DEVELOPING AN EFFECTIVE WESTERN FLOWER THRIPS MANAGEMENT PROGRAM

WESTERN FLOWER THRIPS CAN BE DIFFICULT TO MANAGE FOR A NUMBER OF REASONS. READ ON FOR SOME PRACTICAL AND EFFECTIVE SUGGESTIONS TO MANAGE THESE DESTRUCTIVE PESTS.

By Raymond A. Cloyd

Western flower thrips (WFT), *Frankliniella occidentalis*, is still one of the most destructive insect pests of commercial greenhouses feeding on a wide variety of horticultural crops. WFT damage potential is due not only to its ability to directly damage greenhouse-grown crops by feeding on leaves and flowers, but also because they may vector destructive tospoviruses. This article is intended to provide applicable information so growers can develop effective strategies in dealing with WFT.

First and foremost, to effectively manage WFT, it is critical to develop a scouting program, which combines the use of yellow or blue sticky cards to monitor adult population trends, and visual inspection of crops to assess infestation levels of the nymphal stages. This is vital to the development of an effective and "sustainable" WFT management program. It should be the goal of all greenhouse producers worldwide to develop WFT management programs that preserve the longevity and effectiveness of currently available products.

Biology

A general knowledge of WFT biology is essential to understand the challenges associated with developing an effective management program. WFT are small (about 2.0 mm long) insects with piercing-sucking mouthparts. The life cycle consists of an egg stage, two nymphal stages, two pupal stages and an adult.

The lifecycle (from egg to adult), generally takes two to three weeks. However, development time from egg to adult is host and temperature dependent, with the optimum range between 79 to 84° F. Under these temperatures, the life cycle from egg to adult may be completed in nine to 13 days resulting in multiple generations occurring during a single cropping cycle. Females can live up to 45 days and lay 150 to 300 eggs during their lifetime. Females typically lay eggs underneath the epidermal layer of the leaf surface, which protects them from exposure to contact pest control materials and biological control agents such as predators and beneficial nematodes.

Figure 1. *Western Flower Thrips and leaf scarring*

Eggs hatch into first instar nymphs that eventually transform into second instar nymphs. These are the two stages that acquire the tospoviruses (mentioned below), which are then transmitted by adults. The second instar nymphs migrate to the base of a plant and enter the growing medium to pupate. The pupal stage does not feed and is very tolerate or immune to most pest control materials used to regulate WFT nymph and adult populations.

WFT may also pupate in the open flowers of certain plants with complex floral architectures, such as chrysanthemum. Adults emerge from the pupal stage after approximately six days. Both adults and nymphs may aggregate in flowers or other concealed locations on plants; however, adults (particularly females) prefer to feed on pollen. WFT exhibit thigmotactic behavior, which means the body is in constant contact with a surface. This is why WFT are typically present in secluded habitats on plants, which again protects them from exposure to contact insecticides and biological control agents.

Damage

WFT damage plants by feeding on leaves and flowers. Although WFTs have piercing-sucking mouthparts, they do not feed exclusively in the phloem sieve tubes like aphids and whiteflies. Instead they feed within the mesophyll and epidermal cells of leaf tissues using a single stylet in the mouth, and then inserting a set of paired stylets, which lacerate and damage cell tissues and function to imbibe cell fluids.

Symptoms of WFT feeding include leaf scarring, distorted growth, sunken tissues on leaf undersides, and flower deformation (Figures 1 through 3). Fecal deposits ("thrips poop") may be present on leaf undersides (Figure 5). Flowers and leaves have a characteristic "silvery" appearance due to the influx of air after the removal of plant fluids (Figure 4). In addition to the direct damage caused by WFT feeding, they may cause indirect damage by vectoring the tospoviruses: Impatiens Necrotic Spot Virus (Figure 6) and tomato spotted wilt virus.

Management

It is difficult to manage WFT in greenhouses for a number of reasons, including its ability to feed on a broad range of plant types, high female reproductive capacity, rapid lifecycle (egg to adult), small size (≈ 2.0 mm long), feeding habit, cryptic habitats (e.g., unopened flower buds) and resistance to pest control materials. Since the tolerance for WFT damage on most greenhouse-grown crops is relatively "low," the principal management strategy used to deal with WFT populations involves the use of pest control materials. The key to WFT management with pest control materials is to initiate applications when populations are "low," which avoids having to deal with

Clockwise from top left:
Figure 2. *Sunken tissue on leaf underside*
Figure 3. *Western Flower Thrips damage on gerbera*
Figure 4. *Western Flower Thrips feeding damage silvering*
Figure 5. *Western Flower Thrips fecal deposits on leaf underside*

different age structures or life stages simultaneously over the course of the crop production cycle.

However, in most cases, WFT management is "reactive" or occurs when populations are already abundant, which unfortunately limits options. Once WFT populations reach "high" levels, then growers rely on pest control materials, and more frequent applications (at three- to six-day intervals) may be required; however, this may promote the onset of resistance.

Pest control materials must be applied before WFT enter terminal or flower buds because once they do, it is very difficult to obtain adequate regulation and prevent injury. Pest control materials with contact or translaminar properties are often used to regulate WFT populations whereas systemic pest control materials when applied as a drench or granules to the growing medium typically do not translocate into flower portions (e.g., petals and sepals) at sufficient concentrations to impact WFT adults that normally feed on flowers.

Pest control materials with translaminar properties (the material penetrates and resides in leaf tissues forming a reservoir of active ingredient) may provide enough residual activity even after spray residues have dried. As such, those materials with translaminar properties are more likely to be effective in killing WFT in terminal or flower buds. Applications conducted after flowers open are, in general, too late since damage has already occurred.

Most currently available pest control materials only directly kill the nymphs or adult, with no activity on either the egg or pupae stages because these stages are typically located in the leaf or growing medium; thus escaping exposure from applications of pest control materials. Therefore, repeat applications are typically

warranted to kill the life stages that were not affected by previous applications. This is where scouting helps time applications of pest control materials accordingly. Three to five applications in a seven to 10-day period may be needed to obtain sufficient kill when WFT populations are "high" and there are different life stages (eggs, nymphs, pupae, and adults) and/or overlapping generations present, which occurs mainly from spring through late fall. However, frequent applications may result in WFT populations developing resistance.

In addition to resistance, there are other reasons for poor regulation of WFT populations when using pest control materials including 1) using the wrong pest control material (this does happen); 2) spray timing, which is associated with the age structure of WFT populations (again, scouting will avoid this problem); 3) spray coverage (especially when using contact pest control materials); 4) pH of the spray solution; 5) frequency of applications; and 6) migration of WFT populations into greenhouses from outdoors, which may have already been exposed to a similar mode of action that will be used in the greenhouse.

The mode of action and activity type (contact, translaminar, systemic, and stomach poison) of the pest control materials registered for use against WFT are presented in Table 1. In addition to using pest control materials, there is always the option of purchasing and releasing biological control agents (predators and benefical nematodes). For more information on using biological control agents on WFT, consult the publication *Western Flower Thrips: Management on Greenhouse-Grown Crops*, which is available at http:www.ksre.ksu.edu/library/entml2/mf2922.pdf

Early in the cropping cycle, and when plants are primarily in the vegetable stage, try to avoid using the "big guns" or those pest control materials with specific modes of action. You want to preserve these compounds for when you are dealing with "high" WFT populations. Instead, use pest control materials with broad modes of activity such as *Beauveria bassiana* alone, or mixed with azadirachtin, insecticidal soap, horticultural oils, or insect growth regulators such as novaluron.

You can also use the neonicotinoids including imidacloprid, acetamiprid, dinotefuran, and/or thiamethoxam. Furthermore, consider releasing biological control agents such as *Neoseilus* (=*Amblyseius*) *cucumeris*, *Amblyseius swirskii*, or the minute pirate bug, *Orius insidiosus*.

Once you start seeing an increase in numbers on the sticky cards, which may be above your established threshold (e.g., 10 to 20 adult WFT per sticky card per week), then you may need to use a different set of pest control materials including abamectin, acephate, methiocarb, spinosad, chlorfenapyr and/or pyridalyl to

Table 1. Pest control materials registered for use against the Western Flower Thrips (*Frankliniella occidentalis*) in greenhouses. Information includes common name (active ingredient), trade name, mode of action, activity type (contact, translaminar, systemic and/or stomach poison).

Common Name	Trade Name(s)	Mode of Action	Activity Type*
Beauveria bassiana[1]	BotaniGard	Unclassified mode of action	C
Paecilomyces fumosoroseus	PFR-97/NoFly		C
Azadirachtin[2]	Azatin/Ornazin/Molt-X/ Azatrol	Ecdysone antagonist	C and SP
Flonicamid	Aria	Selective feeding blocker and obstruction of potassium channels	C and S
Tolfenpyrad	Hachi-Hachi	Mitochondria electron transport inhibitor	C
Pyrethrins	Pyreth-It/Pyrethrum	Prolong opening of sodium channels	C
Novaluron	Pedestal	Chitin synthesis inhibitor	C,T and SP
Fenoxycarb	Preclude	Juvenile hormone mimic	C
Kinoprene	Enstar II/AQ	Juvenile hormone mimic	C
Petroleum oil	Ultra-Pure Oil/SuffOil-X	Suffocation or membrane disruption	C
Potassium salts of fatty acids	M-Pede	Desiccation or membrane disruption	C
Bifenthrin	Talstar/Attain	Prolong opening of sodium channels	C
Cyfluthrin	Decathlon	Prolong opening of sodium channels	C
Fluvalinate	Mavrik	Prolong opening of sodium channels	C
Bifenazate + Abamectin	Sirocco	Mitochondria electron transport inhibitor + GABA chloride channel activator	C and T
Chlorpyrifos	DuraGuard	Acetylcholine esterase inhibitor	C
Acephate	Orthene	Acetylcholine esterase inhibitor	C,T and S
Methiocarb	Mesurol	Acetylchloline esterase inhibitor	C
Spinosad	Conserve	Nicotinic acetylcholine receptor agonist and GABA chloride channel activator	C,T and SP
Chlorfenapyr	Pylon	Oxidative phosphorylation inhibitor	C and T
Abamectin	Avid	GABA chloride channel activator	C and T
Pyridalyl	Overture	Unknown mode of action	C

* Activity Type: C=Contact, T=Translaminar, S=Systemic and SP=Stomach poison

1 Products containing Beauveria bassiana as the active ingredient may be mixed with those products containing azadirachtin as the active ingredient.

2 Products containing azadirachtin as the active ingredient may be mixed with those products containing Beauveria bassiana as the active ingredient.

'knock down' populations. If used appropriately, these options should avoid or at least alleviate WFT populations from building-up.

However, it is important to note that any WFT management program will only work if you diligently scout your crops. The only way to maintain WFT populations at "low" levels are by timing of applications and thorough coverage of all plant parts. You can have the best pest control materials at your disposal but if you don't use or apply them correctly they will not be effective. Another thing to consider is once plants are purchased and placed into gardens or landscapes then WFT populations are subject to a variety of factors that cause mortality (death) including natural enemies (e.g., predators) and weather (e.g., rainfall). Also, customers tend to have a higher tolerance for plant damage or are less scrutinizing than growers do. In fact, most consumers don't even know what a WFT is.

Another factor to consider is that due to the current trend of increased pest control material regulation combined with the increasing availability of low cost generic products and the excessive registration costs, growers are likely to see fewer new active ingredients registered for use against WFT and should develop management programs that maintain the effectiveness of currently available products.

A successful WFT management program does not require "eradication" of the pest, but instead maintaining WFT populations at levels such that no "major" damage is noticeable. This will avoid unnecessary applications of pest control materials, which reduces selection pressure and thus the potential for resistance. In fact, two weeks before you anticipate shipping the crop, take a leisurely walk through your greenhouses and if you don't see any noticeable crop damage and the crop looks marketable then consider not applying any pest control materials. Give yourself some credit, at this point, you have done all you can to maintain WFT populations low enough to avoid economic crop damage.

Below are some key points to contemplate when implementing a pest

management program against WFT:

• The first line of defense in any pest management program is sanitation. Be sure to remove all weeds, which are reservoirs for WFT and potential inoculum sources for the viruses transmitted by WFT.

• Scout crops routinely using colored (yellow or blue) sticky cards. Determine which crops, and even cultivars, are "most" susceptible to WFT and pay particular attention to these in your scouting program.

• Establish thresholds (e.g., 10 to 20 adults per sticky card per week) for WFT adults, but be flexible, as these will likely change based on the crops grown, especially those that are susceptible to the viruses transmitted by WFT.

• Use pest control materials with broad modes of action early in the crop production cycle and if populations are starting to increase (based on numbers of WFT captured on sticky cards) then incorporate pest control materials with site-specific modes of action. Also, be sure to develop rotation programs that involve pest control materials with different modes of action (refer to Table 1).

• Use biological control agents such as predatory mites, predatory bugs, and possibly beneficial nematodes (*Steinernema feltiae*) early in the crop production cycle and make releases on a regular basis.

• Be sure to contact your local or regional extension entomologist if you have questions or require assistance regarding management of WFT.

Figure 6. *Symptoms of INSV on impatiens*

** Mention of specific products in this article does not constitute an endorsement.*

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