Laboratory and Field Evaluations of Attracticidal Traps as Tools for Control of Spotted Wing Drosophila, *Drosophila suzukii* (Matsumura)

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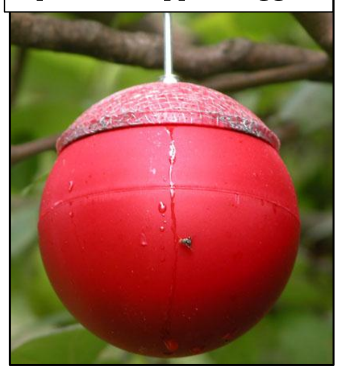
Project Background

The spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura), is an invasive species recently introduced into the U.S. Unlike many other fruit fly species, SWD will readily oviposit into ripening berries, brambles, grapes and stone fruits leading to potential economic losses in quality and yield. Once the eggs are laid and the maggots hatch, the fruit likely cannot be recovered and thus control efforts must focus on the adult SWD. To properly mitigate injury to the crop, chemical control measures must be timed to kill adults prior to oviposition. However, commercial growers still do not have tools that allow them to monitor at regular, short intervals to permit a properly timed spray and thus invasion into plots may occur before treatment can be applied.

Fig. 1. Attracticidal sphere for apple maggot



Current monitoring traps require growers to positively identify the small fruit fly and repeatedly replace the liquid attractant or a sticky card so as to ascertain when new populations develop. Given that SWD has a very short developmental period, growers need to constantly monitor and reapply insecticides through harvest. A potential solution to this problem is a behaviorally based management strategy: an attract-and-kill system that is very attractive to SWD, pulling them away from the host plants where a lethal dose of toxicant can be delivered to the adult fly. Here, we evaluated the potential of attracticidal spheres developed for controlling apple maggot fly, *Rhagoletis pomonella* (Walsh), as an attract-and-kill system for SWD (Wright et al. 2012).

Objectives

1. Evaluate lethality of attracticidal spheres against SWD in the laboratory.

We evaluated the lethality of attracticidal spheres, originally developed for apple maggot fly, against SWD. Visually integrated caps were formulated with spinosad (Entrust), spinetoram (Delegate), bifenthrin (Brigade) and lambda-cyhalothrin (Kaiso). For these trials, we formulated caps of each candidate insecticide at the following rates (a.i.): 0.0, 0.01, 0.1, 0.5 and 1.0%. Each of these caps was fitted to a flat-topped red sphere base and then misted with water for activation. At least forty SWD (20 males and 20 females) were exposed individually to spheres of each treatment. For each trial, a single SWD was gently placed at or near the equator of the sphere and allowed to forage freely for up to 5 min. Total foraging time was recorded for each SWD, and flies were held individually with food and water. Fly condition (alive, moribund, or dead) was assessed 24 and 48 h after exposure to spheres.

2. Determine if SWD will orient to and alight on attracticidal spheres under semi-field conditions.

In order to determine if SWD will orient to and alight on attracticidal spheres, we enclosed individual potted raspberry plants bearing ripe fruit inside 2.0 m^3 screened cages. Cages without potted plants served as a control. At the start of each test interval, one of three treatments was assigned: 1) an attracticidal sphere with attractant bait (Monterey Insect Bait, Monterey AgResources, Fresno, CA), 2) an attracticidal sphere without attractant bait, and 3) no sphere. Spheres were covered with a thin layer of Tangletrap (the killing agent) and hung in each field cage at a height equal to that of the fruit on the potted plants. Subsequently, 50 (25 females and 25 males) mature SWD were released in each enclosure and allowed to forage freely for 48 h. At the end of the exposure period, spheres and potted plants were removed from cages. The number of SWD captured per sphere was counted. Raspberry fruit were isolated from the plant and subsequently evaluated for the presence of larvae and pupae. The number of flies captured on baited and unbaited spheres with and without plants were compared, as was the number of larvae and pupae found in fruit.

Preliminary Results

1. Evaluate lethality of attracticidal spheres against SWD in the laboratory.

We found that SWD will readily feed on spheres (Fig. 2). We also are observing a rate response for all insecticides. We have observed high mortality (>95%) after 24h for caps formulated with 1% spinetoram, spinosad, and lambda-cyhalothrin. Bifenthrin was lower, at 72.5% but increased to 92.5% after 48h (Table 1).

Fig. 2. SWD feeding on attracticidal sphere.

Table 1. Mortality of SWD following exposure to attracticidal spheres in laboratory.

Chemical	N	Rate (% a.i.)	Mortality (%) 24 h	Mortality (%) 48 h
Bifenthrin	**40**	**1.0**	72.5	92.5
	40	**0.5**	55.0	75.0
	40	**0.1**	37.5	40.0
	40	**0.01**	5.0	10.0
	40	**0**	10.0	12.5
Spinetoram	**52**	**1.0**	98.1	98.1
	40	**0.5**	90.0	90.0
	49	**0.1**	75.5	77.6
	40	**0.01**	20.0	32.5
	78	**0**	9.0	25.6
Spinosad	**40**	**1.0**	97.5	97.5
	40	**0.5**	87.5	95.0
	40	**0.1**	40.0	77.5
	40	**0.01**	12.5	12.5
	80	**0**	1.3	8.8
Lambda-Cyhalothrin	**40**	**1.0**	100.0	100.0
	40	**0.5**	97.5	100.0
	40	**0.1**	97.5	100.0
	40	**0.01**	37.5	55.0
	100	**0**	25.0	30.0

2. Determine if SWD will orient to and alight on attracticidal spheres under semi-field conditions.

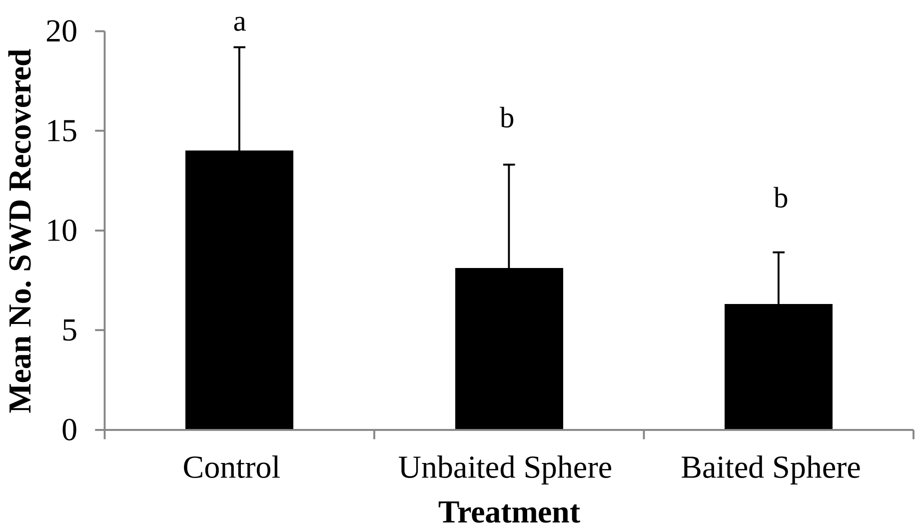
We have found that SWD will alight on red spheres. In semi-field studies, ~40% of all released flies will land on spheres with and without baits (Table 2). When raspberry plants were included, the number of flies declined significantly to between ~14-18% (Table 2). However, infestation in raspberries declined significantly when spheres were present, by >40%, indicating that presence of spheres reduced oviposition in berries (Fig. 3).

Table 2. Mean No. SWD ± SE and % captured on baited and unbaited red spheres in semi-field cages with and without raspberry plants.

Treatment	**Mean No. SWD ±SE**	**% Captured**
Unbaited Sphere	19.0±2.4a[1]	38.0%
Baited Sphere	20.4±1.7 a	40.1%
Unbaited Sphere + Raspberry	9.0±1.6 b	18.0%
Baited Sphere + Raspberry	7.3±1.2 b	14.6%

[1]Means in the same column followed by a different letter are significantly different according to Tukey's HSD.

Fig. 3. Mean ±SE number of SWD larvae and pupae recovered from raspberries when in association with baited and unbaited spheres or nothing (control).



Tentative Conclusions

We have found that the concept of an attracticidal sphere for direct, behaviorally based management of SWD holds potential. Flies will actively feed on attracticidal spheres, and several compounds hold good potential as toxicants. SWD also will alight directly on the sphere surface based on captures on Tangletrap-coated spheres. Sphere presence in association with an attractive host, red raspberry, resulted in nearly 50% reduction in the number of SWD larvae and pupae present in fruit. However, visual stimuli most attractive to SWD have not been identified.

It is likely we can improve orientation and attraction to attracticidal traps by identifying optimal visual stimuli for SWD.

The Monterrey insect bait used in these trials appeared to have no impact on SWD response. However, we know that SWD will orient to volatile cues. Thus, by identifying and using olfactory cues that are very attractive to SWD in association with attracticidal traps, we can increase the power of this attract-and-kill approach for management of SWD.

Reference. Wright, S.E., T.C. Leskey, I. Jacome, J. Pinero, and R.J. Prokopy. 2012. Integration of insecticidal, phagostimulatory, and visual elements of an attract and kill system for apple maggot fly. J.Econ. Entomol. 105: 1548-1556.

Future SWD Studies

Based on our recent work, we now have "proof of concept" for the attracticidal sphere project. We have documented the following: 1) SWD will feed on attracticidal spheres, 2) several toxicants are effective against SWD, 3) SWD will alight on spheres; and 4) sphere presence results in reductions in infestation.

Therefore, we propose to conduct the following studies to improve the performance of an attracticidal traps for SWD.

1. Identify optimal visual stimuli for SWD.

We will conduct laboratory, semi-field and field studies with SWD to identify attractive visual stimuli for SWD based on shape, size, and color (spectral reflectance). The most attractive of these stimuli will be incorporated into a SWD-specific attracticidal trap design.

2. Evaluate foraging activity of SWD in host crops.

We will conduct direct observations of SWD orientation and utilization of several contrasting host plants (raspberry, blueberry, and/or cherry) to establish foraging patterns of and cues used by SWD. We will compare different physiological states of SWD (mated vs. unmated, sexually mature vs. immature, young vs. old) to determine how this affects host acceptance and oviposition. These data will enable us to establish parameters for attracticidal trap optimization.

3. Evaluate SWD-prototype attracticidal traps in association with host crops.

We will evaluate SWD-specific attracticidal traps in association with berry crops to evaluate their performance and ability to reduce infestation in berries. We will include existing and novel attractants (as they become available) to increase attraction to attracticidal traps.

Outcome. SWD continues to exploit weaknesses in available management tactics. An attract-and-kill approach can provide a continuous strategy for targeting the damaging population - mature, egg-laying females.

Timeframe. We expect to be able to conduct these experiments over the course of the next 12-18 months.