Oregon State University | Extension Service

Protecting Garden Fruits from Spotted Wing Drosophila

Drosophila suzukii

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Spotted wing drosophila (*Drosophila suzukii*; SWD) is a new, invasive pest that attacks stone fruits and berries. This pest is native to Japan, where the first reports of this "vinegar fly" date to 1916, and has been established in Hawaii since the early 1980s, although no noticeable damage has been reported there. On the mainland United States, SWD was first discovered in the fall of 2008, maturing on raspberry and strawberry fruits in California. In 2009, SWD was reported in Oregon, Washington, Florida, and British Columbia, Canada. In 2010, SWD flies were caught in monitoring traps in Michigan, Utah, North Carolina, South Carolina, and Louisiana. In 2011, SWD was reported for the first time in Baja, Mexico.

In Oregon, SWD has been confirmed in 17 counties (figure 1). These counties are home to several commercial fruit producers as well as many home gardeners who tend backyard berries and fruits. Given the rapid spread of SWD in Oregon and across the United States, it is reasonable to suspect that SWD is widespread, well established, and most likely present in additional counties and states.

Because this relatively small fly (2 to 3 mm in body length; figure 2) infests a variety of fruits (table 1), it could have a considerable negative effect on Oregon's commercial fruit industry. Although commercial monitoring and management tools are being developed, gardeners also have an important role to play in protecting Oregon's fruit producers.

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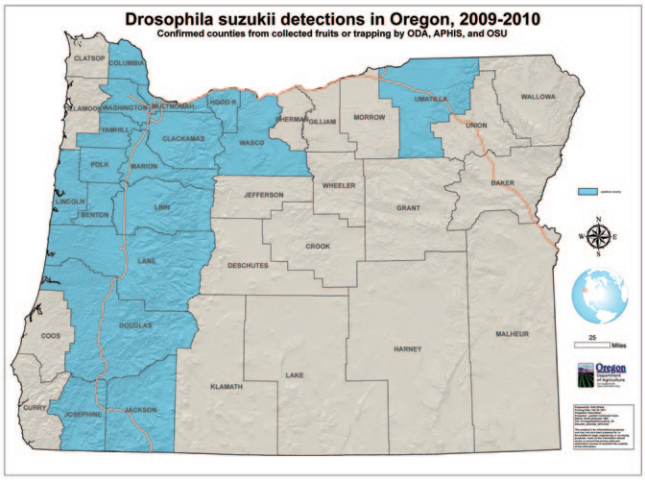

Figure 1. Following the 2009 and 2010 growing seasons, spotted wing drosophila was known to be present in Benton, Clackamas, Columbia, Douglas, Hood River, Jackson, Josephine, Lane, Linn, Lincoln, Marion, Multnomah, Polk, Wasco, Washington, Umatilla, and Yamhill counties. SWD presence was confirmed by identifying flies collected in traps or fly larvae in infested fruit.

Image by Helmuth Rogg, Oregon Department of Agriculture, reproduced by permission.

Figure 2. Spotted wing drosophila male on caneberry fruits. Note the small size of the fly relative to the berries.

Photos by Amanda Ohrn, © Oregon State University.

If you grow tree fruits (e.g., cherries, mulberries, and peaches) or berries (e.g., strawberries, raspberries, blackberries, and blueberries) in a home or community garden, you can reduce the effect of SWD on your own fruits and berries as well as help protect Oregon's farmers. This publication provides the information gardeners need to monitor and responsibly manage this pest.

Identifying Spotted Wing Drosophila

Adult SWD flies belong to the same family as, and resemble, common pomace or vinegar flies. Sometimes SWD flies are incorrectly referred to as small fruit flies. However, the true fruit fly (Mediterranean fruit fly, *Ceratitis capitata*) is much larger and typically has banded wings. You may have seen common vinegar flies in your kitchen, around your compost pile, or on fallen and rotting fruit in your garden. Vinegar flies are attracted to the smell of yeast, wine, and rotting or fermenting fruit; they prefer overripe and rotting fruit that has **fallen from the plant**. This feeding behavior differs from that of SWD flies, which prefer ripe fruit **on the plant**.

If not carefully examined, SWD flies may be confused with common vinegar flies. However, they are slightly more robust than most vinegar flies, including *Drosophila melanogastor*, which is commonly used in biology classes. Both SWD and the common vinegar fly have red eyes and an amber-colored body. Observant gardeners will not be fooled by these similarities but instead will focus on characteristics that enable accurate identification.

Two key characteristics distinguish SWD from other vinegar flies:

- Adult male flies have a black spot near the leading edge of each wing tip.
- Females have a prominent, serrated, sawlike ovipositor on their hind end that is used to insert eggs into ripe fruit (figure 3).

Only males have wing spots (which may be dark or faded), and only females have an ovipositor. Males also have two sets of black combs, which appear as bands on their front legs. Using a magnifying glass, small hand lens, or head-mounted magnifier can make it easier to see these key characteristics.

What Fruits Are at Risk?

SWD flies can infest a variety of stone fruits and berries that are grown in home and community gardens (table 1). Preferred hosts tend to have softer and thinner skin than other fruits. Some fruits, such as figs, apples, tomatoes, and grapes, are subject to SWD infestation if they are damaged or have split skin. Susceptible fruits appear to be most vulnerable when ripe or slightly overripe.

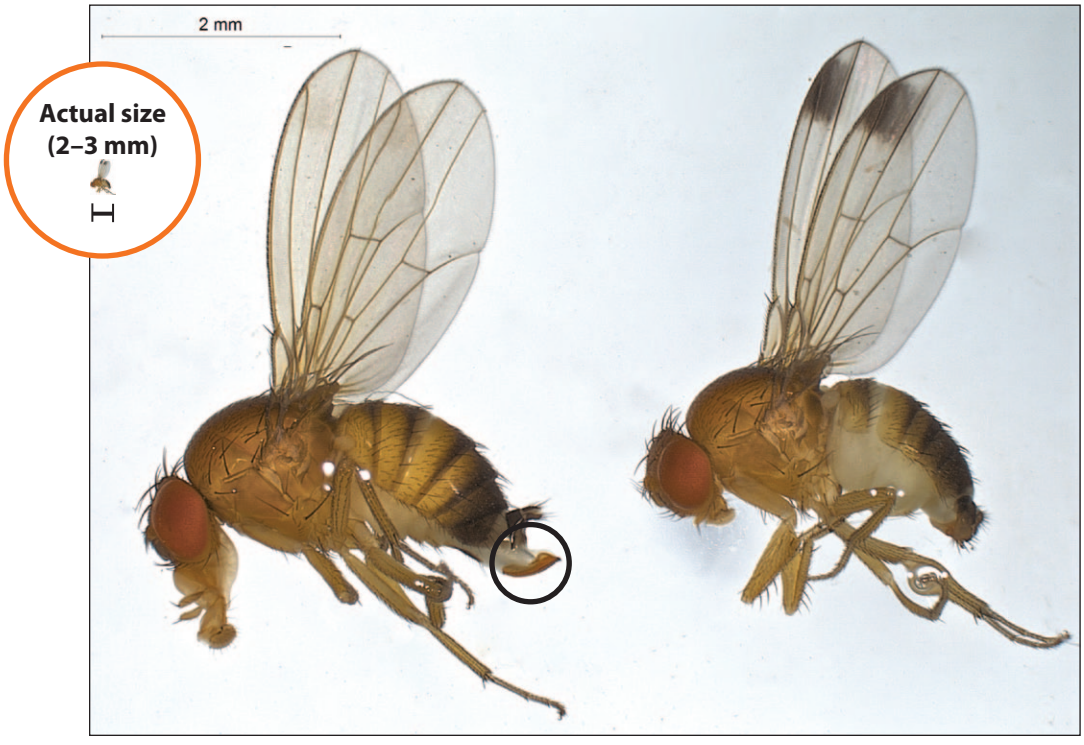

Figure 3. Adult spotted wing drosophila female (left) and male (right) flies. Females have a sawlike ovipositor on their hind end (circled). The ovipositor is tucked under the abdomen when not in use and protrudes only after flies have been soaked in a liquid, such as the apple cider vinegar bait. Males have black spots near the leading edge of each wing tip and two sets of black combs on their front legs (not shown).

Photo by Eric LaGassa, Washington State Department of Agriculture, reproduced by permission.

Table 1. Documented host plants that may be affected by spotted wing drosophila

Backyard fruits	Wildland, ornamental fruits, and weeds
Plant family: Rosaceae	
Asian pear[1]	Elderberry (*Sambucus* spp.)
Asian plum (*Prunus* spp.)	Flowering crabapple (*Malus* spp.)
Blackberry (*Rubus* spp.)[1]	Hawthorne (*Crateagus* spp.)
Boysenberry[1]	Himalayan wild blackberry (*Rubus armeniacus*)[1]
Cherry (*Prunus* spp.)[1]	Mountain ash (*Sorbus* spp.)
Damaged apples[1]	Ornamental blackberry/raspberry
Italian prune (*Prunus domestica*)[1]	Ornamental plum and cherry (*Prunus* spp.)
Loganberry (*Rubus ursinus* var. *loganobaccus*)[1]	Wild rose; rose hips (*Rosa* spp.)
Marionberry (*Rubus* L. subgenus *Rubus*)[1]	
Other caneberries	
Peach (*Prunus* spp.)[1]	
Plumcot	
Raspberry (*Rubus* spp.)[1]	
Strawberry (*Fragaria* spp.)[1]	
Plant family: Ericaceae	
Blueberry (*Vaccinium* spp.)[1]	
Plant family: Elaeagnaceae	
	Sea buckthorn (*Hippophae rhamnoides*)
Plant family: Sapindaceae	
	Soapberry (*Sapindus* spp.)
Plant family: Caprifoliaceae	
	Japanese honeysuckle (*Lonicera japonica*)
	Snowberry (*Symphoricarpos* spp.)
Plant family: Moraceae	
Fig (*Ficus* spp.)[1]	Mulberry (*Morus* spp.)[1]
	Osage orange (*Maclura pomifera*)
Plant family: Cornaceae	
	Japanese dogwood (*Cornus kousa*)[1]
Plant family: Vitaceae	
Grape; Table[1] and Wine[1] (*Vitis* spp.)	
Plant family: Solanaceae	
Damaged tomatoes[1]	Nightshade (*Solanum* spp.)
	Pokeweed (*Phytolacca* sp.)
Plant family: Ebenaceae	
Damaged persimmons (*Diospyros* spp.)	
Plant family: Actinidiaceae	
Kiwi (*Actinidia* spp.)[1]	

Note: Actual infestations depend on the specific fruit as well as environmental conditions, ecosystem structure, and management practices.

[1] Confirmed finding in Oregon.

Recognizing Infested Fruit

In addition to recognizing SWD flies, look for evidence of eggs, larvae, or pupae in fruit, and identify "suspect" fruit that might be infested with SWD.

To recognize infested fruit, it is helpful to know the SWD lifecycle. A single female can lay several hundred eggs in her lifetime, depositing one to three eggs per fruit. A tiny, inconspicuous scar or spot marks the location where the female pierced the fruit with her ovipositor to lay eggs. Each egg has two fine, white, hair-like structures that stick out of the fruit. These function as "breathing tubes" for the eggs.

Fruit will begin to collapse, bruise, or wrinkle within 2 to 3 days after the female has laid eggs. The fruit softens, and mold may grow from the wound where eggs were laid and larvae are feeding (figure 4). Juice from the fruit may seep out of the wound. Larvae feed inside the fruit for about 5 to 7 days until they are ready to pupate. The brownish-yellow pupa is a nonfeeding stage lasting 4 to 5 days. Most pupae remain inside of fruit with their respiratory horns sticking out until the adult flies emerge. The adults then mate and begin a new generation of pests. It has been estimated that three to nine generations per year might occur in Oregon depending on environmental conditions.

Heavily infested fruit is ruined because of the damage caused by larvae as they feed and accelerate rotting. Although infested fruit is not toxic, most people prefer not to eat insect-infested fruit. Therefore, SWD can have negative effects on a home berry harvest. In addition, SWD flies from home and community gardens can infest commercial farms.

Monitoring for Spotted Wing Drosophila

Monitoring is essential to managing SWD. Monitoring allows for early detection of SWD and implementation of effective management programs. You can monitor for adult flies or infested fruit. Monitoring for adult flies allows you to proactively manage SWD in your garden before the flies infest your fruit. Also, placing many baited traps in or near your garden can draw SWD flies away from your plants. Monitoring for larvae in infested fruit allows you to develop an informed approach to managing SWD in your garden.

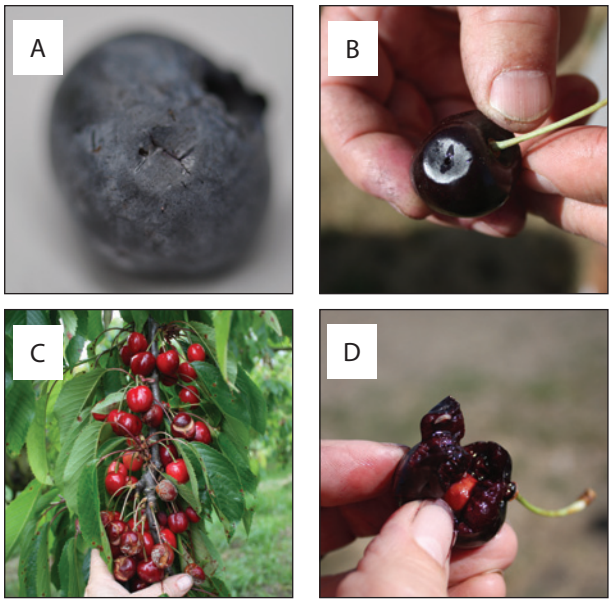

Figure 4. Spotted wing drosophila damage on garden fruits. (A) Egg-laying females leave oviposition holes/scars on the surface of the fruit, as shown on this blueberry. (B) Fruit collapses at the oviposition site, as shown on this cherry. (C) Fruit juices may seep out of the hole where SWD eggs are laid, and fruits can soften and mold may grow at the damaged site. (D) Opening the fruit reveals the presence of small, white larvae.

Photos by Amy Dreves, © Oregon State University.

Monitoring for Adult Flies

You can construct a simple trap to monitor for adult flies (figure 5). Drill several 3/16-inch holes around the side of a sturdy, clear plastic cup (16- to 32-ounce size) with a removable lid. Leaving 3 inches on one side of the cup undrilled will allow you to more easily change the bait solution. New trap designs are being explored. Please check the SWD website (*http://swd.hort.oregonstate.edu/*) for the latest updates.

Add 1.5 inches of **pure** apple cider vinegar to the cup. (Do not use flavored apple cider vinegar; it is less attractive to the flies.) Any flies in your garden will be attracted to the trap. Adding a drop of unscented liquid soap will break the surface tension of the liquid, allowing flies to sink to the bottom of the cup. Use a coated wire or piece of twine to hang the trap within the shaded side of the plant canopy near fruit level (for stone fruits and berries), or place the trap on the ground within the plants (for strawberries).

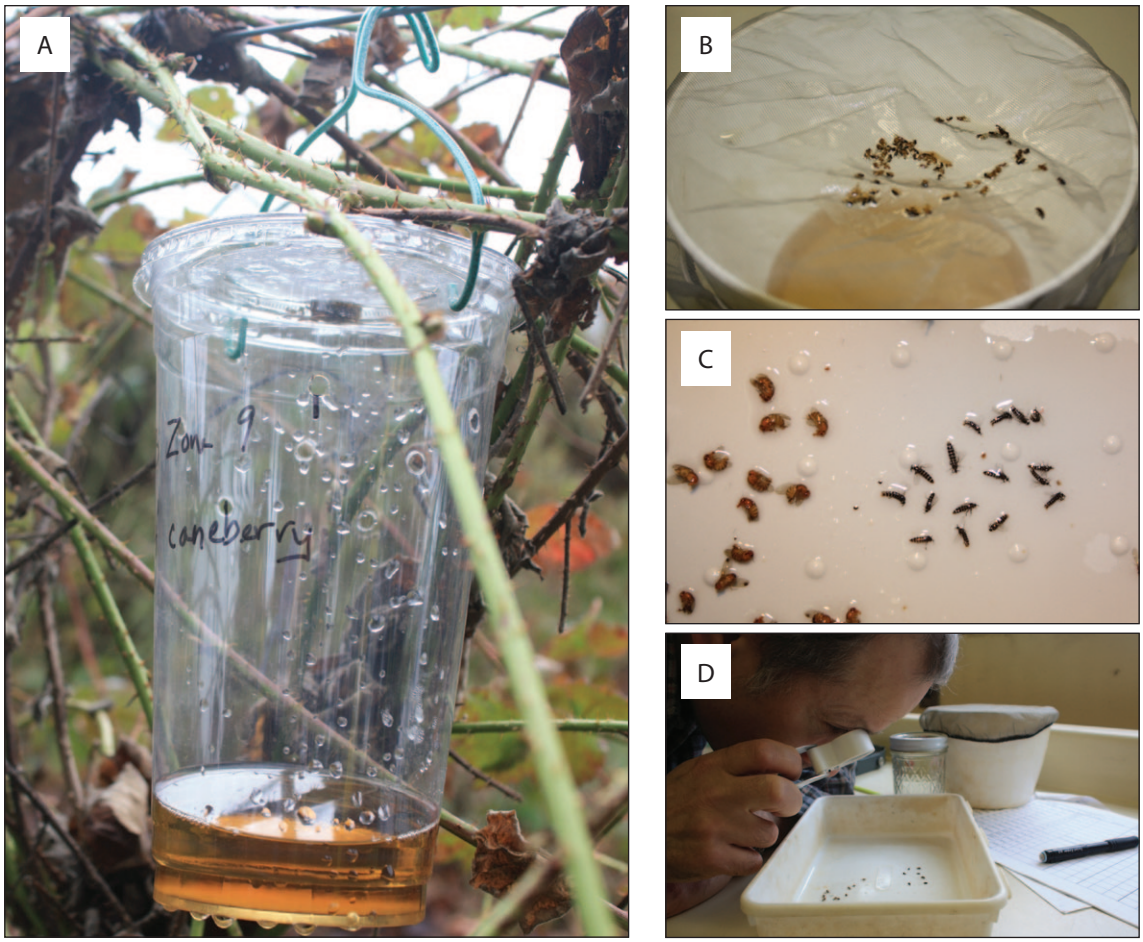

Figure 5. It is easy to construct a monitoring trap for spotted wing drosophila. (A) Materials used in a SWD trap are a clear plastic cup with lid, pure apple cider vinegar, a drop of liquid soap, and wire or twine to hang the trap. (B) A strainer is used to filter flies from the bait solution. (C) A white pan is useful for holding specimens for examination. (D) A 30X magnifying glass or hands lens can make it easier to identify key SWD characteristics, such as spotted wings on males and sawlike ovipositors on females. Record your findings in a notebook or garden journal.

Photos by Amy Dreves, © Oregon State University.

Check traps for flies and replace the bait solution with fresh apple cider vinegar at least once a week. Follow these procedures when servicing traps:

1. Hold the trap up to the light, and look for adult flies. Pay particular attention to flies that have a spot on the leading edge of their wing tips; these may be SWD males.
2. To get a closer look at the flies, filter trap contents through a strainer. Because vinegar has mild herbicidal properties, **do not** empty traps into garden beds. In addition, **do not** use the strained vinegar as a drain cleaner, and **do not** pour it down your storm sewer. **Do** filter traps in an area of your yard where the potential for vinegar damage is not a concern, such as on small lawn weeds.
3. Dump the strainer contents onto a surface with a solid white background (e.g., a shallow, white pan). Spread the flies out using a small paintbrush or tweezers, and examine your catch. Look for the black spot on males' wing tips (figure 3), which you should be able to see with the naked eye but can see more easily with a magnifying glass or hand lens. Look for the sawlike ovipositor on females (figure 3), which is likely to be more visible if the fly has been soaking in the vinegar bait.

Monitoring for Larvae in Fruit

You can also look for SWD larvae in fruit. Collect fruit that you suspect may be infested. You can see small, white larvae with the naked eye. Use the salt extraction (figure 6A and 6B) or fruit dunk flotation method (figure 6C) to separate larvae from fruit.

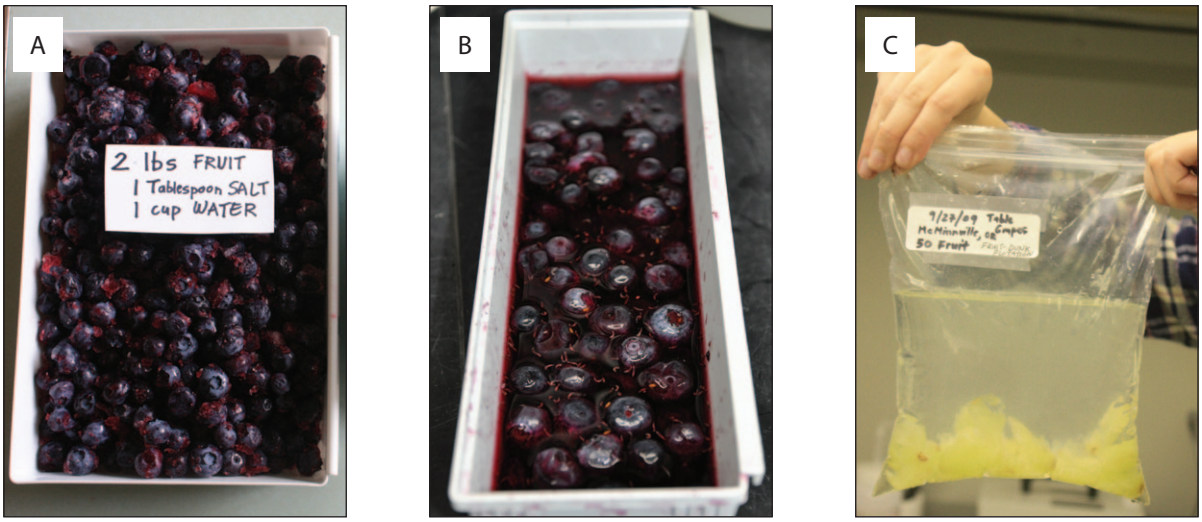

Figure 6. The salt extraction (A and B) and fruit dunk flotation (C) methods are useful for monitoring for SWD larvae in fruit. Photos by Amy Dreves, © Oregon State University.

Salt Extraction Method: Place the collected fruit in a shallow, white pan. Prepare a salt solution by adding 1 tablespoon of salt to 1 cup of warm water. Allow the salt to dissolve, and then pour the solution over the fruit. The salt will cause larvae to exit the fruit and move to the top layer of the salt solution. Within minutes, if larvae are present, you should see small, white, moving larvae on the top layer of the liquid. However, the larvae will eventually die and sink to the bottom of the pan.

Fruit Dunk Flotation Method: Lightly crush the collected fruit, and place it into a plastic sandwich bag. Prepare a sugar solution by adding 1 tablespoon of sugar to 1 cup of water. Allow the sugar to dissolve, and then pour the solution into the bag. If the fruit is infested, you will generally see the white SWD larvae floating in the bag. As the fruit settles to the bottom, some larvae will float to the top. However, depending on their weight and sugar content, some fruit may float. It may take up to an hour for the larvae and fruit to separate. Hold the bag up to the light to better see the larvae floating among the fruit. If the larvae are small, a hand lens may be useful.

Record Your Findings

Monitoring for SWD provides the information needed to effectively manage this pest in gardens. Record weekly findings in a notebook or garden journal; note the date and whether flies were found in traps or larvae were found in fruit. If flies were found in traps, note where the traps were placed (including surrounding environment) and the number of males (with black spots) collected. If you know how to accurately identify females, you can also record the number of females collected. If larvae were found in fruit, note the type of fruit and its condition (e.g., overripe, damaged, or injured).

If you record this information, you can share it with Oregon State University (OSU) researchers. By developing a better understanding of SWD population dynamics (i.e., when and how many) in gardens, researchers hope to better manage this pest in commercial fruit growers' fields. To share your findings with OSU researchers, collect as much of the requested information as possible (see sample form in table 2), and e-mail it to *OSUSWD@gmail.com*.

Table 2. Example of a data form gardeners can use to record the results of spotted wing drosophila monitoring efforts

SWD flies in monitoring traps						Infested fruit		
Date trap placed	Date trap checked	Nearest host plant to trap	Males	Females (optional)	Total	Type	Number infested	Total number checked
6/18/2011	6/25/2011	Sweet cherry tree	15	13	28	NA	NA	NA

Managing Spotted Wing Drosophila

One of the most important things you can do to manage SWD in your garden is systematically monitor for adults (using apple cider vinegar traps) and larvae (using the salt extraction or fruit dunk flotation method). For best results, combine the information you gain through monitoring with multiple pest control methods (cultural, physical, biological, and chemical).

Cultural Control

Cultural controls rely on good horticultural practices to prevent or reduce the probability of SWD infestations. These methods should be considered the first line of defense against SWD. In the absence of cultural controls, the incidence of SWD is likely to increase, and SWD infestations will be difficult to manage.

The following paragraphs describe key cultural controls for SWD.

Manage irrigation to avoid fruit splitting. Splitting refers to a break in the skin or pulp of the fruit and often occurs after a period of drought that is followed by intense irrigation. To avoid splitting, pay attention to plants' irrigation needs. Do not allow plants to dry out between waterings, and do not overwater.

Harvest fruit in a timely manner. Because females prefer to lay eggs in ripe and overripe fruit, it is important to harvest ripe fruit on a regular basis (i.e., at least three times per week). In addition, do not allow overripe or damaged fruit to remain on the plant during the growing season. These practices reduce egg-laying opportunities for SWD females and help prevent SWD infestations.

Clean up infested fruit. If you caught SWD flies in monitoring traps during the season, fruit on the plant or on the ground may be infested. To avoid increasing the SWD population, harvest fruit in a timely manner, and use tested sanitation methods to clean up leftover, fallen, and infested fruit. Sanitation methods that showed promise in small-scale trials at OSU were bagging, solarizing, and crushing.

- **Bagging**: Place small quantities of fallen, overripe, or infested fruit into a heavy-duty plastic bag. Tightly seal the bag for 1 week, and place it in a sunny location. After 1 week, dispose of the bag in the trash. Do not compost the contents of the bag if you suspect that any larvae have survived. In preliminary OSU trials, dead SWD larvae were found inside both clear and black plastic bags. The fruit decomposed into liquid. Larvae did not escape from the bag.
- **Solarizing**: Solarization uses heat from the sun to kill pests. Trapped light heats the fruit to temperatures detrimental to SWD. Place infested and potentially infested fruit on the ground in a sunny location away from fruit-bearing plants. Place clear, plastic sheeting (preferably 1 to 2 mil thick) over the pile, and tightly secure the edges of the tarp to hold in the heat. Remove any visible air pockets as these may result in a poor seal and can compromise the effectiveness of this pest control method. Patch holes or tears with clear packing tape or duct tape. Adjust the solarization time according to local weather conditions. To kill SWD larvae in fruit, the temperature beneath the tarp should remain at 120°F for at least a couple of days; heavy rains or overcast skies can slow the process.
- **Crushing**: Place infested and potentially infested fruit on the ground in a sunny location away from fruit-bearing plants. Crush fruits by stepping on them (for berries), rolling something over them (e.g., tire, PVC pipe, or rolling pin), or cutting and crushing them with a shovel or other garden tool (for larger fruits). The sun helps desiccate crushed fruit, killing the larvae inside. In preliminary OSU trials, SWD did not survive in flattened, dried, crushed fruit. However, precipitation from rain or sprinklers, uncrushed fruit, and fruit placed in shady areas increased SWD survival.

Dispose of SWD-infested fruit. Dispose of unmarketable fruit to prevent SWD access. After bagging or solarizing the fruit and ensuring that all larvae are dead, dispose of the fruit in your compost pile. Make sure you have killed all SWD larvae and rendered the fruit unsuitable for egg-laying SWD females before you compost. Composting alone is an unreliable method for killing SWD larvae. If you have doubts as to whether all larvae were killed by bagging or solarizing, dispose of the fruit in the trash.

Physical Control

Physical controls create a barrier between the pest and the fruit to decrease the probability of SWD infestation. Cover individual fruits (for peaches and other larger fruits), fruiting clusters, or entire fruiting plants (for berries) with a fine netting (0.98-mm mesh), nylon stocking, or paint strainer bag. Organza fabric is useful for this purpose. Make sure the fruit is completely covered and the netting is secured such that SWD can't sneak in under the bottom of the net.

Determining when to cover plants can be tricky. If you cover plants too early, you can exclude pollinators from flowering plants. This will reduce yield. If you cover plants too late, you can trap SWD with the fruit. This will increase, rather than decrease, SWD pest problems. For best results, cover plants at the first sign of SWD adults in traps but after plants have finished flowering.

Biological Control

Biological controls use naturally occurring predators (e.g., spider or predaceous bug), parasitoids (e.g., parasitic wasp), or pathogens (e.g., fungi, bacteria, or virus) to kill or impair a target pest. More research is needed to determine the specific predators and parasitoids that feed on or lay eggs on SWD. However, anecdotal observations suggest that predaceous bugs (e.g., minute pirate bugs and big-eyed bugs), parasitic wasps, and lacewing larvae may be important biological controls for SWD.

To maximize the biological control of SWD, you should work to protect and encourage these beneficial insects in your garden. Leave an area of your garden undisturbed to provide shelter. Grow plants that are known to attract beneficial insects, such as coreopsis, coneflower, sunflower, and goldenrod. Reduce or eliminate the use of broad-spectrum pesticides to help protect beneficial organisms. If you have a pest problem that requires insecticides, spot treat the problem area rather than broadcasting an insecticide over a wide area.

Chemical Control

Chemical controls should be used **only** if monitoring efforts reveal SWD adult flies or larvae. Take time to properly identify the flies and larvae and verify that you have SWD before using chemical controls. Spraying chemicals **will not** prevent SWD from visiting your garden and will instead result in a needless application that may negatively affect biological controls and the environment.

If SWD numbers are high and other methods are not providing adequate control, insecticides can be an important management tool. Choose a product that is registered for home use. Time pesticide applications to coincide with the period when fruit is susceptible to SWD (after fruit coloring and ripening) **and** when SWD flies are active. It has been reported that SWD flies are most active on fruiting plants during early morning and late evening when temperatures are between 65°F and 70°F. SWD flies are generally less active at higher temperatures (86°F).

Home-use chemicals include spinosyns, pyrethroids, carbamates, and organophosphates. Some spinosyns are labeled for organic crop production. These chemicals will affect SWD adults but will have no effect on larvae that are developing within, and are protected by, the fruit.

Follow the pesticide label for application rates and risks. Do not apply pesticides when bees and other pollinators are present on the plants. Rotate chemical families to avoid resistance.

For more information and the latest SWD news, visit *http://swd.hort.oregonstate.edu/* **and click the "For Gardeners" link on the left side of the page:** *http://swd.hort.oregonstate.edu/gardeners***.**

Use pesticides safely!

- Wear protective clothing and safety devices as recommended on the label. Bathe or shower after each use.
- Read the pesticide label—even if you've used the pesticide before. Follow closely the instructions on the label (and any other directions you have).
- Be cautious when you apply pesticides. Know your legal responsibility as a pesticide applicator. You may be liable for injury or damage resulting from pesticide use.

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