Managing Spotted Wing Drosophila in Michigan Cherry

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KEY POINTS:

- Each SWD female is capable of laying 300+ eggs, developing into adults in as little as 8 days.
- SWD produce multiple over-lapping generations within a single season.
- SWD populations typically surge in July, often coinciding with cherry harvest.
- Cherries are at risk of infestation when they first start to color all the way through harvest.
- Use on-farm monitoring to assess SWD adult populations and to determine when to begin management.
- Protect ripening cherries through harvest using effective, registered insecticides.
- Use high spray volumes and apply full covers.
- Tighten spray intervals and follow up with another insecticide after rainfall.
- Use the sugar test to determine whether your management program is effective.
- Do not delay harvesting ripe fruit – the longer fruit stays on trees, the more likely it is to be infested.

BIOLOGY, DISTRIBUTION, KEY CHARACTERISTICS

Distribution and history in Michigan Spotted wing drosophila (SWD), *Drosophila suzukii*, is an invasive pest that attacks a wide range of soft-skinned fruit crops, as well as many wild hosts growing in field margins. SWD is native to Asia and was first discovered in California raspberries in 2008. It was first detected in Michigan in a trap set up by MSU researchers in September 2010 and is now widespread, first becoming a serious pest in fall red raspberries and late season blueberries, and now it is the most important late season pest for tart cherry producers in Michigan.

Pest biology as it relates to cherry infestation. Female SWD will lay eggs in a wide range of thin-skinned fruit, both cultivated and wild. Unlike other related *Drosophila* species (e.g., the common vinegar or fruit fly, *D. melanogaster*), SWD is able to attack fruit that is just beginning to ripen with multiple overlapping generations occurring through the growing season.

Since 2015, this pest has become the number one concern for tart cherry growers in Michigan close to cherry harvest. When the risk of infestation is high, this pest is not easily controlled. Left unchecked, SWD will infest ripening fruit close to harvest. If larvae are detected, fruit loads can be rejected.

This management guide has been developed to provide the most up-to-date methods for controlling this key pest in cherries. Because larvae feed inside the fruit, control actions should primarily target adults before eggs are laid. Excellent coverage is required when adults are active. Post-infestation treatments will not eradicate larvae, but there are some cultural methods that look promising with respect to reducing local populations.

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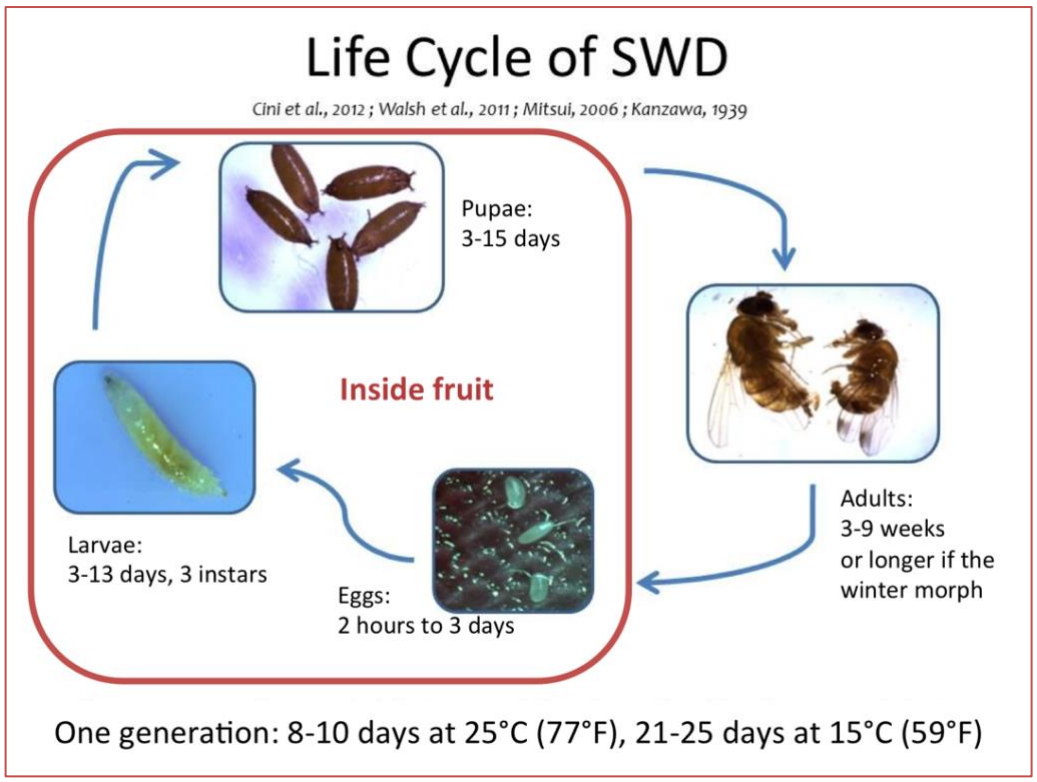

Figure 1 (left). Life cycle and development times for spotted wing drosophila associated with different temperatures. Generation time is 8-10 days at 25°C (77°F) and 21-25 days at 15°C (59°F). Eggs develop into first instars in 2 hours to 3 days. There are three larval stages lasting a total of 3-13 days. The pupal stage lasts between 3-15 days. Adults last 3-9 weeks or longer if it is the winter morph.

SWD lifecycle.

SWD development is largely driven by temperature and day length (Fig. 1). Under warm weather conditions (77°F), SWD will develop from egg to adult rapidly – in as little as 8 days – with multiple overlapping generations typical. Under cooler conditions (~59°F), or when temperatures rise above 86°F, development will be slower or will halt until favorable conditions resume. Adults are active for 3-9 weeks. Each female is capable of laying as many as 300 eggs. Eggs hatch into larvae between 2 hours to 3 days after they are deposited under the fruit skin. Three larval instars feed on the fruit for 3-13 days, pupate within the same fruit, and emerge as adults 3-15 days later. In fall, with shorter day length and cooler temperatures, the last adults enter an overwintering phase (i.e. diapause) and are slightly larger and darker in color; these insects are known as the "winter morphs".

Key characteristics for identification.

Adult SWD have several key features to help distinguish them from other flies: females have a darkened, serrated (toothed) ovipositor that allows them to saw into intact, ripening fruit; mature males have a dark spot on each wing near the margin, and two dark bands on each foreleg (Fig. 2). For detailed fact sheets, identification guides and weekly reports on this pest during the growing season, see the online resource page at: www.ipm.msu.edu/SWD.htm

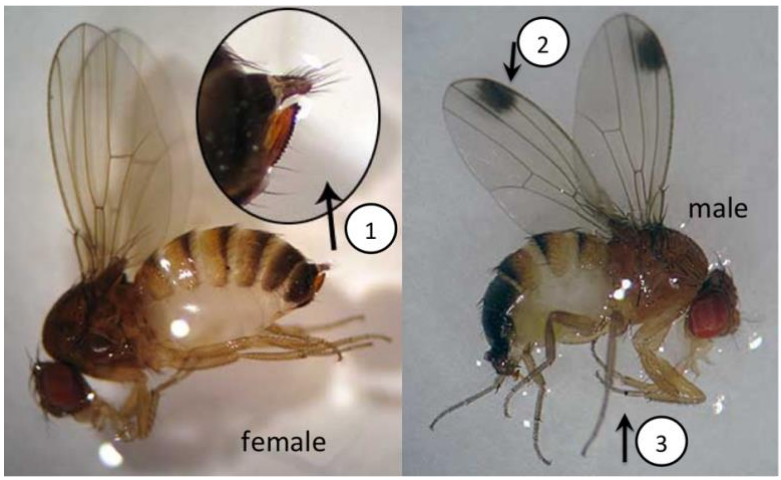

Figure 2. Key identifying features of female and male spotted wing drosophila. Female SWD (left) have a darkened, serrated ovipositor (labeled as 1); male SWD (right) have a dark spot on the margin of each wing (labeled as 2) and two dark bands on each foreleg (labeled as 3).

TRAPPING FOR ADULTS

The first step toward managing SWD is to determine whether they are present in the orchard. Monitoring for SWD from fruit set until the end of harvest will help identify the start of fly activity and determine when populations are increasing. Traps provide valuable information, particularly in helping growers make reliable management decisions. Traps and lures can be made at home or they can be purchased from commercial suppliers.

The most commonly used trap.

A simple monitoring trap consists of a plastic 32-ounce cup perforated with ten 3/16"-3/8" holes near the lip of the cup. The trap contains an inch of liquid bait or a lure hung above a soapy water drowning solution to attract flies (Fig. 3). The small holes allow access to vinegar flies, but keep out larger insects. A small yellow sticky card can be placed inside, hung on a paper clip, to facilitate the capture of flies, but is not necessary.

Figure 3. Examples of SWD traps baited with yeast-sugar solution (left) or with a commercial lure suspended above a soapy water drowning solution (right).

Making the yeast-sugar bait.

The best homemade bait is a yeast-sugar mix, which ferments and attracts the flies. To make the yeast-sugar bait, combine 1 tablespoon of active dry yeast, 4 tablespoons of sugar, a drop of dish soap, and 12 ounces of water. If using the yeast-sugar bait, the solution needs to be changed at least weekly, and the fermented liquid should be disposed of away from the trapping area.

Figure 4. Contents of an SWD trap, strained over a mesh screen (left); examining the sample with a dissecting microscope (right).

Commercial lures.

Several commercial lures are available and work about as well as the yeast-sugar mix. Each lure has its own requirement as far as when it needs to be changed, generally on a 3-4 week interval. The lure is hung over an inch of soapy water, and the liquid can be checked each week for SWD adults. As mentioned above, an optional sticky insert can be used to facilitate fly capture and checking.

Trap density and placement.

Traps should be hung in a shaded area of the tree near fruit using a wire attached to the top of the trap. At least one trap should be placed per orchard block along the perimeter near a wooded edge, particularly near non-crop host plants that ripen earlier than cherries (for a list of recorded non-crop host plants, see: http://www.ipm.msu.edu/uploads/files/SWD/em9113.pdf), but because SWD distribution can be spotty, especially early in the season, more traps, including some within the orchard block are going to provide more information than a single trap for local management decisions. Traps should be checked at a minimum of once per week and the number SWD recorded.

SAMPLING FRUIT FOR LARVAE

In addition to trapping for SWD adults at a particular site, a salt or sugar test is an excellent back-up method to determine if fruit are infested. The sugar method allows for detection of living larvae as they emerge from the fruit. Instructions for how to complete a sugar test follow:

- Dissolve 1.5 pounds of brown sugar per 1 gallon of warm water. Warm water helps the sugar dissolve and reduces the time it takes for the larvae to exit the fruit; cold water will reduce larval activity.
- Lightly squeeze about 1-2 cups of fruit in a plastic bag to disturb the larvae, taking care not to break the skins as the flesh of Montmorency cherry has whitish colored veins that can be mistaken for SWD larvae (Figure 5).
- Place fruit in a shallow pan and cover with the sugar solution. Stir the fruit every few minutes to thoroughly mix the fruit in the sugar solution and further disturb the larvae.
- After 10-15 minutes, inspect the mixture for larvae exiting fruit.
- Detection of small larvae will require good lighting and the use of a hand lens (15-20x will work, but 30x is better). If a quantitative sample is necessary, count the number of larvae quickly while they are still alive and moving.

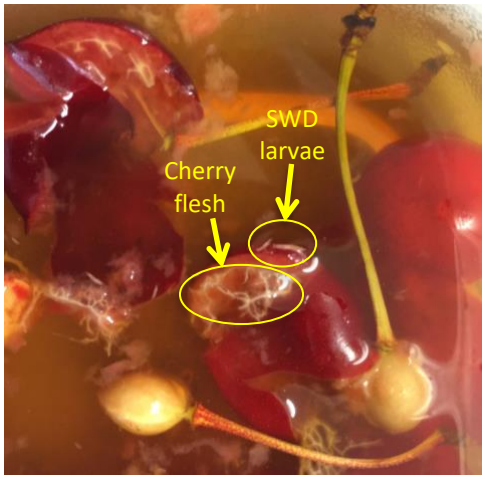

Figure 5. Tart cherries in brown sugar solution used to detect larvae emerging from fruit. Apparent in this image are different larval instars as well as the white veins of the crushed

SWD CONTROL

Given the potential for rapid SWD population growth starting mid-summer, ripening cherries require targeted management of adult flies to prevent fruit infestation from the time the fruit loses its green color until the end of harvest. SWD presents a new challenge to our current cherry pest management program. As SWD populations rise, which occurs quickly under warm summer conditions, management can be challenging, especially with frequent rain events. Pesticide registrations and recommendations will change as we learn how to better manage this pest, and growers can remain informed through the MSU SWD website, local Extension Educators, and the MSU Extension News for Agriculture (www.msue.anr.msu.edu/topic/info/fruit).

Figure 6. Cherries are susceptible to SWD infestation as soon as they start turning from green to straw color and all the way through harvest.

Keys to success.

An effective management program entails the following:
1) Protecting ripening cherries through harvest using effective, registered insecticides, 2) Using on-farm monitoring to assess fly distribution and population size (via multiple traps throughout the farm for helping to indicate hot spots), 3) Using the salt or sugar test on ripening fruit to determine whether the current management program is effective, and 4) Minimizing any delay in harvest – the longer ripe fruit remain on trees, the more likely they are to be infested and SWD populations rise quickly later in the season.

When to begin your management program.

Because of the mandated zero tolerance for larvae in cherries at harvest, a conservative management approach is currently suggested. If you are trapping on your own farm, management programs should begin when fruit start to turn color *and* you have captured an SWD fly in one of your traps. In our regional trapping in the past, we have often caught single flies in traps for several weeks prior to the fruit being vulnerable or the summer population surge. If using the regional trapping reports to guide management decisions, some growers may opt to treat vulnerable orchards soon after the first SWD flies are captured. However, our experience suggests that management can be initiated when 5-10% of the traps in the region are reporting SWD catches without risking infestation.

Maintain coverage, tighten spray intervals.

Because SWD can complete a single generation in 8-10 days at 77°F, it is crucial to maintain excellent coverage with effective insecticides *and* alternate insecticides with different modes of action to reduce the risk of creating insecticide-resistant SWD populations. Excellent coverage requires tighter spray intervals, particularly in rainy conditions, applying full covers rather than alternate row middle sprays, reducing tractor speeds, accurately calibrating sprayers, and using adequate spray volumes. Growers should **not** stretch spray intervals, even with materials that are rated as excellent against SWD (Table 1). **Based on our experience in Michigan cherries and in other crops, SWD control will likely require a minimum 7-day spray interval under dry conditions with tighter intervals following rain or other wetting event.**

Effective materials against SWD in cherry.

Based on laboratory and field efficacy trials, we have found insecticides in the pyrethroid, organophosphate, diamide, and spinosyn chemical classes to be effective for SWD control in cherries. The most effective products against SWD in recent MSU trials include Danitol, Exirel, Imidan, Mustang Maxx and Warrior (see Table 1). Always follow the specific label restrictions for cherry. With more frequent spraying, it is also important to understand the seasonal limits for each product, re-entry interval (REI) restrictions, and their re-treatment intervals or minimum number of days between applications (please refer to the product label).

OMRI approved materials.

There are only two products approved by the Organic Materials Review Institute (OMRI) that show some activity against SWD, Entrust and Grandevo. Entrust has a 7-day PHI and Grandevo has a 0-day PHI. Preliminary data suggest that Entrust has improved activity against SWD compared with Grandevo.

Selecting materials effective against multiple pests.

Growers should also consider best options for controlling other pests that may be present and potential impacts on existing IPM programs. Cherry fruit fly and leafrollers are the other main pests that may need to be managed when SWD are active (Figure 7). Many of the insecticides that are effective against these pests will also provide good protection against SWD, but only if coverage and timing are excellent. Table 1 also contains the cross-efficacy ratings for these main late season tart cherry pests. Consult the current version of the Michigan Fruit Management Guide E-154 for more details on cross-efficacy against other cherry pests.

Figure 7. Other common late-season pests of cherries. The cherry fruit fly (left), *Rhagoletis cingulata* (Loew), and the black cherry fruit fly (middle), *Rhagoletis fausta* (Osten Sacken) are two closely related species that can infest cherries around the same time as SWD, but they are much larger and only produce a single generation per season. The oblique-banded leafroller (right), *Choristoneura rosaceana* (Harris), a moth pest of both pome and stone fruit, can also be a problem in cherries close to harvest. Traps to monitor for these pests are commercially available. *Photos courtesy NY State Ag Experiment Station.*

Maximum residue limits.

Another consideration for applying pesticides close to harvest is their potential for leaving residues that exceed the tolerances of export markets, also known as maximum residue limits or MRLs. If used according to label, detectable residues for most of the materials listed in Table 1 should not exceed export tolerances for Michigan cherry markets. However, there are some important exceptions. Exirel has a 3-day PHI, but there is a risk of exceeding the MRLs for China and Taiwan if used within 1 month of harvest. Danitol also has a 3-day PHI, but is likely to exceed the MRL for EU markets if used within a month of harvest. Delegate and Imidan each have a 7-day PHI, but both would exceed the MRLs for China and Israel if used within a month of harvest. Because MRLs can be a moving target, the conservative approach when exporting fruit, is to avoid using materials listed as having stricter MRLs than the U.S.

Table 1. Insecticides registered for use in Michigan CHERRIES and their expected efficacy against SWD, cherry fruit flies, and leafrollers, the main late season targets.[1]

Trade Name	Active Ingredient	Class (IRAC Group)	PHI (days)	REI (days)	Rate per acre (lbs of AI)	Max ai/A per season	Relative efficacy against:		
							SWD	Cherry fruit flies	Leaf-rollers
Grandevo [2]	*Chromo-bacterium subtsugae*	biological	0	NS	3 lb (0.9 lb ai)	NS	G		G
Danitol 2.4 EC	fenpropathrin	pyrethroid (3)	3	10	21.3 fl oz (0.4 lb ai)	0.8 lb	E	G	G
Exirel 10SE	cyantraniliprole	diamide (28)	3	7	13.5-20.5 fl oz (0.088-0.133 lb ai)	0.4 lb	E	E	E
Mustang Maxx 8EC	zeta-cypermethrin	pyrethroid (3)	3*	7	4 fl oz (0.025 lb ai)	0.15 lb	E	F	G
Baythroid XL	beta-cyfluthrin	pyrethroid (3)	7	14	2.4-2.8 oz (0.019-0.022 lb ai)	0.044 lb	G	G	G
Delegate WG [3]	spinetoram	spinosyn (5)	7	7	4.5-7 oz (0.071-0.109 lb ai)	0.438 lb	G	G	E
Entrust SC [2]	spinosad	spinosyn (5)	7	7	4-8 oz (0.062-0.124 lb ai)	0.45 lb	E	G	E
Imidan 70-W [4]	phosmet	OP (1B)	7	NS	2.125 lb (1.5 lb ai)	5.25 lb	E	E	E
Movento 2F	spirotetramat	LBI (23)	7	14	6-9 fl oz (0.09-0.14 lb ai)	0.24 lb	G, S		
Verdepryn	cyclaniliprole	diamide (28)	7	7	Not yet registered		E	G	E
Rimon 0.83EC	novaluron	benzoylurea (15)	8	7	20-40 fl oz (0.129-0.259)	0.97 lb	G [5]	G	E
Apta 15SC	tolfenpyrad	METI (21A)	14	10	21-27 fl oz (0.22-0.28 lb ai)	0.56 lb	E, S		
Warrior II 2CS [3]	lambda-cyhalothrin	pyrethroid (3)	14	5	2.56 fl oz (0.04 lb ai)	0.2 lb	E	G	G

KEY: NS = not specified on product label; NR = not rated yet because the product is so new; S = specimen label lists this material as suppressive only; F = Fair, G = Good, E = Excellent, based on MSU field/lab bioassays. For more information about efficacy ratings, please refer to the current Michigan Fruit Management Guide, MSU Extension Bulletin E-0154.

NOTES:

***** Mustang Maxx 8EC is now available for use up to 3 days pre-harvest in **tart cherries** with the 24C label issued during the 2018 field season.

[1] This is not meant to be an exhaustive list, for more pest and disease ratings on materials registered for use in cherries, please refer to the Michigan Fruit Management Guide E-154. If there is no efficacy rating listed for a given product/pest combination, efficacy should be considered unknown for that particular pest. For more information on the proper use of individual insecticides, please refer to the specimen label for each material.

[2] This material is OMRI approved.

[3] SWD is not listed as a target pest on the label for stone fruit, but relative efficacy against SWD has been evaluated through field and/or lab bioassays at MSU.

[4] Not labeled for use in sweet cherry due to phytotoxicity issues.

[5] While not having contact toxicity to adults, sub-lethal effects following adult exposure leads to nonviable eggs.

Post-harvest and off season considerations.

Post-harvest management options against SWD in cherry are limited. However, for other susceptible fruit (e.g. blueberries) refrigeration for 72 hours at 35°F has been found to slow the development of eggs and larvae, and freezing will halt development all together. These techniques are presumed to be effective for cherries with otherwise undetectable infestation at harvest. Processing tart cherries for juice will also effectively halt development.

At the end of harvest, cherries left on the tree can be readily infested by SWD leading to increasing pest densities. For fruit that drops to the ground, there is evidence that flailing or otherwise crushing the fruit will help reduce post-harvest opportunities for SWD infestation, build-up and movement to adjacent orchards.

Preliminary data suggest that pruning the tree canopy during the dormant season could help to decrease population pressure by reducing the relative humidity and shading that SWD prefer. This work is on-going and we are refining pruning strategies. Opening up the canopy along with good sprayer calibration should also improve spray coverage to better protect fruit from infestation.

For more information

MSU Integrated Pest Management SWD Resource page:
http://www.ipm.msu.edu/invasive_species/spotted_wing_drosophila

MSU Extension News for Agriculture Fruit & Nut page:
http://msue.anr.msu.edu/topic/info/fruit

Michigan Fruit Management Guide: Bulletin E0154
http://shop.msu.edu/product_p/bulletin-e0154.htm

Pesticide Label Database:
http://www.cdms.net/Label-Database

List of SWD non-crop host plants:
http://www.ipm.msu.edu/uploads/files/SWD/em9113.pdf