A new food-grade behavior disruptor as a management tool for spotted-wing drosophila

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Spotted-wing drosophila (SWD) on raspberry.

Background

Small fruit growers experience national and international competition and must achieve target yields and produce high quality fruit to retain market share and realize profitable returns and social benefits. In particular, fresh caneberry production is a segment that does not tolerate fruit damage. Spotted-wing drosophila (SWD) is a key pest of raspberry and blackberry. Its economic impact, indicated by annual control costs, may exceed $1000 per acre (Fernandez-Cornejo et al., 2014). At this time, caneberry growers are highly dependent on insecticides to deliver high-quality fruit to market.

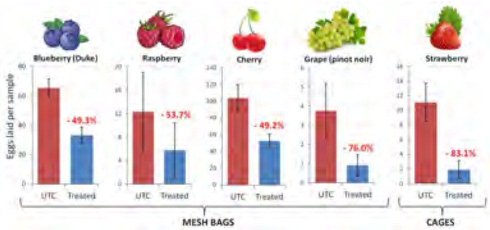

Figure 1: Efficacy of the behavioral disruptor. Infestation reductions achieved on different crops and in high pest pressure condition (organza mesh bags and cages exposure field trials).

Decoy, an innovative product for the management of SWD was developed and patented at Oregon State University (Tait et al. 2018). Decoy is a a mixture of food-grade ingredients which is highly attractive to SWD and competes with the ripening fruit throughout the season (Tait et al. 2020; Rossi Stacconi et al. 2020). Decoy modifies various SWD behaviors, ultimately resulting in a significant decrease in fruit damage. First the product diverts SWD away from ripening fruit. Second, it results in significant retention of the pest, keeping it away from fruit. Third, Decoy acts as an egg sink. Since the SWD eggs laid in this medium cannot develop, this translates in a substantial reduction of the pest population growth.

The goal of this project was to create a commercially viable and field-ready Decoy prototype for grower use. To this end, we proposed:

- to enhance and stabilize Decoy's active ingredients into prototypic release devices **(objective 1)**.
- to test the prototypic release devices under field conditions to compare its efficacy to conventional insecticides and refine Decoy into a readily deployed form **(Objective 2)**.

Objective 1: enhance and stabilize Decoy's active ingredients into prototypic release devices

Making Decoy 100% organic.

Decoy contains a mixture of adjuvants and plant-derived active ingredients. Adjuvants consist of stabilizing agents (humectants, encapsulants and preservatives) that absorb and retain water and avoid proliferation of molds and bacteria. Hydration (Fig. 2) is necessary to activate the product, since water triggers chemical reactions that allow the release of key attractive volatile compounds.

Initially, Decoy was formulated using a synthetically-produced micro encapsulant that allows slow release of volatiles and prolongs the time during which Decoy is effective. In 2019, several laboratory experiments were performed in order to find an alternative organic encapsulant without reducing efficacy. A plant-derived substitute was found, rendering the Decoy formulation completely organic.

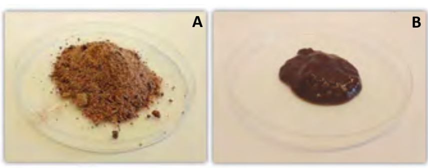

Figure 2: Decoy dry powder (A) and hydrated Decoy (B).

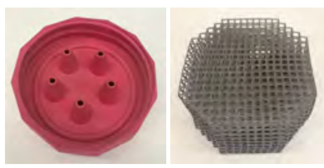

Figure 3: Examples of 3D-printed prototypic release devices developed to deploy Decoy in the field. Most of these devices did not prevent desiccation of Decoy and were abandoned.

Finding the right release rate of volatiles.

We conducted a study to identify the best delivery device for Decoy. We looked at 3D-printed structures (Fig. 3) with high surface-to-volume ratios. This property promotes efficient gaseous exchange and translates into high rates of volatile emissions. Ultimately, these surfaces also resulted in faster Decoy dehydration, reducing longevity of volatilization.

Adapting the delivery devices to drip irrigation systems.

The reduction in free water is the ultimate limitor for Decoy efficacy over time. We addressed this issue on two fronts: 1) improving the formulation with adjuvants that would limit water loss and 2) developing a system that would allow continuous water supply directly from the field. We developed several delivery devices that can be connected (Fig 4A) or simply put in contact (Fig. 4B-C) with the drip irrigation system. These allow the system to store and slowly release the water necessary to maintain an optimal hydration level of Decoy.

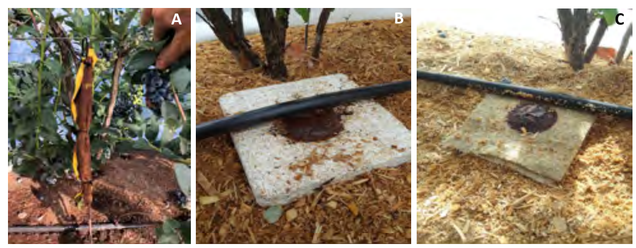

Figure 4: Release devices tested in the field using daily water supply from the drip irrigation system. Decoy was placed on 3 different supports: a microfiber cloth (A), a pressed and fermented hemp chips pad (B) and a hemp fiber pad (C).

Objective 2: comparative field testing of the prototypic release device

Differences between delivery devices:

The different water storage capacities and permeabilities of the delivery devices tested greatly affected the efficacy of Decoy during preliminary trials. Some devices were not able to retain sufficient water to support Decoy until the next irrigation cycle. Some devices retained too much water and wash out the product (Fig. 5). When choosing the best delivery device, we also considered the practicality of deploying the product in the field. Ready distribution throughout the field will reduce the labor required to deploy Decoy.

Figure 5: Some of the tested delivery devices had low permeability and resulted in water pooling on top of the substrate, causing Decoy to spill out.

Materials and methods: Cage trials were conducted in commercial blueberry fields over a period of 3 weeks. Within each cage, an artificial SWD infestation was simulated; over a three-week period, 200 mated SWD (50:50 male:female) were released weekly into each cage for a total of 600 individuals/cage. We trialed different treatments to compare reduction in fruit damage:

- ✓ **Insecticide program 1:** Application of a HIGH-efficacy insecticide (Z-cypermethrin - Mustang Max) in week 1 followed by a LOW-efficacy insecticide (Cyantraniliprole -.Exirel) in week 2.
- ✓ **Insecticide program 2:** Application of a LOW-efficacy insecticide (Cyantraniliprole -.Exirel) in week 1 followed by a HIGH-efficacy insecticide (Z-cypermethrin - Mustang Max) in week 2.
- ✓ **Decoy:** A single initial application of Decoy just before the first release of flies.
- ✓ **No intervention (Control):** no treatment (pesticide or Decoy) was applied.

Each treatment was replicated three times. Pesticide treatments were applied using a backpack hand pump sprayer. The Decoy was applied on a microfiber cloth connected to the drip irrigation system through a 0.5 inch microporous hosepipe and hung on the left side of each treatment cage, 15 inches above ground level (Fig. 4a).

Each cage was 20 ft long and contained 7 blueberry bushes (Fig. 6C). Fruit samples were collected every 3 days over the 3-week period. Within each cage, sampling points (SP) were set every 5 ft. At each sampling point, 25 berries were collected from the lower and the upper sections of the canopy (total 250 berries/cage). All fruit were carefully checked for eggs under the microscope and sampled using the salt test method for detecting SWD larvae.

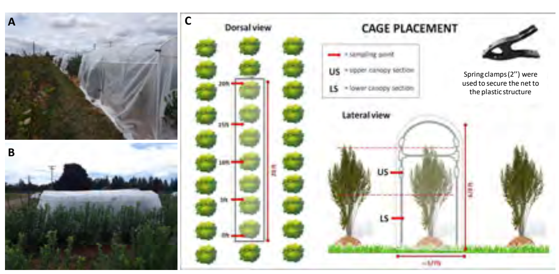

Figure 6: Cages used in the field trials. A, B) Each cage consisted of a PVC pipe structure enclosed by a fine mesh (0.8 mm). The piping was inserted over rebar hammered into the ground. Spring clamps secured the net on the structure (2''). C) Schematic drawings of the net cage show the size of the structures and the locations of the sampling points (red arrows).

Results: A single application of Decoy at the beginning of the 21-day experimental period consistently reduced SWD infestation over the entire 3 weeks of the trial (Fig 7). Decoy's efficacy was comparable to that of the two insecticide spray programs, even under high pest pressure conditions.

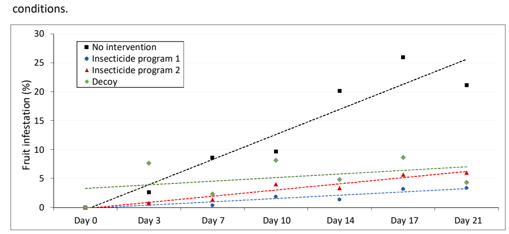

Figure 7: Results of the 2019 cage trial experiment comparing the efficacy of a single Decoy application with that of two pesticide spray programs.

Conclusions:

This study demonstrated the efficacy of Decoy as behavioral modifier for SWD and provided additional insights into future uses of this tool in integrated pest management programs. A cheap and easy-to-use substrate, consisting in a hemp fiber pad carrying a 6g Decoy disc (Fig. 8), was selected as the optimal delivery device for this product.

Because of this work, the original Decoy formulation has been amended for use in organic production systems and is currently undergoing certification by the Organic Materials Review Institute (OMRI).

Decoy may provide organic growers with an alternative technique and reduce dependence on toxic insecticides. The need for new approaches to SWD management becomes more evident considering recent studies suggesting that SWD is becoming resistant to spinosad, the only efficacious insecticide certified by the Organic Materials Review Institute against this pest.

References:

- Tait G. et al. (2018) A food-grade gum as a management tool for *Drosophila suzukii*. *Bulletin of Insectology.* LXXI (2): 295-307.
- Tait G. et al. (2020). Reproductive Site Selection: Evidence of an Oviposition Cue in a Highly Adaptive Dipteran, Drosophila suzukii (Diptera: Drosophilidae). *Environmental Entomology.* doi: 10.1093/ee/nvaa005.
- Rossi Stacconi et al. (2020). Gumming up the works: field tests of a new food-grade gum as behavioral disruptor for Drosophila suzukii. *Journal of Economic Entomology*. Submitted.

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