

Trap type	Total number		Average number of specimens caught per trap ± Sd
	Number of caught specimens	*Number of installed traps*	
T1	482	6	80.33 ± 59.08
T2	643	6	107.16 ± 59.92
T3	682	6	113.67 ± 71.57
T4	695	6	115.83 ± 72.26
S	8 099	33	245.42 ± 53.11

The best results i.e. the highest number (8 099) of specimens caught in the experimental period were found in trap S, followed by T4 (695), T3 (682), T2 (643) and T1 (482). Table 1 and Figure 2 give the average and total numbers of specimens caught per trap.
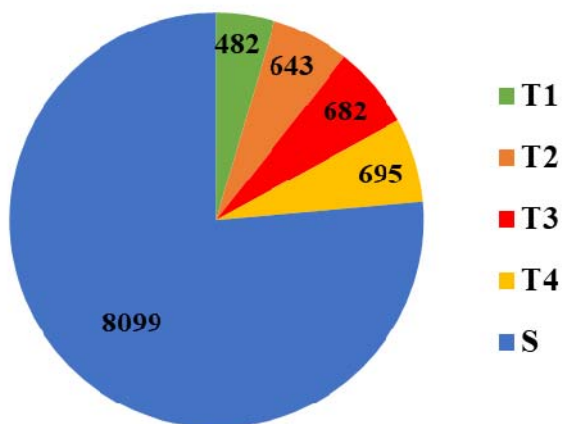

Figure 4. Total number of specimens caught per trap

The red wine + apple cider vinegar attractant was the best bait during the mass trapping of SWD in this trial. Also, in this research, T4, T3 and T2 baits were equally attractive, and the lowest attractiveness was determined for T1. These results are opposite to Kovačević (2018) results. Her results indicate that T1 bait (apple cider + dry yeast) was highly efficient, subsequent to T4. This could be explained by the fact that SWD in nochoice conditions flew to T1, because this type of blends (apple cider + dry yeast) was not installed.

Based on the obtained results, the highest number of caught specimens was recorded between the end of May and the beginning of June (Table 2) in all trap types, and this overlapped with the beginning of the fruit ripening phase. Later in the growing season, the number of caught specimens decreased, which was in agreement with the results of Kovačević (2018) and Stojković Jovanović (2018). Also, this is completely consistent with the results of Wang *et al*. (2016). At 28 locations in California, these authors determined that the first peak numbers occurred at the same time as the beginning of fruit ripening, and the second later in the growing season on spontaneous plants (weeds). This implies that SWD migrates from orchards, and suggests that adjacent biotopes and biocenoses are not only alternative host sources but also very dangerous reservoirs of pest populations in the next spring for orchards and plantings (Briem *et al*., 2016).

The statistical analysis of the obtained data is shown in Table 2.

Table 2. The mean number of caught *Drosophila suzukii* specimens ($\bar{x} \pm Sd$) per trap across inspections

Trap type	*Date of inspection*					
	4 June	*12 June*	*22 June*	*2 July*	*11 July*	*31 July*
T1	16.17 ± 9.82	17.67 ± 10.58	31.0 ± 34.22	10.5 ± 11.76	2.67 ± 3.14	2.33 ± 3.09
T2	24,.7 ± 12.02	25.00 ± 12.58	33.00 ± 49.50	8.50 ± 8.10	10.00 ± 21.05	6.50 ± 7.07
T3	18.0 ± 11.46	27,83 ± 14,54	40.5 ± 39.35	12.67 ± 10.21	7.00 ± 12.18	7.67 ± 4.07
T4	31.33 ± 21.93	25.67 ± 16.01	35.67 ± 45.33	10.83 ± 9.25	5.67 ± 8.69	6.67 ± 12.71
S	53.85 ± 54.84	49.64 ± 50.16	33.42 ± 32.66	51.09 ± 64.07	43.21 ± 69.25	14.21 ± 17.78

The statistical analyses indicate very significant differences between trap S and trap T1 (F=1.93 and p=0.004**). Statistical differences were found between trap S and the other three trap types i.e. T2 (F=1.87 and p=0.12*), T3 (F=1.31 and p=0.022*) and T4 (F=1.29 and p=0.024*). The comparison of the four trap types (T1, T2, T3 and T4) showed no statistical differences in the average

number of specimens caught per trap. Practically, this indicates that regardless of the trap type used in SWD mass trapping, there were no significant differences in the number of specimens caught.

The statistical analysis of the average number of specimens caught per trap across inspections confirmed very significant differences between trap S and all other types (t=6.69; p=0.0011**), indicating that trap S was the most efficient trap type.

The comparison of the other types of traps for the same parameter (specimens caught per trap across inspections), T1 (t=3.04; p=0.0287*), T2 (t=3.99; p=0.0103*), T3 (t=3.55; p=0.0164*), and T4 (t=3.58; p=0.0158*), showed significant differences in the average number of specimens caught per inspection for the entire experimental period.

Evidently, agroenvironmental conditions influence the number of caught specimens (Tochen *et al*., 2014), as confirmed in this research. An increase in the number of caught specimens of *D. suzukii* is caused by lower air temperatures, high relative humidity and lower/lack of precipitation amounts. Population declines are due to higher temperatures, lower relative humidity and different precipitation amounts. Cultural practices, such as irrigation, pruning and maintenance of intra- and inter-row spacing, play an important role in increasing SWD populations (Tochen *et al*., 2014).

Conclusion

Based on monitoring, field sampling and laboratory research, the following conclusions were reached:
1. The highest efficiency in the number of caught insects, except in the third inspection (22 June 2017), was shown by the trap S (red wine + apple cider vinegar).
2. A total of 8.099 specimens were trapped in trap S. Trapping efficiency decreased to T4 (695 specimens), T3 (682 specimens), T2 (643 specimens) and T1 (482 specimens).
3. The highest average number of adults in the growing season was caught by attractant S (245.42 specimens per trap), followed by the attractants T4 (115.83), T3 (113.67) and T2 (107.16). The lowest overall efficiency was shown by attractant T1, with an average catch of 80.33 specimens per trap.

The results suggest that the most efficient trap was the standard trap, with 8 099 specimens caught (about 3.2 times more than the total catch for the other four traps). The findings indicate that attractant S (red wine + apple cider vinegar) can be recommended to farmers as highly efficient in mass trapping SWD in raspberry plantings.

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EFIKASNOST RAZLIČITIH TIPOVA KLOPKI U IZLOVU DROSOPHILA SUZUKII (DIPTERA, DROSOPHILIDAE) U ZASADU MALINE

Miloš Marjanović, Snežana Tanasković

Agronomski fakultet u Čačku, Cara Dušana 34,
32000 Čačak, Srbija

Rezime

Drosophila suzukii (Matsumura, 1931) je invazivna, izrazito polifagna štetočina poreklom iz jugoistočne Azije. Prvi dokumentovan i potvrđen nalaz u Srbiji potiče iz 2014. godine. Ekonomska značajnost ove vrste posledica je njene aktivnosti, jer je štetočina fiziološki zdravog i zrelog ploda. Cilj rada je bio da se ispita efikasnost različitih atraktanata u masovnom izlovu ove nove štetne vrste u zasadu maline. Za masovno izlovljavanje imaga *D. suzukii* korišćeno je pet različitih tipova klopki. Ogled je postavljen 27. maja 2017. godine, a terenski pregledi i prikupljanje uzoraka obavljani su na svakih 7 do 10 dana, od 4. juna do 31. jula 2017. godine. Analizom prikupljenih podataka sa terena utvrđeno je da je u masovnom izlovu najefikasnija klopka u tipu S, sa izlovljenih 8099 primeraka. Po efikasnosti izlovljenih imaga slede tipovi klopki, T4 (695), T3 (682), T2 (643) i kao najmanje efikasan tip T1 (482). Statistička analiza pokazuje da se tip klopke S veoma značajno razlikuje od tipa klopke T1, dok se od ostalih tipova klopki T2, T3 i T4 značajno razlikuje po prosečnom broju izlovljenih imaga. Između ostalih tipova klopki nije bilo značajne statističke razlike u broju izlovljenih imaga.

Ključne reči: *Drosophila suzukii,* atraktant, klopka, efikasnost, malina.