Mechanisms of Insecticide Resistance in Western Flower Thrips, *Frankliniella occidentalis* (Pergande)

IRAC
Insecticide Resistance Action Committee

www.irac-online.org

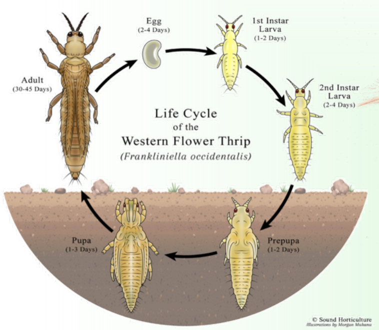
Introduction and biological background

The Western Flower Thrips, *Frankliniella occidentalis* (Pergande) (WFT) is a cosmopolitan and polyphagous pest of vegetables, fruits and ornamental crops. Both adults and larvae show a preference to feed on flowers, buds, foliage, and fruits. They are particularly difficult to control in flowers. In addition to direct plant damage, WFT is a highly efficient vector of different plant tospoviruses such as the Tomato Spotted Wilt Virus (TSWV). Both direct damage by feeding and oviposition and viral infections reduce yields and quality.

Originating in Western USA in the 1960, it spread east in the 1970's, then appeared in Europe in 1983, Japan 1990, Australia 1993, spreading mainly in horticultural crops. In addition, increased atmospheric CO2 concentrations and global warming are likely to increase both spread of WFT, and its reproductive success and consequent economic damage.

Identification and Life Cycle of *F. occidentalis*

- Small (1-2 mm long), slender, soft-bodied insects that are yellow to light brown in color, with darker abdominal segments. Males smaller and paler.
- Females arise from fertilized eggs and males from unfertilized eggs.
- Adults have distinctive fringed wings but are weak flyers that rely on wind dispersal.
- Antennae with 8 segments, the first paler than the second.
- It completes its lifecycle in 2-3 weeks at temperatures between 20 and 25ºC.
- Adult females lay up to 250 eggs in plant tissue under the epidermis.
- Two larval instars. 2nd instar larvae drop to the soil to go through the prepupal and pupal stages Winged adults emerge and return to the plants.



Adult female *F. Occidentalis* Micorphotograph courtesy of http://www.ozthrips.org

Resistance Mechanisms

First reports of insecticide resistance in WFT date to the 1980's. Three factors may contribute to the development of resistance in WFT: Short generation time, high fecundity, and haploid males in which resistance genes are directly exposed to selection by insecticide treatment.

Studies indicate that enhanced metabolic detoxification mediated by cytochrome P-450 monooxygenases is likely to be a major factor in resistance to carbamates (Group 1A), OP's (1B), pyrethroids (3A), neonicotinoids (Group 4A), avermectins (Group 6), and pyriproxyfen (Group 7C) in WFT. Resistance to each of these modes of action may occur independently, whilst in some documented cases multiple resistance to one or more of the modes of action has been reported in the same population. Studies with pyrethroid resistant WFT revealed the presence of a mutation (L1014F) in the voltage-gated sodium channel. This mutation is known to confer low-medium level pyrethroid resistance.

Research with spinosad-resistant WFT showed that resistance is associated with target-site changes, rather than enhanced metabolism, and a nicotinic acetylcholine receptor point mutation (G275E) was confirmed and identified from field collected resistant WFT. Spinosad-resistant WFT showed no cross-resistance to acrinathrin (3A), formetanate (1A) or methiocarb (1A) in laboratory strains selected for resistance towards each insecticide.

Frankliniella occidentalis Resistance around the Globe

Resistance Management Guidelines

The table below shows modes of action registered for WFT management. The number of MoA may vary according to number of products registered in each country. The following guidelines may help preserve the effective management tools:

- ✓ Use each compound only when needed as part of an IPM program and according to the label recommendations.
- ✓ Alternate products from different chemical MoA groups using a window approach. Since overlapping generations of WFT are typically present, this is generally simplified by using 3-week windows when only 2 generations are exposed to the same MoA.
- ✓ Use as many different MoA groups as possible.
- ✓ Avoid treating subsequent generations with the same MoA group assuming there is no cross-resistance between products with different MoA.
- ✓ Avoid rotating molecules of different MoA, when similar metabolic resistance mechanisms have been identified.

MoA Group	Primary Site of Action	Chemical Subgroup or exemplifying active ingredient
1A	Acetylcholinesterase (AChE) inhibitors	Carbamates
1B	AChE inhibitors	Organophosphates
2A	GABA-gated chloride channel antagonists	Cyclodiene organochlorines
2B	GABA-gated chloride channel antagonists	Phenylpyrazoles (Fiproles)
3A	Sodium channel modulators	Pyrethroids
4A	Nicotinic acetylcholine receptor (nACHhR) competitive modulators	Neonicotinoids
5	nAChR allosteric activators	Spinosyns
6	Chloride channel activators	Avermectins
7C	Juvenile hormone mimics	Pyriproxyfen
13	Uncouplers of oxidative phosphorylation via disruption of the proton gradient	Chlorfenapyr
15	Inhibitors of chitin biosynthesis affecting CHS21	Benzoylureas
28	Ryanodine receptor modulator	cyantraniliprole
30	GABA-gates chloride channel allosteric modulators	Meta-diamides, isoxalines
UN	Compounds of unknown or uncertain MoA	azadirachtin
UNF	Fungal agents of unknown or uncertain MoA	*Beauveria bassiana*, *Paecilomyces fumosoroseus*

IPM for Western Flower Thrips control

As with any other pest, relying on a single control method is not effective or sustainable. Several tactics have proven useful at reducing WFT populations. Some of these tactics are more suitable for greenhouse and covered crops:

- When available, plants that are resistant to WFT feeding damage or to WFT transmitted viruses should be used.
- Use plastic covers (including UV reflective mulches) and netting or screens that serve as barriers to prevent WFT arrivals or reduce densities.
- Blue sticky traps can be employed to catch flying adult thrips.
- Performance of traps can be enhanced with pheromones.
- Monitor for presence of natural enemies before relying on insecticidal control.
- Predators can be released onto leaves to hunt and kill larval thrips. Examples of predators include: anthocorid bugs (*Orius* spp.), lacewings (*Chrysoperla* spp) and predatory mites (*Amblyseius* spp., *Stratiolaelaps* spp).

Orius laevigatus predatory bug nymph

Amblyseius cucumeris predatory mites

- Rove beetles (*Dalotia* spp.) predate on WFT pupae in the soil.
- Entomopathogenic nematodes (EPN) can be used to control thrips in the soil. An example of EPN is *Steinernema feltiae.*
- Entomopathogenic fungi (EPF) can be used as foliar sprays in flowering crops to reduce adult thrips, if humidity conditions are high enough. Examples of EPF include: *Beauveria, Paecilimyces sp.*
- Use crop rotation and elimination of green bridges in temperate regions.
- Some weeds are known reservoirs for WFT. Weed management helps reduce thrips populations.
- Use insecticides when necessary (economic threshold is reached). Always follow label recommendations regarding spray equipment, application volumes and rates, and adjuvants or additives, which can increase plant penetration that enhance insecticide efficacy.
- For transplant seedlings, do not use the same MoA insecticides that were used in the nurseries, plant propagation houses or greenhouses by commercial transplant producers.
- Use beneficial-compatible compounds or those with low foliar residual effect to limit long term effects on beneficial organisms (for example potassium salts of fatty acids, maltodextrin). Use chemical clean up sprays at the beginning and end of the season where appropriate.

References

1. Bielza, P. et al. 2008. Inheritance of resistance to acrinathrin in *Frankliniella occidentalis* (Thysanoptera : Thripidae) Pest Manag. Science. 64:. 584-588.
2. Bielza, P. 2008. Insecticide resistance management strategies against the western flower thrips, *Frankliniella occidentalis.* Pest Manag. Science. 64: 1131-1138
3. Espinosa PJ, et al. 2005. Metabolic mechanisms of insecticide resistance in the western flower thrips, *Frankliniella occidentalis* (Pergande). Pest Manag. Sci 61:1009–1015.
4. Gao, Y. et al. 2012. Western flower thrips resistance to insecticides: detection, mechanisms and management strategies. Pest Manag. Sci. 68: 1111-1121.
5. Kirk, W. D., & Terry, L. I. 2003. The spread of the western flower thrips *Frankliniella occidentalis* (Pergande). Agr Forest Entomol. 5(4). 301-310.
6. Pappu, H. R., et al. 2009. Global status of tospovirus epidemics in diverse cropping systems: successes achieved and challenges ahead. Virus res. 141(2). 219-236.
7. Puinean, A.M. 2013. A nicotinic acetylcholine receptor transmembrane point mutation (G275E) associated with resistance to spinosad in *Frankliniella occidentalis*. Journal of Neurochemistry. 124: 590–601
8. Reitz et al. 2020. Invasion biology, ecology, and management of Western flower thrips. Ann Rev Ent.

Designed & produced by IRAC Sucking Pest WG, February 2020, Poster Ver. 6
For further information visit the IRAC website: **www.irac-online.org** IRAC document protected by © Copyright