Final Report to
Western IPM Center Grants Program
March 20, 2008

A. Grant Data

- **Grant Agreement #:** Campus Subaward No. 009607-Sonoma
- **Title:** *Monitoring and mass trapping olive fruit fly*
- **Lead Investigator:** Paul Vossen, Farm Advisor, UCCE Sonoma County
133 Aviation Bl, Suite 109
Santa Rosa, CA 95403
Ph. 707-565-2621
Fax 707-565-2623
pmvossen@ucdavis.edu
- **Team members:** Alexandra Kicenik Devarenne, Louise Ferguson, and Frank Zalom
- **First year funded and number of years funded:** January 1, 2005 to December 14, 2007
- **Funding amount:** $59,281

B. Nontechnical Summary

The recently introduced olive fruit fly (OLF) is the most economically significant pest of olives in California. Because the fly larvae feed on olives as they develop, tunneling through the fruit and destroying the flesh, the tolerance for fly damage in California pickling olives is 0%. The widely cited European tolerance for damage in oil olives is 10%. The validity of this threshold for California producers has not been tested. In order to minimize the environmental impact of control measures, an integrated approach to managing olive fruit fly is important. The standard treatment for OLF is a bait formulation of spinosad, a fermentation by-product of bacteria. Mass-trapping has had considerable success in Europe on OLF and in the control of various tephritid fruit flies in other locations. A barrier film made from kaolin clay, Surround, is also registered for use on olives. The purpose of this study was to compare the various spray treatments and mass trapping for the control of OLF. Monitoring for the OLF to determine a treatment threshold might help reduce the amount of pesticide required over the season, so the trial included extensive monitoring with yellow sticky traps, and correlation with harvest damage levels. In addition, an examination of the sensory effects of fly damage on olive oil was conducted to establish more accurate damage thresholds. All of the mass trapping methods reduced OLF damage by 50 to 70% of what was observed on untreated control trees. Some mass trapping devices are easier to use and less expensive than others. The two spray treatments were both very effective at controlling OLF, so farmers need to look to material costs, application costs (number of applications and if applied as a bait or cover spray), and the environmental implications of both. In the last year of the trial we found that one late season application of barrier film as a cover spray, just prior to when most of the OLF damage occurs, may offer the best control for the cost. This is especially true when considering that olive for oil can tolerate extensive OLF damage and even up to about 5% fruit rot before quality is significantly compromised. Since olives are a popular landscape tree in California, and those trees are a safe harbor for OLF outside commercial orchards, public outreach on the issue was part of the project, seeking to educate residential olive growers about control measures.

C. Introduction

The olive oil industry in California has grown tremendously in the past 15 years, recently passing 10,000 in the number of acres of olives planted for oil. Although still a small industry, olive oil has become a very high profile part of California agriculture (with a cachet similar to wine). Previously, olives were considered a fairly low-pest crop, suffering primarily from easily treated foliar disease, olive knot and some scale insects. The olive fly posed the first critical pest management challenge for the industry; heavy OLF infestation can lead to total crop loss for that season. The situation is particularly dire for the table olive industry, already reeling under heavy pressure from cheap imports. There is a 0% tolerance for OLF damage among California table olive processors. In 2005 one of the major canners rejected loads from Butte County because of OLF damage in some fruit. Olive oil allows more latitude in fly damage, but it is still a potentially devastating pest and the new industry in California does not have experience with the relationship between damage levels and oil quality. Virtually all the information used by the California olive oil industry came from Europe initially, including the 10% damage tolerance for OLF in oil olives. In Europe there is also a heavy reliance on conventional pesticides, such as the organophosphate dimethoate, for OLF control in many large olive-growing regions. There is concern there about pesticide residues in olive oil and wastewater, as well as effects on the environment. The registered products for OLF in the US are considerably less toxic, but like all pesticides must be evaluated in the greater context of the local ecology. The spinosad bait product that is currently the standard treatment for OLF in California, is expensive. The product itself is costly, and it needs to be applied every week or two for good control. Even then, its effectiveness is somewhat density-dependant and it may be inadequate in situations of extremely high fly pressure. The addition of an expensive pest management program to the already precarious bottom line of many olive growers is enough to drive them out of business. Establishing cost-effective management protocols in the US that minimize health and environmental impacts requires exploration of all potential control measures to determine which techniques are most effective. OLF is a serious pest, but developing an integrated management approach using the various options available will allow California's table and oil olive growers to control the pest in a way and to a degree appropriate to their situation.


OLF maggot (larvae) emerging from an olive

D. Objectives

Objective one – Continue established replicated trials in which several of the most practical monitoring traps are being compared. Trap catches will be recorded weekly during the growing season and related to the damage levels observed at harvest. Observe efficacy of trap styles and attractants for fly monitoring purposes.

a) Place a minimum of four replications of promising trap styles and attractants at various rates and monitor trap catches each week.
b) Vary the interval between changing and renewing attractants (minimum four replications).

c) Compare trap styles, including: yellow and red sticky panels, McPhail and modified McPhail traps in red and yellow, OLIPE traps, and the “apple maggot” red sphere trap.
d) Compare attractants, including: Torula yeast, other yeasts, ammonium carbonate, and various pheromone lures (Suterra, ISCA, Trécé, and Scentry).


OLIPE bottle trap

Attractants and trap styles were compared during each phase of the trial from 2003 to 2005. In 2006 there was a crop failure and only three suitable replications were possible. The attractants were changed according to manufacturer’s recommendations on dry lures, and at consistent 4 week intervals with liquid baits. The effectiveness of the yeast bait was good for a month, but at that point spoilage became an issue. Red sticky panels were not available, but yellow sticky panels of various types were used.

Objective two – Continue established replicated trials where several different combinations of trap styles and attractants (food and pheromone) are being compared. The attractants and trap designs that best reduce OLF damage at harvest will be further evaluated in 2005 and 2006.

a) Use the best of the above listed trap styles and attractants [objective 1 - c and d] placed at two different rates in small-scale orchards and one per tree in individual landscape trees. (Minimum of 4 replications per treatment). Measure trap catches every week and evaluate fruit damage mid summer and at harvest.

Various trap styles and attractants were deployed for mass-trapping OLF control efforts. Traps were used at a rate of one per tree in all situations, because of the small scale of the subject orchards. An attract and kill device was used in the mass-trapping part of the trial as well as the more conventional traps. Two evaluations were done in 2005, but in 2006 a single evaluation was done at harvest.


Yellow sticky trap used to monitor for OLF

Objective three – Collect fruit with various levels of OLF infestation (oviposition stings, young larval feeding, older larval feeding, etc.) and compare the sensory qualities of the oil to undamaged fruit. The fruit will be gathered from existing orchards with various levels of fruit damage at several harvest maturity stages. The effect of fruit storage delay prior to processing will also be evaluated. A taste panel that has been officially recognized by the International Olive Oil Council is available at a very low cost to evaluate the oils under specific unbiased blind tasting procedures. (IOOC 1996)

a) Collect fruit from four different varieties (Manzanillo, Mission, Frantoio, and Arbequina) at five different levels of fruit damage (0%, 1-10%, 10-40%, 40-80% and

80-100%). Additionally, fruit containing damage at 1-10% and 40-80% will be stored for 48 hours prior to processing to evaluate fruit deterioration and oil quality.

b) Process the fruit within a few hours, except where noted, in the Abencor system, which can produce 100 ml samples of oil from 2 lbs. of fruit. (Martinez et al 1975)
c) Evaluate and compare those samples following internationally recognized testing procedures using the California Olive Oil Council Taste Panel.
d) Evaluate the samples through standard laboratory procedures for free acidity and peroxide level to determine their non-subjective quality parameters.
e) Develop damage threshold levels based on the minimum detectible levels of perception of defects by the tasters and laboratory analysis.


Paul Vossen tasting olive oil to determine OLF damage threshold

Fruit was collected at various levels of damage and processed with the Abencor. Five different damage levels was found to be impractical because of the difficulty of finding fruit with the precise damage amounts desired, and because previous experience showed that oil from fruit with oviposition stings was identical to undamaged oil. Instead, severely damaged and undamaged fruit was collected and mixed together in different proportions for the various samples. The taste panel blind tasted those oils and evaluated them using the UC 15-point scale instead of the IOC profile sheet because of the greater accuracy of the UC system. New damage recommendations were developed based on the results of the tastings. In 2007, fruit with different levels of rot, associated with OLF damage, were made into oil and compared for sensory qualities.

Objective four **–** Expand the alternative and conventional spray materials comparison program to include new materials that show promise from other research programs.

a) Conduct spray trials with five single-tree replications at two orchard locations to evaluate the efficacy of: GF-120, kaolin clay, other formulations of Spinosad, compost tea, neem oil and any other materials showing promise.

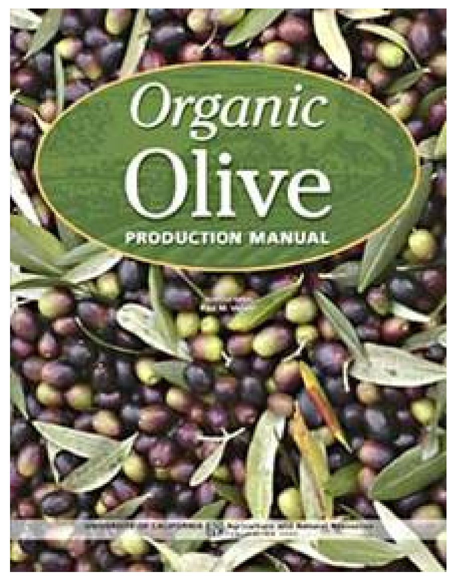

Spraying Spinosad bait for OLF control

Discussion with other researchers about the various spray possibilities resulted in a decision to discard cover sprays as an option. The consensus was that a cover spray could only be effective if it had high residual potency or was applied over a very large area, neither of which was a viable option. The comparison was limited to the products: GF-120 (spinosad bait) and Surround (kaolin clay). An attempt to locate an alternate bait product to mix with spinosad was unsuccessful. In 2007, a comparison was also made between mass trapping OLIPE traps and a single late application of Kaolin clay in combination and alone in an effort to minimize control costs.

Objective five – Create practical educational handouts, posters, and Power-Point presentations (in PDF) that can be downloaded, viewed, or printed by anyone.

a) Develop materials specifically for homeowners on the control of OLF that can be disseminated by any extension agent or commission in California, Arizona, or Texas.
b) Model a program of information dissemination to backyard olive growers through the Sonoma County Master Gardener Program that can easily be adopted by other counties.
c) Collaborate with other UC researchers and educators to expand and update existing OLFF publications and recommendations as information changes.
d) Conduct an organic olive oil production short course in 2005 in cooperation with the various certifying organizations and CDFA in California.
e) Conduct practical presentations to commercial small-scale growers and agencies in Southern, Central, and Northern California regarding alternative methods for OLF control. These would also be made available to the industries in Arizona and Texas.

An OLF control handout aimed at homeowners was created, as was another more detailed handout for serious hobbyists or commercial growers. The homeowner version was distributed through the master gardeners, and an educational display was created with information on OLF. Both of these handouts are updated as necessary and posted on the UCCE Sonoma County website. The organic olive oil production short course was held on May 27th, 2005. Presentations on OLF control were presented at various meetings of growers and as continuing education for DPR license holders. The UC Sonoma website http://cesonoma.ucdavis.edu has been updated to include information for both commercial and non-commercial olive growers regarding OLF control. The Organic Olive Production Manual – DANR publication # 3505 was published in April of 2007 and contains a chapter on OLF control



E. Approach

The research was conducted in Sonoma County in small-scale orchards and landscape plantings at 28 different sites, with four replications of each treatment including at least one untreated control tree in each area. In 2005 we compared various treatments at 28-30 different sites, with four replications of each treatment including at least one untreated control group of trees in each area. At a rate of one trap per tree, we tested: 1) Attract and kill device (Magnet OL). 2) Yellow Multi-Lure and yellow ISCA ball McPhail-type traps, with torula yeast and water. 3) Homemade OLIPE bottle traps with torula yeast bait. 4) Yellow sticky panel trap renewed periodically and changed every 8 weeks. The yellow sticky traps came from ISCA Technologies and used encapsulated petroleum jelly-based ammonium and spiroketal lures. We also compared: 5) Kaolin clay applied three times (June, August, and Sept.). 6) Spinosad bait applied every 1-2 weeks, and 7) Untreated control trees. At each site there was a yellow sticky trap for monitoring.

In 2006 the attract and kill device was unavailable so it was not included in the trial design. It was also decided that using the yellow sticky panels for control at a rate of one per tree was impractical and expensive, and unlikely to be used given its unspectacular results. The treatments used in year four were 1) McPhail and Ball traps with torula yeast, 2) OLIPE trap with torula yeast, 3) Kaolin clay applied every five weeks (July, August, Oct. and November) 4) Spinosad bait applied every 1-2 weeks, and 5) Untreated control. Each site had a yellow panel trap for monitoring and fly catches were recorded every week. Weekly trap counts were recorded for the monitor traps at all the locations, and weekly trap counts for selected traps in the mass-trapping set-ups.

In 2007, four different sites received the following five treatments: 1) OLIPE traps – one per tree, 2) Kaolin clay applied once late in the season – early September, 3) OLIPE traps – one pre tree plus Kaolin clay applied once in early September, 4) Spinosad bait applied every 1-2 weeks, and 5) Untreated control.

The effectiveness of the treatments was measured by assessing the fruit for signs of maggot infestation. Fruit damage was measured 2-3 times per season for each treatment at each location, including one assessment at harvest. Oil made from OLF damaged olives using a small Abencor (Martínez et al 1975) processing system was blind tasted by a panel of trained olive oil tasters. Manzanillo and Ascolano olives were sorted into the two batches: 100% OLF damage and 100% OLF damage at a stage where some of the fruit has started to rot. Fly-damaged Ascolano, Frantoio, and Leccino olives were also processed, with a damage level of 0 and 50%, and Mission olives with fly damage of 0, 25 and 50%. When we discovered that the amount of fly damage was less important than the type of damage, we began to evaluate olives by their percentage of rot (0% - 1% - 5% and 10%), making them into oil and evaluating for detection threshold with trained tasters.

F. Results

Kaolin clay (Surround) residue on olives

In 2005 the McPhail-type traps had the highest catches. The McPhail-type Ball trap was satisfactory; its larger capacity kept it from drying out and it caught slightly more flies than the other McPhails. The yellow sticky traps had considerably lower catches, and as monitor traps failed to predict damage levels at harvest. The OLIPE's were the least effective traps; the McPhail-type traps provided the best control of the traps with an average damage level of 16.7%. The OLIPE averaged 30.6%. The attract and kill device gave mixed results, with damage ranging from over 90% to less than 7% (average 41.6%). In locations where it was deployed in an isolated group of trees it did very well at suppressing damage. Yellow sticky traps (46.0%) provided similar average levels of control to the attract and kill, but no location had less than 13.4% damage. Spinosad bait had 7.8% damage at harvest, and kaolin clay had 2.3%. Untreated control trees averaged 94.9% damage.

The weather in 2006 caused numerous problems with the trial. The olive crop was poor and infestation levels were extremely uneven; some of the sites had no OLF at all, others had extraordinary pressure. In one location with the latter situation, the only fruiting trees on the property, Ascolano olives, sustained serious damage despite treatments known to be effective. The trees treated with Spinosad bait had 59% OLF damage, and the kaolin treated trees had 11.76%. The damage averages for 2006 were as follows: OLIPE 24.58%, McPhail-type 3.43%, kaolin clay 3.13% and Spinosad bait 11.43%. The damage on the untreated control trees was much lower than in previous years: 35.82%.

In 2007, the comparison between the easy to use and low cost OLIPE traps as a mass-trapping control measure to reduce the population of OLF plus one supplemental kaolin clay cover spray late in the season just prior to when most of the OLF damage occurs, was very successful. But so was the single kaolin clay treatment applied late in the season. The OLIPE treatment by itself had 24.6% OLF damaged fruit at harvest while the kaolin clay and GF-120 treatments had 4.5 and 3.13% damage at harvest respectively. The combination of OLIPE traps and one kaolin clay (barrier film) treatment had 1.24% OLF damaged olives at harvest and the untreated control trees had 55.8% damaged fruit.

Overall, the success of traps used to monitor fly numbers and predict damage at harvest was spotty at best. In some cases there was a correlation between large trap catches and high damage, or low trap catches and low damage, but in many instances there was no correlation at all. The conclusion was that it is precarious to depend solely on trap catches to determine the need for treatment. Monitor traps might still be very useful for indicating general flight trends, but should never be taken as a guarantee of the absence of OLF. Probably the most effective trap for monitoring, because of its higher catches, is the McPhail, but the yellow sticky panel is likely to be the trap of choice for most growers because of the easier fly identification.

Trained tasters evaluating olive oils

Sensory analysis of the oils made from olives with different degrees of OLF damage showed a tremendous difference was very interesting. The Manzanillo olives with 100% damage and no rot yielded an oil that did not show any obvious classic defects. The oil was quite pungent, as would be expected of fairly green fruit, but at the same time had a fruity character that was almost over-ripe. The batch of Manzanillo olives containing the rotten olives, on the other hand, produced an oil that was both rancid and fusty. The pungency persisted, but the defects overwhelmed any other positive characteristics. The Mission olives with damage from 0 to 50%, but no rot also fared pretty well in blind tastings. Only the 50% damage level was found by a majority of tasters to have either a wood/hay/straw characteristic or a dusty off-flavor (characteristic of OLF-caused secondary fungal contamination). The Ascolano olives with damage levels of 0 to 50% produced oil with no detectible defects. The Frantoio and Leccino olives with rot levels of 0%, 1%, and 5% rotten fruit and about 35% OLF damage produced oils with no detectible defects. When rot levels reached 10% however, the tasters noted significant off flavors.

G. Impacts

1. Safeguarding human health and the environment:

This research provides data to support less pesticide use by oil olive growers. By field testing the various tools in the OLF IPM "toolbox" this trial established the efficacy of a number of alternatives to the standard insecticide treatment, GF-120. Mass-trapping with McPhail-type traps in particular could certainly be used in an IPM program to reduce the population of OLF and make a less frequent spray schedule possible. By using traps to monitor the flight trends of OLF, an oil olive grower could institute a spray-as-required program instead of calendar spraying, potentially reducing the amount of pesticide used by more than half. Because our damage assessments showed that the most severe OLF damage occurred late in the season, an oil grower could be particularly sparing in his use of bait sprays early in the summer. Table olive growers, with the zero tolerance policy in place, have a possible alternative to calendar spraying of GF-120 with the non-toxic barrier film Surround. Because it is applied only a few times in a season, it is considerably easier to use than the bait spray. There is a need for research in collaboration with table olive processors to establish the acceptability of the product in processing.

The findings on the effects of OLF damage on olive oil quality are also critical to the reduction of pesticide use in the olive oil industry. The 10% tolerance is clearly too low for olives that are fly-damaged but otherwise sound. Our tastings indicated clearly that the problem was not the damage done by the fly but the subsequent deterioration of the fruit. A set of recommendations to oil olive growers that includes this insight will further help to reduce the amount of pesticide used to control OLF damage.

Attract & Kill trap for OLF control

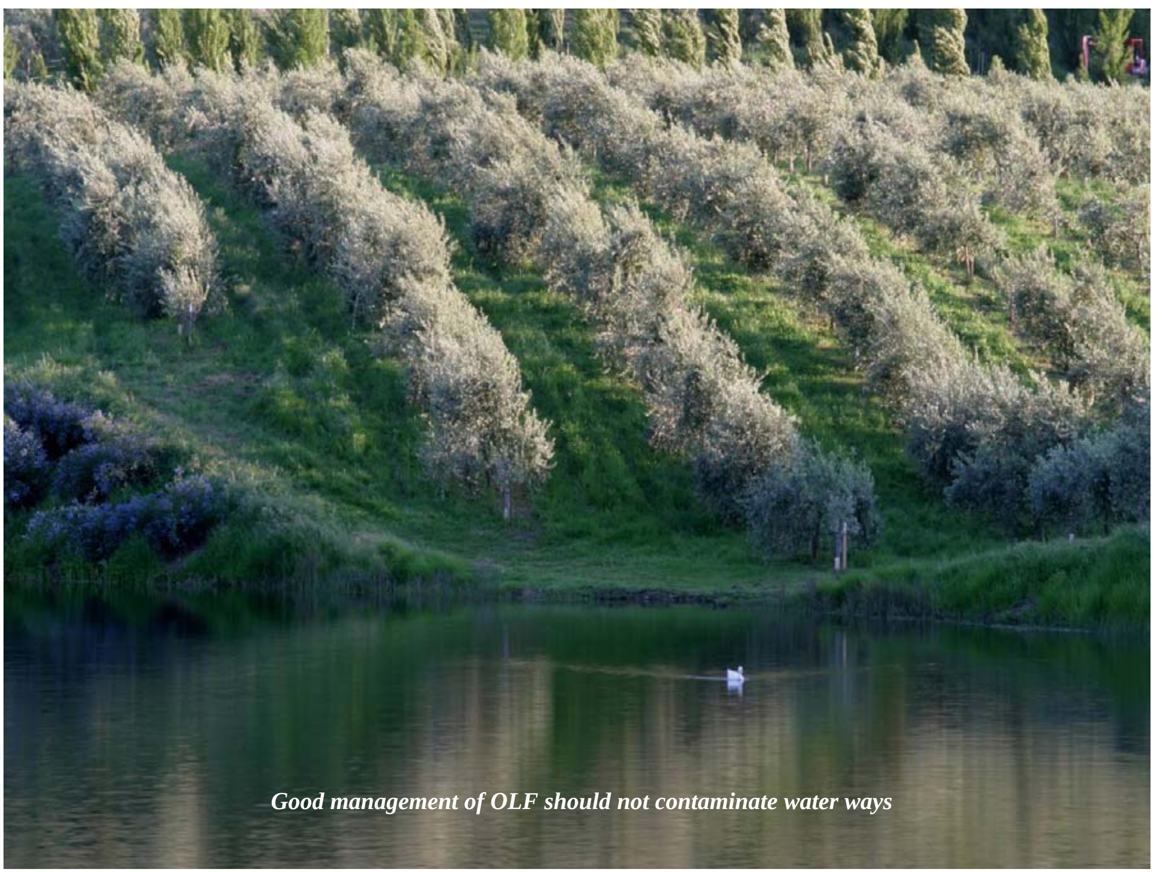
The success of the attract and kill device is also good news for the environment. The Magnet OL is unparalleled for convenience, making it an ideal choice for pest control districts and residential applications. Our research has indicated that it is not a good stand-alone measure in a location where untreated trees surround the property, but can be extremely effective in the right location. A neighborhood or city-wide campaign to place attract and kill devices in all ornamental and roadside olive trees would probably reduce the fly population enormously.

The most attractive results were obtained in 2007 where only one kaolin clay (barrier film) application was made with or without supplemental OLIPE mass trapping to keep the population low throughout the season. This along with the relatively high damage threshold levels of OLF damage on fruit for oil, could lead to farmers applying very little and very low toxicity products to control this pest to an adequate level and maintain excellent oil quality.

2. *Economic Benefits:*

Olives and olive oil in California are commodities with a very narrow profit margin. A conventional spray program would run about $9.50/acre/application, for a total of $114/acre for a biweekly spray program from mid-June to November. If a grower could cut his spray schedule in half, that would be a substantial saving. The cost of McPhail-type traps is about $8 each, but they last for many years if taken care of. Our research showed that the larger ball McPhail-type was lower maintenance since it dried out less quickly, so by using those traps, topped up as needed and changing the yeast monthly, a grower could quickly recoup his costs with fewer sprays. There are about 250 table olive and 650 oil olive growers in California. The additional burden of OLF control can be the last straw for a financially strapped grower. A more varied IPM approach to OLF control will make olive ranches more viable. The single low cost application of kaolin clay with or without the low cost OLIPE traps used for mass trapping has the potential to save oil growers money in OLF control.

The viability of olives and olive oil as commodities has implications for the future of California agriculture. Looking to a future of higher prices and lower availability for water, olives are an excellent choice for our climate. Demand for olive oil is increasing, and is likely to continue to do so, particularly in light of the growing body of evidence about olive oil's health benefits. A diversified agriculture is good for the environment and good for economic security. Olives are an excellent addition to a diverse farm and a sustainable California.



Good management of OLF should not contaminate water ways

3. Implementation of IPM

The use of mass-trapping was shown to be moderately effective in reducing OLF populations. The efficacy of the standard treatment, GF-120 (Spinosad bait), was confirmed, and an alternative spray treatment, Surround (Kaolin clay), was demonstrated to be extraordinarily good at controlling OLF in very high fly-pressure situations. Depending on the degree of control required, a grower can choose from kaolin clay, spinosad bait, McPhail-type traps, attract and kill devices, OLIPE traps and yellow sticky panels. In cultural controls, our research indicated that earlier harvest can be a very effective technique for coping with OLF damage.

The Organic Olive Production Short Course was held on May 27, 2005 at the Luther Burbank Center in Santa Rosa. It attracted 821 people, a capacity crowd. The course notebook was the starting point for the Organic Olive Production Manual which was published by ANR Communications in April 2007. In the 8 months since its publication, the manual has sold 519 copies. The manual includes a detailed chapter on OLF, presenting an IPM approach to its control. The findings of all the OLF control research done at UCCE Sonoma summarized in a poster entitled Organic Control of Olive Fruit Fly. This poster is aimed at the grower, not the researcher, and gives a concise and readable overview of the trials.

One popular method of distribution for the olive fly handouts has been the UCCE Sonoma website. The OLF handouts have also been distributed at the Santa Rosa Junior College Olive Oil Production class, in November 2005 and 2006. Classes on olive oil for the general public through the master gardener program taught by A. Devarenne provided another outlet (Oct. 8, 2005 – 23 people; Jan. 28, 2006 – 37 people; Sept. 23, 2006 – 35 people). It is also distributed at pesticide applicator continuing education classes on OLF biology and control taught by Paul Vossen or A. Devarenne (Feb. 25, 2005 – 36 people; Nov. 2, 2005 - 41 people; Nov. 30, 2005 – 52 people).

The First Press newsletter goes out to 544 statewide subscribers quarterly and has had two articles updating readers regarding the status of OLF control.