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Scientific Article

Effect of toxic baits on adult spotted-wing drosophila under laboratory conditions

Efeito de iscas tóxicas em adultos de drosófila da asa manchada em condições de laboratório

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ABSTRACT - *Drosophila suzukii* is an exotic pest identified in Brazil in 2013 that has the potential to cause quantitative and qualitative losses to small fruit crops. Its wide range of hosts and short life cycle combined with continuous fruit availability make its management challenging. Insecticide application is the main control strategy currently used; however, this control method is highly harmful to human health and the environment. The strategy of using toxic bait contributes to reductions in insecticide application in in terms of total area. Thus, this study aimed to assess the effect of toxic baits on adult *Drosophila suzukii* under laboratory conditions. Four bioassays with different treatments were conducted to test different ready-to-use toxic baits, as well as homemade and commercial bait formulations combined with insecticide. Twenty µL of each toxic bait were offered to 5 five-day-old pairs of *D. suzukii* for 2 hours. Adult mortality was assessed at 2, 4, 6, 8, 10, 12, 24, 48, 72, and 96 hours after exposure. All toxic baits caused mortality ranging from 10% to 65%. The toxic bait Droskidrink + 0.15% malathion + 0.3% sugar resulted in 65% adult mortality, denoting potential for evaluating the management of *D. suzukii* in semi-field and field studies.

Keywords: *Drosophila suzukii*. Integrated Pest Management. Attract -and-kill strategy. Semiochemicals.

RESUMO - *Drosophila suzukii* é uma praga exótica identificada no Brasil em 2013, que tem potencial para causar danos quantitativos e qualitativos em pequenas fruteiras. Devido à sua ampla gama de hospedeiros, disponibilidade contínua de frutos e ciclo de vida curto, seu manejo é desafiador. A principal estratégia de controle atualmente utilizada é o uso de inseticidas. No entanto, essa estratégia de controle é altamente prejudicial à saúde humana e ao meio ambiente. A estratégia de iscas tóxicas reduz a aplicação de inseticidas na área total. Assim, este trabalho teve como objetivo avaliar o efeito de iscas tóxicas em adultos de *Drosophila suzukii* em condições de laboratório. Foram realizados quatro bioensaios com diferentes tratamentos, onde foram testadas diferentes formulações de iscas de pronto uso, caseiras e comerciais, e suas combinações com inseticida. 20 µL de cada isca tóxica foram oferecidos a 5 casais de *D. suzukii* com 5 dias de idade por 2 horas. A mortalidade adulta foi avaliada 2, 4, 6, 8, 10, 12, 24, 48, 72 e 96 horas após a exposição. Todas as iscas tóxicas causaram mortalidade variando de 10 a 65%. A Droskidrink + 0,3% de açúcar + 0,15 malationa causou 65% de mortalidade de adultos, mostrando-se promissora para futuros estudos de campo e semi-campo para o manejo de *D. suzukii*.

Palavras-chave: *Drosophila suzukii*. Manejo Integrado de Pragas. Estratégia de atrair e matar. Semioquímicos.

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INTRODUCTION

The South region of Brazil stands out in the production of temperate fruit trees, where the presence of *Drosophila suzukii* (Matsumura, 1931) (Diptera: Drosophilidae) was detected in 2013 (DEPRÁ et al., 2014), raising the attention of researchers, technicians, and farmers due its high potential for damage. More than 30% losses in strawberry crops in the state of Rio Grande do Sul were recorded in 2014 due to *D. suzukii* infestation (SANTOS, 2014). Currently, the spotted-wing drosophila has been identified attacking many native fruits and commercial orchards in the South, Southeast, and Central-West regions of Brazil (SANTOS, 2014; SOUZA et al., 2017; FOPPA et al., 2018; WOLLMANN et al., 2020).

In contrast to other fly species in the family Drosophilidae, *D. suzukii* has a serrated ovipositor, which facilitates oviposition in healthy and soft-skinned fruits, causing qualitative and quantitative losses (GOODHUE et al., 2011). Phytosanitary management for controlling *D. suzukii* is challenging in Brazil due to the wide range of hosts, rapid and short life cycle of the species, and continuous fruit availability (WALSH et al., 2011). Additionally, a high variation in weather conditions in Brazil favor the rapid reproduction of this species.

Spraying organophosphates, spinosyns, and pyrethroids is the main management used for controlling adult *D. suzukii* in the United States (HAVILAND; BEERS, 2012), with some growers conducting calendar spray applications using non-selective insecticides (DIEPENBROCK et al., 2016). An economic threshold for *D. suzukii* has not yet been established in Brazil, where an active active ingredient (spinosad) is currently registered with the Brazilian Ministry of Agriculture, Livestock, and Supply for controlling this pest (SANTOS, 2014; BRASIL, 2023).

In general, pre-harvest insecticide applications are unfeasible for fruit production due to the maximum residue limits allowed for fruits (DIEPENBROCK et al., 2016; HAVILAND; BEERS, 2012). Spraying insecticides at approved rates before harvest often does not reduce infestation damage to fruits (GARGANI et al., 2013), as larvae are inside the fruits and difficult to be reached by insecticide molecules. Additionally, insecticides such as pyrethroids and organophosphates are harmful to pollinators and other beneficial insects, and their excessive use can contribute to the selection of resistant *D. suzukii* populations (CHAGNON et al., 2015; SMIRLE et al., 2017). In general, improper insecticide applications to the entire crop area can result in environmental contamination and harm to human health (CHAGNON et al., 2015). Therefore, the development of strategies for controlling *D. suzukii* acceptable in integrated management programs and organic fruit production systems is essential.

The use of toxic bait involves combining a food attractant with an insecticide. Considering a strategy of attracting and killing insects, the toxic bait should be locally applied over the orchard area by spraying coarse droplets directly on the three trunks or plant leaves (BOTTON et al., 2016). Consequently, toxic baits promote the selectivity of beneficial insects, in addition to reducing the quantity of applied insecticides, which contributes to the reduction of the risk of fruit and environmental contamination. Toxic baits can be ready-to-use, i.e., containing insecticides in their formulations, or they can be prepared on farms (BOTTON et al., 2016).

Currently, several ready-to-use products and homemade formulations for preparing toxic baits are used in Brazil for controlling fruit flies, especially those of the family Tephritidae (NUNES et al., 2019). However, available management methods and strategies for controlling the species *D. suzukii* are still limited in Brazil. In this context, the development of research studies under laboratory and field conditions is significantly important to evaluate the management and control of *D. suzukii* and provide information for growers. Therefore, this study aimed to assess the effects of ready-to-use and commercial and homemade formulations of toxic baits on adult *D. suzukii* under laboratory conditions.

MATERIAL AND METHODS

Drosophila suzukii rearing

The insects used in the bioassays were from a laboratory population of *D. suzukii* kept in plastic cages (28 × 28 × 28 cm) at a temperature of 25 ± 2 °C, relative humidity of 65 ± 10%, and 12-hour photophase. Insect culture began in March 2019 using *D. suzukii* pupae from the Entomology Laboratory at Embrapa Clima Temperado, Pelotas, RS, Brazil. Adults were fed an artificial diet based on corn meal (80 g), yeast (40 g), sugar (100 g), agar (8 g), propionic acid (3 mL), methylparaben (Nipagin) (8 mL, in a 10% alcohol dilution), and 1 L of distilled water, as recommended by Schlesener et al. (2018).

Toxic baits

The toxic baits tested in the bioassays are described in Table 1. Ready-to-use toxic baits used in Bioassay A were: Success® (Dow Agrosciences), containing spinosad; and Gelsura® (BASF), containing alpha-cypermethrin. Homemade formulations were also tested, with the addition of the insecticide malathion as the lethal agent. Therefore, toxic baits containing sugarcane molasses, Flyral®, Anamed®, Biofruit®, and 20% sugar solution with the addition of the insecticide malathion as the lethal agent were tested in Bioassay B. These baits (Biofruit®, sugarcane molasses, Flyral®, and Anamed®) were selected because they are widely used by fruit growers in Brazil for formulating toxic baits to control *Anastrepha fraterculus* and *Ceratitis capitata* (Diptera: Tephritidae), also serving as a positive control with broad insecticidal potential against *D. suzukii*. Spinosad was chosen because it is a reference active ingredient for total area application and formulation of toxic baits for controlling fruit flies of the family Tephritidae; it is also legally registered for *D. suzukii* control.

Table 1. Description of ready-to-use and homemade toxic bait formulations tested in mortality bioassays for adult *Drosophila suzukii* under laboratory conditions (25 ± 2 °C, relative humidity of 65 ± 10%, and 12-hour photophase).

Type	Bait	Dilution (%)	Active ingredient	Chemical Class	Concentration (a.i.)[1]
Read-to-use	Success®	40	Spinosad	Spinosyns	0.2 g
	Gelsura®	33	Alpha-cypermethrin	Pyrethroids	6.0 g
Homemade	Biofruit®	3	Malathion	Organophosphates	1.5 mL
	Sugarcane molasses	7			
	Flyral®	1.25			
	Sugar solution[2]	20			
	Anamed®				
Food attractant	Droskidrink	-	Malathion	Organophosphates	1.5 mL
	Suzukii Trap®	-			

[1]Active ingredient concentration in L^{-1} of water. [2] Refined white sugar (Caravelas®).

Two food attractants (Droskidrink and Suzukii Trap®) commonly used for field monitoring of *D. suzukii* were tested in Bioassay C for better understand the feeding preference of adult *D. suzukii*, including the addition of malathion as the lethal agent. Bioassay D involved the addition of 0.3% sugar to toxic baits for evaluating the potential increase in their attractiveness/phagostimulation to adult *D. suzukii*; thus, based on preliminary results about *D. suzukii* mortality, Success®, Biofruit®, sugarcane molasses, and Droskidrink were selected for Bioassay D, including the addition of malathion as the lethal agent.

Bioassays

Five-day-old male and female *D. suzukii* reared in laboratory were deprived of solid diet for 17 hours before bioassays; they were provided only with a 20% sugar solution soaked in cotton during this period (RICE; SHORT; LESKEY, 2017; ANDREAZZA et al., 2017). Each experimental unit consisted of screened cages made of transparent plastic containers (500 mL), with a hollow bottom covered by voile fabric and overturned onto a plastic lid (11 cm in diameter) lined with filter paper.

Five pairs of *D. suzukii* were released in each cage, where they received two drops (20 µL) of toxic bait placed on an acrylic film plate (1 cm^2) for 2 hours (ANDREAZZA et al., 2017). The toxic bait was removed after the exposure period and replaced with a 20% sugar solution soaked in cotton (RICE; SHORT; LESKEY, 2017). The cages with the flies were kept under laboratory conditions for up to five days after exposure. Adult mortality was assessed at 2, 4, 6, 8, 10, 12, 24, 48, 72, and 96 hours after exposure to the toxic bait. Insects showing no reaction to touch with fine-tipped bristle brushes were considered dead (ANDREAZZA et al., 2017).

The experimental design used was completely randomized, with 10 replications per treatment, totaling 100 adults per treatment; four different bioassays were conducted to test the toxic baits. The bioassays were performed under laboratory conditions with a temperature of 25 ± 2 °C, relative humidity of 65 ± 10%, and 12-hour photophase.

Data analysis

Adult *D. suzukii* mortality data were analyzed using generalized linear models (GLM) with a Binomial or quasi-Binomial model with a dispersion parameter. The factors treatment and time after exposure were considered in the model. Probit, Logit, and complementary log-log were tested as link functions. For the model selection, the Akaike's information criterion and diagnostic plots were used for model selection. The Kaplan-Meier survival plot was used to represent the mortality behavior.

The adult female mortality rate was determined by the quotient between the number of dead females and the total number of evaluated females. The comparison of the number of dead adults after 96 hours and female mortality rate was performed using the Normal model, followed by Tukey's test when the treatments presented significance. In this case, model assumptions were verified using Bartlett's test for homogeneity of variances, whereas half-normal plots with simulated envelopes were used for normality of residuals. All statistical analyses were conducted using the survival (THERNEAU, 2023), MASS (VENABLES; RIPLEY, 2002), multcomp (HOTHORN; BRETZ; WESTFALL, 2008), and hnp (MORAL; HINDE; DEMÉTRIO, 2017) packages, with the assistance of the program R (R CORE TEAM, 2019).

RESULTS AND DISCUSSION

Mortality times

All toxic baits caused mortality in adult *Drosophila suzukii* from two hours of exposure (Figure 1). Considering the total number of dead adults, 95% of mortality occurred within 12 hours after exposure. Ready-to-use toxic baits (Success® and Gelsura®) caused mortality within 12 and 24 hours after exposure, respectively (Figure 1). Toxic baits that can quickly cause mortality are desirable, as female *D. suzukii* can start laying eggs at two days of age, depending on weather conditions (CINI; IORIATTI; ANFORA, 2012).

Sugarcane molasses, Biofruit®, and 20% sugar solution, with the addition of 0.15% of the insecticide malathion, caused mortality within 72 hours after exposure, whereas Flyral® and Anamed® containing 0.15% malathion caused mortality within 48 hours after exposure (Figure 1B). The food attractants Droskidrink and Suzukii Trap® (recommended and used for monitoring *D. suzukii*) containing 0.15% malathion had a more rapid toxic effect, causing mortality within 6 hours after exposure (Figure 1C). This result may be related to the attractiveness of these baits.

Although all tested solutions (formulated or homemade) in all the different bioassays caused mortality in adult *D. suzukii* within periods ranging from 2 to 96 hours after exposure, the mortality rates were less than 55%. The lethal time ranged from 2 to 72 hours after exposure (Figure 1).

The the addition of 0.3% sugar to the toxic baits with sugarcane molasses and Biofruit® caused mortality only in the first 4 hours after exposure. The toxic baits with Success® (ready-to-use toxic bait) and Droskidrink (food attractant) caused mortality within 8 hours after exposure (Figure 1D). The addition of 0.3% sugar to the toxic baits with Success® and Droskidrink resulted in increases of up to 30% in mortality; however, adding 0.3% sugar to the toxic baits with sugar molasses and Biofruit® did not increase the mortality of adult *D. suzukii* (Figure 1D).

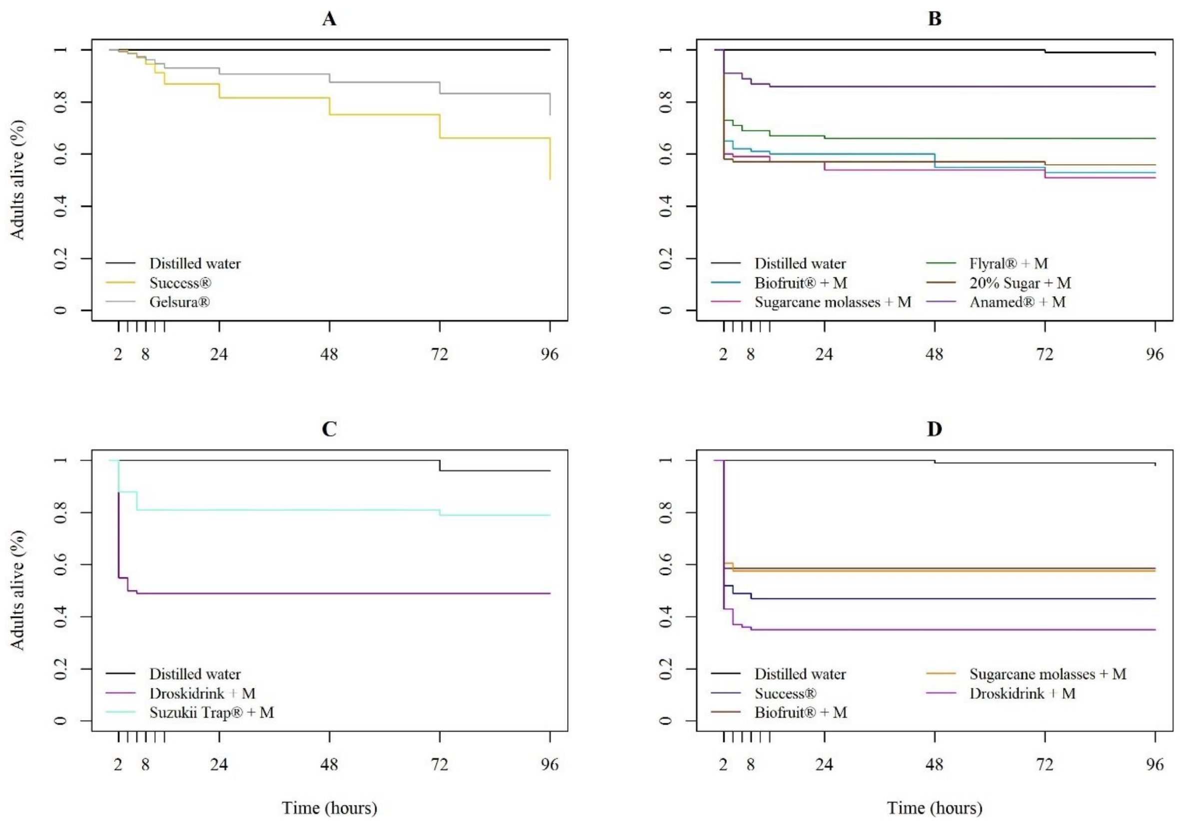

Figure 1. Kaplan-Meier survival curve for adult *Drosophila suzukii* at 2, 4, 6, 8, 10, 12, 24, 48, 72, and 96 hours after exposure to toxic baits in four bioassays (A, B, C, and D). + M = addition of 0.15% malathion.

Mortality of adult *Drosophila suzukii*

Considering the mortality caused by the tested toxic baits, the rates ranged from 10% (Gelsura®) to 65% (Droskidrink + 0.15% malathion + 0.3% sugar) (Table 2).

Success® resulted in higher mortality of adult *D. suzukii* (24%) in Bioassay A (ready-to-use toxic baits). Considering the formulations with the addition of 0.15% malathion (Bioassay B), the lowest mortality rate (14%) was found for the toxic bait with Anamed®, whereas the highest (49%) was found for sugarcane molasses, which did not differ significantly from the others (Table 2). Droskidrink resulted in a mortality of 52% in Bioassay C, whereas Suzukii Trap® resulted in 20% mortality (Table 2).

Adding 0.3% sugar to the toxic baits with Droskidrink and Success® caused mortality of 65% and 53%, respectively. However, only the toxic bait with Droskidrink differed significantly from the others tested in Bioassay D (Table 2). Sugarcane molasses and Biofruit® caused mortality of 43% and 42%, respectively, not differing significantly from the ready-to-use toxic bait Success®.

Bioassays C and D showed significantly different female mortality rates (Table 2). Considering Bioassay C, the mortality caused by the toxic bait Droskidrink + 0.15% malathion was higher than that caused by Suzukii Trap® + 0.15% malathion, but these mortality rates did not differ significantly. Regarding Bioassay D, the addition of sugar to Droskidrink + 0.15% malathion increased the mortality of adult female (Table 2); this may be attributed to the composition of the food attractant used (based on vinegar and wine), as sugar has an essential function in the fermentation of these compounds. This fermentation process enhances the release of volatile compounds, making the bait more attractive. However, Droskidrink + 0.15% malathion + 0.3% sugar differed significantly only from sugarcane molasses (7%) + 0.15% malathion + 0.3% sugar in Bioassay D (Table 2).

Some bioassays presented no significant difference in female mortality rate; however, the analysis of this parameter is significantly important, as endophytic oviposition causes initial damage to fruits. Rice, Short, and Leskey (2017) also found no significant difference in percentages of dead females of *D. suzukii* when testing toxic baits consisting of sugar solution and insecticides. The 95% mortality rate was found within the first 12 hours after exposing adult *D. suzukii* individuals to toxic baits. Considering control efficiency, mortality after the first hours of exposure and relative increases in mortality rate are desirable. The faster the action of the lethal agent, the lower the probability of females finding fruits and laying eggs in them.

The lethal agents spinosad (spinosine), alpha-cypermethrin (pyrethroid), and malathion (organophosphate) used at concentrations of 0.008%, 0.2%, and 0.15%, respectively, caused mortality in *D. suzukii* adults when ingested. Mortality caused by the ingestion of toxic baits containing these lethal agents were reported by Borges et al. (2015) in adult *Anastrepha fraterculus* (Diptera: Tephritidae), by Baronio et al. (2019) in adult *Ceratitis capitata* (Diptera: Tephritidae), and by Andreazza et al. (2017) in adult *D. suzukii*.

Table 2. Total adult mortality rate (M% ± SE) and female mortality rate (FM% ± SE) for *Drosophila suzukii* fed with toxic baits in different bioassays under laboratory conditions (25 ± 2 ºC, relative humidity of 65 ± 10%, and 12-hour photophase).

Treatment	M% ± SE	FM% ± SE
Bioassay A		
Control (distilled water)[1]	0±0	-
Success® 1:1.5	24±4 a	24±9[NS]
Gelsura® 1:2	10±3 b	17±8
p-value	<0.001	0.5457
Bioassay B		
Control (distilled water)[1]	1±1[1]	0±0 [NS]
Biofruit® 3% + 0.15% malathion	47±9 a	48±9
7% Sugarcane molasses + 0.15% malathion	49±8 a	46±9
1.25% Flyral® + 0.15% malathion	34±5 a	30±7
20% sugar solution + 0.15% malathion	44±5 a	40±6
Anamed® + 0.15% malathion	14±4 b	22±9
p-value	0.0004	0.2274
Bioassay C		
Control (distilled water)[1]	4±2 c	15±5 b
Droskidrink + 0.15% malathion	51±6 a	62±8 a
Suzukii Trap® + 0.15% malathion	21±9 b	37±13 a
p-value	<0.001	0.0175
Bioassay D		
Control (distilled water)[1]	2±1[1]	10±10 c
Success® + 0.3% sugar	53±4 ab	50±7 ab
3% Biofruit® + 0.15% malathion + 0.3% sugar	41±4 b	50±9 ab
7% sugarcane molasses + 0.15% malathion + 0.3% sugar	42±6 b	38±8 bc
Droskidrink + 0.15% malathion + 0.3% sugar	65±9 a	70±7 a
p-value	0.0059	0.0112

[1]Treatment excluded from the comparison for presenting low mortality. [NS] = not significant by the Tukey's test (p>0.05). Means followed by the same letter in the column are not significantly different from each other by the Tukey's test (p <0.05).

According to Andreazza et al. (2017), neonicotinoids, organophosphates, pyrethroids, spinosyns, tetranortriterpenoids, pyrroles, and diamides added to the food attractant Suzukii Trap® presented toxicity to *D. suzukii*, indicating a viable alternative to a sequential application. They found mortality up to 67% within 96 hours after exposing adult *D. suzukii* individuals to Suzukii Trap® + 0.2% malathion. Rice, Short, and Leskey (2017) reported a 100% mortality of adult *D. suzukii* within 24 hours after exposure to a toxic bait containing 1% spinosad. In the present study, the mortality rate caused by Suzukii Trap® + 0.15% malathion was 20%, whereas that caused by spinosad (Success®) was 24%, indicating that the lethal agent concentration may affect mortality rates or that these baits are not highly attractive to *D. suzukii.*

The toxic bait Droskidrink + 0.15% malathion + 0.3% sugar resulted in a mortality rate of 65%; however, assessing its toxicity to natural enemies, the environment, and human health should be considered. The active ingredients malathion and alpha-cypermethrin belong to the chemical groups of organophosphates and pyrethroids, respectively, and are non-selective and highly toxic to natural enemies and beneficial insects (LALAH et al., 2022). On the other hand, the active ingredient spinosad, which belongs to the chemical group of spinosyns, is selective to natural enemies and low toxic to mammals and the environment (WILLIAMS; VALLE; VIÑUELA, 2003).

Another factor that may have affected the obtained results is the route of exposure of insects to insecticides. Malathion and alpha-cypermethrin have contact and ingestion modes of action, whereas spinosyns act mainly through ingestion. The difference found in mortality rates caused by the ready-to-use toxic baits Success® and Gelsura® may be attributed to bait attractiveness, as both active ingredients (spinosad and apha-cypermethrin) act mainly through ingestion, with a mode of action on the insects' nervous system. Gelsura®, Biofruit®, and Flyral® are composed only of hydrolyzed proteins, whereas Success® is composed of proteins and sugars (BARONIO et al., 2019), and sugar may have a phagostimulant effect.

Although Success® may have a phagostimulant effect, Valtierra-de-Luis et al. (2019) found that the estimated LD_{50} of spinosad for adult *D. suzukii* is 2.927 ng of active ingredient per insect. In the present study, the spinosad concentration contained in the baits was higher, but it caused 50% mortality in adult *D. suzukii* only when sugar was added to the treatment. These results denote an insufficient phagostimulant effect of Success® to cause 50% mortality in adult *D. suzukii*.

The performance found for the toxic baits with sugarcane molasses and 20% sugar solution may be attributed to the presence of sugars, although they did not differ significantly from the other toxic baits tested in Bioassay B. These results reinforce the hypothesis that the performance of baits is more closely related to their phagostimulant effect (attractiveness) than to the lethal agent. This hypothesis is supported by the results found in Bioassay B, in which all baits contained 0.15% malathion, a molecule of the chemical group of organophosphates that acts on the nervous system. Despite the addition of 0.15% malathion, the bait with Anamed® (composed of plant extracts and waxes) caused only 14% mortality, denoting a lack of attractiveness of the components of the Anamed® formulation to adult *D. suzukii*. This toxic bait was tested in the present study focusing on assessing whether its application to the field for controlling *A. fraterculus* could also control *D. suzukii* in the meantime.

The mortality rate of adult *D. suzukii* exposed to Droskidrink (sugar, vinegar, and wine) + 0.15% malathion differed significantly from that found with Suzukii Trap® (organic acids and peptides) + 0.15% de malathion. Droskidrink and Suzukii Trap® contain organic acids in their compositions, but Droskidrink contains acetic acid from the mixture of vinegar and wine, which may have favored its attractiveness (phagostimulant effect). Studies have reported that adult *D. suzukii* is attracted to fermenting food substances, and the combination of vinegar and wine is more attractive than when used separately (LANDOLT et al., 2012). Additionally, the sugar content may also affect attractiveness, considering that *D. suzukii* is a fruit fly species (SANTOS et al., 2016).

According to Landolt et al. (2012), the addition of sugar can improve attractiveness to *D. suzukii*, as it contributes for the fermentation of the solution, releasing more volatile compounds such as acetoin, methanol, and ethanol, which induce olfactory responses in adult individuals. The addition of 0.3% sugar to the toxic baits Droskidrik + 0.15% malathion and Success® resulted in an increased mortality, reinforcing that the improved performance of baits is associated with the attractive and/or stimulating agent in their formulations. Cowles et al. (2015) reported that the addition of sugar (phagostimulant effect) to the lethal agent spinosad increased the mortality of adult *D. suzukii*, resulting in a 50% reduction in larval infestation on strawberries compared to plots treated only with the insecticide. The increased mortality of adult *D. suzukii* found by adding sugar to the toxic baits may be due to the behavior of Drosophilidae species, which are regulated by taste receptor neurons in their legs (THOMA et al., 2016), stimulating feeding when in contact with sweetened substance surfaces.

The addition of sugar to baits that already contain high sugar contents in their compositions does not result in increased mortality, as found for sugarcane molasses + 0.15% malathion. The combination of sugarcane molasses with an organophosphate insecticide is among the main homemade toxic bait formulations used in orchards for controlling *A. fraterculus* in the South region of Brazil (BOTTON et al., 2016). Therefore, further studies evaluating different sugar concentrations are necessary for determining the optimal sugar concentration for each bait. The addition of sugar to toxic baits has always been controversial regarding selectivity to natural enemies and pollinators. However, some studies have reported that adding low sugar concentrations to baits does not attract beneficial insects (PADILHA et al., 2019). Nevertheless, efforts should be directed toward the development of sustainable food attractants as alternatives to these harmful methods to protect both the environment and human health. In general, the commercial toxic baits tested in the present study are formulated and recommended for use in the integrated management of fruit flies from the family Tephritidae. Baronio et al. (2019) found that toxic baits composed of Biofruit® + malathion, Anamed® + malathion, Flyral® + malathion, sugarcane molasses + malathion, Gelsura®, and Success® caused mortality rates higher than 75% for adult *C. capitata* in laboratory assays. However, similar treatments under laboratory conditions resulted in mortality rates lower than 54% for adult *D. suzukii*. Thus, these results suggest that fruit flies from the family Drosophilidae have a different food preference compared to Tephritidae flies; additionally, others biological characteristics, such as pre-oviposition period, may have significant effects. Overall, adult flies of Drosophilidae species are attracted to odors of fermentation from yeasts and bacteria associated with plant materials, such as decomposing fruits (MARKOW; O'GRADY, 2008). Tephritidae flies prefer plant substances, proteins, secretions from other insects, and even animal manure (birds) (PROKOPY; ROITBERG, 1984).

Additionally, Nunes et al. (2020) reported that the effectiveness of toxic bait is also related to the origin of the insect population, formulation of the toxic bait and exposure time to it, period of food deprivation, and age of the insects. Thus, the development of further studies is important to evaluate different combinations of baits and lethal agents, as well as their combinations with phagostimulant products for the management of *D. suzukii* in small and large fruit crops.

CONCLUSION

All the evaluated toxic baits caused mortality ranging from 10% to 65% in adult *Drosophila suzukii.*

The addition of 0.3% sugar increased the mortality rates for the toxic baits containing Success® (from 24% to 53%) and Droskidrink + 0.15% malathion (from 51% to 65%).

The toxic bait containing Droskidrink + 0.15% malathion + 0.3% sugar resulted in 65% mortality of adult *D. suzukii* and 70% mortality of female *D. suzukii*.

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