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Oviposition deterrent as a component of a push–pull management approach for *Drosophila suzukii*

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Drosophila suzukii, spotted-wing drosophila, is a major pest of berries and cherries worldwide that attacks fruits at the ripening stage shortly before harvest. Recently, a mixture of octanoic acid and decanoic acid was developed as a 2-component oviposition deterrent (2c) as an alternative to spatial repellents for the behavioral control of spotted-wing drosophila infestation. In this study, we evaluated the efficacy of the oviposition deterrent as a "push" component in a spotted-wing drosophila push–pull, in combination with a previously identified 4-component spotted-wing drosophila attractant (4c) as the "pull", and compared the effect of push (2c), pull (4c), push–pull (2c + 4c), and control on spotted-wing drosophila oviposition in the laboratory and field. In both laboratory choice and no-choice bioassays using raspberry agar as an oviposition substrate, the pull treatment alone (4c) did not result in oviposition reduction. In contrast, both 2c and 2c + 4c resulted in a similar level of reduction in spotted-wing drosophila oviposition compared to control, indicating limited efficacy of the 4c as a pull as tested in this study. Similar results were also observed in the field, where fewer spotted-wing drosophila pupae emerged from raspberries from the 2c or 2c + 4c treated raspberries compared to untreated control, for both ripening field raspberries and store-bought sentinel raspberries. No significant difference in spotted-wing drosophila infestation was observed between control and 4c treatment. Our results suggest that an oviposition deterrent has a potential use as a push component in spotted-wing drosophila push–pull.

Keywords: spotted-wing drosophila, behavioral management, sprayable formulation, deterrent

Introduction

Drosophila suzukii, spotted-wing drosophila (SWD), is an invasive pest from Asia (Matsumura in 1931). Using its serrated ovipositor, it attacks healthy ripening stages of soft-skinned fruits, such as raspberry, blueberry, cherry, strawberry, apricot, plum, fig, or grape (Lee et al. 2011, Cini et al. 2012, Poyet et al. 2015, Kenis et al. 2016). Since it was first recorded in North America and Europe in 2008, it has invaded South America in 2013 and Africa in 2020 (Hauser 2011, Asplen et al. 2015, Tait et al. 2018, Boughdad et al. 2021, Kwadha et al. 2021), becoming a major pest of berries and cherries worldwide (Goodhue et al. 2011). Calendar-based application of insecticides such as spinosyns, pyrethroids, organophosphates, and diamides has been the major approach to manage SWD (Beers et al. 2011, Van Timmeren and Isaacs 2013, Diepenbrock et al. 2016). However, insecticide resistance has been reported in field populations of SWD in commercial berry production areas (Van Timmeren et al. 2018, Gress and Zalom 2019, Ganjisaffar et al. 2022, Deans and Hutchison 2022). Thus, there is a critical need to develop alternative management strategies for SWD (Cha et al. 2012, Wallingford et al. 2016, Cloonan et al. 2018, Tait et al. 2021).

Push–pull management is a behavioral manipulative management approach, which combines both antagonistic and agonistic stimuli to protect fruit by "pushing" target insects away from host fruit using a repellent, while "pulling" target pest away from the host using an attractant (Pyke et al. 1987). Agonistic sources such as attractive trap plant, pheromone, kairomone, or visual cues have been selected as a "pull" component, while antagonistic sources such as repellent plants, repellent volatiles, or antifeedants have been used as a "push" component (Prokopy 1968, Miller and Cowles 1990, Khan et al. 2000, Duraimurugan and Regupathy 2005). The majority of the repellent plants or volatiles so far tested act based on spatial repellency that induces an oriented movement of a target pest away from an area or a source that needs to be protected from the target pest (Deletre et al. 2016, Parker et al. 2016, Renkema et al. 2016). Thus, to be effective, maintaining the concentration of these volatile repellents at an effective concentration in the field is important (Renkema et al. 2017, Wallingford et al. 2018, Reher et al. 2019), although this has been often logistically challenging due to unpredictable local stochastic factors such as wind, temperature, pressure, and canopy structure (Reher et al. 2019). Moreover, when the repellent is highly volatile and requires a relatively high release rate to be effective, maintaining ambient concentration of the repellent at an effective level in the field has been shown especially challenging (eg Wallingford et al. 2018, Cha et al. 2021, Shrestha et al. 2024). This suggests that an oviposition deterrent that is not as highly volatile and more contact-based than spatially mediated repellents may be a useful alternative to overcome the disadvantage of using highly volatile spatial repellents as a push component.

As a first proof-of-concept study of this hypothesis, here we evaluated a 2-component oviposition deterrent (2c), shown effective at reducing SWD oviposition in raspberries in the laboratory and field (Roh et al. 2023), as an alternative spatial repellent in a SWD push–pull management system. These compounds are less volatile than some of the known SWD repellents tested in the field (eg 2-pentylfuran; Cha et al. 2021, Shrestha et al. 2024) and previous research with the Tephritid *Zeugodacus cucurbitae* indicates most of the efficacy occurs after contact rather than at a distance (Movva et al. 2025). Using the 2c as the "push" and the 4-component SWD lure (4c; Cha et al. 2014) as the "pull", we evaluated the effects of push (2c), pull (4c), and push–pull (2c + 4c combination) on SWD oviposition using (i) 2-choice, (ii) no-choice, and (iii) 4-choice assays in the laboratory or greenhouse with raspberry agar as an oviposition substrate, and (iv) 4-choice test in a raspberry field.

Material and Methods

Insects

The SWD adults used for the laboratory assays were from colonies maintained at USDA-ARS, Hilo, Hawaii, USA. The initial colony flies were originally reared out from strawberry guava fruit (*Psidium cattleyanum* Sabine) collected near Hilo, Hawaii in 2020 and, periodically supplemented with wild flies and were reared at 22.1 ± 1.9 °C, 71.7 ± 3.1% relative humidity (RH), 12 h:12 h (light:dark) on Drosophila medium (Carolina Biological Supply Co., Burlington, NC, USA) with brewer's yeast (ACH Foods, Ankeny, IA, USA). Laboratory trials were conducted using 7- to 10-d-old flies.

Chemicals

Octanoic acid ($C_{8:0}$) and decanoic acid ($C_{10:0}$) (both ≥98% purity) were purchased from Sigma-Aldrich (St. Louis, MO, USA) to formulate 2c as described in Roh et al. (2023). $C_{8:0}$ and $C_{10:0}$ were mixed at a ratio of 6.9:7.3 and diluted in ethanol (Pharmco, HPLC grade, 200 proof) at 2 mg of 2c mixture/200 µl ethanol, which was effective at reducing SWD oviposition in raspberries (Roh et al. 2023). Acetic acid (≥99% purity), acetoin (≥95% purity), and methionol (≥98% purity) were purchased from Sigma-Aldrich (St. Louis, MO, USA) to formulate 4-component SWD lure composed of acetoin, methionol, acetic acid, and ethanol (4c-lure; Cha et al. 2014).

Laboratory Bioassays

Two-Choice Bioassay

A series of 2-choice bioassays were conducted in different combinations of treatments as follows: (i) control vs. push, (ii) control vs. pull, (iii) control vs. push–pull, (iv) push vs. pull, (v) push vs. push–pull, and (vi) pull vs. push–pull at USDA-ARS, Hilo, Hawaii, using raspberry agar (0.75%) as an oviposition substrate (Roh et al. 2023). Choice tests were conducted in screened cages (30 × 30 × 30 cm (W × L × H); shop.bugdorm.com) with 30 female and 10 male SWD (7 to 10 d old) per cage with each cage provided with water on a cotton ball in an environmentally controlled room (22.1 ± 1.9 °C, 71.7 ± 3.1% RH). In each cage, 2 raspberry agar plates treated with 1 of the 6 treatment combinations above were placed 17 cm apart from each other (Fig. 1A). Raspberry agar plates were Petri dishes (60 × 15 mm) filled with 10 ml of 0.75% agar (Sigma-Aldrich) mixed in raspberry juice (50 ml) prepared by hand straining fresh, ripe raspberries through a layer of fine mesh to separate the juice from the pulp and seeds. Depending on the treatments, the agar plates were either surface-treated with 200 µl of ethanol (control), with 200 µl of 2c blend (push treatment), with 200 µl of ethanol plus a beaker trap baited with 4c-lure (pull treatment), or with 200 µl of 2c-blend plus a beaker trap baited with 4c-lure (push–pull treatment). Each beaker trap consisted of a 100 ml glass beaker covered with aluminum foil with a cut centrifuge vial (0.7 cm diameter) inserted at the center to facilitate the entry of the flies and restrict flies from escaping. Each trap was baited with the 4c-lure. For 4c, acetoin and methionol was released from a 4 ml polypropylene vial with a 3 mm hole in the vial cap, loaded with 1 ml of neat 1:1 mixture of acetoin and methionol. Acetic acid and ethanol were released from 10 ml of drowning solution with 1.6% acetic acid and 7.2% ethanol with 0.0125% of unscented soap (Cha et al. 2014). After 15 h, the number of eggs on the raspberry agar surface were gently separated and counted under a microscope and the number of flies in beaker traps baited with 4c-lure were also counted and sexed. Each experiment was replicated 5 times.

No-choice Bioassay

The effect of control, push, pull, and push–pull treatment on SWD oviposition in raspberry agar was also evaluated using no-choice bioassays. The experimental setup was identical to the 2-choice cage bioassay described above, except that only 1 treatment was placed inside the cage depending on the treatment tested. The experiment was replicated 5 times.

Laboratory Push–Pull Test Using Raspberry Agar

The effect of control, push, pull, and push–pull treatments on SWD oviposition in raspberry agar was compared with all 4 treatments randomly placed in a larger arena (Fig. 1B; 60 × 60 × 60 cm (W × L × H); shop.bugdorm.com). Each treatment was prepared as described above. For each arena, 60 female and 30 male SWD of 7 to 10-d-old flies were tested. The experiment was replicated 4 times.

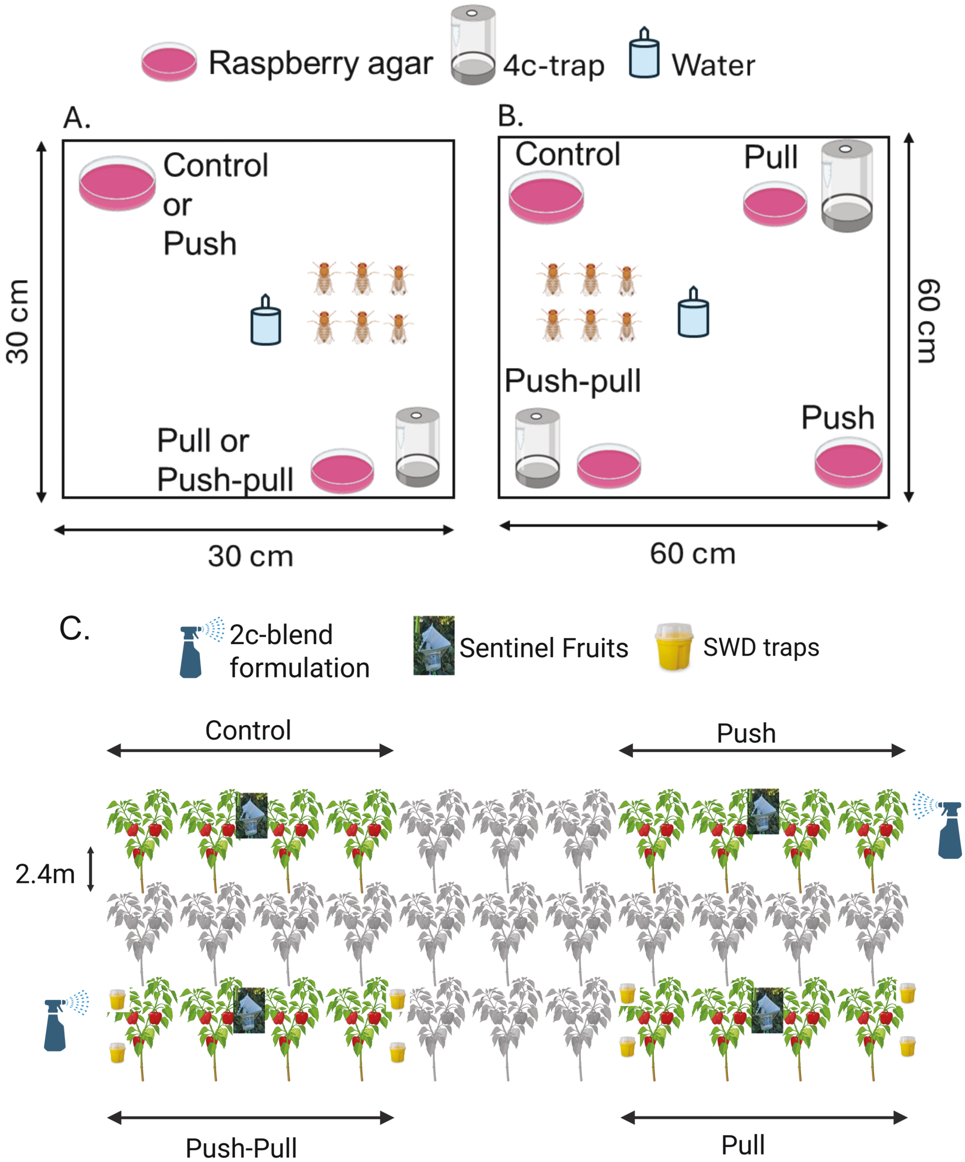

Fig. 1. Diagram of experimental setup for: A) 2-choice bioassay using 30 × 30 × 30 cm (W × L × H) cages, B) 4-choice push–pull bioassay using 60 × 60 × 60 cm (W × L × H) cages in the laboratory, and C) experimental setup for the push–pull experiment in the raspberry field. Control: raspberry agar treated with solvent (ethanol); Push: raspberry agar treated with the oviposition deterrent; Pull: raspberry agar treated with solvent plus gated trap baited with the 4-component spotted-wing drosophila lure (4c-trap); Push–pull: raspberry agar treated with the oviposition deterrent plus the 4c-trap. The figure created with BioRender.com, accessed on April 16, 2025.

Field Trial

Field experiments were carried out to evaluate the effect of a "push–pull" strategy on SWD infestation in raspberries, using 6 raspberry microplots established at Cornell AgriTech, Geneva, New York. Each raspberry plot was separated at least by 0.5 km and considered as a replicate in a randomized block design. Briefly, each plot had three rows (7 m each) of raspberries with 11 raspberry plants in each row with 2.4 m spacing between the rows. The plantings were established in 2018 and the field trial was conducted in August 2023 during high levels of SWD infestations in the area. Within each plot, each corner of the first and third rows were selected for 1 of the 4 treatments (see below), leaving the middle row and middle parts of the first and third rows as an untreated buffer zone. The 3 to 4 plants at each of 4 corners in each plot (both ends of first and third rows) were selected and randomly assigned to 1 of the 4 treatments: control, push, pull, and push–pull. From the selected plants at each corner, 5 fruiting canes were selected 1 wk before the trial. After all ripe berries were removed from the selected fruiting canes, remaining green berries on the canes were enclosed in fine mesh bags (Trimaco, Inc., Morrisville, NC, USA), which were sealed around the cane with a twist tie to avoid infestation by resident SWD. The mesh bags were removed just before the application of treatments on the day of the experiment.

For the "push" treatment, the 2c oviposition deterrent blend was mixed in food grade coating "Endura-Fresh 9000" (JBT, Florida, USA) at the final concentration of 2 mg of 2c in 200 µl of the coating as an experimental sprayable formulation and sprayed on the fruiting cane at a rate of approximately 20 ml/cane (ie 200 mg of 2c/cane). For the "pull" treatment, 4 commercial SWD traps (Scentry Biologicals, Billings, MT, USA) baited with Scentry SWD lures (same compounds as 4c used above) were hung near the 3 to 4 selected corner plants (2 traps hung at 1.3 m height and 2 traps at 0.6 m height on trellis at the right and left end of 3 to 4 selected plants zone). For "push–pull" treatment, the raspberry fruiting canes were sprayed with the 2c-blend formulation as described for the "push" treatment and 4 SWD traps deployed around the raspberry plants as described for "pull" treatment. Our preliminary assays with Endura-Fresh 9000 showed no effect on SWD oviposition in the laboratory when compared to ethanol control using raspberry agar (Endura-fresh: 27.4 ± 0.75 eggs/agar; control: 25.8 ± 2.53 eggs/agar; $F_{1,4}$ = 0.24, P = 0.6495). Hence, "control" and "pull" treatments were not sprayed with the food coating. Also, no blank traps were deployed around the plants in "control" and "push" treatments. Two days after treatments were applied, previously bagged ripe raspberries from the experimental canes were harvested, transferred to the laboratory, and held in rearing containers with 1% water agar media in walk-in growth chamber (25 °C, 55% RH, 16:8 L:D) over 6 d until the total number of pupae were counted. Also, the total number of male and female adult SWD captured in Scentry traps were counted after 2 d of treatment in the field.

The effects of push and/or pull treatments were also tested using sentinel raspberry fruits simultaneously during the above-described field experiments. Store-bought organic raspberries were placed in a deli cup container (473 ml; 5 raspberries/container) filled with 50 ml of 1% water agar media. One deli container with sentinel raspberries was hung at 1.3 m height per treatment, on a bamboo stick staked in the middle part of the 3 to 4 selected raspberry plants from each corner that were randomly assigned to control, pull, push, or push–pull treatment. Small holes (1 cm diameter, 8 to 10 holes) were perforated around the deli cup to allow SWD access to sentinel raspberries. The sentinel raspberries used in the push or push–pull treatments were coated with 200 µl of the 2c-blend formulation, consistent with the "push" treatment. Sentinel berries for control and pull treatments did not get any coating. Sentinel raspberries were collected 1 d after treatments and returned to the laboratory and held in rearing containers in walk-in growth chamber (25 °C, 55% RH, 16:8 L:D) over 6 d for pupation. Number of SWD pupae was determined as described above.

Statistical Analysis

Differences in the numbers of eggs, pupae, or flies from various treatments in laboratory assays and field experiments were analyzed using a generalized linear mixed model in a randomized block design, using a Poisson distribution with log link function and maximum likelihood estimation. Different push–pull treatments were considered as a fixed factor, while block (replication) was a random factor. Treatment means were compared using Tukey–Kramer test (Proc Glimmix, SAS Studio).

Results

Evaluation of Push and Pull in 2-choice Bioassays

In 2-choice bioassays, using oviposition deterrent (2c) as a "push" component was effective at reducing SWD oviposition on raspberry agar. Numbers of SWD eggs on raspberry agar were significantly reduced by the push treatment compared with the control ($F_{1,4}$ = 19.52, P = 0.0115; Fig. 2A). However, using the 4-component SWD lure (4c) as a "pull" did not result in reduced SWD oviposition compared to control ($F_{1,4}$ = 0.21, P = 0.6702; Fig. 2B). Further tests showed that the combination of push and pull treatment resulted in significant reduction in SWD oviposition than control ($F_{1,4}$ = 21.08, P = 0.0101; Fig. 2C). The effect of push–pull treatment appeared to be mostly derived by the effect of the push treatment. When the push and pull were compared, raspberry agar treated with the push treatment had significantly fewer SWD eggs than raspberry agar treated with the pull treatment ($F_{1,4}$ = 16.87, P = 0.0148, Fig. 2D). There was

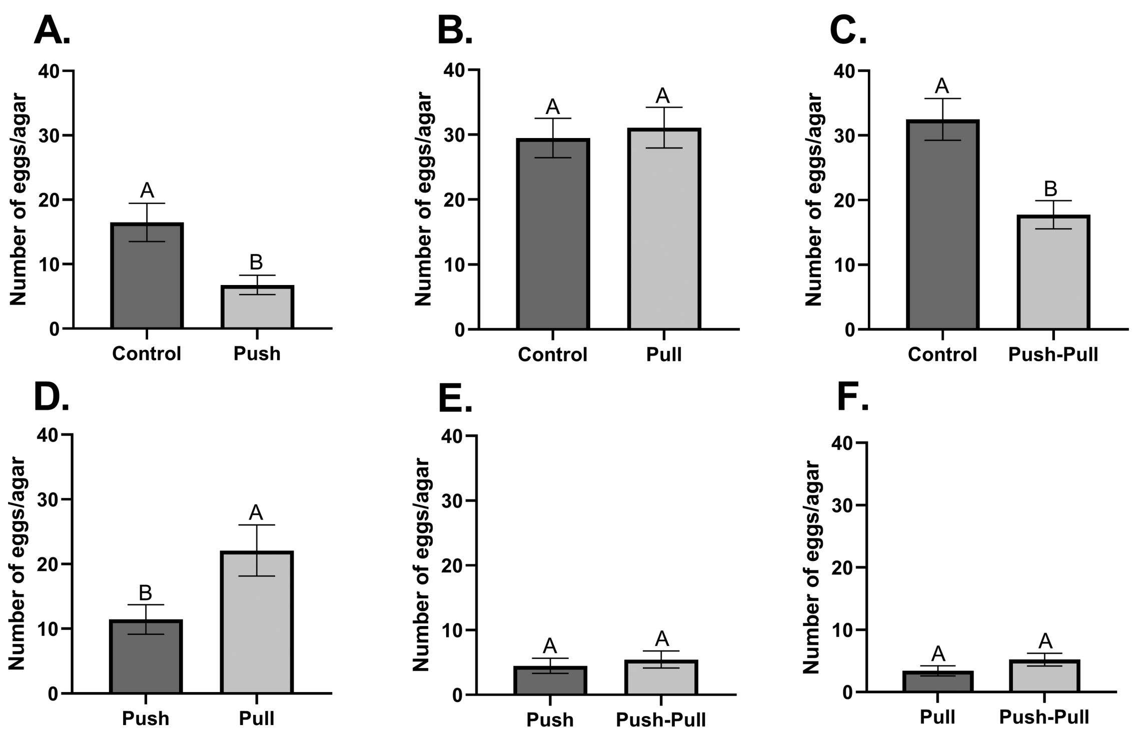

Fig. 2. Comparison of number (mean ± SEM) of *Drosophila suzukii* eggs oviposited on raspberry agar in laboratory 2-choice tests using 2c as a "push" and 4-component SWD lure as a "pull": A) Control vs push, B) control vs pull, C) control vs push–pull, D) push vs pull, E) push vs push–pull and F) pull vs push–pull. For each test, different letters on the bars indicate significant differences by Tukey–Kramer tests at P < 0.05, N = 5.

no significant difference in SWD oviposition between the push and push–pull treatments ($F_{1,4} = 0.49$, $P = 0.5231$, Fig. 2E). No significant difference in SWD oviposition was observed between the pull and push–pull treatments ($F_{1,4} = 1.86$, $P = 0.2448$, Fig. 2F). In the above-described tests, the 4c traps in the pull or push–pull treatments captured a varying range of released female SWDs (captured 60.0% of released female SWD when used as a part of pull treatment, Fig. 2B; 34.0% in push–pull, Fig. 2C; 14% in pull, Fig. 2D; 29.3% in push–pull, Fig. 2E; 9.1% in pull and 5.8% in push–pull, Fig. 2F).

Evaluation of Push and Pull Component in No-choice Bioassays

In no-choice bioassays, numbers of SWD oviposition on raspberry agars treated with the push or push–pull treatment were significantly lower than numbers of eggs oviposited on agars treated with control or the pull treatment ($F_{3,12} = 28.42$, $P < 0.0001$; Fig. 3). Push and push–pull treatments resulted in similar reductions in SWD oviposition compared to control, with 65.5% and 74.0% oviposition reduction from the push and push–pull treatment, respectively, despite the fact that the 4c traps in push–pull treatment captured 57% and 28% of female and male *D. suzukii* released in the cage. The lack of significant effect of pull treatment was also observed in the no-choice test. There were no significant differences in SWD oviposition between control vs. pull treatment, although the 4c traps in the pull treatment captured 58.0% and 42.0% of female and male SWD, respectively.

Evaluation of Push and Pull Components in 4-choice Laboratory Bioassays

The results from the 4-choice bioassay among control, push, pull, and push–pull treatments were similar to the results from the no-choice assay. Both the push and push–pull treatments resulted in significant, similar level of reduction in SWD oviposition on raspberry agar, while the pull treatment did not result in oviposition reduction ($F_{3,9} = 18.93$, $P = 0.0003$, Fig. 4). The 4c traps in pull and push–pull treatments captured 26.6% and 43.3% of released SWD females, respectively.

Field Evaluation of Push and Pull Components in the Raspberry Field

Similar to laboratory results, using the 2c as a "push" component of the push–pull strategy was effective at reducing SWD infestation in both the natural and sentinel raspberries in the field (natural raspberry: $F_{3,15} = 13.54$, $P = 0.0002$, Fig. 5A; sentinel raspberries: $F_{3,15} = 9.72$, $P = 0.0008$, Fig. 5B). Numbers of SWD pupae reared out from previously bagged, field grown raspberry fruits were 53.9% and 36.0% lower under the push and push–pull treatments, respectively, compared to control. However, there was no significant difference between the number of SWD pupae emerged from the raspberries treated with the pull treatment and the number of pupae from the control raspberries (Fig. 5A). Similar to field grown raspberries, both push and push–pull treatments significantly reduced SWD infestation in sentinel raspberries. Numbers of SWD pupae emerged from sentinel berries were 79.5% and 70.9% lower in the push and push–pull treatments, respectively, compared to sentinel fruits from control plots. In terms of number of SWD captured in Scentry traps deployed in the pull and push–pull plots, the traps in the push–pull plots captured twice the number of SWD (males: 119.6 ± 25.3 flies/trap; females: 114.0 ± 7.4 flies/trap) than the traps in the pull plots (males: 53.8 ± 13.7 flies/trap; females: 57.8 ± 5.8 flies/trap; SWD males: $F_{1,5} = 142.18$, $P < 0.0001$; SWD females; $F_{1,5} = 93.88$, $P = 0.0002$).

Discussion

Our results show that an effective oviposition deterrent has a potential as an alternative push component of a spatial repellent in a SWD push–pull system. When the 2-component oviposition deterrent (2c; Roh et al. 2023) was applied either on raspberry agar in the laboratory or on raspberry fruit in the field, the 2c-based push treatment resulted in a significant reduction in SWD oviposition or fruit infestation. This is the first demonstration of the effectiveness of an SWD oviposition deterrent in a push–pull system and supports the use of the oviposition deterrent as a potential alternative to other SWD repellents, such as 1-octen-3-ol (Wallingford et al. 2018) and 2-pentylfuran (Stockton et al. 2021, Shrestha et al. 2024), that are being evaluated as a push component of SWD push–pull. One of the advantages of the more contact-based and less volatile oviposition deterrent than more volatile spatial repellents may be that it could manifest its effect even after an insect contacts the fruit (Roh et al. 2023). For example, the vapor pressures of the 2c compounds tested in this study (octanoic acid: 3.71×10^{-3} mm Hg at 25 °C; decanoic acid: 3.66×10^{-4} mm Hg at 25 °C) are much lower than the vapor pressures of some of the known spatial repellents

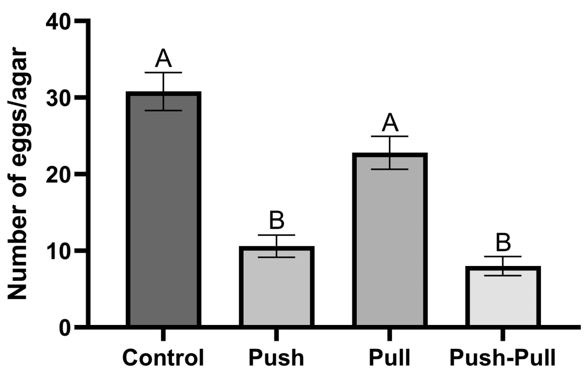

Fig. 3. Comparison of number (mean ± SEM) of *Drosophila suzukii* eggs oviposited on raspberry agar in laboratory no-choice test using 2c as a "push", 4-component SWD lure as a "pull", and the combination of 2 as "push–pull". Different letters on the bars indicate significant differences by Tukey–Kramer tests at $P < 0.05$, $N = 5$.

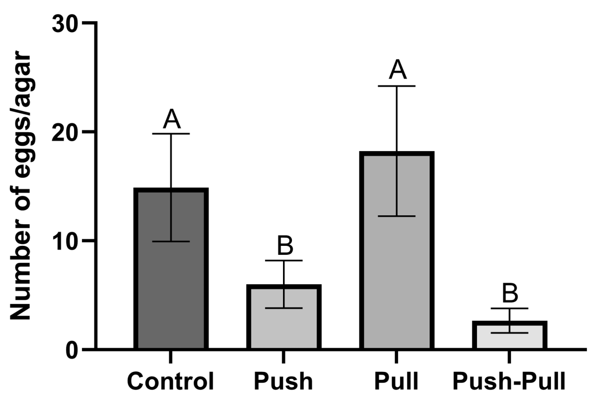

Fig. 4. Comparison of number (mean ± SEM) of *Drosophila suzukii* eggs oviposited on raspberry agar in laboratory 4-choice tests conducted in a greenhouse, using 2c as a "push", 4-component SWD lure as a "pull", and the combination of 2 as "push–pull". Different letters on the bars indicate significant difference by Tukey–Kramer tests at $P < 0.05$, $N = 4$.

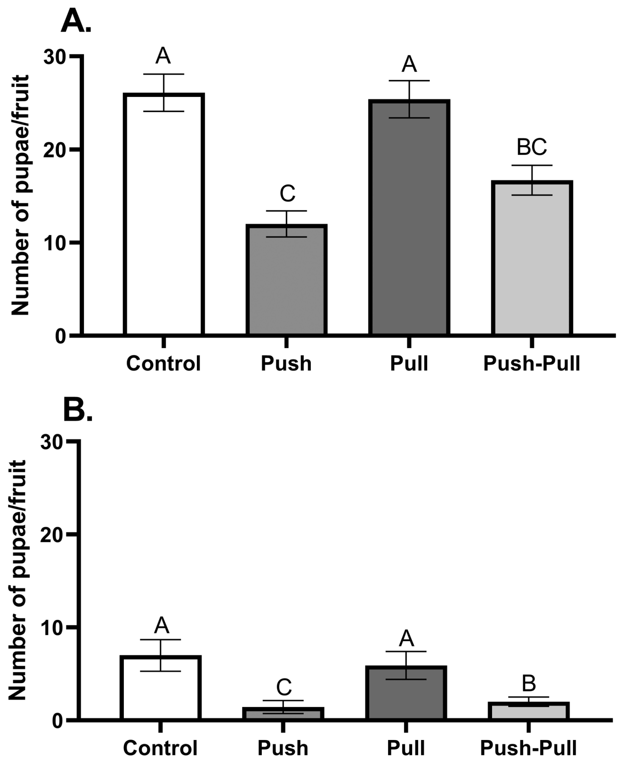

Fig. 5. Comparison of number (mean ± SEM) of *Drosophila suzukii* pupae reared out from: A) bagged raspberry fruits and B) stored bought sentinel raspberries from field trials, using 2c as a "push", 4-component SWD lure baited trap as a "pull", and the combination of 2 as "push–pull". Different letters on the bars indicate significant differences by Tukey–Kramer tests at $P < 0.05$, $N = 6$.

of SWD [eg 1-octen-3-ol: 2.25 mm Hg at 50 °C (Wallingford et al. 2017); 2-pentylfuran: 2.02 mm Hg at 25 °C (Cha et al. 2021)]. This makes an oviposition deterrent a good alternative to a spatial repellent in terms of maintaining effective concentration of antagonistic compounds in the field, which has been shown to be logistically challenging especially for spatial repellents with high volatility (Shrestha et al. 2024).

In contrast to the demonstrated efficacy of the oviposition deterrent in the field, the pull treatment based on the 4c SWD lure (Cha et al. 2012, 2014) did not lead to reductions in SWD oviposition or fruit infestation in either laboratory or field studies. The observed reduction in oviposition from the push-only treatment was comparable to that of the push–pull treatment, indicating no additive or synergistic effect when combining the push and pull components in this way. Although push–pull systems are generally more effective when such interactions prevent fruit damage, this was not observed in this study or in prior research (Wallingford et al. 2018). This suggests that the 4c SWD lure, as tested in this study, may not be an optimal choice as the pull component in SWD push–pull systems. Furthermore, both laboratory and field experiments revealed no consistent relationship between the number of female SWD captured and reductions in oviposition or fruit damage, further supporting the lack of efficacy of the 4c as pull component as tested in this study. The reasons for the pull treatment's inability to reduce SWD damage remain unclear but may include: (i) insufficient SWD capture to mitigate fruit damage, especially under high SWD pressure observed during the raspberry plot experiment (personal observation: GML and DHC), (ii) a potential spillover effect, where SWD attracted but not captured by traps contributed to local fruit damage (Hampton et al. 2014), and/or (iii) ineffective targeting of female SWD that were physiologically ready to lay eggs (Wong et al. 2018). Further research is underway to elucidate the underlying factors contributing to the observed lack of efficacy of 4c as a pull treatment in this study.

Although the 2c has low volatility, evidence indicates that the behavioral mode underlying the oviposition reduction may be a combination of contact deterrence and spatial repellency as suggested by Roh et al. (2023). The same was also supported in a recent study developing an oviposition deterrent of melon fly, *Z. cucurbitae*, which identified a mixture of 5 fatty acid compounds, including octanoic acid and decanoic acid, as the key oviposition deterrent components (Movva et al. 2025). In the study, when given a choice, melon fly made 48.5% fewer visits, spent 39% less time, and oviposited 88.2% fewer eggs per min on the oviposition deterrent treated host fruit agar than on control agar, indicating that the oviposition reduction resulted from both reduced visitation (spatial repellency) and reduced oviposition after contact (contact deterrence).

There have been several SWD repellents that showed field efficacy in SWD oviposition reduction (Renkema et al. 2016, Wallingford et al. 2016, Cha et al. 2021, Gale et al. 2024, Shrestha et al. 2024). This study adds an oviposition deterrent such as 2c (Roh et al. 2023), as a feasible candidate for a push component in a push–pull management system for SWD. Given their relatively low volatility, the oviposition deterrent can have longer residence time on the crop after application and may provide residual deterrent activity over a longer period of time compared to other more volatile repellent compounds that require potentially more frequent release in the field (Shrestha et al. 2024). Both octanoic and decanoic acids are naturally occurring medium-chain fatty acids found in food-grade substances such as coconut oil and are classified as generally recognized as safe (GRAS). However, we recognize that, although applying an oviposition deterrent directly to the crop might be more effective than hanging spatial repellents in dispensers, this could result in classifying the compounds as a bioinsecticide, which may subject it to additional regulations. Future research is required to study the effects of breakdown products of the oviposition deterrent on SWD activity, the effect of different doses and longevity on their efficacy in the field, potential synergistic effect with other known SWD repellents, the potential impact on fruit quality and flavor, and optimization of a SWD mass-trapping method as a pull component.

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