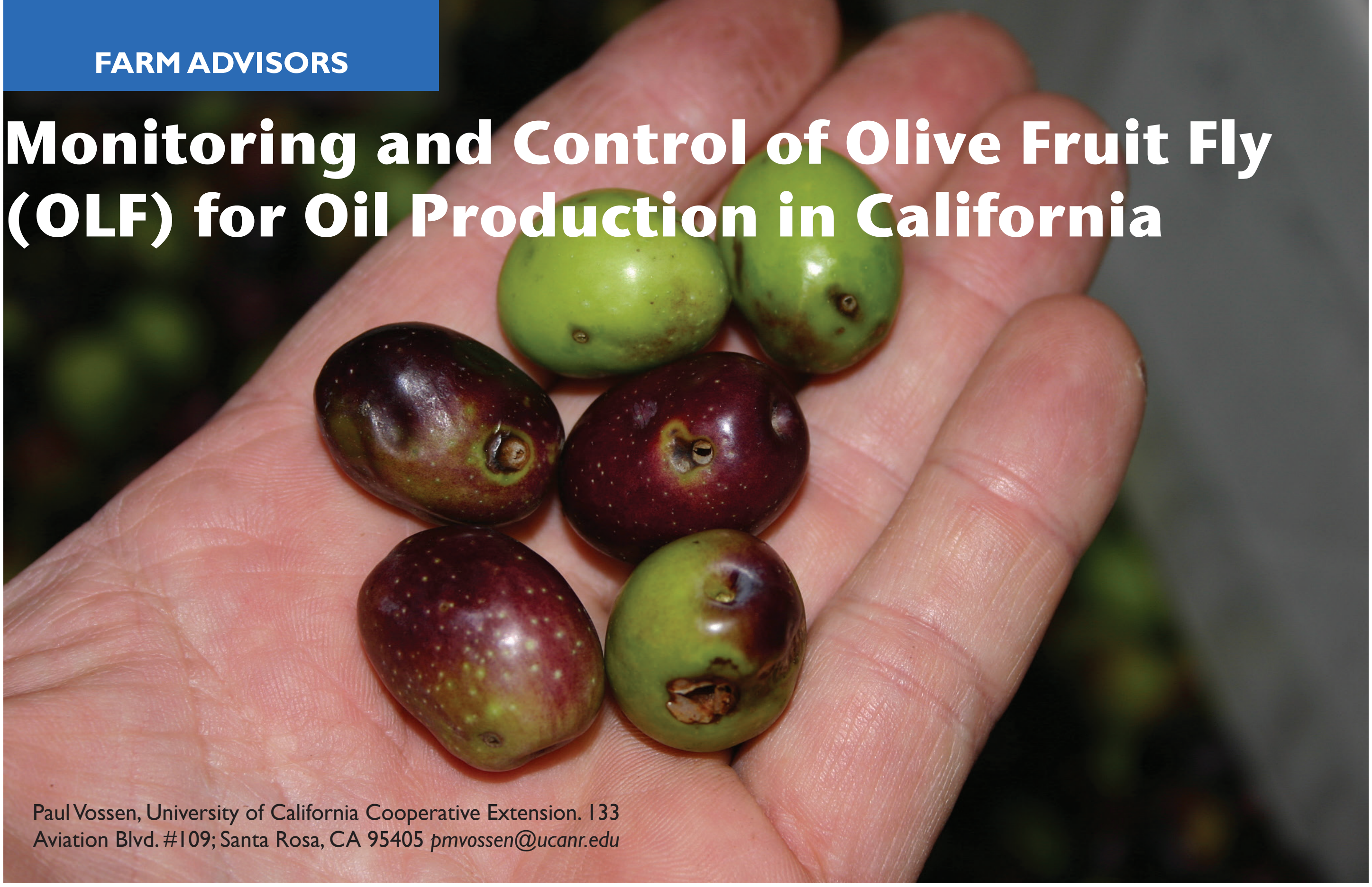
Monitoring and Control of Olive Fruit Fly (OLF) for Oil Production in California



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Introduction:

Olive fruit fly (OLF) *Bactrocera oleae* was found for the first time in urban Los Angeles, California in 1998 and rapidly spread to the rest of California by 2002. The standard treatment over the last fifteen years has primarily relied on the use of spinosad bait. Last year, however, many growers throughout California, especially oil producers, suffered extensive damage. In some cases the damage led to total crop loss and to the speculation that OLF had developed resistance to spinosad.

The severe OLF infestation of 2013 occurred all over California simultaneously. It is not typical to see an insect develop resistance to an insecticide in several different areas at the same time, therefore the problem was likely due to other factors. In conversations with growers who experienced severe OLF damage it became clear that many had not been following proper treatment protocols for spinosad bait sprays. Some orchardists were delaying treatment until too late, waiting too long between treatments, diluting the product with too much water, or experimenting with their own mixes of various baits and generic spinosad. Consequently, when the perfect weather conditions led to higher than normal insect numbers, they got blindsided.

Olive Fly Biology:

The OLF adult fly is approximately 3/16 inch (4-5 mm) long and has a single dark spot near the tip of each clear wing. Its larvae are yellowish-white legless maggots. It is active at temperatures between 60°-90°F, but prefers 75°F with moist conditions. The lower temperature threshold for most developmental stages (egg, larva and pupa) is around 43-50°F with the upper temperature threshold 86-96°F. Larvae inside fruit usually die at temperatures above 90°F. The range in temperature for adult development is between 32-104°F. Hot, dry weather limits its population somewhat in the inland valleys, but in coastal locations up to 100% of the fruit can be infested. Olive fly has several generations per year, about 30 days apart in the summer, so it multiplies very rapidly. In the winter, generation time is 134-

143 days. Adult females can lay 200-500 eggs and live for 50-80 days in the summer to 168-175 days in the winter.

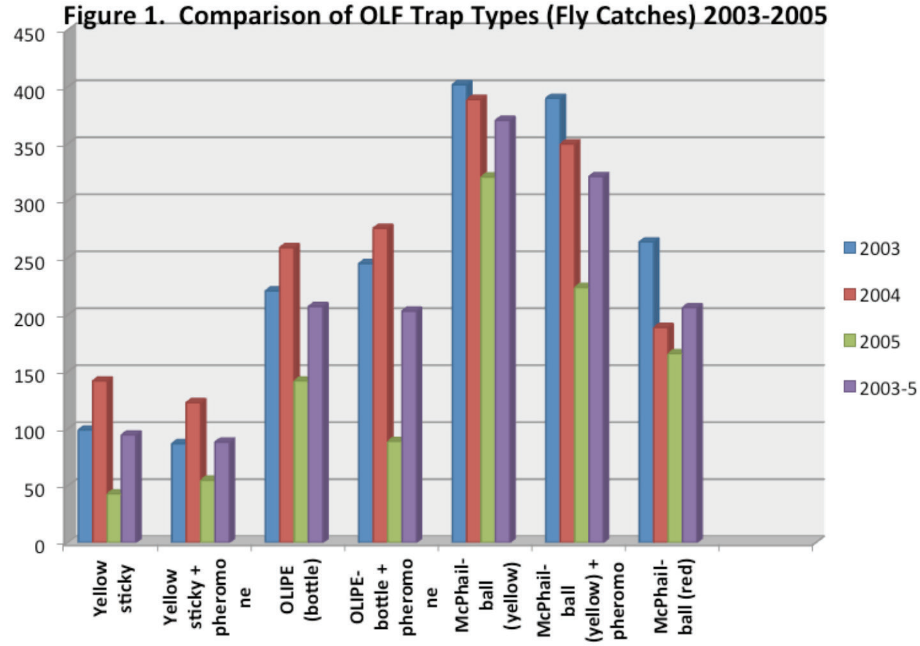
The first generation adults appear in the spring. The susceptibility of the olives to egg laying begins around the time of pit hardening when the fruit is about pea sized. The greatest damage occurs later in the season (September to November) when populations are highest. The olive fly lays its eggs just beneath the skin of the fruit leaving brown spots. The larvae (maggots) tunnel throughout the olive eating the flesh. They either pupate within the fruit or in the soil where fruit has fallen. OLF can overwinter either as an adult, or as a pupa in the soil or in fallen fruit.

The Importance of Monitoring OLF Populations

Monitoring with Traps: In most crops and for most pests, Integrated Pest Management (IPM) is used to determine when or even if it is necessary to treat for control. Unfortunately for OLF, IPM treatment thresholds don't exist. Research from 2003 to 2005 and many years of grower experience have often shown that OLF traps placed in untreated areas frequently indicated either low fly numbers and high damage levels or high trap catches and low damage levels at harvest (figure 2). Since there is no reliable correlation between trap catches and fruit damage at harvest, it has always been recommended to start with spinosad bait sprays in the spring, treat at regular intervals, and continue even after harvest. The postharvest treatment is designed to reduce the number of flies reproducing on un-harvested fruit left in the trees. The main reason for monitoring OLF populations using traps is to indicate the effectiveness of control treatments by comparing fly numbers caught before and after a spray application.

Comparisons of OLF trap types over several years has shown that the yellow colored McPhail-ball trap is better than any of the other trap types, especially compared to

Figure 1. Comparison of OLF Trap Types (Fly Catches) 2003-2005



the yellow sticky trap (figure 1). The McPhail-ball trap and OLIPE (bottle) trap use water and torula yeast (changed monthly) as an attractant. The yellow sticky trap is baited with ammonium carbonate (changed every 7 days) plus spiroketal pheromone (changed every 8 weeks). This research shows that the spiroketal pheromone did not significantly improve trap catches. Counting insects is more difficult with a liquid trap because it is time consuming and messy to separate the olive flies from other insects that also get caught. Yellow sticky traps require replacement when covered by too many insects or dust.

Fruit Monitoring: Since monitoring traps are a hassle to deal with and damage is not correlated with trap catch numbers, some growers are now relying mostly on checking fruit to determine treatment effectiveness and to monitor the percentage of fruit infestation. For fruit monitoring, it is important to note that olive fruit size is very important. Research has shown that large-fruited cultivars (Sevillano, Mission, Manzanillo, and Ascolano) suffer more damage compared to medium-sized cultivars (Frantoio, Leccino, Pendolino, Maurino, etc.), which are attacked more than small-fruited cultivars (Arbequina, Arbosana, and Koroneiki). Flies also, in most cases, do not lay eggs into fruit before the pit hardening stage of growth (mid-June) because the fruit is too small. Once olives are about pea-sized, however, weekly fruit monitoring can be conducted. This is done by selecting 100-200 fruit at random from throughout the orchard, or if the orchard is large, per each sector by cultivar. Fruit should be observed for stings and those with obvious damage should be cut open to check for live larvae. Anything over 1% damage with live larvae would warrant a treatment.

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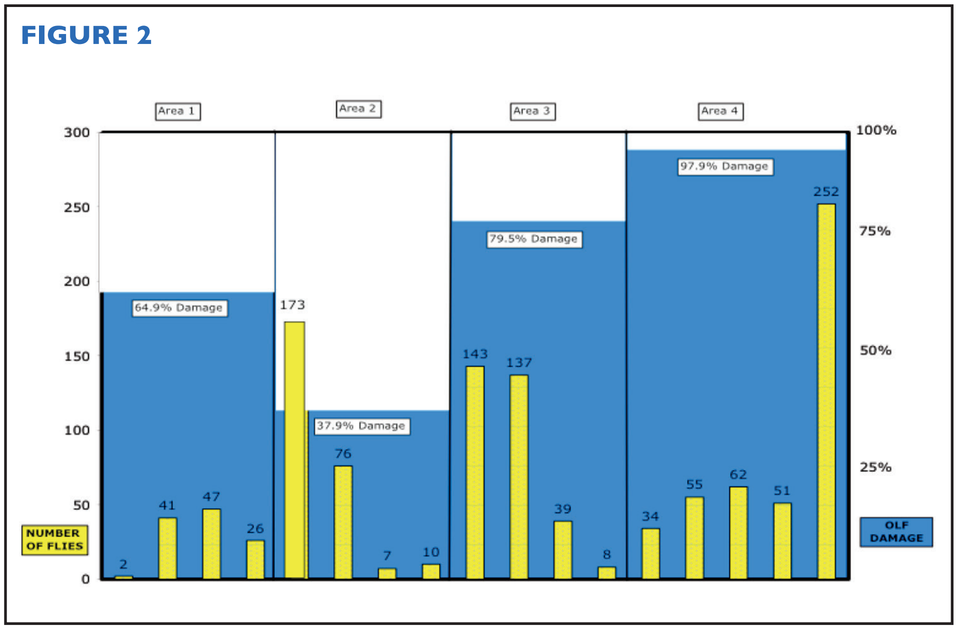

Figure 2. 2003-2005 comparison of trap catches and OLF damage levels in untreated areas with 4-5 replications.
Yellow bars show total fly catches in monitoring traps by location for the season. The blue area represents the amount of olive fly damage at harvest in untreated areas. Traps placed in each untreated area showed no significant correlation between trap catches and total damage levels at harvest.

Mass Trapping and Spray Treatments for OLF Control

Mass trapping and spray treatment control trials were conducted on Mission, Leccino, and Frantoio olive trees in Sonoma County for five years from 2004 thru 2008. All treatments were replicated four times in a randomized design. Each replicate had 6 to 45 trees. The treatments were as follows:

(1) Attract & kill device: is a shallow cardboard cone permeated with lambda cyhalothrin (synthetic pyrethroid insecticide), with ammonium bicarbonate and pheromone lures. Flies landing on the cardboard are killed, but no pesticide comes in contact with the fruit or the environment. One trap per tree put up in June – lasting the entire season. In Europe this is an organic treatment.

(2) McPhail-ball trap: a liquid trap with a large opening at the base. Baited with 3 torula yeast tablets per liter of water, which was changed monthly. One trap per tree put up in early May.

(3) Sticky panel traps: yellow cardboard panels about 5" x 10" in size, covered with a non-drying sticky coating, using both ammonium carbonate and pheromone (sex attractant) lures. One trap per tree put up after bloom and changed every 8 weeks.

(4) OLIPE (bottle) trap: a homemade 1-2 liter plastic bottle with several 5 mm holes in the shoulder, containing the same torula yeast and water attractant as the McPhail traps – changed monthly. One trap per tree put up in early May.

(5) Kaolin clay: an inert, mined mineral that creates a fine clay film on the fruit, which is a barrier to egg laying. It is recognized as an "organic" product for certification. It was applied in 2004 (twice) on 6-24, and 8-2; in 2005 (three times) on 6-29, 8-10, and 9-2; in 2006 (four times) on 7-24, 8-30, 10-4, and 11-4; in 2007 (once) on 9-11; and in 2008 (once) on 9-20 sprayed to full coverage at a rate of 50 lbs./100 gallons with a hand gun sprayer.

(6) Combination of OLIPE + Kaolin clay: one trap per tree as described under # 4 above with kaolin clay applied once in 2007 on 9-11 and once in 2008 on 9-20 at 50 lbs./100 gallons with a hand gun sprayer. Timing of the kaolin spray treatments in 2007 and 2008 were based on checking the trees once per week for fresh stings starting in late August. Two hundred fruit were selected at random and the spray was applied when >1% of the fruit had new stings.

(7) Spinosad bait: an "organic" product recognized for certification made from the actinomycete bacteria *Saccharopolyspora spinosa* combined with a sugar and protein based feeding attractant. Used at a dilution rate of 1:4 – applying one ounce of mixed product per tree – every two weeks from June 1st until harvest.

(8) Untreated check: Untreated trees used to determine damage levels without any OLF treatments.

Results from the OLF Control Trials:

The effectiveness of the various treatments was measured by sampling 200 fruit from each replicate just prior to harvest each year. Fruit was evaluated as damaged (stings with live larvae, larval tunneling, and fruit with exit holes) or undamaged (see Table 1).

Overall results show the overwhelming success of kaolin clay and spinosad bait as stand-alone treatments for OLF. These two spray products performed consistently well with no significant differences between treatments except in one year. For kaolin clay in years 2004-2006, multiple applications kept OLF damage at harvest down to an average of 2.5%. In 2007 and 2008 it worked very well with only one application timed in September as fruit stings began to increase beyond the 1% damage level. Spinosad bait sprayed every 1-2 weeks kept the average damage level down below 6.0% ranging from 3.1 to 11.4% damage. Mass trapping by placing a trap or an attract and kill device in each tree did not work well as a stand-alone treatment for OLF control. The average damage at harvest was about 25% and ranged from 3.4 to 46.0%. However, mass trapping was somewhat effective in keeping populations lower because the average damage level for untreated trees was about 70% and ranged from 36-95%.

Table 1. OLF Damage by Treatment and Year

Treatment	2004	2005	2006	2007	2008
Attract and Kill Device	14.5 b	41.6 c			
McPhail-ball type trap	33.5 c	16.7 b	3.4 a		
Yellow Sticky trap	30.8 c	46.0 c			
OLIPE (bottle) trap	33.9 c	30.6 c	24.6 c	24.5 c	30.4 b
Kaolin clay	2.2 a	2.3 a	3.1 a	4.5 ab	0.7 a
OLIPE (bottle) + Kaolin clay				1.2 a	1.8 a
Spinosad bait	3.9 a	7.8 a	11.4 b	3.1 ab	2.9 a
Untreated	87.6 d	94.9 d	35.8 d	55.8 d	72.0 c
LSD at 5% level					

OLF Damage Threshold Research

Variations in the stage and severity of OLF feeding, degree of fruit decomposition, and fruit maturity level have made it difficult to quantify the effects of OLF on oil quality. Fruit damaged with stings is less severe than if fruit is turning brown even though the percentage of damage may be the same or lower. In Europe there is a loose standard of about 10% OLF damage to produce Extra Virgin Olive Oil (EVOO), but the type of damage has never been defined and the EVOO standard is not very stringent. European researchers have documented that oils made from fruit with extensive larval tunneling had higher free fatty acid and peroxide levels than oils made from undamaged fruit. Those oils also had a shorter shelf life and turned rancid sooner.

Research conducted in California between 2003-2008 to establish an OLF damage threshold for oil showed that the real culprit in influencing olive oil flavor was the amount of rotten fruit. In that research, the University of California Cooperative Extension (UCCE) Olive Oil Research Taste Panel in Santa Rosa evaluated numerous experimental oils made in small batches that had been made from fruit damaged with different levels and types of OLF feeding. The panel consisted of qualified, veteran tasters who served on the original UC Taste Panel that was recognized by the International Olive Council in 2001. Oils were tasted blind and tastings were replicated to get statistically valid results using the triangle test. There were no significant differences in oil flavor between any of the damage levels as long as the fruit did not have any soft, brown spots (rot). Once rot was present at levels above 1%, however, the tasters could identify it. Oils made from fruit with between 1% to 5% soft brown spots was classified as defective with fermentation “off” flavors. Those oils tasted fusty, greasy, lacked freshness, and were slightly rancid.

Discussion

Olive Fruit Fly has the potential to be a devastating pest that reproduces so rapidly that it can quickly render a crop as not-worthy-of-harvest. It is almost impossible and certainly extremely expensive to sort out damaged fruit by hand, consequently control really needs to be preventive. In order to minimize treatment costs and environmental contamination, research has sought to find the most effective monitoring tools and treatment options. Life cycle and insect behavior studies were conducted to help time treatments. Damage threshold levels have also been determined so that suitable care can be devoted to preventing undesirable flavors in the oil.

Monitoring traps do not effectively predict damage at harvest, but might be used to help determine if treatments are working properly. OLF primarily attacks fruit that is larger than pea size (at about pit hardening stage), so it is likely not necessary to start treatments until then. Fruit monitoring is the only way, however, to be sure of the OLF infestation level. Cultivars with large fruit or low polyphenol levels need to be more carefully monitored and treated because they are more susceptible to infestation and the effects of OLF.

Spinosad bait and Kaolin clay were found to be very effective in preventing OLF damage. Spinosad bait needs to be applied properly with the correct dilution rate, frequency, timing, and spray droplet size. Some treatment considerations are:

- Start spraying early, just before pit hardening, to keep fly numbers low
- Use mixing rates between 1.0 part spinosad bait and 1.5 to 4.0 parts water
- Keep spray tank pressure low, using 0.028 inch nozzle size, to create large (1/4") size droplets
- Spray in cooler parts of the day or evening and into shady areas of the tree to keep the bait viable longer
- Re-apply or apply more frequently if the bait is not tacky, fly populations are high, or fruit stings exceed 1%.

Kaolin clay - barrier film prevents egg laying. Because its mode of action repels rather than attracts, it is well suited to controlling damage in a high fly-pressure situation where flies may be coming in from untreated trees. For assurance of full season control it requires 2-3 applications spaced every 5-6 weeks, so that a film of clay is maintained on the fruit surface at all times. This requires full tree coverage and a high pressure sprayer. One application of kaolin clay to non-infested fruit late in the season, when most OLF damage occurs may be an option. One of its major drawbacks is its appearance; since olives are frequently planted for aesthetic reasons, covering them with white powder may not be desirable.

Mass trapping (one trap per tree) using **OLIPE (bottle), sticky panel, McPhail-ball traps**, or the **Attract and Kill Device** has been shown to help keep damage levels down, but was not effective as a stand-alone treatment option. Combining mass trapping with spray treatments may have some potential to improve control and or reduce treatment costs.

Landscape and small-scale plantings in or near untreated trees are difficult sites for any type of OLF control, because of the surrounding reservoir of flies, especially with treatments that rely on attracting the pest. Isolated plantings have fewer OLF problems.

Growers can tolerate very high levels of OLF fruit damage without negatively effecting oil flavor as long as the fruit is not turning brown and rotting. Harvesting early, when fruit is still quite green, before it reaches the stage of having over 1% rot will help assure that the oil has no off flavor defects. Oils made from sound green fruit, but with extensive larval tunneling is likely to keep poorly, however, and may have elevated peroxide values and free fatty acid levels. Processing OLF infested fruit

immediately after harvest, without any delay, will not allow for further decay of fruit and will minimize oil quality problems. This is especially true if weather during harvest is warm or wet.

Over the last few years several University of California researchers have evaluated other products for OLF control. The most effective and least disruptive is fenpropathrin), which is a synthetic pyrethroid (conventional pesticide). It should only be used as a last resort if fly stings continue to increase with the use of use of other control methods and significant damage is anticipated. Use of fenpropaghrin should not be routine as it may cause an increase in secondary pests such as mites, scale or other pests.

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