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Visual stimulus brightness influences the efficiency of attractant-baited traps for catching *Drosophila suzukii* Matsumura (Diptera: Drosophilidae)

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Abstract

Drosophila suzukii (Matsumura) is an exotic pest of economic importance that affects several soft-skinned fruits in Mexico. Previously, we found that yellow or yellow-green rectangular cards inside a transparent trap baited with attractants improved *D. suzukii* capture. In this study, we evaluated the influence of rectangular cards with different yellow shades inside a transparent multi-hole trap baited with apple cider vinegar (ACV) on *D. suzukii* capture in the field. Second, we tested whether ACV-baited traps with cards of other geometric shapes affected *D. suzukii* catches compared to traps with rectangular cards. Third, we evaluated the effects of commercial lures combined with a more efficient visual stimulus from previous experiments on trapping *D. suzukii* flies. We found that ACV-baited traps plus a yellow-shaded rectangle card with 67% reflectance at a 549.74 nm dominant wavelength captured more flies than ACV-baited traps with yellow rectangle cards with a higher reflectance. Overall, ACV-baited traps with rectangles and squares caught more flies than did ACV-baited traps without visual stimuli. The traps baited with SuzukiiLURE-Max, ACV and Z-Kinol plus yellow rectangles caught 57, 70 and 101% more flies, respectively, than the traps baited with the lure but without a visual stimulus.

Introduction

Olfactory and visual cues function synergistically to increase insect attraction to host plants (Prokopy and Owens, 1983; Campbell and Borden, 2009; Wenninger *et al.*, 2009; Burger *et al.*, 2010). The host choice of the vinegar fly spotted-wing drosophila, *Drosophila suzukii* (Matsumara) (Diptera: Drosophilidae), could be affected by several stimuli associated with fruit ripening, including size, shape, colour, volatile profiles, skin firmness, sweetness and acidity (Lee *et al.*, 2011, 2015; Burrack *et al.*, 2013; Poyet *et al.*, 2015; Entling *et al.*, 2019; Little *et al.*, 2020). Some of these characteristics have been used to design lures and traps for monitoring both sexes of *D. suzukii* in the field (Lee *et al.*, 2011, 2016; Kirkpatrick *et al.*, 2016, 2018; Cha *et al.*, 2017, 2017; Cloonan *et al.*, 2018; Little *et al.*, 2019; Cruz-Esteban *et al.*, 2021a, 2021b).

The influence of colour on trapping *D. suzukii* is a disputable issue because published results are inconsistent and, in some cases, contradictory (Basoalto *et al.*, 2013; Lee *et al.*, 2013; Iglesias *et al.*, 2014; Renkema *et al.*, 2014; Kirkpatrick *et al.*, 2016; Rice *et al.*, 2016; Lasa *et al.*, 2017). For instance, Lee *et al.* (2013) reported that yellow traps hung in shady spots and spaced 2–3 m apart caught more *D. suzukii* flies than did clear traps. In contrast, Renkema *et al.* (2014) found that red and black traps captured more *D. suzukii* flies than did clear and yellow traps. However, a colour is determined not only by its hue (e.g. green, red, blue or yellow), but also by two additional perceptual colour dimensions: saturation (saturation/chroma) and brightness (light intensity) (Wyszecki and Stiles, 2000). Little *et al.* (2019) proposed that colour contrast, rather than colour appearance, might be of greater significance during the attraction of *D. suzukii* to host fruits. They concluded that differences in reflectance within opponent colour pairs promoted colour discrimination in *D. suzukii*. Colour contrast is defined as the perceptual contrast in the colour appearance of two objects (e.g. a flower and a green leaf) (van der Kooi and Spaethe, 2022). We previously determined that neither trap design nor trap colour had a significant influence on the attraction and capture of *D. suzukii* in cultivated berry fields (Cruz-Esteban *et al.*, 2021a, 2021b). In these studies, we found no significant differences in the capture of both sexes of *D. suzukii* by attractant-baited transparent, red or red-black traps. Furthermore, attractant-baited transparent traps with a rectangular yellow card inside as a visual stimulus captured more *D. suzukii* flies than transparent traps without visual stimulus (Cruz-Esteban, 2021). However, it is not yet known whether the reflectance of specific shades of yellow rectangular cards or geometric shapes affects the catches of *D. suzukii* flies using attractant-baited traps.

In this study, we evaluated the influence of rectangular cards with different yellow shades inside a transparent multi-hole trap baited with apple cider vinegar (ACV) on *D. suzukii* capture in the field. Second, we tested whether ACV-baited traps with cards of other geometric shapes affected *D. suzukii* catches compared to traps with rectangular cards. Third, we evaluated the effects of commercial lures combined with a more efficient visual stimulus from previous experiments on trapping *D. suzukii* flies.

Materials and methods

Field tests

Three field experiments were performed in blackberry crops covered with polytunnels in Tiripetio (19° 31′ 55″ N, 101° 22′ 10″ W) in the Municipality of Morelia, Michoacan, and in uncovered crops in Tacambaro of Codallos (19° 12′ 18.35″ N, 101° 26′ 52.44″ W), Michoacan. The first experiment was conducted in March 2021, the second in June 2021 and the third in October 2022. During the experiments, the crops exhibited fruits at different maturity levels.

Traps

Multi-hole transparent traps were used for the three field trials. The traps consisted of cylindrical plastic containers (14 cm high × 10.5 cm diameter) with flat lids (Plastics Adheribles del Bajío, León, Mexico). Approximately 50 holes (2.5 mm diameter) were distributed on the top and sides of the container to allow insect entry (Cruz-Esteban *et al*., 2021a).

Effect of yellow shades on trapping D. suzukii *flies*

In the first experiment, the effects of six different human yellow shades (hereafter yellow-1–yellow-6; see fig. S1; Cartulina Jiss Color Plus, Mexico) as visual stimuli on trapping *D. suzukii* flies were evaluated. We added a cardboard rectangle (5 × 8 cm) of one of the yellow shades to be evaluated inside each trap. All traps were baited with ACV (5% acetic acid; La Costeña, Ecatepec, Mexico) as an attractant and drowning solution. The spectral reflectance curves of the different yellow shades were measured using a spectrometer (USB4000-VIS-NIR, Ocean Optics, Dunedin, FL, USA) with an optical resolution of approximately 1.5 nm (full width at half maximum), a tungsten-halogen light source (LS-1, Ocean Optics) and a reflection probe (R200-7-VIS-NIR, Ocean Optics). Raw reflectance spectra were corrected for the dark current of the detector and normalised to the spectrum obtained from the light source reflected by a white reference standard. This figure was constructed using the reflectance value determined for each colour from 400 to 1000 nm.

Influence of geometric shapes on trapping D. suzukii *flies*

In the second experiment, we evaluated the influence of different geometric shapes, in contrast to a dark background, on *D. suzukii* catches (fig. S2). The geometric shapes were made of yellow cardboard, using the shade that presented the highest catches of *D. suzukii* flies in the first experiment. A dark green card (5 cm × 8 cm) was used as the background for the geometric shapes. The geometric shapes evaluated were circle (4 cm in diameter), half circle (4 cm in diameter), square (4 × 4 cm), rhombus (3 cm per side) and triangle (4 cm per side). A yellow-4 card (5 × 8 cm) without a green background was used as the positive control. Traps with yellow-4 shade showed the highest capture rate in the first experiment. All traps were baited with ACV. A trap without visual stimulus was used as the control.

Effect of lure type combined with a yellow rectangle on trapping D. suzukii *flies*

In this study, we evaluated the effect of commercial lures combined with a more efficient yellow shade rectangle from previous experiments on trapping *D. suzukii* flies. The first lure was Z-Kinol (Squid Biological and Pheromones S.A. de C.V., Mexico), which was formulated using acetoin, methionol, acetic acid and ethanol. The drowning solution consisted of 250 ml water containing odourless soap (0.5%). This lure is highly attractive to populations of *D. suzukii* in Mexico (Cruz-Esteban *et al*., 2021a). The second lure was SuzukiiLURE-Max (Dinusa, Oaxaca, Mexico), a liquid food bait composed of amino acids and fruit ferments. SuzukiiLURE-Max acted as attractant and drowning solution. ACV was used as a control. The three lures (Z-Kinol, SuzukiiLURE-Max, and ACV) were evaluated with and without a yellow card inside the traps.

Experimental design

The experimental design in all trials was a randomised complete block design, replicated in four blocks. Each block contained all treatments in each experiment. The blocks were arranged in parallel lines (transects) 30 m apart within blueberry fields. The traps were placed 1 m above the ground within each block between the plants, and the distance between the traps was 30 m. In all experiments, traps were inspected, emptied and rotated clockwise within the same block every 3 days, for 21 weeks. The drowning solution was adjusted to the initial volume after the traps were checked. Z-Kinol lures were not changed during the experimental period. The captured flies were taken to the Instituto de Ecologia A.C. (Patzcuaro, Michoacan, Mexico) for identification, sexing and counting. Species identification and sex differentiation were carried out based on the identification characteristics provided by the Collection of Insects Associated with Cultivated Plants of ECOSUR (Tapachula Unit) and Miller *et al*. (2017). Voucher specimens were deposited in the insect collection of ECOSUR and the Instituto de Ecologia A.C.

Statistical analysis

Data were analysed using the statistical software R version 4.3.1 (R Development Core Team, 2023). Catches by sex were compared using the χ^2 test with Yates correction using the DescTools package (Signorell *et al*., 2016). The captures/trap/day of *D. suzukii* flies were analysed using the linear mixed-effects model, with treatments and dates as fixed effects ($\alpha < 0.05$) and blocks as random effects. The models met the assumptions of normality and homoscedasticity. The nlme and effects packages were used (Fox and Weisberg, 2018; Pinheiro *et al.*, 2020). The means were separated using Tukey's test ($\alpha < 0.05$) with the agricolae package (De Mendiburu and Simon, 2015).

Results

Effect of yellow shades on trapping D. suzukii *flies*

The spectral reflectance patterns of the cards differed among the yellow shades (fig. 1). All shades had two reflectance peaks, one between 451 and 453 nm and another between 518 and 578 nm. Yellow-1 had an 88.39% reflection at 520.23 nm dominant wavelength, yellow-2 had 92.68% reflection at 530.34 nm dominant wavelength, yellow-3 had 88.38% reflection at 578.61 nm dominant wavelength, yellow-4 had 66.63% reflection at 549.74 nm dominant wavelength, yellow-5 had 91.05% reflection at 518.78 nm dominant wavelength and yellow-6 had 97.68% reflection at 518.78 nm dominant wavelength.

In this experiment, more *D. suzukii* females than males were captured in both study regions: 52.4% ($\chi^2 = 15.5$, $P < 0.001$) and 63.4% ($\chi^2 = 177.8$, $P < 0.001$) in Tiripetio and Tacambaro, respectively. In both study regions, the catch of *D. suzukii* was significantly affected by the treatment and date. The interaction between the treatment and date was also significant (table 1). In Tiripetio, ACV-baited traps with yellow-4 rectangular cards captured more *D. suzukii* than ACV-baited traps without visual stimuli. Catches in ACV-baited traps with other yellow shade cards were not significantly different from those in ACV-baited traps with yellow-4 cards or ACV-baited traps without cards (fig. 2a). In Tacambaro, ACV-baited traps with yellow-4 rectangular cards captured more *D. suzukii* than ACV-baited traps with other yellow cards or those without visual stimuli (fig. 2b). During the experiment, ACV-baited traps with yellow-4 cards had the highest capture on all monitoring dates in both the regions (fig. 3a, b). ACV-baited traps without visual stimuli had the lowest catches, except for Tacambaro, where ACV-baited traps with yellow-1 and yellow-5 cards had the lowest captures in the last 3 weeks (fig. 3a, b).

Influence of geometric shapes on trapping D. suzukii *flies*

In the second experiment, more *D. suzukii* females than males were captured in both study regions; in Tiripetio, 58.6% females and 41.4% males ($\chi^2 = 293.9$, $P < 0.001$), and in Tacambaro, 59.1% females and 40.9% males ($\chi^2 = 259.3$, $P < 0.001$). In both study regions, the catch of *D. suzukii* was significantly affected by the treatment and date. However, the interaction between the treatment and date was not significant (table 1). In Tiripetio, ACV-baited traps plus yellow rectangular cards or

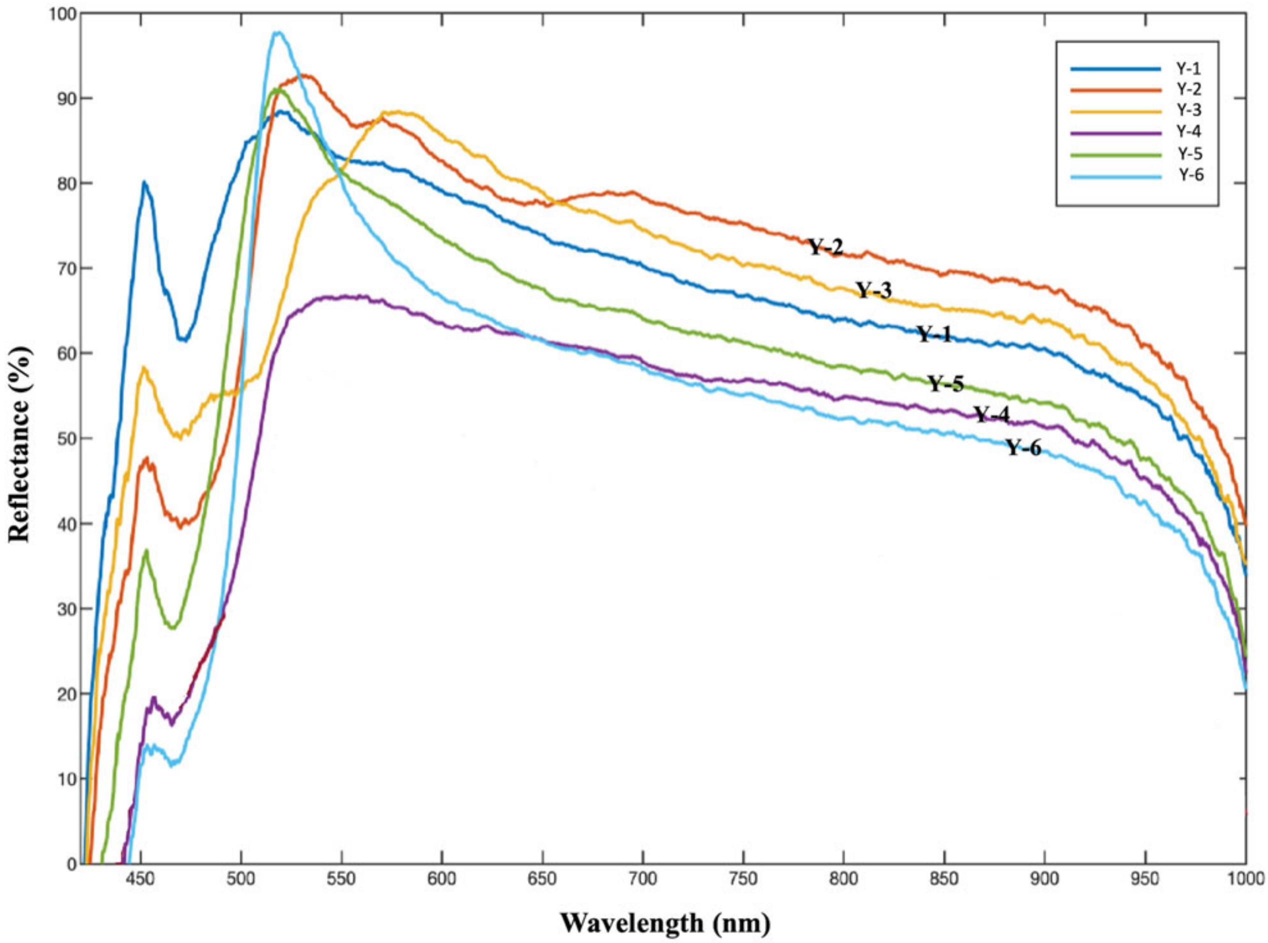

Figure 1. Spectral reflectance curves of different yellow shades used in the experiment of visual stimuli on trapping *D. suzukii* flies.

Table 1. Fitting linear mixed-effects model (LMMs) for the capture of drosophilids

	Tacámbaro			*Tiripitío*		
First experiment	*F*-value	df	*P*-value	*F*-value	df	*P*-value
Intercept	146.5	1, 123	<0.0001	2249.2	1, 165	<0.0001
Treatments	6.5	6, 123	<0.0001	3.8	6, 165	<0.0001
Dates	5.9	5, 123	<0.0001	7.9	7, 165	<0.0001
Treatments × date	3.8	30, 123	0.0261	1.6	42, 165	0.0222
Second experiment						
Intercept	568.9	1, 123	<0.0001	74.9	1, 144	<0.0001
Treatments	22.8	6, 123	<0.0001	0.9383	6, 144	0.4596
Dates	9.1	5, 123	<0.0001	12.1	6, 144	<0.0001
Treatments × date	0.34	30, 123	0.9994	0.7	36, 144	0.8647
Third experiment						
Intercept	4193.8	1, 123	<0.0001	4743.7	1, 123	<0.0001
Treatments	162.4	5, 123	<0.0001	170.6	5, 123	<0.0001
Dates	17.6	6, 123	<0.0001	16.4	6, 123	<0.0001
Treatments × date	5.4	30, 123	<0.0001	5.9	30, 123	<0.0001

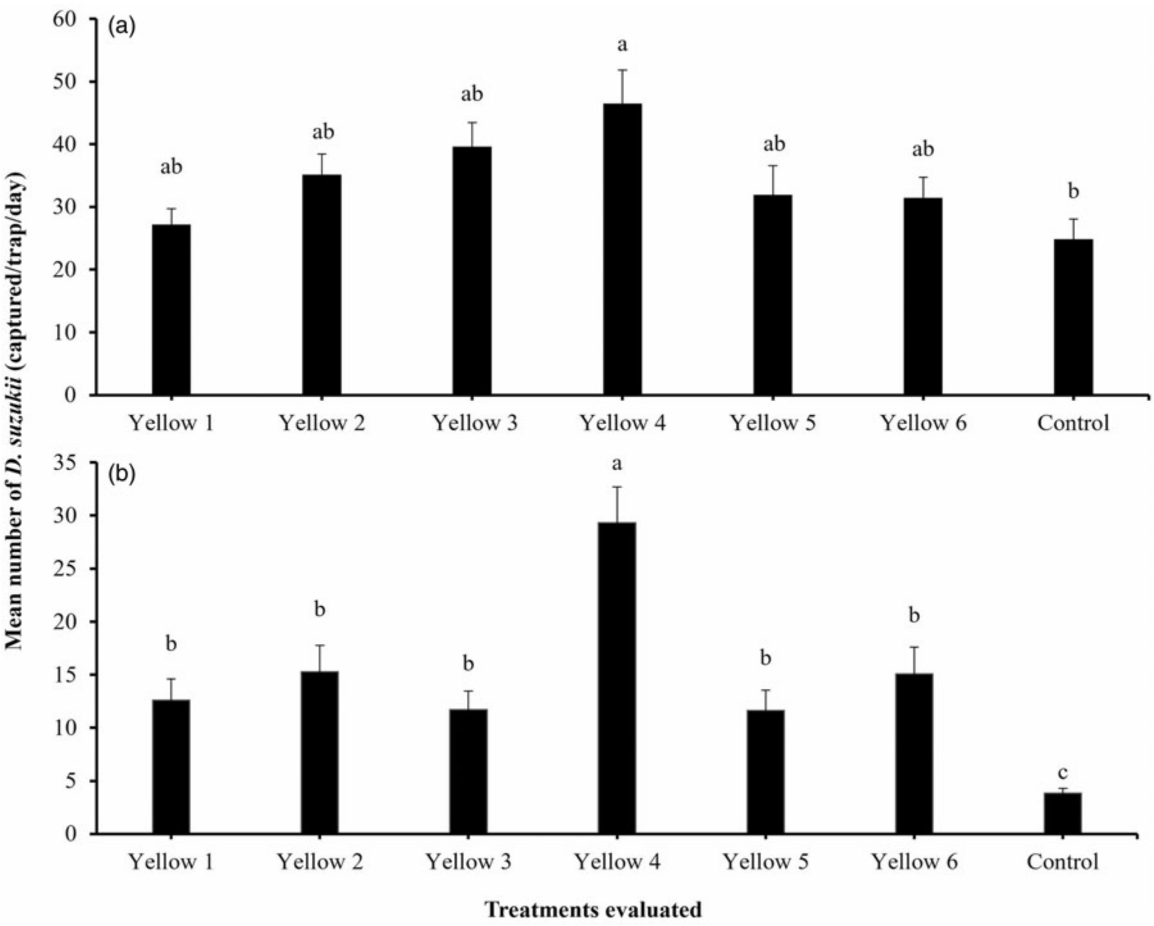

Figure 2. Mean number (±SE) of *D. suzukii* captured in the two regions evaluated with traps with visual stimuli of different yellow shades in its inside (yellow-1–yellow-6, see fig. S1). (a) Tiripetio, Michoacan, and (b) Tacambaro, Michoacan. The bars with the same letters are not significantly different (Tukey's test, α = 0.05).

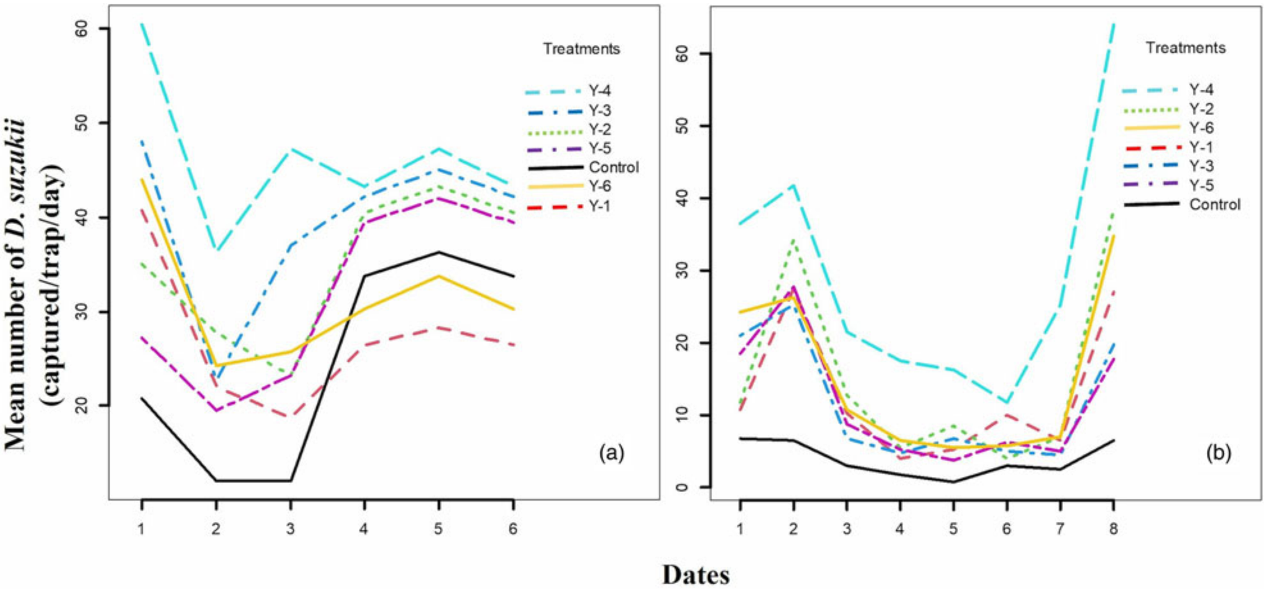

Figure 3. Interaction graph between treatment and date monitored in the captures of *D. suzukii* in both regions evaluated (yellow-1–yellow-6 = different yellow shades, see fig. S1). (a) Tiripetio, Michoacan, and (b) Tacambaro, Michoacan. 1 = March 8, 2 = March 11, 3 = March 14, 4 = March 17, 5 = March 20 and 6 = March 23, of the year 2021.

green cards with yellow square shapes caught more flies than ACV-baited traps without visual stimuli. The number of flies caught in ACV-baited traps with green cards plus yellow circular, half-circular, diamond or triangular shapes and ACV-baited traps without visual stimuli was not significantly different from each other (fig. 4a). In Tacambaro, ACV-baited traps plus rectangular yellow cards and green cards plus yellow square, diamond and triangular shapes captured more flies than ACV-baited traps with green cards plus yellow circular and half-circular shapes, and ACV-baited traps without visual stimuli. The number of flies captured in ACV-baited traps with green cards plus yellow circular and half-circular shapes and ACV-baited traps without visual stimuli was not significantly different from each other (fig. 4b). The highest catches of *D. suzukii* in both regions

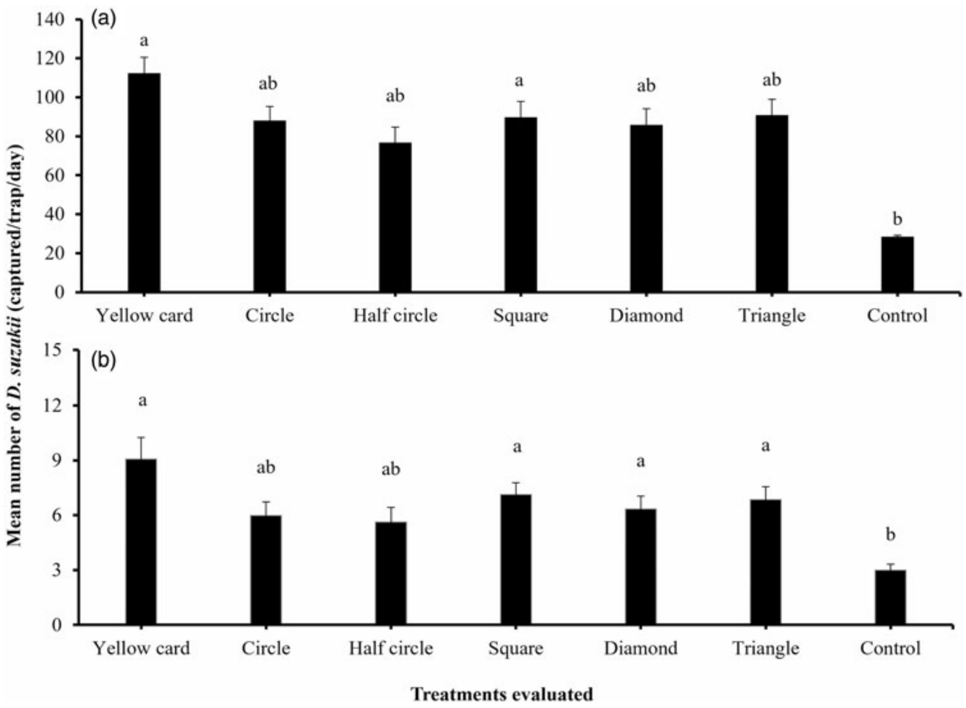

Figure 4. Mean number (±SE) of *D. suzukii* captured in the two regions assessed with traps with visual stimuli inside. Visual stimuli were geometric figures (yellow-4) in a single plane on a dark background (see fig. S2): (a) Tiripetio, Michoacán, and (b) Tacambaro, Michoacan. Bars with the same letters are not significantly different (Tukey test, $\alpha = 0.05$).

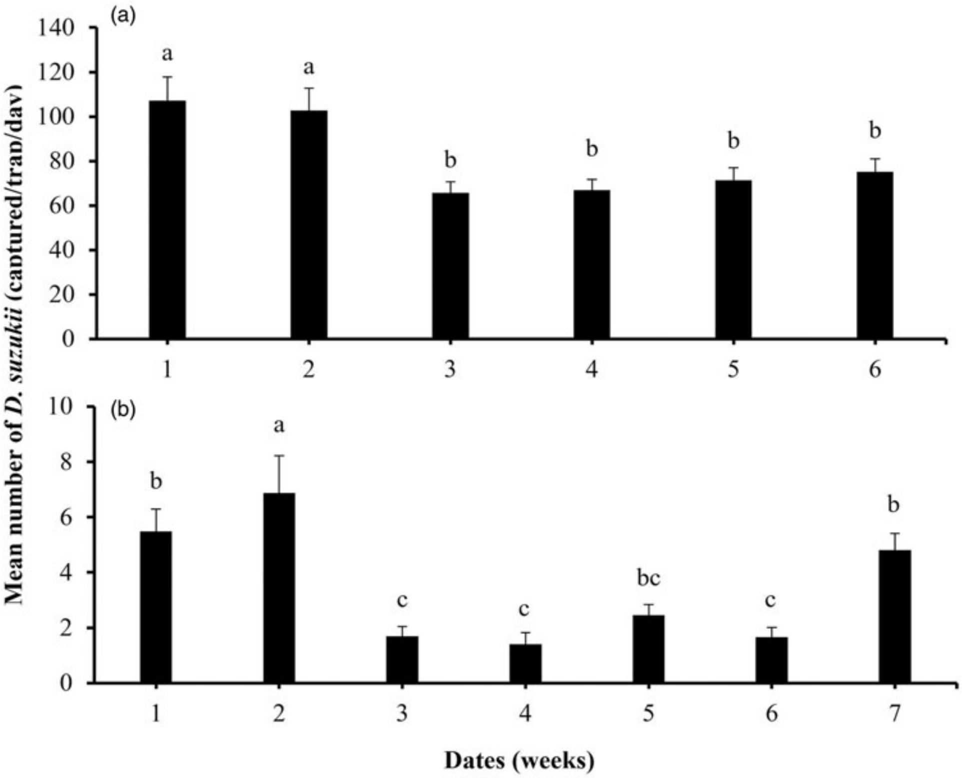

Figure 5. Mean number (±SE) of *D. suzukii* captured on the different monitoring dates in the two study regions bye traps with visual stimuli of geometric figures in a single plane on a dark background. (a) Tiripetio, Michoacan, and (b) Tacambaro, Michoacán. 1 = June 7, 2 = June 10, 3 = June 13, 4 = June 16, 5 = June 19 and 6 = June 22, of the year 2021. Bars with the same letters are not significantly different (Tukey test, α = 0.05).

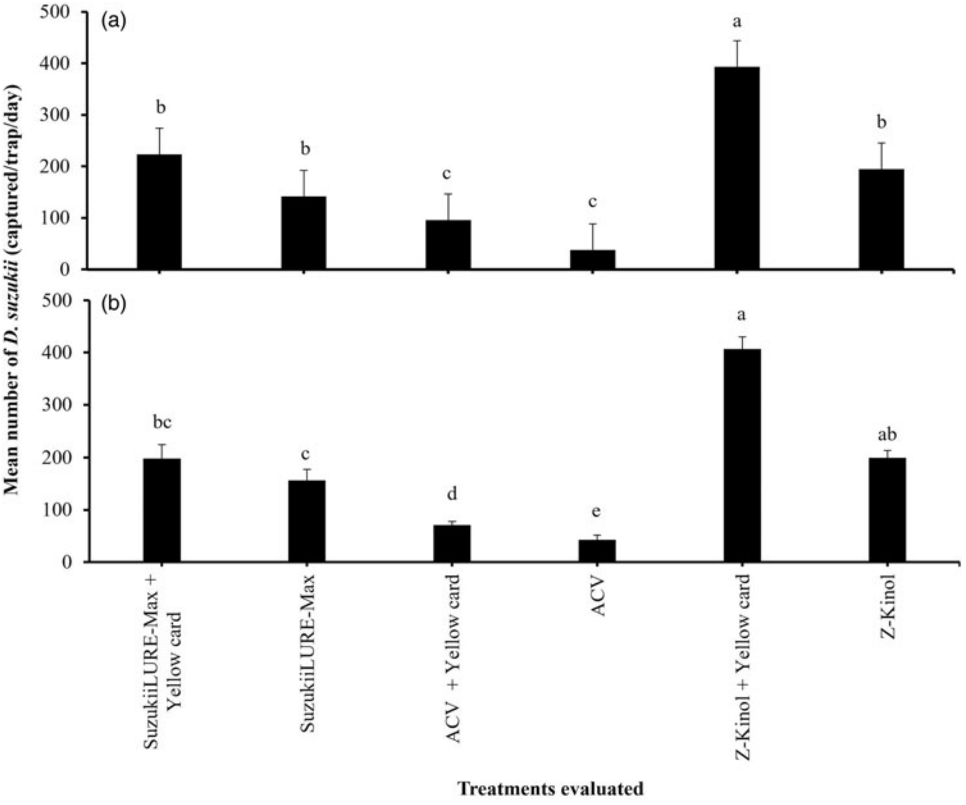

Figure 6. Mean number (±SE) of *D. suzukii* captured in the two regions assessed with traps bated commercial lures only and combined with a more efficient yellow shade rectangle from previous experiments on trapping flies. (a) Tiripetio, Michoacan, and (b) Tacambaro, Michoacan. Bars with the same letters are not significantly different (Tukey test, α = 0.05).

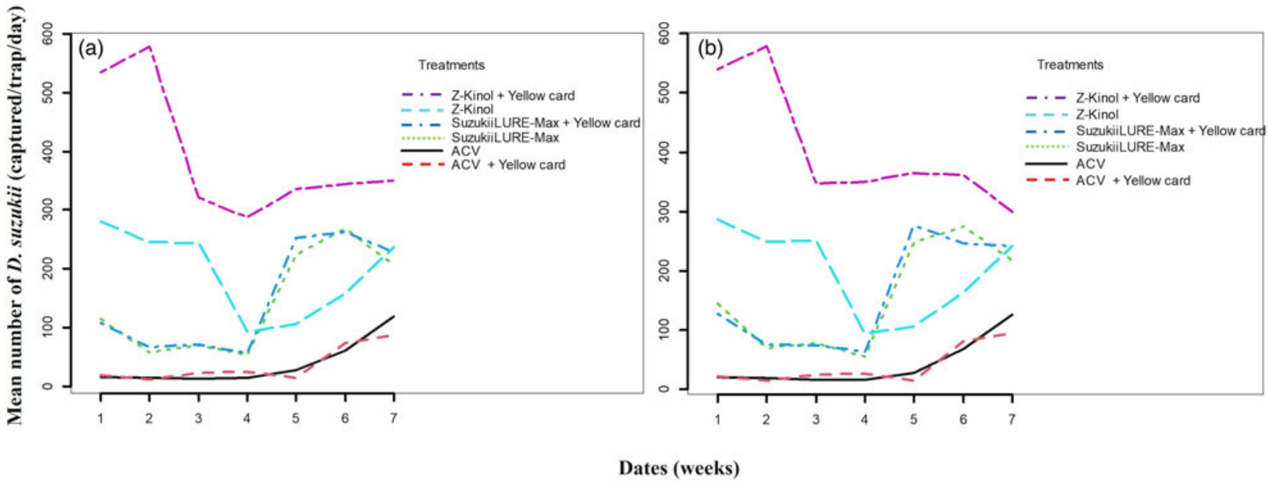

Figure 7. Interaction graph between treatment and date monitored in the captures of *D. suzukii* in both regions evaluated. (a) Tiripetio, Michoacan, and (b) Tacambaro, Michoacan. 1 = October 3, 2 = October 6, 3 = October 9, 4 = October 12, 5 = October 15 and 6 = October 18, of the year 2022.

occurred during the first 2 weeks of sampling. However, in Tacambaro, capture increased during the last week (fig. 5a, b).

Effect of lure type combined with a yellow card on trapping D. suzukii *flies*

In the third experiment, more female than male *D. suzukii* were captured in both study regions. In Tiripetio, 56.1% were females, and 43.9% were males ($\chi^2 = 350.8$, $P < 0.001$), and in Tacambaro, 55.5% were females, and 44.5% were males ($\chi^2 = 373.4$, $P < 0.001$). In both study regions, the catch of *D. suzukii* was significantly affected by the treatment and date. The interaction between the treatment and date was also significant (table 1). In both regions, traps baited with Z-Kinol plus a visual stimulus captured more flies than traps baited with the other two attractants, with or without visual stimulus (fig. 6a, b). Traps baited with SuzukiiLURE-Max plus a yellow card caught 57% more flies than traps baited with a lure but without a yellow card. Traps baited with ACV plus a yellow card caught 70% more flies than traps baited with ACV but without a yellow card. Traps baited with Z-Kinol plus a yellow card captured 101% more flies than traps baited with a lure but without a yellow card (fig. 6a, b). Overall, the highest capture of *D. suzukii* flies occurred during the first week of the experiment (fig. 7a, b).

Discussion

In this study, we found that the reflectance of the yellow card inside the transparent trap was a key factor affecting the capture of *D. suzukii*. Our results showed that yellow cards, with the lowest reflectance of all yellow shades tested, increased *D. suzukii* capture. However, the geometrical shape of the visual stimuli in contrasting green backgrounds does not seem to influence fly catches. We also found that the response of *D. suzukii* to visual cues is influenced by the type of lure used. Traps baited with Z-Kinol with a visual stimulus captured 101% more than traps baited with Z-Kinol alone. Traps with SuzukiiLURE-Max plus a visual cue caught 57% more flies than did those without visual cues. Traps with ACV and a visual stimulus caught 70% more than those without a visual stimulus.

Insect colour vision involves comparing the outputs of two or more photoreceptor classes that differ in their spectral sensitivity (van der Kooi *et al.*, 2021). Because photoreceptors often have overlapping sensitivity ranges, most wavelengths of light excite more than one class of photoreceptors, but to different degrees. Colour stimulus is estimated through opponent responses that measure arousal ratios between combinations of two or more photoreceptor classes (Skorupski and Chittka, 2011). Thus, initial colour vision depends on the number of photoreceptor classes, their spectral sensitivity and the opponent processing mechanisms exhibited by a given animal.

Visual detection of plants may involve the use of colour or other physical cues such as the size and shape of the hosts (Prokopy and Owens, 1983). Thus, insects can only be attracted to the colour or form of the host plant (Reeves, 2011). For example, field experiments have shown that visual cues alone are sufficient to attract the leaf beetle *Altica engstroemi* (J. Sahlberg) (Coleoptera: Chrysomelidae) when a choice between a bagged host plant and a bagged green dummy plant is presented (Stenberg and Ericson, 2007). However, attraction to visual cues generally occurs only with an appropriate olfactory stimulus (Parkes and Bruce, 1961; Björklund *et al.*, 2005). In the absence of wind, mature *Neoceratitis cyanescens* (Bezzi) (Diptera: Tephritidae) females mostly use visual cues to find a host fruit. Under wind conditions, fruit odour increases the likelihood and speed of finding a host (Brévault and Quilici, 2010). In a wind tunnel, when a visual model was offered without ACV, *Drosophila melanogaster* (Meigen) (Diptera: Drosophilidae) flies maintained an upwind flight but did not approach the visual model. However, the model became attractive to flies when AVC was released. Before landing, flies aligned themselves along the plume axis as they approached the visual model with the ACV, whereas their flight towards the model without odour was not directed along any specific axis (Saxena *et al.*, 2018). Visual cues can also induce landing on host plants. Hessian fly females, *Mayetolia destructor* (Say) (Diptera: Cecidomyiidae), landed more often on a target size of 8 × 8 cm than on smaller targets (Harris *et al.*, 1993). In choice tests, between bright orange spheres, mature *N. cyanescens* females landed more often on 7.5 cm diameter models than on the 3.7 and 1.9 cm diameter ones (Brévault and Quilici, 2007). Because our results were obtained from endpoint experiments, we did not know whether the flies were attracted to the colour, induced to land or both. However, we previously reported that unbaited coloured traps did not capture *D. suzukii* under field conditions (Cruz-Esteban *et al*., 2021a). Nevertheless, it is difficult to determine whether insects respond to chemical or visual cues at a distance or if catching is the result of short-range arrest in trapping experiments (Eigenbrode and Bernays, 1997). Further experiments should be performed using direct observations to investigate the response of *D. suzukii* to traps.

In our study, we found significant differences among the visual stimuli tested only in the open-field trial. Trap catches with yellow-4 visual stimuli were higher than those with the other evaluated yellow shades. In the crop under the tunnel trial, captures by traps with yellow-4 were only higher than those captured by traps without visual stimuli, but not by traps with other yellow shades. In the open field, sunlight fully penetrated the plants compared with polytunnel-protected cultivation, where sunlight penetration was obstructed. Thus, the amount of light reflected by the yellow cards varied from one experiment to another. In a natural setting, traps are subjected to a large variety of illumination conditions, owing to weather conditions, daylight cycles and landscape components that emit shadows (Domingues *et al*., 2022). For example, shadows from cherry leaves and branches in yellow traps influence the catches of *Rhagoletis cerasi* (L.) (Diptera: Tephritidae) (Daniel *et al*., 2014). Thus, the location of traps within a habitat can affect their performance (Ozanne, 2005). However, our results showed that the influence of the appropriate colour inside the traps for the capture of *D. suzukii* is important. Yudin *et al*. (1987) reported that insect colour perception is an important trait when optimising trap design.

Contrast is a key component of stimulus visibility, and single-colour traps rely on background contrast, which differs between crop growth and light environments (Dearden *et al*., 2023). In our results, the one-dimensional geometric shapes placed on the green cards inside the traps did not affect the capture of *D. suzukii* in the openfield culture and were protected with polytunnels. Therefore, the background contrast that the crop offers to the trap with a yellow card could be of greater importance. In previous research, Rice *et al*. (2016) found that flies did not exhibit a significant preference for different three-dimensional shapes without chemical stimuli, such as spheres, cubes, pyramids, inverted pyramids, vertical or horizontal cylinders. However, they did demonstrate a preference for traps due to their colours and sizes. On the other hand, the thrips *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) showed a preference for yellow colour in the form of one-dimensional circles against a dark background (Mainali and Lim, 2010). In a more recent study, *F. occidentalis* exhibited a preference for shades of blue and yellow, which have lower reflectance compared to its other tones. Nevertheless, this preference did not extend to geometric shapes of these colours when presented in one dimension and contrasting against dark backgrounds (Dearden *et al*., 2023).

The volatile chemical compounds emitted by plants are the main cues used by many phytophagous insects during their orientation towards host plants. Previous studies have identified compounds derived from fermentation such as acetoin, methionol, acetic acid and ethanol that have been highly attractive to *D. suzukii* flies in the field (Cha *et al*., 2014, 2015, 2017). Likewise, *D. suzukii* flies are attracted to fermented products such as hydrolysed proteins (SuzukiiTrap) and ACV (Cruz-Esteban *et al*., 2021a). In this study, Z-Kinol, a highly effective product developed based on the studies by Cha *et al*. (2014, 2015, 2017), and a SuzukiiLURE-Max hydrolysed protein made from fruit ferments were used. Both products were effective in attracting and capturing *D. suzukii*. However, SuzukiiLURE-Max, which acts as an attractant and drowning solution, decreases its attractive action after the first 2 weeks, which does not occur with Z-Kinol, which has a polyethylene releaser that allows a more controlled emission of volatile compounds. SuzukiiLURE-Max is not contained in a system that regulates the emission of attractive volatile compounds. Therefore, volatiles can easily evaporate and mix with the decomposition compounds from captured insects, which could interfere with the attractive effect of the SuzukiiLURE-Max bait (Hampton *et al*., 2014; Iglesias *et al*., 2014; Frewin *et al*., 2017).

The fact that *D. suzukii* flies were captured mostly by traps baited Z-Kinol and with a yellow card may be due first to the effective long-distance chemical attraction that the baits offered, and then to the low reflectance offered by the visual stimulus (66.63% reflection at 549.74 nm dominant wavelength) at a short distance. This result agrees with that reported by Little *et al*. (2020), who found that fruits that offered less reflectance were the most attractive to *D. suzukii* females in the laboratory.

For many insect pests, insecticide use can be reduced by using traps to monitor populations and ensure timely targeted intervention (Muvea *et al*., 2014; Sampson *et al*., 2021; van Tol *et al*., 2021). Similarly, traps can be deployed on a large scale for mass capture as an alternative or complementary control measure (Mouden *et al*., 2017; Reitz *et al*., 2020). Therefore, there is an urgent need to ensure that traps work as efficiently as possible for the monitoring and mass capture of insect pests (Dearden *et al*., 2023). Our results add to this effort by optimising an effective trap for monitoring and massive trapping of *D. suzukii* in berry crops.

In conclusion, our results show that a specific visual stimulus improves the attraction and capture of *D. suzukii* in blueberry crops. Bright yellow (yellow-4), which exhibited the lowest reflectance, proved to be the most suitable visual stimulus because it acted synergistically with the evaluated attractants. These findings are relevant for enhancing monitoring systems and mass capture of *D. suzukii* in berry crops.

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Competing interests. The authors declare that they have no conflict of interest.

Ethical standards. All applicable international, national and/or institutional guidelines for the care and use of animals were followed. All procedures performed in studies involving animals were in accordance with the ethical standards of the institution at which the studies were conducted.

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