ALTERNATIVES TO THE USE OF CYFLUTHRIN

TO CONTROL THRIPS DAMAGE

IN THE ORANGE GROWING INDUSTRY

FINAL REPORT

MARCH 20, 2008

Prepared by:
By: Lisa J. Bunin, Ph.D.
Environmental Research Consultant
bunin@cruzio.com
(831) 425-7121

For the:
California Department of Public Health, Occupational Health Branch
http://www.cdph.ca.gov/programs/OHB/pages/Default.aspx

Addendum to CDPH Report
"Alternatives to the Use of Cyfluthrin to Control Thrips Damage in the Orange Growing Industry"

January 22, 2009

Messages in this addendum:

- In addition to thrips, another citrus pest, the katydid, was present in the orange grove implicated in the May 2005 pesticide incident described in the CDPH report.
- Spinosad was used to control citrus thrips and cyfluthrin was used to control katydids.
- Even though the cyfluthrin application rate was lower than the full rate specified by the label, grape workers in a neighboring field became ill when the pesticide drifted onto them.
- Although the presence of multiple pests can complicate pest management decisions, we recommend that the safest alternatives be considered.
- If a pesticide must be used to prevent crop loss or economic damage, we recommend that the lowest effective dose and safest application method be used. Resources such as Integrated Pest Management guidelines should be utilized when making pesticide use decisions.

Full Addendum:

The CDPH report, titled "Alternatives to the Use of Cyfluthrin to Control Thrips Damage in the Orange Growing Industry," focused on methods that organic orange growers have successfully used to control citrus thrips. In addition to thrips, another citrus pest, the katydid, was present in the orange grove implicated in the May 2005 pesticide incident described in the report. A few katydids can damage large quantities of fruit due to the way they feed: a katydid will take a single bite of a young fruit and then move on to another site on the same or nearby fruit. The feeding results in scar tissue and distortion of the fruit as it grows. Katydids also eat holes in leaves and in maturing fruit.[1]

For the pesticide application that preceded the May 2005 incident, the Pest Control Advisor (PCA) chose spinosad (trade name Success) to control citrus thrips and cyfluthrin (trade name Baythroid 2E) to control katydids. The CDPH report recommends spinosad, a lower toxicity pesticide that is derived from a soil microbe, as one alternative to cyfluthrin use for thrips control. Under the United States Department of Agriculture's organic rules, spinosad as the formulation Entrust can be used on organic farms. The PCA chose cyfluthrin to control katydids because spinosad is not effective in controlling this pest.[2] University of California Statewide Integrated Pest Management (UC IPM) Program Pest Management Guidelines state that, past a certain growth level (larger instars), katydids are not well controlled by spinosad.[1]

To control katydids, the PCA recommended applying a lower rate of Baythroid 2E than the full rate specified by the label: 2.0 ounces per acre, rather than 6.4 ounces per acre. This lower application rate of cyfluthrin does not control citrus thrips.[2] Even though the cyfluthrin application rate was lower than the specified rate, grape workers in a neighboring field became ill when the air blast application process resulted in drift away from the target crop and onto the workers. CDPH determined that the illness was due to cyfluthrin.

Conclusion/ Recommendations

While using reduced rates of pesticide application is encouraged, this incident illustrates that this may not prevent pesticide illness. PCAs should continue to utilize the lowest effective dose of a pesticide, as this may mitigate the negative impacts of pesticides. This includes reducing damage to natural insect enemies. Protecting natural enemies helps in the long-term management of some pest problems and, in turn, can prevent the need for additional pesticide use.[3] Since katydids are not well-controlled by natural enemies, the decision to reduce pesticide use during the May 2005 incident may have helped to preserve natural enemies needed for other pests.[1]

The presence of a second or multiple pests, a reality growers and PCAs face,[4] complicates pest management decisions and may make the use of safer alternatives less straightforward. However, the use of safer alternatives where feasible and in any form – cultivation practices, biological controls, less toxic pesticides, lower application rates – should be pursued as a way to decrease pesticide exposures to workers, surrounding community members, natural insect predators, and on the environment in general. PCAs can learn about lowest effective rates and the safest methods of controlling multiple pests by consulting UC IPM guidelines developed by UC researchers and farm advisors.

1. University of California. Citrus – Katydids. UC Statewide Integrated Pest Management Program. [cited 2008 Dec 2]. Available at: URL: http://www.ipm.ucdavis.edu/PMG/r107300411.html

2. Grafton-Cardwell, Elizabeth, personal communications, November 25, 2008, January 14, 2009.

3. University of California Statewide Integrated Pest Management Project. The Safe and Effective Use of Pesticides, 2nd Edition. Agriculture and Natural Resources Publication 3324; 2000:234-5.

4. University of California. Citrus – When to Monitor Pests and Natural Enemies. UC Statewide Integrated Pest Management Program. [cited 2008 Dec 16]. Available at: URL: http://www.ipm.ucdavis.edu/PMG/r107901311.html

TABLE OF CONTENTS

Executive Summary

The Occupational Health Branch (OHB), California Department of Public Health, is committed to promoting sustainable, non-chemical and lower toxicity alternatives to pesticides. In 2005, OHB investigated an incident in Kern County that resulted in 27 farmworkers becoming ill due to drift of the pyrethroid pesticide, cyfluthrin. This report describes the currently available growing practices that eliminate the need for cyfluthrin use to control citrus thrips in the orange growing industry.

Conventional orange growers in the Central Valley, where Kern County is located, regularly use cyfluthrin to control thrips. The use of cyfluthrin has increased over 1,000 percent in recent years which has increased the potential for exposure to farmworkers and the neighboring community due to pesticide drift. Although citrus thrips cause cosmetic damage by scarring the orange peel, this does not affect the flavor, nutrition or overall quality of the fruit under the peel.

Non-chemical and less toxic remedies exist and have been used successfully by some Central Valley farmers, as described in this report. The information presented is based on interviews with farmers, pest control advisors, farm advisors, and non-governmental organizations, and on review of investigative documents and other published literature.

Alternative methods for controlling thrips include:

- Incorporating compost and organic fertilizers in the soil and as foliar sprays
- Allowing weeds and cover crops to grow between orange tree rows to attract beneficial insects, facilitate water penetration, moderate extreme soil temperatures, and create mulch to fertilize soil when mowed
- Releasing beneficial insects to prey on pests
- Planting different varieties of oranges to create biological diversity and to reduce the possibility of the entire crop being affected by pest infestations
- Using less toxic pesticides, usually biologically-derived substances
- Applying mineral oil to smother over-wintering thrips eggs.

Pesticide illnesses due to cyfluthrin can be reduced or eliminated if cyfluthrin spraying for thrips control is replaced with the methods discussed in this report. Alternative farming methods offer a variety of tools to prevent thrips damage. While some of the recommendations in this report are specific to controlling citrus thrips, other practices may be applied to a wide variety of crops. In addition to the obvious human health benefits afforded by using agricultural practices that eliminate the use of pesticides, such practices also build healthy ecological systems. We encourage citrus growers and others to consider adopting the alternative pest control methods described here.

Introduction and Background

On 12 May 2005, 27 farmworkers working on a 160 acre grape vineyard in Kern County, California, became ill from exposure to the insecticide cyfluthrin (Baythroid 2) when it drifted from a neighboring orange grove during ground spraying. Although other chemicals were sprayed during the time of the incident including spinosad and petroleum oil, the California Department of Public Health (CDPH) Occupational Health Branch, (OHB) identified cyfluthrin as the main cause of illness to the neighboring workers (1). Most farmworkers interviewed stated that they did not see or feel the pesticide mist or see the spray rigs, although some heard the trucks. Their symptoms developed at the same time as they smelled the odor of the pesticide (2).

A medical evaluation, conducted as part of a Kern County Agricultural Commission (CAC) investigation, found that of the 25 farmworkers exposed to cyfluthrin, 60 percent reported dermal paresthesias — a tingling or burning sensation on the skin surface. Sixty-eight percent reported a sore throat or upper respiratory irritation, symptoms “typical of those expected following exposure to cyfluthrin and other pyrethroid compounds” (2). According to OHB, “symptoms most commonly reported by the 27 farmworkers were headache (96%), nausea (89%), eye irritation (70%), muscle weakness (70%), anxiety (67%), and shortness of breath (64%)” (1). Workers also complained of other discomforts such as chest pain, vomiting, tingling of the lips, numbness of the lip and tongue, heart palpitations, weakness, chills, and difficulty breathing (2).

Pesticide drift results in many acute pesticide illnesses among farmworkers each year. Drift accounted for 16 percent of all pesticide-related illness cases reported by OHB (3, 4). Moreover, 67% of all drift-related pesticide illnesses occurred in farmworkers (4). Although ground deposition of the largest droplets of air-blasted pesticides drops off rapidly with distance, fine droplets remain in the air at higher concentrations and can be transported for significant distances and in unexpected directions (2, 5). Existing research on pesticide drift in California shows that widely used pesticides regularly drift away from target areas where they are applied and remain airborne at levels that exceed acute and chronic risk assessment levels set by the California Department of Pesticide Regulation (DPR) and the US Environmental Protection Agency (5).

Although they are required to do so, pesticide applicator companies do not always survey the land outside of their immediate target spraying areas to assess potential human exposure to pesticide drift. The CAC report on the cyfluthrin incident described above stated that, “…the pest control was not performed in a careful and effective manner and the meteorological conditions and the crew in the adjacent field led to the likelihood of harm or damage to the grape crew” (2). The CAC further concluded that the pesticide applicator “also allowed the pesticide application to continue when there was a reasonable possibility of contamination of the grape crew south of the application site,” (2). Yet pesticide regulations do not require either the grower or pesticide applicator company to notify nearby field workers of planned applications if the adjacent property is under control of a different operator. In the cyfluthrin incident, the orange grower notified its own farmworkers of the impending pesticide spraying but did not notify workers in the adjacent vineyard (1).

A common problem associated with pesticide spraying is the difficulty in predicting and accounting for variable weather conditions, which often impinges upon Pest Control Advisors (PCAs) and pesticide applicator's ability to ascertain the optimum time for spraying. It is not only logistically difficult but also expensive for pesticide applicator companies and orange growers to react swiftly to accommodate rapidly changing weather (6). The inability to adequately predict the spread of pesticides suggests that a variety of measures must be utilized to prevent pesticide drift. The most effective method to ensure worker health and safety under these unpredictable climate conditions is the primary prevention approach of substituting the use of hazardous pesticides with safer methods whenever possible.

Cyfluthrin use in California agriculture increased 1,100 percent between 1990 and 2003, from 4,099 pounds to 47,610 pounds (1) and consequently, so has the potential for exposure to farmworkers and neighboring populations through pesticide drift (3). Orange growers in the Central Valley, where Kern County is located, regularly use cyfluthrin to control thrips. However, non-toxic and less toxic remedies exist and have been used successfully by some Central Valley farmers to address thrips problems. This study examines alternative methods used by farmers to combat thrips that eliminate the need for cyfluthrin spraying in the orange growing industry. Findings are based on interviews with farmers, PCAs, farm advisors, and non-governmental organizations (NGOs), and review of OHB investigative documents and other literature.

Project Approach

The cyfluthrin exposure incident highlights three significant occupational hazards intrinsic to the orange growing industry:

1. Health risks associated with spraying pesticides such as cyfluthrin in orange groves;

2. The potential for pesticides to drift from the target area where they are sprayed, contaminating farmworkers and other neighbors; and

3. The absence of regulations requiring orange growers and pesticide applicators to notify farmworkers in adjacent fields of an impending pesticide application when the workers are employed by a company other than the one doing the spraying.

The hierarchy of industrial hygiene control measures specifies that the method of first choice to control a toxic chemical hazard is to identify alternatives to the use of that chemical and to make certain that the alternative does not create a new hazard. To that end, OHB contracted this investigative study to assess currently available orange growing practices that eliminate the need for cyfluthrin use to combat thrips damage on oranges.

Cyfluthrin and Thrips Damage

Cyfluthrin, trade name: Baythroid, (manufactured by Bayer) is a pesticide commonly used to combat chewing and sucking insects such as thrips in the orange growing industry. It is a synthetic, type II pyrethroid pesticide with a rapid mode of action that "act[s] on insects by prolonging the inactivation of sodium channels in their nervous systems" (1).

Cyfluthrin is most commonly applied by airblast sprayers. The pesticide is mixed in a tank at the concentration determined by a PCA and pumped through nozzles in an airstream. The volume of water mixed with the chemical, and the rate and timing of the spray determine the effectiveness of the insecticide formulation (6). A pesticide spray rig loaded with the cyfluthrin mixture drives between the rows of orange trees spraying up and down each tree (1, 7, 8).

In the Kern County contamination incident, ground applicators sprayed cyfluthrin from three enclosed-cab tractors, traveling the length of the rows and turning around on a dirt road that borders the orange grove and grape vineyard (1). Detection of cyfluthrin residues in the direction that the airblast sprayers were traveling supported the case for pesticide drifting in the general direction of workers (2).

Cyfluthrin is extremely toxic to honeybees, fish, and other organisms. Because they can rapidly metabolize cyfluthrin, it is considered slightly toxic to mammals, with an LD_{50} of 869-1271 mg/kg in rats. In humans, dermal contact may cause visible skin irritation, itching, burning, and stinging (9, 10). Exposure to cyfluthrin at high doses (such as ingestion or heavy dermal exposure) can lead to pulmonary edema, seizure, coma, and death (1). Low-dose exposure symptoms include paresthesias, erythema, dizziness, headache, fatigue, irritability to sound and touch, and skin, eye, upper respiratory tract, and gastrointestinal irritation (1).

Citrus Thrips: Citrus thrips (*Scirtothrips citri*) are small, orange-yellow flying bugs with fringed wings, the larvae of which (figure 1) burrow into the tender skin of young oranges and scar the rind of the fruit (Appendix A). Females lay about 25 eggs in the spring and fall, primarily in new leaf tissue, young fruit, and green twigs, and lay over-


s

Figure 1: Citrus thrips larvae

Figure 2: Thrips damage in a young orange
Photos by Jack Kelly Clark from UC Statewide IPM website

wintering eggs predominantly in the bark of trees (11).

Citrus thrips puncture the epidermal cells of oranges, damaging the fruit by scarring the peel. As the orange grows, a beige ring is created under the sepals of the young fruit by the thrips that feed there (figure 2). The scar grows as the fruit grows creating a permanent blemish (figure 3). Once the orange is the size of a quarter, scarring begins. The second and third larval stages of thrips development cause the most damage. These wingless larvae can damage oranges only until the fruit reaches the size of a walnut. After that time, the orange rind becomes too tough to chew. Adult thrips do not scar fruit (12).

Figure 3: Thrips-induced scarring in a mature orange
Photos by Jack Kelly Clark from UC Statewide IPM website

When using UC Davis integrated pest management guidelines, PCAs or insect scouts will order the spraying of cyfluthrin when between 5 percent (navel oranges) and 10 percent (Valencia oranges) of the fruit sampled have thrips and when insufficient numbers of predators are present, (6, 8, 11, 12). Thrips monitoring continues for approximately 6 to 8 weeks, until the fruit size reaches 1.5 inches in diameter. In cases of severe infestations, monitoring may continue for a longer period of time and a second spray may be recommended (13).

General Findings

Farmers, PCAs, and research scientists generally agree that although citrus thrips create cosmetic blemishes on oranges they do not interfere with the flavor, nutrition, or overall quality of the fruit beneath the peel (13, 14). While the permanent scarring created by citrus thrips is strictly a cosmetic problem, it nonetheless threatens the marketability of oranges. Packing houses that buy and distribute oranges demand blemish-free fruit and pay top dollar for it. Scarred fruit will be downgraded from “fancy” to “choice” or even “for juice only” and purchased at a lower price (15). When the grade of the fruit decreases so do the payments farmers receive for their oranges. With the high cost of land, water, and other farm inputs in the Central Valley, farmers cannot afford to have a large portion of their oranges downgraded or they risk going out of business (14).

Conventional Orange Growing Practices

When discussing alternatives to the use of cyfluthrin to combat citrus thrips damage in oranges, it is important to consider the broader agricultural context within which thrips outbreaks occur. Most orange growers in the Central Valley manage large, single crop orchards, ranging from hundreds to thousands and tens of thousands of acres (6, 8). This exceedingly high number of monocropped acreage makes maintaining a “wait and see” approach to pesticide spraying not viable for most growers or PCAs when so much is at stake. It is not worth the risk to *not* spray because economic damage has the potential to occur swiftly and spread rapidly (14). According to several PCAs interviewed, conventional farmers can sustain significant damage to their crop in a matter of days if they do not spray. Most growers spray for thrips after the state declares the first petal fall, when 90 percent of the blossoms drop and the bees have left the grove (13). At this time, flowers mature, fruit start to form, and citrus scarring begins.

The irony of this situation is that citrus thrips levels actually increase over time when broad-spectrum pesticides such as pyrethroids (cyfluthrin), carbamates (Carzol or formetanate) and organophosphates (chlorpyrifos) are sprayed. That is because the application of these pesticides kills beneficial predators and parasites that would otherwise keep thrips populations in check (16). Thrips can also be stimulated to reproduce when exposed to broad-spectrum pesticides due to the hormoligosis effect—pesticide-induced thrips reproduction (10). Moreover, thrips quickly develop resistance to repeated applications of broad-spectrum chemicals, creating the need for an increase in the number or concentration of the pesticides sprayed or the use of stronger pesticides (17, 14). Although beneficial insects may also achieve some resistance, because they are higher on the food chain, their numbers are far smaller and they cannot reproduce fast enough to combat thrips in the presence of toxic pesticides (18). According to a PCA interviewed, when broad spectrum chemicals were first introduced in 1997, farmers only needed to spray once to kill the same types of pests that now require two or more pesticide applications to keep pests in check (6). In Kern County, researchers have found thrips resistance to cyfluthrin in several orange groves (11).

The chemical-intensive method of agriculture employed by conventional farmers across the US employs a variety of synthetic fertilizers, pesticides, soil fumigants, growth regulators, etc. to control pests, weeds, and diseases, and to regulate plant growth. Widespread use of agrochemicals have resulted in a significant reduction and even elimination of many of the natural predators, beneficial insects, and wildlife that have traditionally kept these problems at bay on the farm (19, 20). And, as pests develop resistance to pesticides, farmers must use more agrochemicals in higher concentrations to keep pests in check, forcing farmers to increase pesticide use. Giving growers increased knowledge and confidence about the ability to farm without agrochemicals may help to break this cycle.

Organic Orange Growing Practices

A continuum of organic agricultural practices is employed by a small number of orange growers in the Central Valley. Their acreage is also small, comprising 10 to 20 acres to a few hundred acres per grower. Organic practices range from eliminating all synthetic chemicals and becoming organic by default to actively adopting practices that deliberately build fertile, living soils as the foundation for feeding and sustaining healthy trees. In contrast to conventional agricultural methods, organic agriculture necessitates that farmers treat farmland as a living ecological system by "integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance and conserve biodiversity" (21). The National Organic Standards, regulated by the US Department of Agriculture (USDA), prohibit the use of synthetic chemical fertilizers, pesticides, growth regulators or soil fumigants that kill biological activity on the farm. However, the rules do allow the application of pesticides mostly derived from substances found in nature. It takes 3 years from the time farmers eliminate the use of synthetic agrochemical inputs to the time that they can apply for organic certification from one of USDA's deputized certification agencies (21).

Contrary to the thrips problems recounted by conventional growers and PCAs in the Central Valley, most organic farmers interviewed experience only minor thrips problems. Organic farmers attribute this lack of thrips to the preventative strategies they use to build the soil, feed orange trees with organic matter, and encourage habitats that sustain a variety of beneficial insects. Like conventional farmers, organic farmers walk their fields and carefully monitor for thrips. However, organic farming systems require a more in-depth understanding of pest, predators and their interrelationship on the farm. In addition, the methods organic farmers employ to treat thrips and to ensure that thrips populations do not reach economically damaging levels substantially differ from that of their conventional counterpart, as described below.

Alternatives to Cyfluthrin Use

1. <u>Compost & Fertilizers</u>

In an organic farming system, feeding trees a balanced diet is essential for producing thriving orange trees and fruit. This diet begins with the application of compost, one of the most important ingredients for building healthy soils to feed trees and encourage fruit growth. Compost contains a diversity of beneficial bacteria and fungi that help make water and soil nutrients, such as nitrogen, phosphorous and sulfur, available to trees. These fungi and bacteria also help build a good soil structure for holding water, allowing it to reach deep down to the tree roots to improve root growth and nutrient uptake (22, 23).

Some organic farmers prefer vegetable-based rather than animal manure-based composts because vegetative compost is more biologically complex. While manure compost is bacteria-dominated, vegetative compost possesses active fungi and bacteria, a combination that more thoroughly enhances the biological activity in the soil (11).

In more advanced organic farming systems, farmers incorporate one or more fermented herbal tea extracts into foliar sprays to supply plant nutrients, stimulate plant growth, and suppress disease. Examples of herbal teas used for this purpose include: Horsetail (*Equisetum arvense*), stinging nettle (*Urtica dioica*), echinaechia (*Echinacea purea)*, and feverfew (*Tanacetum parthenium*) (24, 25). Some organic farmers also apply liquid manures comprised of a combination of fermented herbs, fish emulsion and/or seaweed extracts for the purpose of encouraging tree and fruit growth (26).

2. Weeds & Cover Crops

Both weeds and cover crops help farmers to control thrips. Allowing weeds to grow up naturally between the rows of orange trees is by far the least expensive tool farmers have to combat thrips. If only invasive weeds like Johnson grass grow, organic farmers recommend growing a mixture of cover crops that suit the geology and climate conditions of the area. Since farmers generally do not irrigate cover crops, the type of crops planted also depends upon the rains available to germinate the seeds (14). In the Central Valley, farmers generally plant various combinations of vetch, bell beans, peas, and clover mixed with oat, rye, barley, or wheat grains (6, 12). Weeds and cover crops afford the following benefits to farmers:

● Provide a habitat to attract and sustain beneficial insects in the early spring, prior to the time when thrips outbreaks occur.

● Reduce heat stress on trees by keeping the soil environment a few degrees cooler in the summer. Less heat stress on trees makes them less susceptible to insect damage. Heat-stressed trees often are susceptible to mites and red scale which are “indicator species,” signifying that the tree is stressed.

● Warm the ground during the winter months to prevent frost damage to trees. On conventional farms where the ground between the rows is cleared and bare heat radiates off the soil at night decreasing temperatures by several degrees. Biologically active ground that is covered with weeds or cover crops actually generate heat warming the soil by several degrees.

● Help water penetration in the summer and winter due to the root structure of the weeds and cover crops.

● Create mulch to fertilize the soil when mowed. Mulch also conserves moisture in the soil and, subsequently, water use.

● Fix nitrogen in the soil, which is critical to plant and fruit growth. Legumes are particularly effective in fixing nitrogen.

Weeds and cover crops require periodic mowing, which creates the need for extra labor on the farm. One grower purchased twelve weeder geese to try to help keep the weeds down (27). This grower also uses a propane flame weeder attached to a plow. However, working with propane and an open flame can be hazardous to farmworkers if the appropriate safety precautions are not taken. Flame weeder training is required to ensure proper equipment use and worker safety (28).

3. Beneficial Insect Releases
When insufficient numbers of naturally occurring beneficial insects are present in the field to combat thrips, a range of natural enemies or predators can be released to keep thrips in check. Such beneficial insects include: green lacewings, predaceous mites (*Euseius tularensis*), predatory wasps (*Aphytis melinus*), minute pirate bugs, coccinellids, and spiders (9, 11).

4. Varieties
The greater the variety of oranges produced on a farm the greater the diversity of beneficial insects available to combat pests. That is because different insects are attracted to different tree species. A diversity of species also ensures that the entire livelihood of a farmer is not wiped out if a particular variety suffers from insect damage or disease.

Certain orange varieties appear to be less susceptible to thrips than others. According to University of California Pest Management Guidelines and some farmers, Valencia oranges are less susceptible to thrips damage than navel and Valencia oranges often do not require any treatment for thrips (11). One farmer interviewed observed that his new hybrid oranges appear to be more vulnerable to thrips and other threats such as red cushiony scale and freeze. He explained how his non-hybrid, hardy, dwarf orange variety seemed much less susceptible to thrips (29). Another farmer stated that his old grove had larger spacing between trees which helped prevent damaging thrips outbreaks (30).

5. Less Toxic Pesticides
Under the USDA's organic rules, the following low toxicity pesticides can be used on organic farms:

● Sabadilla (Trade names: Vertran, Red Devil and Natural Guard) is a botanical pesticide derived from the seeds of the Sabadilla lily (*Schoenocaulon officinale*). It acts as an insect gastrointestinal toxin. With an LD_{50} of 4,000 to 5,000 mg/kg, it ranks low in acute mammalian toxicity. Human exposure to Sabadilla dust can cause irritation of the eyes, nose and throat. Sabadilla does not harm beneficial insects and works the most effectively in the presence of substantial numbers of predators such as predatory mites. However, data gaps do exist with respect to assessing the full range of human health and environmental effects (31).

The major drawback of Sabadilla is that it only lasts 3 to 4 days. Due to its short residual period and its rapid degradation when exposed to sunlight, treatment with Sabadilla must be strategically timed to coincide with the mid-hatch of thrips to work effectively. Some PCAs argue that they need to apply a pesticide that lasts 14 to 21 days, a requirement that makes Sabadilla less than ideal for those users (6, 12).

● Spinosad (Trade names: Success, Entrust, Naturalyte, SpinTor) is a microbial pesticide derived from the soil actinomycete *S. spinosa*. It acts as a nerve toxin, over-stimulating nerve cells of the pests that it contacts and those that consume sprayed foliage. Farmers like Spinosad because it persists for a full week. Although it does not harm most beneficial insects, it is toxic to bees when wet, so farmers should avoid using it during periods when pollinators actively forage. With an LD_{50} of 5,000 mg/kg, Spinosad exhibits low mammalian toxicity. However, it is slightly toxic to fish and highly toxic to marine shellfish (32).

● Neem (trade names: Margosan-O, Azatin Rose Defense, Shield All, Triact, Bio-neem and Neemshine) is a botanical pesticide distilled from the seed of the neem tree. It is a native tree in India and has been used there for more than 4,000 years. As an insect growth regulator, neem prevents treated insects from molting into their next stage of development causing them to die. With an LD_{50} of 5,000 mg/kg, neem exhibits low mammalian toxicity. As an imported product, neem can sometimes be hard to find in certain regions and it can be more expensive relative to other low toxicity pesticides (31). Its effects on beneficial insects are minimal because neem targets herbivorous insects while beneficial insects feed on pests (33).

6. <u>Mineral-Based Oil</u>

Organic farmers can use narrow range 415 and 440 oils, products of oil refining, to smother the eggs of thrips that over-winter in the bark of trees. Although these oils do not occur naturally on their own, they are allowed by the USDA's National Organic Program. They do not affect winged predatory insects (6, 34).

Conclusions

Despite general agreement in the orange growing industry that citrus thrips cause only cosmetic blemishes to oranges, thrips damage still translates into economic losses for farmers unless they take measures to combat thrips. Therefore, pest management strategies must be made available to farmers to stem the tide of economic losses from thrips. As this report has shown, alternative organic farming methods exist that offer a variety of tools to prevent thrips damage and that do not require the application of the toxic pesticide, cyfluthrin.

Since the quality and taste of oranges are not compromised by thrips, another strategy for eliminating cyfluthrin in orange growing could be to educate orange consumers that the ring of skin damage caused by thrips is merely cosmetic. Several individuals interviewed argued that thrips damaged fruit are actually slightly sweeter. Some PCAs and researchers believe that since thrips attack the fruit on the outermost branches of the tree, outside the canopy, those fruit tend to get more sun, ripen longer, and taste sweeter than the fruit picked from the inner branches of the tree.

Pest resistance to broad-spectrum pesticides clearly needs to be addressed in the orange growing industry, which depends upon the development of new and improved pesticides every few years to deal with resistance problems. This approach of depending on the emergence of new pesticides continues to put farm workers, rural communities, and the environment at risk of continued pesticide contamination.

Pesticide drift is an inevitable, unwanted consequence of conventional farming, as evidenced by the numerous pesticide poisonings that occur each year in California. Pesticide illnesses due to cyfluthrin poisoning, however, can be reduced or eliminated if farmers replace cyfluthrin spraying with the organic methods discussed in this report.

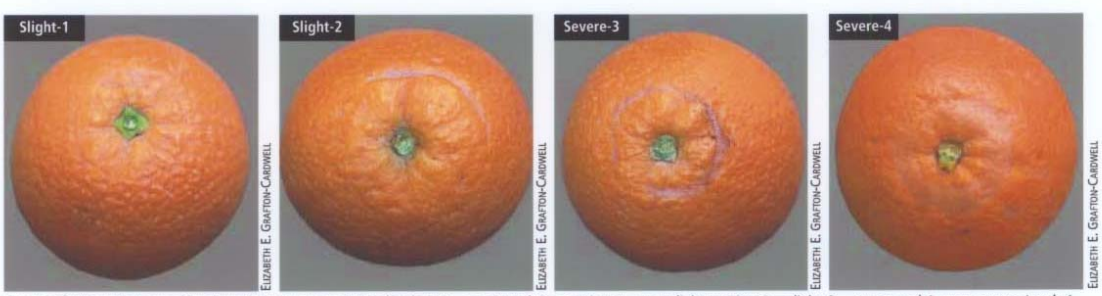
Appendix A
Photographs of Thrips Damage to Oranges

CITRUS THRIPS, *SCIRTOTHRIPS CITRI* (MOULTON) (THYSANOPTERA: THRIPIDAE)

Immature citrus thrips *(left)* spend much of their time (especially when the weather is cool or overcast) under the calyx *(button)* end of the fruit. In spring, this concentrated feeding under the calyx produces a characteristic ring-shaped scar around the stem end of the fruit. The scar expands outward from the calyx as the fruit grows.

Once the fruit reach approximately 1.5" (about 4 cm) in diameter, the rind cells are not so easily damaged by citrus thrips. Adult thrips *(right)* are less important compared to immatures as a cause of fruit damage.

The ring may be slight (a thin circle) or severe (a thick circle, sometimes extending down the side of the fruit, or a heavy partial ring) depending upon the number of thrips, how long they have fed on the fruit, and the age of the fruit. As the fruit grows, the ring moves outward. Fruit damaged by citrus thrips generally are found at the outside of the tree canopy.



In rating fruit scarring caused by citrus thrips, we use a 0-4 scale where 0 = no citrus thrips scarring, 1 = very slight scarring, 2 = slight, 3 = severe, and 4 = very severe. Levels 1 and 2 would not normally be downgraded in the packinghouse since their thrips scarring is not severe. Levels 3 and 4 would be downgraded from first to second grade.

(Excerpted from: Grafton-Cardwell, E. Photographic Guide to Citrus Scaring, Agriculture and Natural Resources Publication 8090, http://narcatalog.ucdavis.edu).

Appendix B

List of Interviews and Contact Information

DATE	NAME
1 May, 2007	Ann Downs CA Dept. of Pesticide Regulation
8 May, 2007	Craig Kallsen, Citrus Advisor UC Coop Ext. Home & Garden Kern County
10 May, 2007	Kathleen Hamilton Owner, Diamond Organic kathleen@diamondorganics.org Distributor of organic oranges
4 June, 2007	Robert Benik Conventional Farmer Sierra Nevada Citrus Porterville, CA
	Anonymous PCA Paramount Citrus
7 June, 2007	Sal Shakra Organic Farmer Blackwell Ranch Bakersfield, CA
12 June, 2007	Brian Baker Organic Materials Research Institute Materials Coordinator
	John France Organic Farmer France Ranch Porterville, CA

20- June, 2007	Helene Beck Beck Grove/Lavigne Ent Organic Farmer Fallbrook, CA
	Anonymous Organic Farmer Reedley, CA
25 June, 2007	Mary Vellema Vellema Ranches Organic Farmer Woodlake, CA
	Rick Nicholas H & R Citrus Organic Farmer Orange Cove, CA
	C.E. (Chuck) Atwood The Atwood Corporation Organic Farmer Strathmore, CA
	Monica Pizura Wicky-Up Ranch Organic Farmer Woodlake, CA
2 July, 2007	Alan Butterfield Independent PCA Kern County
	Melanie Buddell Buddell Farms Organic Farmer Reedley, CA
12 July, 2007	Alan Brewer Independent PCA Kern County
	Jo Ann Baumgartner Director, Wild Farm Alliance Watsonville, CA

Reference List

1. CDC. Worker Illness Related to Ground Application of Pesticide – Kern County, California, 2005. MMWR Weekly, May 5, 2006 / 55(17):486-488. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5517a4.htm

2. Lagasca M, Villatoro A. Priority Pesticide Episode Investigation Report, Kern County Department of Agriculture and Measurement Standards, May 2005.

3. Pesticides Continue to Harm Workers in Occupational Health Watch, California Department of Health Services, Occupational Health Branch, Fall 2005. Accessed at URL: http://www.cdph.ca.gov/programs/ohb/documents/ohw4.pdf

4- California Department of Public Health- Occupational health Branch, Occupational Pesticide Illness Prevention Program; Surveillance database, Unpublished data, 4 March, 2008.

5. Kegley S, Katten A, Moses M. Secondhand Pesticides: Airborne Pesticide Drift in California, Californians for Pesticide Reform, 2003. Accessed at URL: http://www.panna.org/resources/documents/secondhandDriftAvail.dv.html

6. Butterfield, Alan. Telephone interview. 7 July 2007.

7. Kallsen, Craig. Telephone interview. 8 May 2007.

8. Anonymous PCA, Paramount Citrus, Kern County, Interview, 4 June 2007.

9. Casjens H. Environmental Fate of Cyfluthrin. Environmental Monitoring Branch, California Department of Pesticide Regulation, Sacramento, CA (undated).

10. Cyfluthrin. Extension Toxicology Network (EXTOXNET), Pesticide Information Profiles, Oregon State University. Accessed at URL: http://extoxnet.orst.edu/pips/cyfluthr.htm

11. UC Integrated Pest Management. UC Management Guidelines for Citrus Thrips on Citrus, UC Statewide Integrated Pest Management Program. Accessed at URL: http://ipm.ucdavis.edu/PMG/r107301711.html

12. Brewer, Alan. Telephone interview. 12 July 2007.

13. Kerns, D., G. Wright & J. Loghry. Citrus Thrips (Scirtothrips citri), Cooperative Extension, The University of Arizona College of Agriculture, Tucson, AZ. Accessed at URL: http://ag.arizona.edu/crops/citrus/insectspubs.php#thrips

14. France, John. Telephone interview. 12 June 2007.

15. Grafton-Cardwell E, N. O'Connell & C. Kallsen, J. Morse. Photographic Guide to Citrus Fruit Scarring. Publication 8090, Division of Agriculture and Natural Resources, University of California 2003. Accessed at URL: http://anrcatalog.ucdavis.edu/pdf/8090.pdf

16. Schweizer H. & J. Morse. *Predicting Citrus Thrips Damage on Navel Oranges in the San Joaquin Valley*, Citrograph Magazine, April 1999. Accessed at URL: http://citrusent.uckac.edu/pctd.pdf

17. Semiannual Report Summarizing the Reevaluation Status of Pesticide Products during the Period of January 1, 2006 through June 30, 2006. California Department of Pesticide Regulation, California Notice 2006-14.

18. Baumgartner, Jo Ann. Telephone interview. 12 July 2007.

19. Wilson C, Tisdell C. Why farmers continue to use pesticides despite environmental, health and sustainability costs. Ecological Economics 2001;39:449-462.

20. Pimentel D, Acquay H, Biltonen M, Rice P, Silva M, Nelson J, Lipner V, Girodano, S, Horowitz A, D'Amore M. Environmental and Economic Costs of Pesticide Use. BioScience 1992;42(10):750-760.

21. The Organic Foods Production Act of 1990, as amended (7 U.S.C. 6501 et seq.) 65 CFR 80637, Dec. 21, 2000, Subpart A , § 205.2 Terms defined. Accessed at URL: http://www.ams.usda.gov/nop/indexNet.htm

22. Gaskell, M., R. Smith, J. Mitchell, S. Koike, C. Fouche, T. Hartz, W. Horwath & L. Jackson. Soil Fertility Management for Organic Crops, Organic Vegetable Production in California Series, Vegetable Research Information Center (VRIC), UC Davis. Accessed at URL: http://anrcatalog.ucdavis.edu/pdf/7249.pdf

23. Pizura, Monica. Telephone interview. 3 July 2007.

24. Diver, S. Biodynamic Farming & Compost Preparation, Alternative Farming Systems Guide, ATTRA, National Center for Appropriate Technology, February 1999. Accessed at URL: http://attra.ncat.org/

25. Beck, Helene. Telephone interview. 20 June 2007.

26. Vellema, Mary. Telephone interview. 25 June 2007.

27. Buddell, Melanie. Telephone interview. 2 July 2007.

28.. Bunin L. Cultural Practices that Substitute for the Use of Metam Sodium As a Pre-Plant Soil Fumigant, California Department of Health Services, Occupational Health Branch, May 31, 2002.

29. Benik, Robert. Telephone interview. June 2007.

30. Atwood, Chuck. Telephone interview. 25 June 2007.

31. Pottorff L. Friendly Pesticides for Home Gardens, Colorado State University Extension –Horticulture, no 2.945. Accessed at URL: http://www.ext.colostate.edu/pubs/garden/02945.html

32. Boucher T. Spinosad: The First Selective, Broad-Spectrum Insecticide. Integrated Pest Management, University of Connecticut, 1999.

33. Weathersbee, A. A. & C. L. McKenzie. Effect of a Neem Biopesticide on Repellency, Mortality, Oviposition, and Development of Diaphorina Citri (Homoptera: Psyllidae), Florida Entomologist, 88(4): 401-407, December 2005. Accessed at URL: http://www.bioone.org/perlserv/?request=get-archive&issn=0015-4040&volume=88

34. Organic Materials Review Institute. Accessed at URL: http://www.omri.org

Related Websites

1. Alternative Farming Systems Information Center (AFSIC)
http://afsic.nal.usda.gov/nal_display/index.php?tax_level=1&info_center=2
AFSIC specializes in locating and accessing information related to alternative agriculture including sustainable and organic crop and livestock farming systems.

2. ATTRA—National Sustainable Agriculture Information Services
www.attra.org
ATTRA is managed by the National Center for Appropriate Technology (NCAT) and funded by a grant from the USDA's Rural Business-Cooperative Service. It provides information and technical assistance to US farmers, ranchers, extension agents, educators, and others involved in sustainable agriculture.

3. California Certified Organic Farmers (CCOF)
www.ccof.org
Provides a list of organic orange growers by company name, address, contact numbers, and e-mail address.

4. California Department of Public Health, Occupational Health Branch (OHB), Occupational Pesticide Illness Prevention Program
http://www.cdph.ca.gov/programs/ohsep/Pages/Pesticide.aspx
OHB tracks work related illness, performs select case investigations, and researches and promotes less toxic alternatives to pesticides.

5. California Department of Pesticide Regulation (CDPR): Pesticide label information and active ingredients of pesticides
http://www.cdpr.ca.gov/docs/label/labelque.htm

6. CDPR: History of the pesticides used in California
http://www.cdpr.ca.gov/docs/pur/purmain.htm

7. Local Harvest
www.localharvest.org
Local harvest offers a searchable, nationwide database of farms and products that can be searched by zip code, name of farm or state. The list includes both organic and conventional farms.

8. Organic Materials Review Institute (OMRI)
www.omri.org
OMRI is a national nonprofit organization that determines which input products are allowed in organic production and processing. OMRI Listed or approved products may be used on certified organic operations in accordance with USDA's National Organic Program

9. Pesticide Action Network of North America (PANNA)
www.panna.org
PANNA conducts worldwide campaigns aimed at replacing pesticides with ecologically sound and socially just alternatives. The PAN Pesticides Database is a searchable, comprehensive collection of data sources on the current toxicity and regulatory information available on insecticides, herbicides and pesticides.

10. Pesticide Research Institute
http://www.pesticideresearch.com
Conducts research on pesticide related issues including pesticide drift.

11. University of California, Agriculture and Natural Resources (ANR) Statewide Integrated Pest Management Program
http://ipm.ucdavis.edu

12. Wild Farm Alliance (WFA)
www.wildfarmalliance.org
WFA promotes agriculture that helps to protect and restore wild nature whereby ecologically managed farms and ranches are integrated into landscapes that accommodate the full range of native species and ecological processes. Its Biodiversity Guide details the many ways in which biodiversity and conservation practices can be incorporated into organic farming systems by farmers and ranchers as a way to contribute to biodiversity conservation outside the farm’s borders, at the regional and watershed levels.