The Stone Fruit Pest Management Alliance Demonstration Project:

Successes in IPM Implementation and Outreach in Fresh Market Peaches, Plums, and Nectarines

Table of Contents

CD Instructions

Title Page

Navigating through the CD

1. Hit the F5 key (top and center of keyboard) to start the slide-show.

2. Use the *left-click* on your mouse to advance to the next slide (click anywhere except on an icon or button). You can also use the down-arrow key (↓) to advance. Use the up-arrow key (↑) to back up. The *right-click* button on your mouse can also be used—just click it and then scroll down to “Next” or “Previous.”

3. To click on an icon or highlighted WORD, move the mouse back-and-forth for a few seconds until you see the pointer, then move the pointer over the icon/word. When the pointer turns from an “arrowhead” into a “hand,” just click and you’ll be linked to whatever the icon/word represents.

4. To end the slide-show at any time, just hit the “Esc” key (escape key) in the upper left corner of your keyboard. Then you can close PowerPoint altogether, or resume the slide-show by hitting the F5 key.

5. There are other ways to navigate, of course, but we are presenting the ones that are simplest (and easiest to explain). Familiarity with PowerPoint isn’t required, but it will come with time.

A Four-Year Project To Implement Reduced-Risk Integrated Pest Management Condensed into a Compact Disc

Walt Bentley, IPM Entomologist, UC ANR/CVR Kearney Agricultural Center

Shawn Steffan, Staff Research Associate, UC ANR/CVR Kearney Agricultural Center

Diana Bulls, Administrative Assistant II, UC ANR Kearney Agricultural Center

Hit "Esc" key to exit slide show

Click *anywhere* to begin slide show

Chapter One

The Project's Purpose and Personnel

Table of Contents

Background

The Stone Fruit Pest Management Alliance (PMA) is a collaboration between University of California personnel, stone fruit commodity groups (California Tree Fruit Agreement, California Cling Peach Board), California Department of Pesticide Regulation, the agricultural industry (chemical companies, PCAs, nurseries), and private stone fruit growers. The Alliance was formed to develop and demonstrate effective uses of reduced-risk insecticides as alternatives to various organophosphate (OP) materials.

Table of Contents

The Food Quality Protection Act

- The need for reduced-risk materials has become a pressing issue because high levels of commonly used organophosphates have been found in surface water bodies for many years.

- The Food Quality Protection Act (FQPA) was unanimously signed by all members of Congress in 1996, which then directed the US Environmental Protection Agency to implement a new type of risk assessment program, as well as to require States to re-register all OPs.

Table of Contents

The Toolbox May Be Changing

- It is anticipated that risk factors and redundancy within the pool of OPs will result in certain OPs losing their registration. In anticipation of the loss of such materials, the stone fruit industry explored non-OP pest management approaches.

- Past research into IPM technologies and approaches has provided a wealth of information and “tools” over the years, yet adoption has been relatively slow given the historical successes of conventional insecticides.

Table of Contents

Facilitating Change

- To encourage the adoption of new pest management materials and strategies, it is critical to demonstrate that large scale reduced-risk materials can effectively control targeted pests and that these materials are economically competitive.

- The California Tree Fruit Agreement (CTFA) and California Cling Peach Board have funded University of California research over the years. This research has shown workable alternatives to conventional OP and carbamate materials. Although the information is available, many tree fruit growers have been hesitant to change over to IPM techniques and reduced-risk materials.

Table of Contents

Implementation Facilitated through Demonstration

- The PMA Demonstration Project has endeavored to make arrangements with private growers to use reduced-risk materials and IPM techniques. Over the last four years, our growers' fruit quality and insect populations were closely monitored to demonstrate the viability and sustainability of non-OP pest management approaches.

- The PMA Demonstration Project has met with success because the participating growers and their PCAs *made* it work on their own land.

Table of Contents

Less Sometimes Can Mean *More*

- It should be emphasized that the guiding principle was *not* to get rid of all OPs, but rather to demonstrate that other materials exist and can be relied upon for effective pest control. By using certain OPs less, it is likely that pesticide runoff, resistance, and residual issues will be mitigated.

- In the long run, using certain materials less may help to keep them around as backups.

Table of Contents

Grower-Cooperators: 2000

Bill Tos, *Tos Farms*
(Kings County)
'Red Jim' nectarines
PCA: Les Nygren

Rick Schellenberg, *Schellenberg Farms* (Fresno County)
'Grand Rosa' plums
'Elegant Lady' peaches
'Royal Glo' nectarines
'Summer Red' nectarines
PCA: Joe Vasquez

Table of Contents

Grower-Cooperators: 2001

Bill Tos, *Tos Farms* (Kings County)
- 'Red Jim' nectarines
- PCA: Les Nygren

Rick Schellenberg, *Schellenberg Farms* (Fresno County)
- 'Elegant Lady' peaches
- 'Summer Red' nectarines
- PCA: Joe Vasquez

Robert Jackson, *Daybreak Farms* (Tulare County)
- 'Zee Lady' peaches
- 'Arctic Snow' nectarines
- PCA: Keith Heinrichs

Steve Strong, *Rubicon Orchards* (Tulare County)
- 'Fire Pearl' nectarines
- 'Bright Pearl' nectarines
- PCA: Judy Stewart-Leslie

Pat Pinkham, *Pinkham Brothers Farm* (Tulare County)
- 'Fortune' plums
- 'Autumn Beut' plums
- PCA: Jim Stewart

John Deniz, *Deniz Packing* (Madera County)
- 'Angelino' plums
- 'Santa Rosa' plums

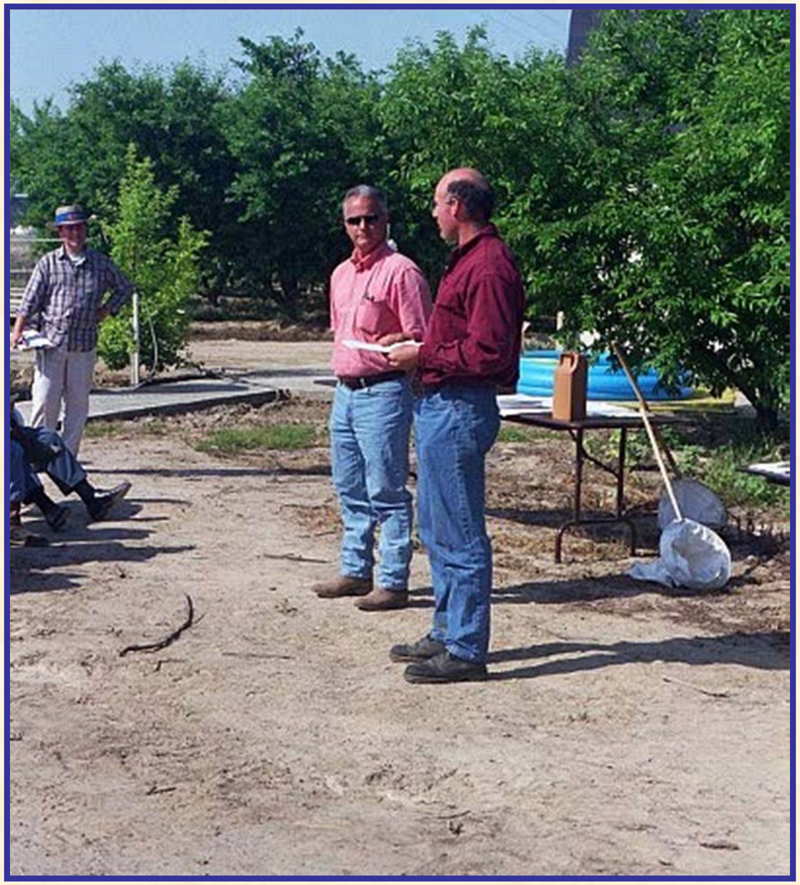


Table of Contents

Grower-Cooperators: 2002-2003

Bill Tos, *Tos Farms* (Kings County)
- 'Red Jim' nectarines
- PCA: Les Nygren

Rick Schellenberg, *Schellenberg Farms* (Fresno County)
- 'Elegant Lady' peaches
- 'Summer Red' nectarines
- PCA: Joe Vasquez

Robert Jackson, *Daybreak Farms*
(Tulare County)
- 'Zee Lady' peaches
- 'Arctic Snow' nectarines
- 'Sweet September' peaches
- PCA: Keith Heinrichs

Steve Strong, *Rubicon Orchards*
(Tulare County)
- 'Fire Pearl' nectarines
- 'Bright Pearl' nectarines
- PCA: Judy Stewart-Leslie

John Deniz, *Deniz Packing* (Madera County)
- 'Sun Diamond' nectarines
- 'Summer Grand' nectarines

Ryan Metzler, *Metzler Farms* (Fresno County)
- 'Summer Fire' nectarines

Table of Contents

Commodity Group Personnel

- *California Tree Fruit Agreement*
  - Gary Van Sickle, Research Director
- *California Cling Peach Board*
  - Heidi Sanders, Research Director

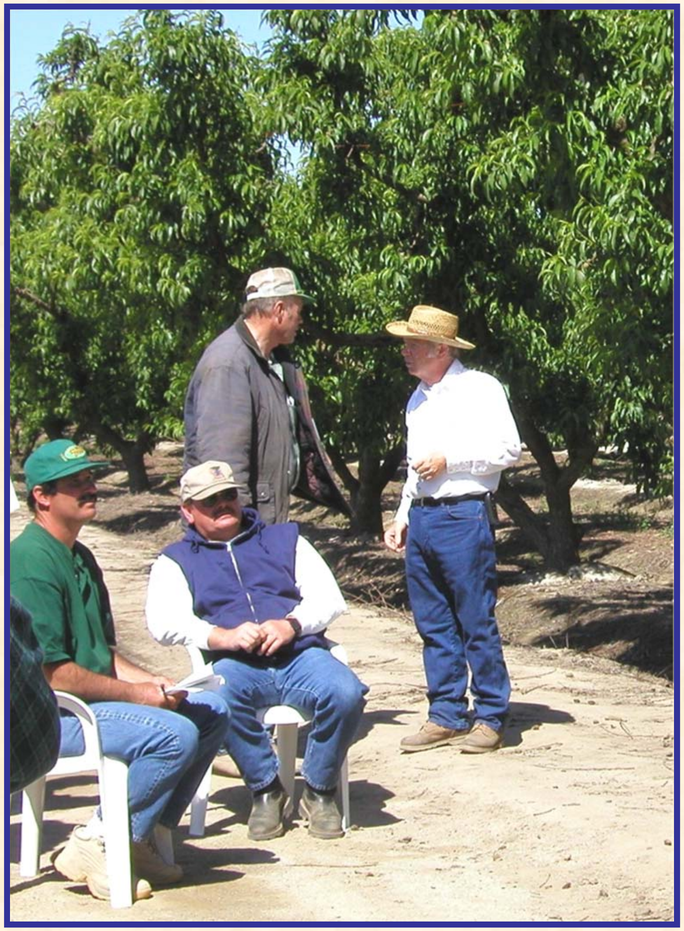


Table of Contents

University of California Personnel

- Harry Andris, Farm Advisor, UCCE Fresno County
- Walter Bentley, IPM Entomologist, UC ANR/CVR Kearney Ag. Center
- Rich Coviello, Farm Advisor, UCCE Fresno County
- Kent Daane, Biological Control Specialist, UC Berkeley
- Janine Hasey, Farm Advisor, UCCE Sutter-Yuba Counties
- Scott Johnson, Extension Pomologist, UC Davis
- Shawn Steffan, Staff Research Associate, UC ANR/CVR Kearney Ag. Center

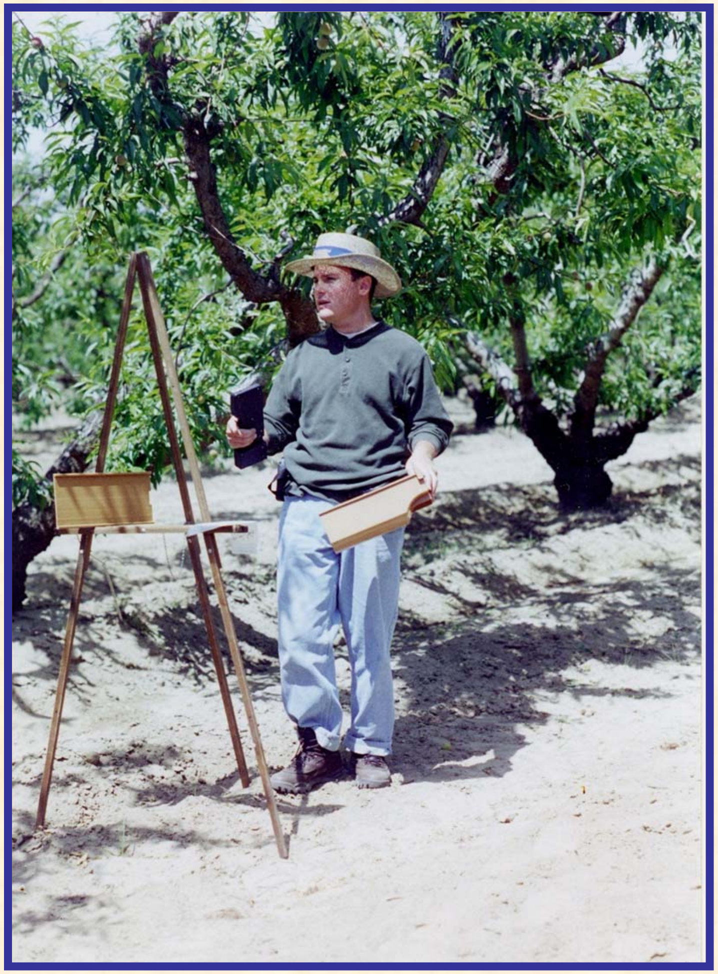


Table of Contents

Agency and Industry Support

Table of Contents

Chapter Two

Insecticide Categories and Use-Trends

Table of Contents

Insecticides, by Category (with examples relevant to stone fruit production)

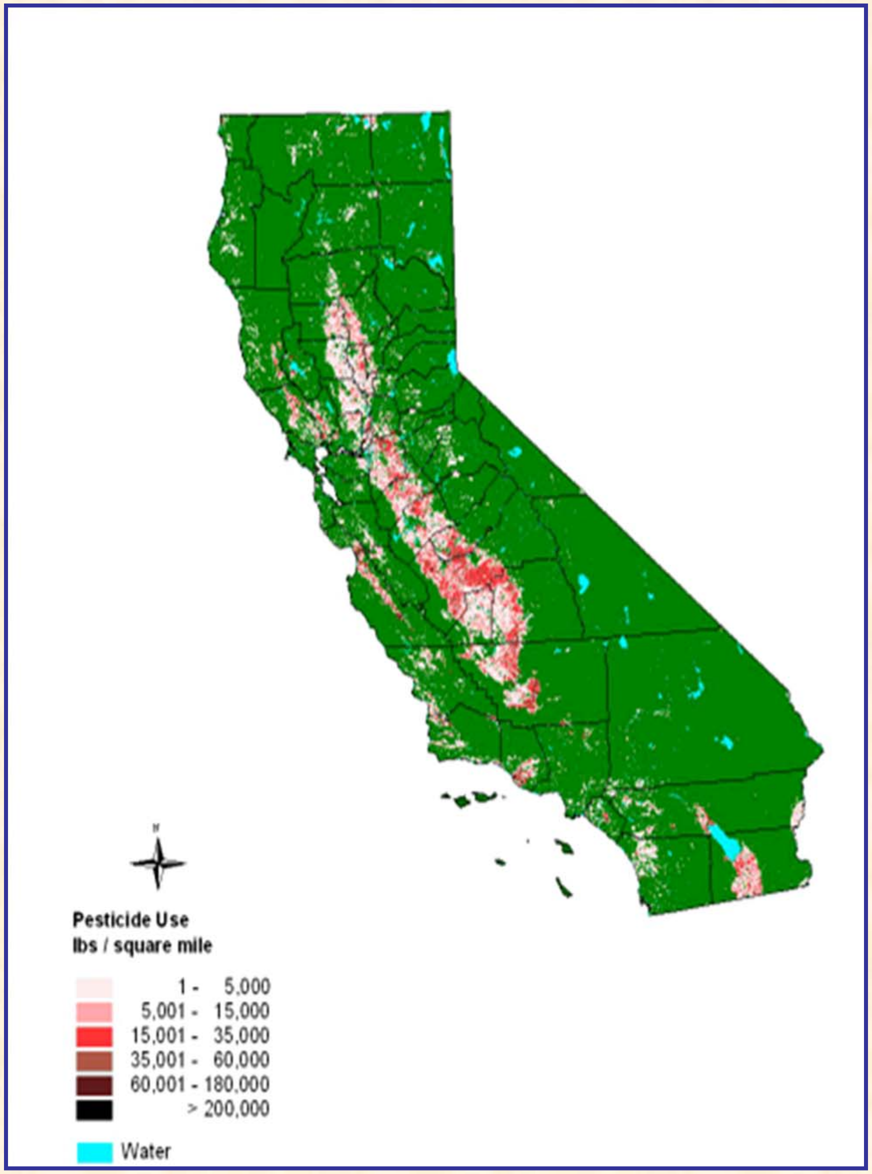
- Antibiotics (Bt, spinosad)
- Botanicals (azadirachtin, pyrethrin)
- Carbamates (carbaryl, methomyl)
- Flourines (cryolite)
- Formamidines (formetanate)
- Horticultural mineral oils
- Insect Growth Regulators
  - Chitin synthesis inhibitors (buprofezin, diflubenzeron)
  - Juvenile hormone mimics (pyriproxifen)
  - Molting hormone agonists (methoxyfenozide, tebufenozide)

Table of Contents

Insecticides, continued

- Mating disruptors (OFM and PTB pheromones)
- Nicotinoids (imidacloprid, acetamiprid)
- Organochlorines (endosulfan)
- Organophosphates (chlorpyrifos, diazinon, methidathion, phosmet)
- Oxadiazines (indoxacarb)
- Pyrazoles (fipronil)
- Pyrethroids (esfenvalerate)

Table of Contents



California Department of Pesticide Regulation data on pesticide loads, derived from 1999 use-reports.

Total pounds of active ingredient applied per square mile are presented.

Click HERE for a closer look at central San Joaquin Valley pesticide use patterns.

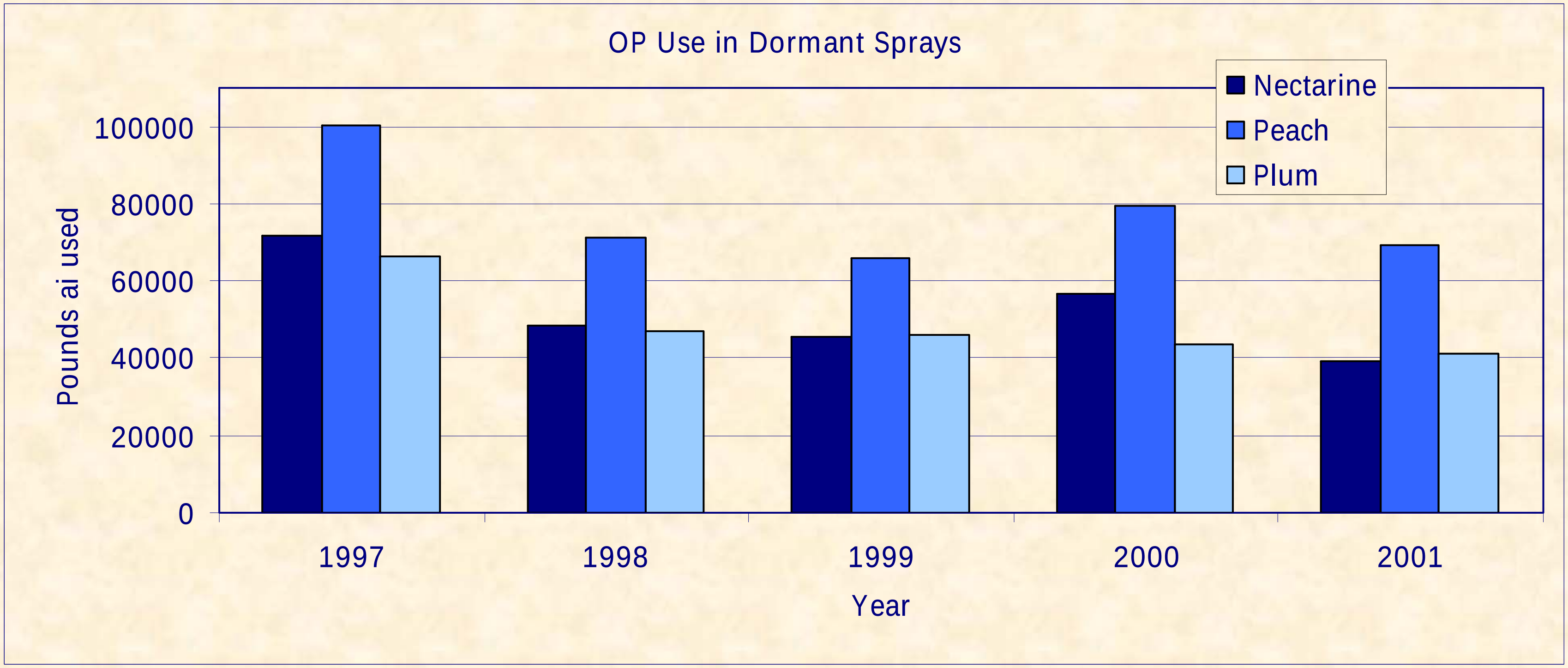
Table of Contents

Dormant-Season Applications Can Result in Runoff Issues for Local Water Quality

- Federal and state agencies monitor for chlorpyrifos and diazinon in California waterways.
- The US EPA has listed 53 water bodies in California as impaired due to diazinon in urban runoff; 7 water bodies are listed as impaired due to chlorpyrifos contamination.
- In 1998, the State of California placed the Sacramento River, the San Joaquin River, and the Delta/Estuary on the Clean Water Act list of impaired waterways.
- The contribution by agriculture to the total pesticide load in the waterways has not been quantified, though water quality data has been correlated with winter rain events that allow runoff from farms to reach waterways.

Table of Contents

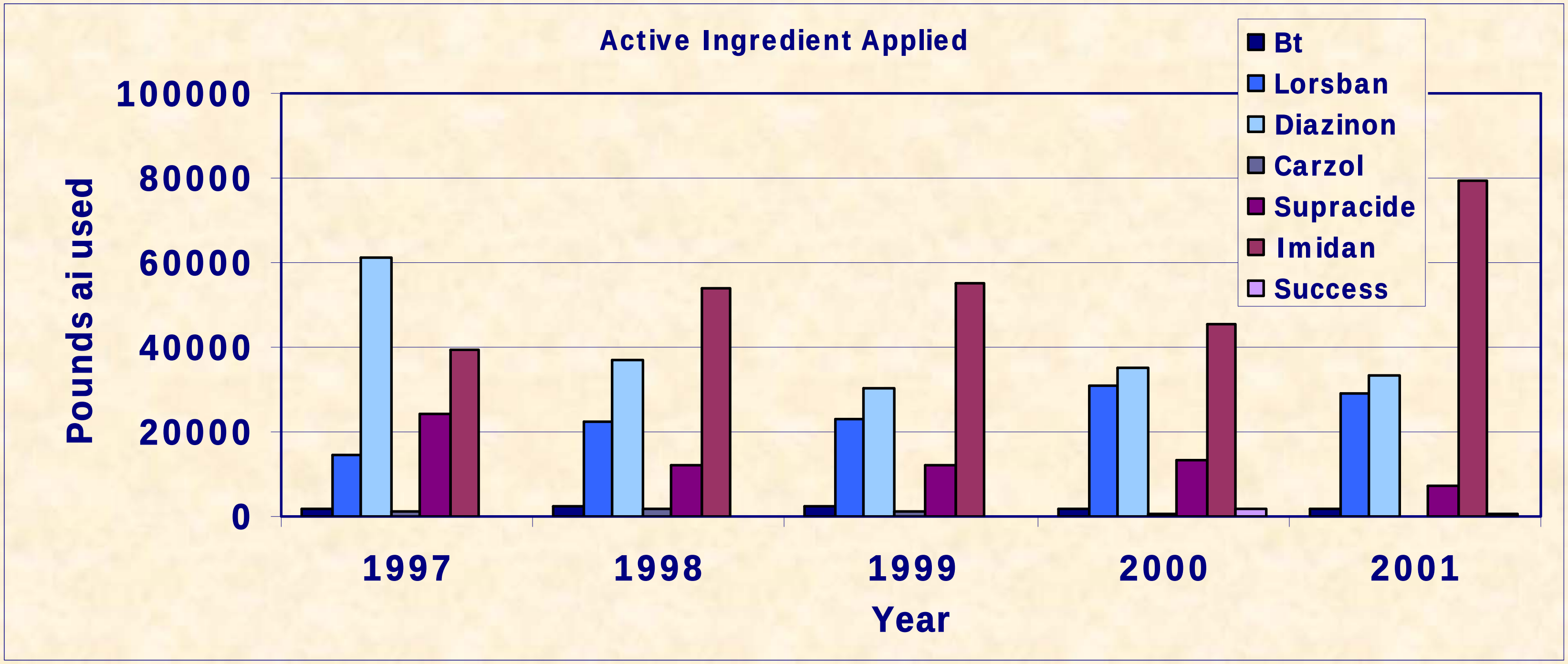
Dormant-Season Applications of OPs



There appears to be a subtle decline in the amount of OPs being applied during the dormant and delayed-dormant applications. In recent years, many growers have opted to use higher rates of horticultural mineral oil (8 gal oil/acre) instead of the typical oil+OP application.

Table of Contents

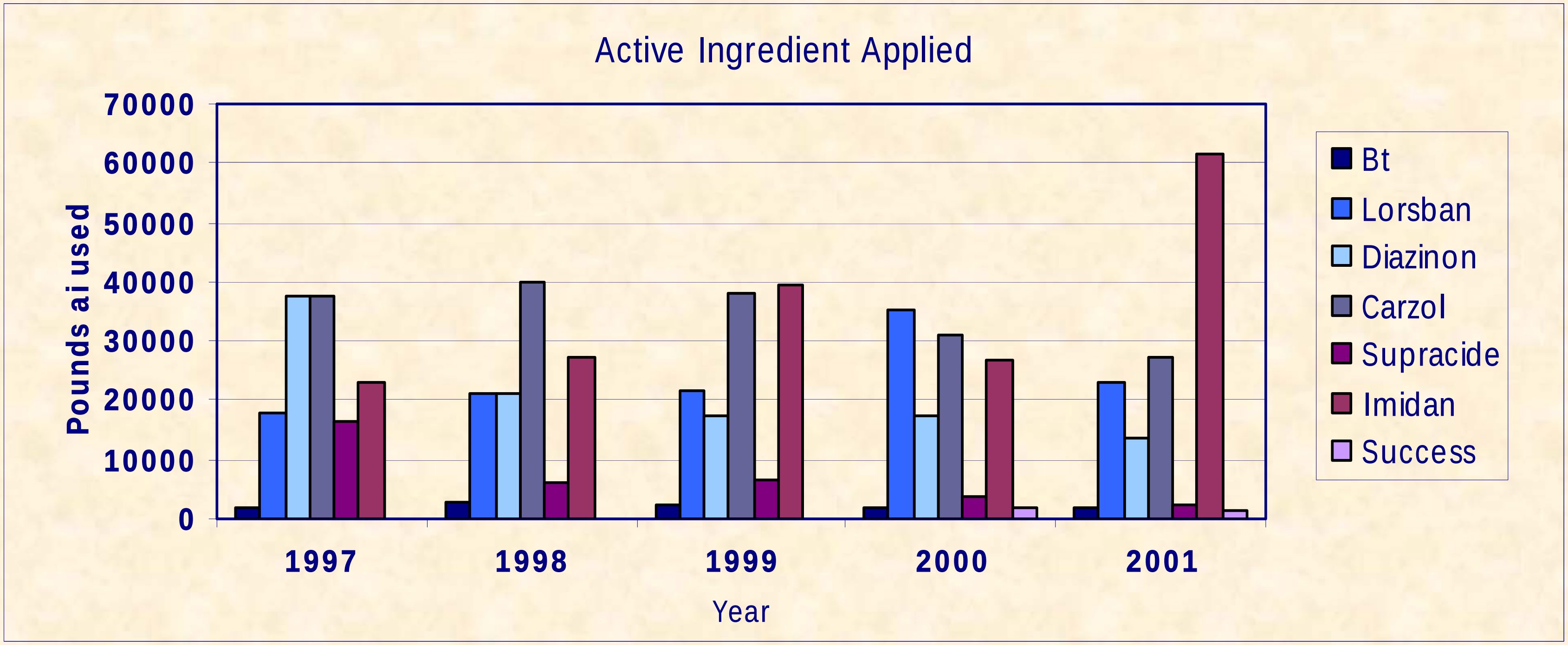
Peach Pesticide Use Reports: 1997-2001



The use of OPs has been a mainstay of peach production. The introduction of Success® in 2000 may have had an effect on Imidan® use. While Diazinon® and Lorsban® applications have plateaued in recent years, Imidan use has increased dramatically.

Table of Contents

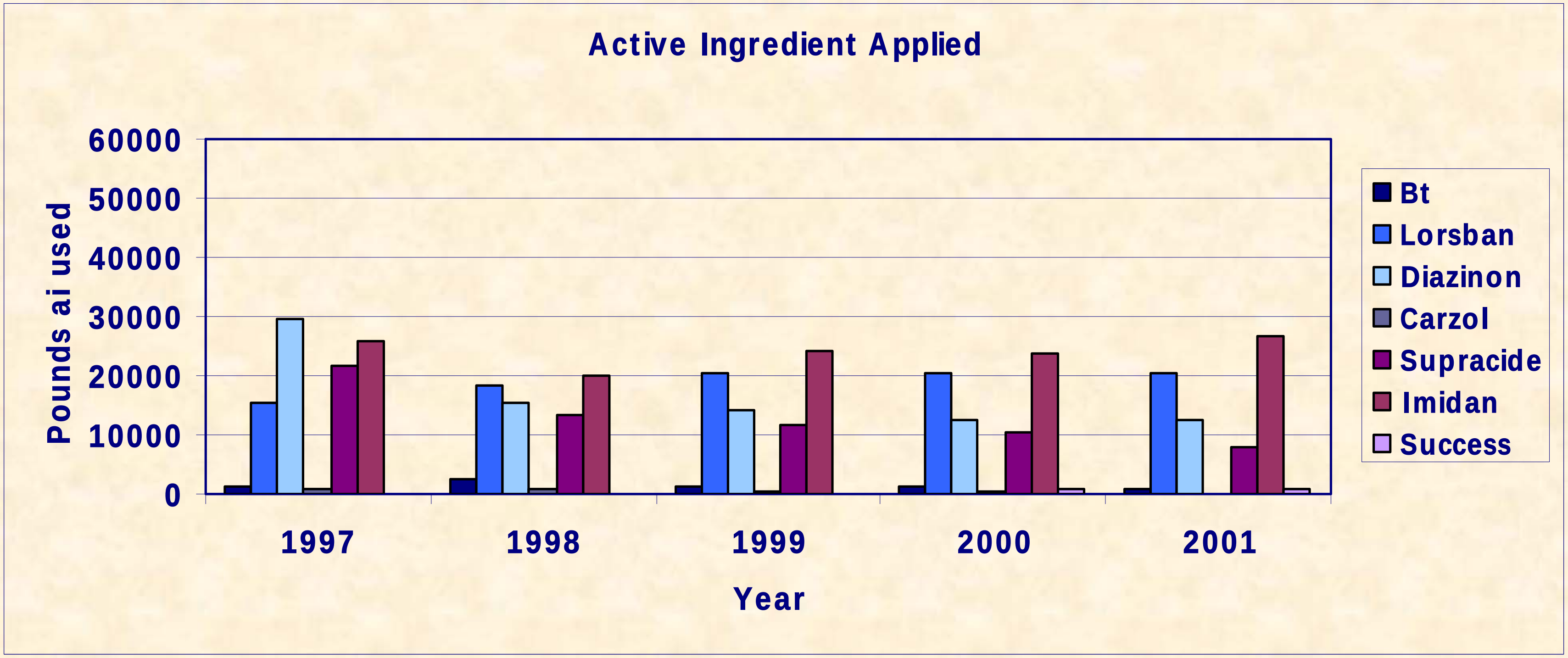
Nectarine Pesticide Use Reports: 1997-2001



Success has emerged as an effective replacement material for bloomtime and in-season applications, and its use appears to be reducing the amount of Carzol® applied to nectarines. OPs such as Supracide, Lorsban, and Diazinon continue to dominate the chemical "tool box."

Table of Contents

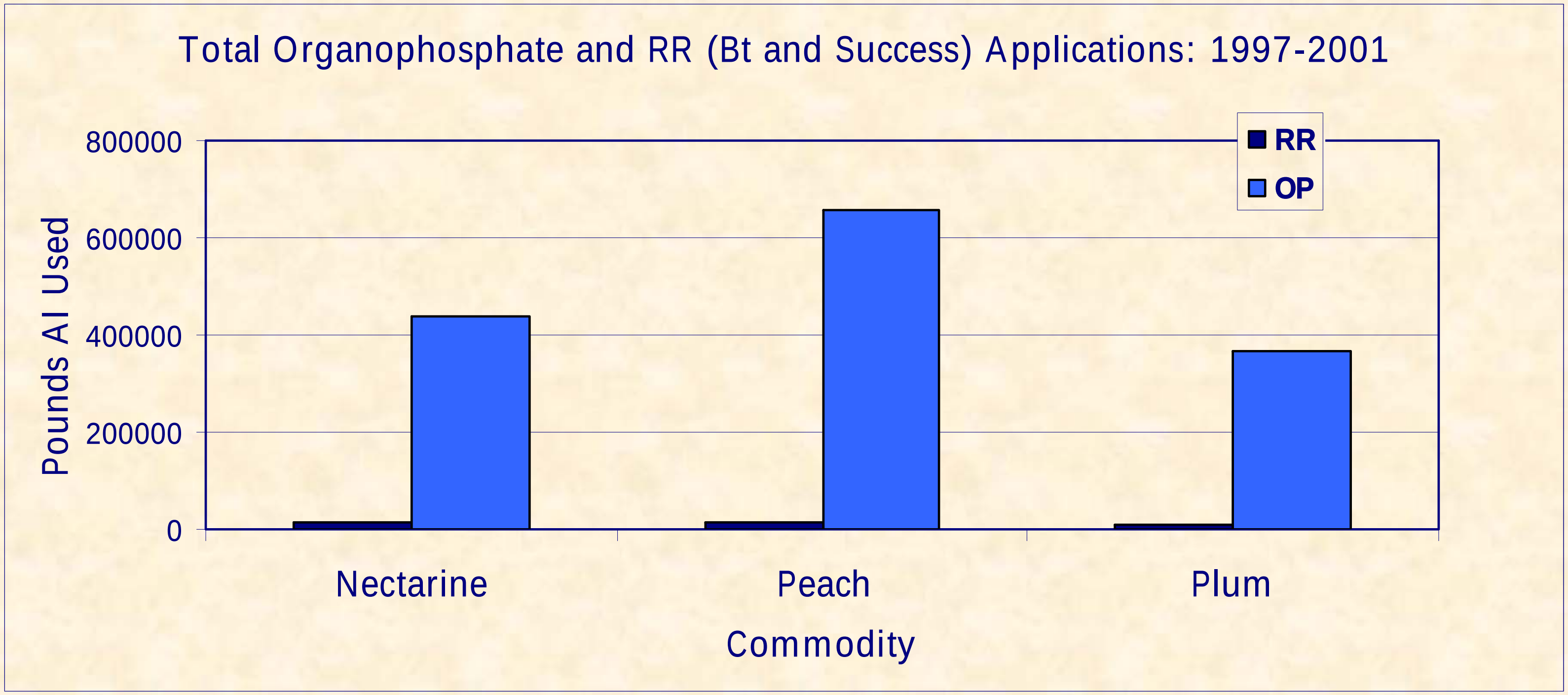
Plum Pesticide Use-Reports: 1997-2001



Lorsban, Diazinon, and Imidan are the primary insecticides used in plum production. Success and Bt are the most commonly used non-OP insecticides.

Table of Contents

Total OP and RR Applied



Looking at nectarine, peach, and plum applications individually, it becomes clear which commodities use the most material per acre. It is also fairly plain to see that two of the most common reduced-risk materials (Bt and Success) pale in comparison when you look at active-ingredient/acre.

Table of Contents

Reduced-Risk (RR) Materials:
Effective, yet less persistent and more selective

"Reduced-risk" is a name given to some of the newer chemistries, as well as certain older materials, that are being developed to control pests.

Many insecticides, miticides, and mating disruption materials have been successfully integrated into production systems for years.

In general, reduced-risk materials are among the more selective insecticides, and they also tend to be less persistent in the environment.

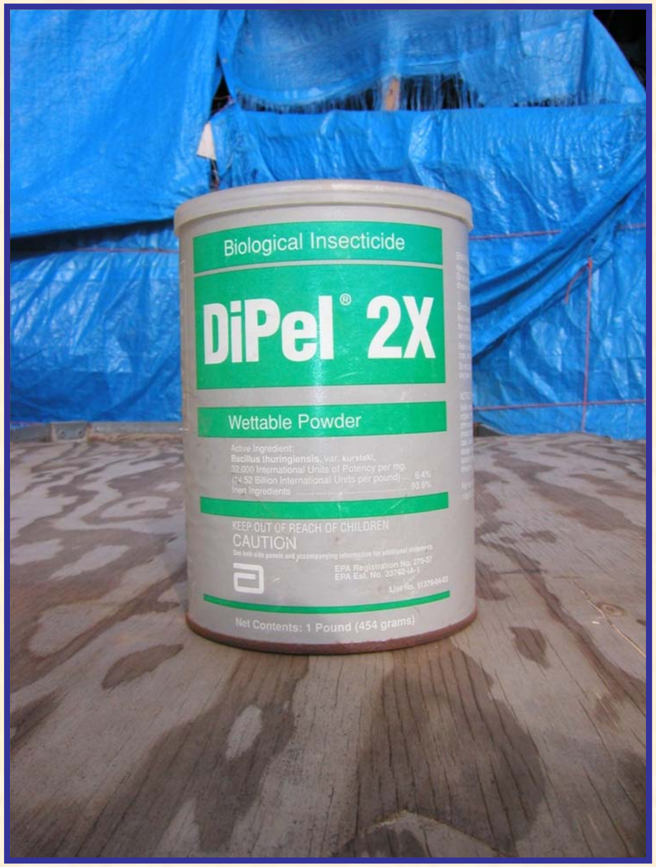


Table of Contents

Examples, Attributes of Reduced-Risk Materials

- Examples
  - Spinosad (Success®)
  - *Bacillus thuringiensis*
  - Horticultural oil (Volck Supreme®)
  - Oriental Fruit Moth pheromone
  - Azadirachtin (AZA-Direct®)
  - Bifenazate (Acramite®)
  - Pyriproxifen (Esteem®)

Many of the newer RR materials target systems in the insect that we don't share with them, such as pheromone communication, molting hormones, and exoskeleton formation.

Effective integration of RR materials into production systems reduces the load of Class I neurotoxins being applied.

Table of Contents

Insecticide Resistance Is a Constant Concern for Any Material

- Documented for decades in virtually all cropping systems.
- Translates into unforeseen pest "blow-ups."
- In the San Joaquin Valley, resistance to major organophosphates exists in populations of:
  - San Jose Scale (1996, R.E. Rice)
  - Oriental Fruit Moth (1993, W.W. Barnett)
- Resistance to pyrethroids has been noted in peach twig borer (2001, UC IPM)

Table of Contents

Pros & Cons of RRs

Pros

- Helps reduce resistance
- Not broad-spectrum
- Easier on beneficials
- Less toxic to workers, consumers
- Mating disruption prevents offspring from ever hatching
- Efficacy

Cons

- Not broad-spectrum
- Less persistent (may require more monitoring for precise application timing)
- Expense, in some cases

Table of Contents

IPM Approaches to Insect Suppression

Monitor pest and beneficial insect populations.

Use knowledge of pest biology, damage potential, and crop status to determine economic injury levels and/or action thresholds.

Spray only when economically necessary, and time the spray to most effectively suppress the pest population.

Use selective insecticides that will minimize disruption of predators and parasitoids.

Table of Contents

Chapter Three

Biology and Control of Pest Species

Table of Contents

Primary Pests of Stone Fruit in the San Joaquin Valley

- Katydids
- Codling Moth
- Obliquebanded Leafroller
- Spider Mites
- Oriental Fruit Moth
- Peach Twig Borer
- San Jose Scale
- Omnivorous Leafroller
- Western Flower Thrips

Table of Contents

Oriental Fruit Moth

Adult OFM are small grayish moths about 0.4 inch long. These moths normally fly in the evenings just after sunset, or occasionally between daybreak and sunrise. Eggs are disk shaped, white to creamy in color when first laid, and about 0.03 inch in diameter. Just before hatching, the black head of the developing larva becomes visible. Larvae are white with a black head when first hatched. As they mature, they gradually turn pink with a brown head. Mature larvae are about 0.5 inch long. Use a hand lens to detect the presence of an anal comb under the last abdominal sclerite, which helps distinguish OFM from other white or pink worms that may be found in stone fruits.

There are usually five generations per year in California, although a sixth generation has been observed in years with warm weather in early spring. OFM overwinter as mature, diapausing larvae inside tightly woven cocoons in protected places on the tree or in the trash near the base of the tree. In early spring, pupation takes place inside the cocoon and adults begin emerging in February or early March. Eggs are deposited on newly emerged shoots and the larva feed in terminals where they complete their development. Second generation larvae feed in shoots, but fruit of some of the earlier maturing peach cultivars may also be attacked. Subsequent generations may attack shoot terminals and green fruit, but as fruit matures it becomes the preferred site of attack by this pest.

Generally OFM larvae bore deeper into the shoot than peach twig borer larvae do. If the larvae are still present, cut strikes open to determine if the infestation is OFM or peach twig borer.

Pest Table of Contents

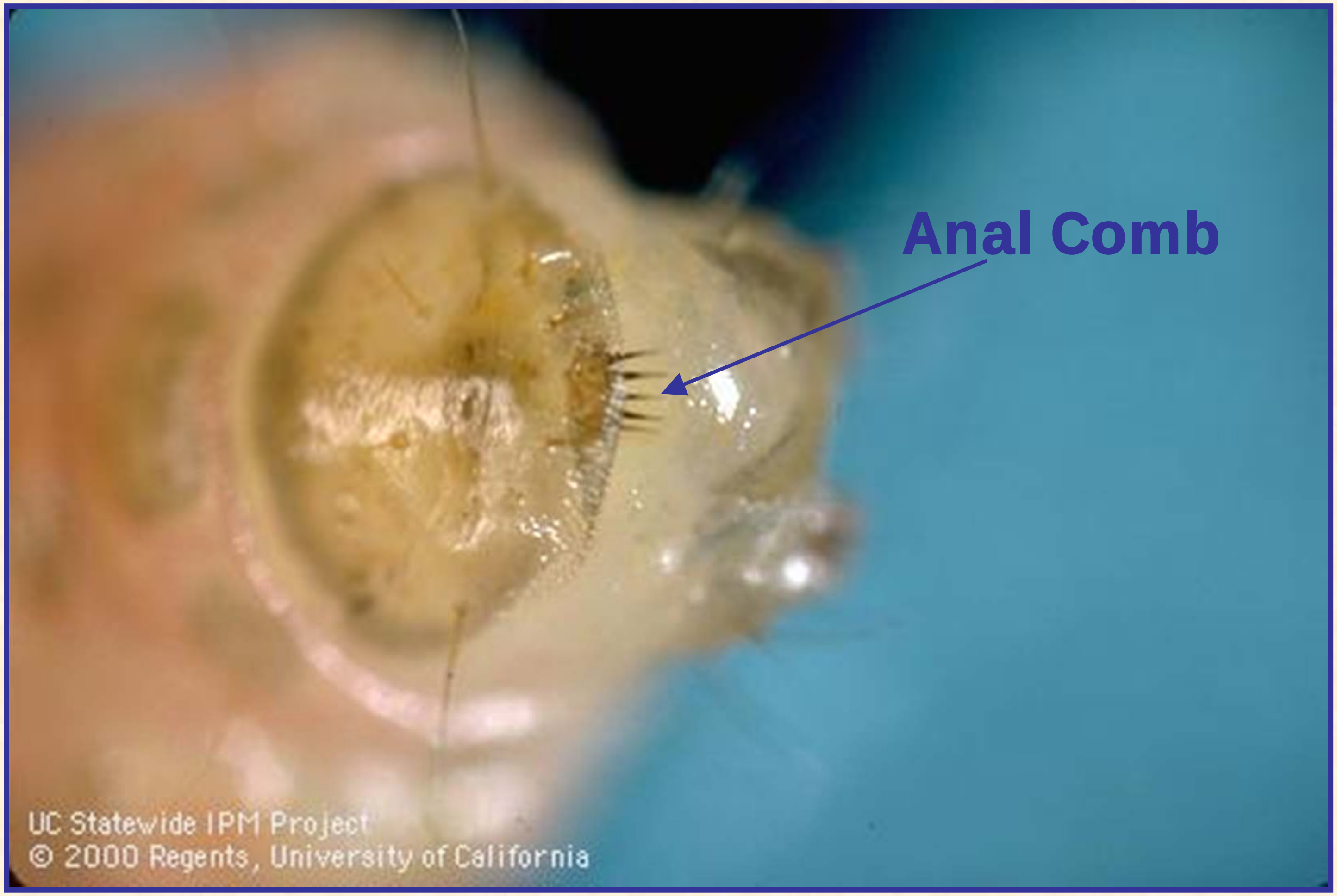
Adult OFM

Back to OFM

Mature OFM Larva

Back to OFM

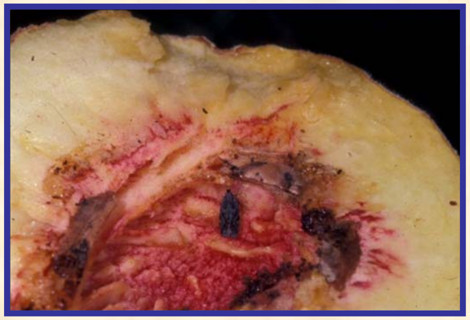
Identifying OFM Larvae



Back to OFM

Pupa of OFM

Back to OFM



Peach Twig Borer

Small larvae of PTB are almost white with a distinct black head. As larvae mature they become chocolate brown with alternating dark and light bands around the abdomen. The light intersegmental membranes contrasted with the brown body distinguishes PTB from other larvae found in stone fruits. Mature larvae are about 0.5 inch long.

Pupae are 0.25 to 0.4 inch long, brown in color and lack a cocoon. Pupation takes place in protected places on the tree and occasionally in the stem cavity of infested fruit.

Adult PTB moths are 0.3 to 0.4 inch long with steel gray, mottled forewings. The long, narrow forewings are lightly fringed; the lighter gray hindwings are more heavily fringed. Prominent palpi on the head give the appearance of a snout. The bluntly oval eggs are yellow white to orange and are laid on twigs, leaves, or on the fruit surface.

PTB overwinters on the tree as a first or second instar larva within a tiny cell, called a hibernaculum, usually in crotches of 1- to 3-year-old wood, in pruning wounds, or in deep cracks in bark. The overwintering site is marked by a chimney of frass and is especially noticeable when first constructed or before winter rains set in. Larvae emerge in early spring, usually just before and during bloom, and migrate up twigs and branches where they attack newly emerged leaves and shoots. As shoots elongate, larvae mine the inside, causing the terminals to die back. Dead shoots are known as shoot strikes or flags. Adults from the overwintered generation usually begin emerging in April or early May. First generation larvae usually develop in twigs during May and June and give rise to the next flight of moths in late June or early July. Larvae from this and subsequent generations may attack either twigs or fruit depending on fruit maturity and population density.

Pest Table of Contents

Adult PTB

Back to PTB

PTB Mature Larva

Back to PTB

PTB Pupa

Back to PTB

San Jose Scale

Female SJS give birth to living young that emerge from under the edge of the scale covering. These tiny yellow crawlers wander in a random fashion until they find a suitable place to settle. Immediately upon settling, the crawlers insert their mouthparts into the host plant and begin feeding and secreting a white waxy material (white cap stage); eventually the waxy covering turns black and is known as the black cap stage.

SJS overwinter predominantly in the black cap stage, although in mild years some adult females may also survive. In late January, these nymphs resume their growth. These overwintering scales become adults during March. Immature male and female scales are indistinguishable until after the first molt when the body of the male begins to elongate. Males molt a total of four times after which yellowish, winged adult males emerge to mate with females. The adult female SJS remains under its shell, which is gray and circular; the body under the shell covering is yellow. After a period of about two months, crawlers from the overwintering females begin emerging in April, with their peak emergence usually in early May. Although crawlers are present throughout the summer and fall, there are usually four generations per year.

Pest Table of Contents

SJS White Caps & Crawlers

Back to SJS

SJS Black Cap

Back to SJS

SJS Adult Male

Back to SJS

SJS Adult Female

Back to SJS

Omnivorous Leafroller

OLR is primarily a pest of peaches in the San Joaquin Valley. It occurs in the Sacramento Valley, but seldom causes damage. OLR overwinters as immature larvae in mummy fruit and does not enter dormancy. Larvae are light colored with dark brown or black heads. When mature they are about 0.6 inch (1.5 cm) long and have two slightly raised, oblong whitish spots on the upper surface of each abdominal segment. Abdominal segments may have a greenish brown tinge. They pupate inside a webbed shelter.

Adults of the overwintering generation emerge in March. They are small, dark brown moths, 0.5 to 0.375 inch (9-12 mm) long with a dark band on the wing and a long snout. Eggs are laid in overlapping rows that resemble fish scales. The first generation of eggs usually is laid on weed hosts, and adults from this generation emerge in May or June to lay eggs in orchards on leaves and fruit. Larvae that hatch from this generation of eggs can cause significant damage in stone fruits. All have the characteristic behavior of wriggling backward when disturbed and dropping from a silk thread attached to the leaf or fruit surface.

Pest Table of Contents

Adult OLR

Back to OLR

Larval OLR

Back to OLR

OLR Close-up

Back to OLR

Western Flower Thrips

WFT are minute insects, about 0.03 inch long, with two pairs of fringed wings. The adult has three color forms that vary in abundance depending on the time of year. There is a pale form that is white and yellow, except for slight brown spots or blemishes on the top of the abdomen; an intermediate color form with an orange thorax and brown abdomen; and a dark form that is dark brown. The intermediate form is present throughout the year, but in spring the dark form predominates while the pale form is most abundant at other times throughout the year.

First instar nymphs are opaque or light yellow, turning to golden yellow after the first molt. The nymphal stage lasts from 5 to 20 days.

WFT overwinter as adults in weeds, grasses, alfalfa, and other hosts, either in the orchard floor or nearby. In early spring, if overwintering sites are disturbed or dry up, thrips migrate to flowering trees and plants and deposit eggs in the tender portions of the host plant, e.g. shoots, buds, and flower parts. The peak infestation is usually reached in May or June.

Pest Table of Contents

Adult Western Flower Thrips

Back to WFT

Western Flower Thrips Nymph (feeding on mite eggs)

Back to WFT

Katydids

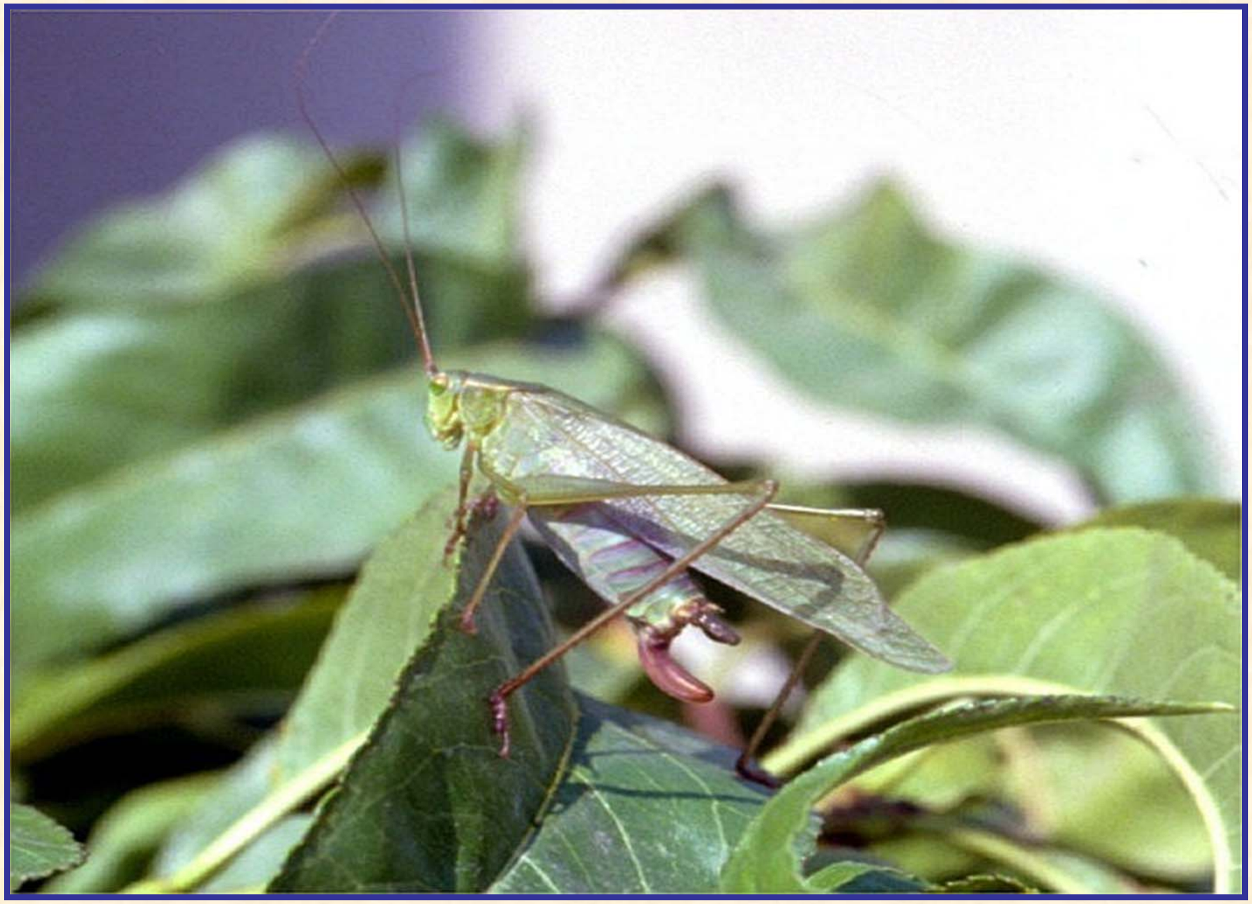
In the San Joaquin Valley, katydids (Orthoptera: Tettigoniidae) have become perennial pests of stone fruit production, particularly in nectarine orchards. The predominant katydid species, *Scudderia furcata* Brunner, is commonly known as the fork-tailed bush katydid (FTBK).

Nymphs and adults feed directly on the fruit, causing rapid and substantial yield loss. The other katydid species, *Microcentrum retinerve* (the angularwinged katydid) occurs less frequently, though it can cause direct damage to developing fruit. Both nymphs and adults of this species have a distinct humpbacked appearance. The FTBK is smaller and is not humpbacked.

Katydids lay disc-shaped eggs in fall. The eggs of the angularwinged katydid are 0.125 to 0.15 inch long (3-6 mm) and laid in two overlapping rows on the surface of twigs and leaves. FTBK eggs are about 0.125 inch long (3 mm) and are inserted into the edges of leaves. Eggs of both species hatch in April and May. Adult katydids appear in midsummer and lay eggs in fall. Angularwinged katydids have only one generation a year, while the FTBK has two.

Pest Table of Contents

Fork-Tailed Bush Katydid



Back to Katydid

Fork-Tailed Bush Katydid Eggs

Back to Katydid

Fork-Tailed Bush Katydid Nymph

Back to Katydid

Angularwinged Katydid

Back to Katydid

Angularwinged Katydid Eggs

Back to Katydid

Angularwinged Katydid Nymphs

Back to Katydid

Codling Moth

Larvae are white to pinkish caterpillars with brown to black heads. Adult moths have gray wings with a copper spot on each wing tip. After overwintering as mature larvae in silken cells under loose bark on the tree, moths emerge from March to May. Adults mate and lay eggs; larvae feed on small fruit. A second generation appears in June and often a third one in August, depending on temperatures.

Pest Table of Contents

Codling Moth Adults

Back to CM

Codling Moth Larva

Back to CM

Oblique-Banded Leafroller

Oblique-banded leafroller overwinter as third-instar larvae under bark scales. The overwintered larvae pupate in spring, and the first generation of adults emerges in late April or May. Larvae are yellowish green with brown to black heads. As they mature, larvae construct tubular shelters from a single leaf. Adults are reddish brown moths with dark brown bands on the wings. There are two or three generations a year in the Central Valley.

Pest Table of Contents

Oblique-Banded Leafroller Adult

Back to OBLR

Larva of obliquebanded leafroller

Back to OBLR

Webspinning Spider Mites

Pacific and twospotted spider mites overwinter as adult females in protected places on the tree or in the litter, trash, and weeds on the orchard floor. The overwintering forms of both species are reddish orange. The mites become active in early spring soon after trees leaf out and begin feeding on weeds or in the lower part of the trees. Both species are favored by hot, dry conditions, and as the weather becomes warmer, they increase in numbers and move up the center of the tree until the entire tree is infested. Adult females are about 0.03 inch long. Active summer females are greenish or pale yellow with large dark spots on each side of the body. The Pacific mite may also have a second pair of spots near the posterior end of the body which helps distinguish it from the twospotted mite. Females can complete a generation in as little as 10 days during the hot part of summer. There may be from 8 to 18 generations per year depending on temperature.

Eggs are spherical and almost translucent when first laid. They are generally deposited on the underside of leaves. As heavy populations build up, eggs may be deposited on both surfaces.

Pest Table of Contents

Adult Pacific spider mite

Back to spider mites

Adult twospotted spider mite

Back to spider mites

Information on Control Methods

- *Integrated Pest Management for Stone Fruits*. 1999. UC Statewide Integrated Pest Management Project. Publication # 3389. 264 pp.

<u>FOR ONLINE INFORMATION</u>:

- *Oriental Fruit Moth:* http://www.ipm.ucdavis.edu/PMG/r540300211.html
- *Oblique-Banded Leafroller:* http://www.ipm.ucdavis.edu/PMG/r540301111.html
- *Katydid:* http://www.ipm.ucdavis.edu/PMG/r540301311.html
- *Codling Moth:* http://www.ipm.ucdavis.edu/PMG/r611301011.html
- *Peach Twig Borer:* http://www.ipm.ucdavis.edu/PMG/r540300611.html
- *San Jose Scale:* http://www.ipm.ucdavis.edu/PMG/r540300711.html
- *Omnivorous Leafroller:* http://www.ipm.ucdavis.edu/PMG/selectnewpest.nectarine.html
- *Western Flower Thrips:* http://www.ipm.ucdavis.edu/PMG/r540300411.html

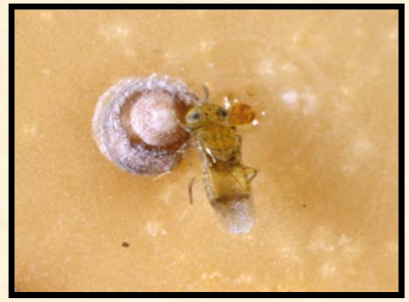
Chapter Four

Pheromone Trap Monitoring

Table of Contents

Seasonal Flight Dynamics: 2000-2002

Oriental Fruit Moth



***Aphytis* spp.**

Peach Twig Borer

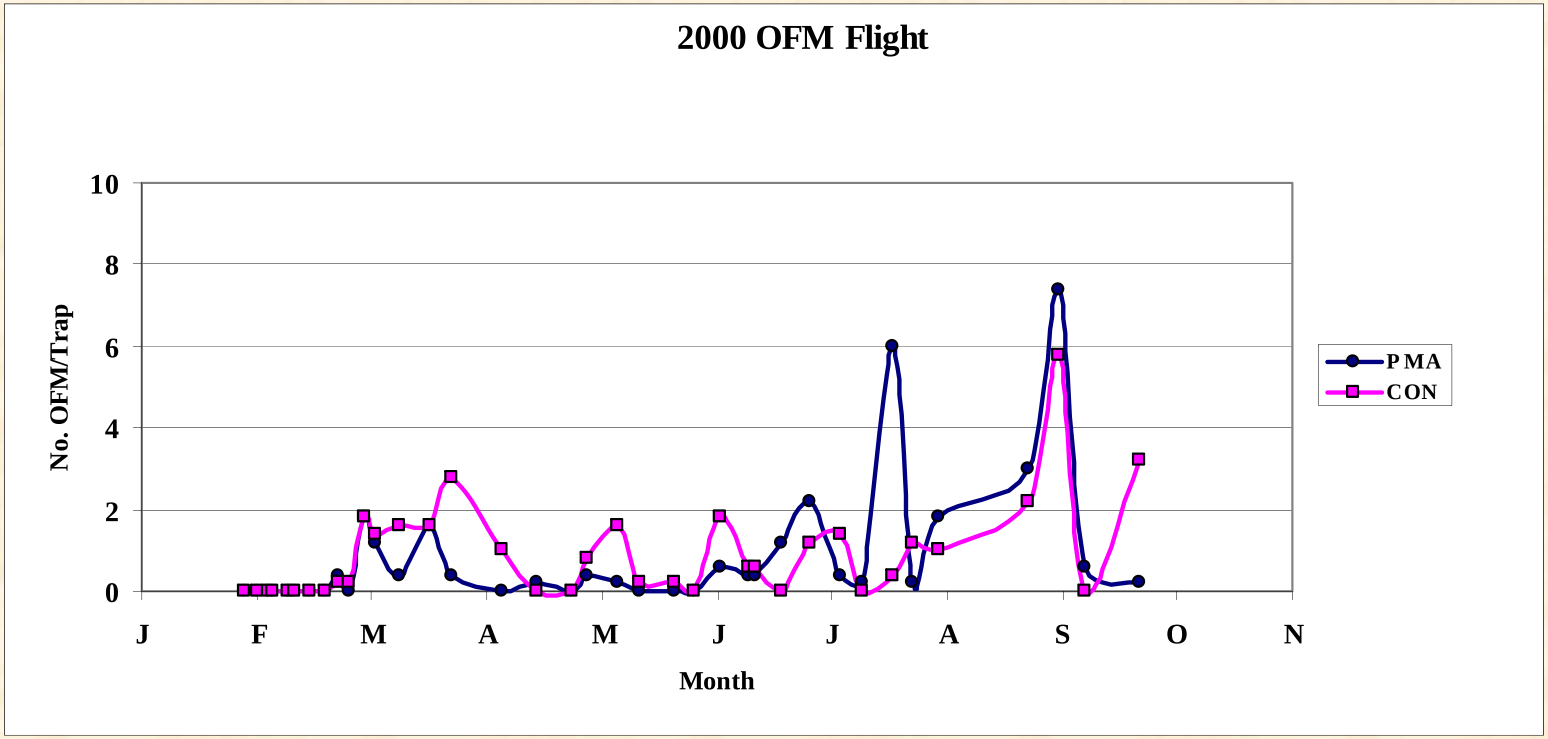
Encarsia perniciosi

Omnivorous Leafroller

San Jose Scale

Table of Contents

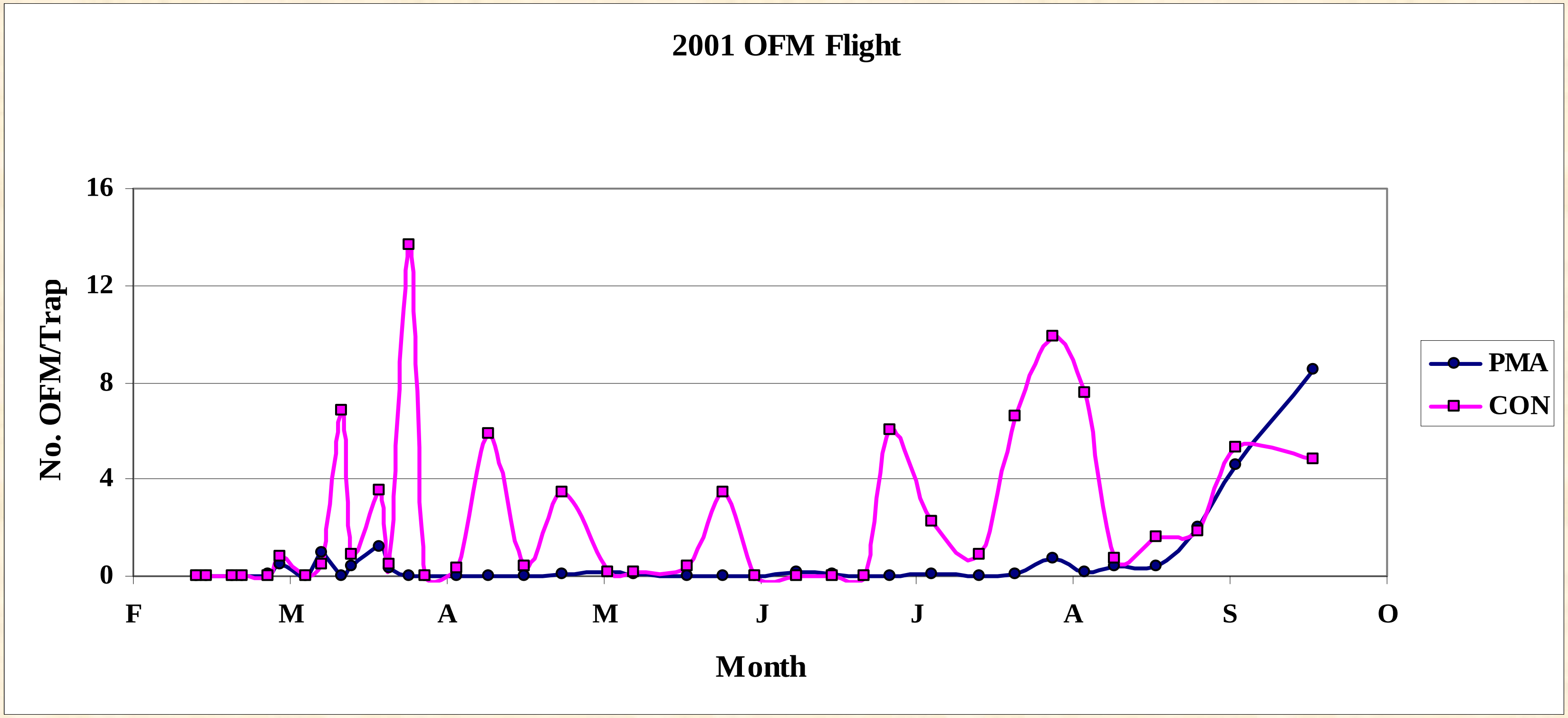
OFM: 2000 Seasonal Flight Dynamics



"PMA" and "CON" are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 5 varieties monitored in 2000.

During most of the growing season, the CON traps produced greater trap catches, and this is attributable to the use of pheromone mating disruption in PMA blocks. Later in the season (post-harvest), the counts in PMA blocks rose markedly.

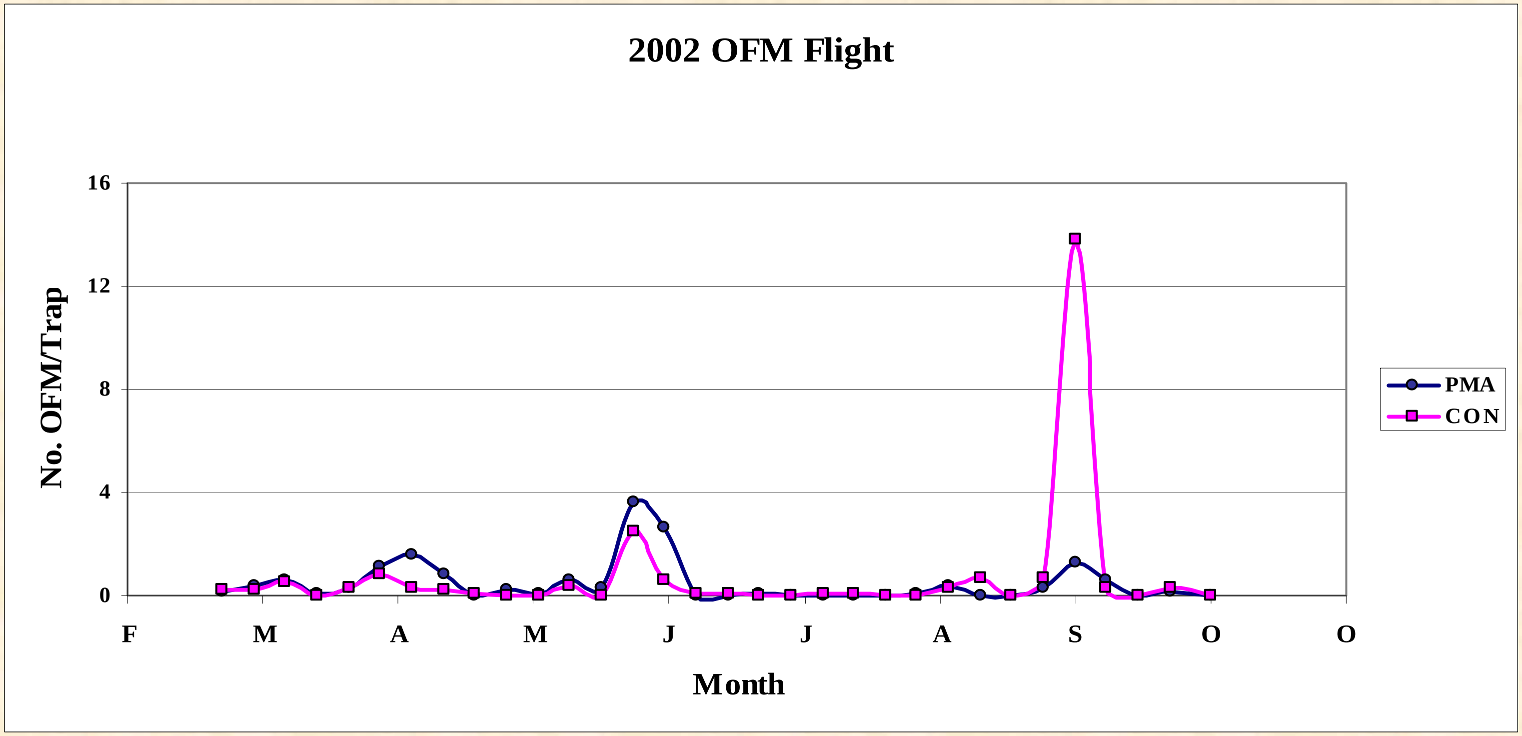
OFM: 2001 Seasonal Flight Dynamics



PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 11 varieties monitored in 2001.

The effect of mating disruption is more pronounced in 2001 than in 2000. In 2001, an experimental delivery system for OFM pheromone was initiated in blocks with typically high OFM populations. The delivery medium was a paraffin emulsion, applied with hand-held sprayers. Ties were used in all other PMA blocks.

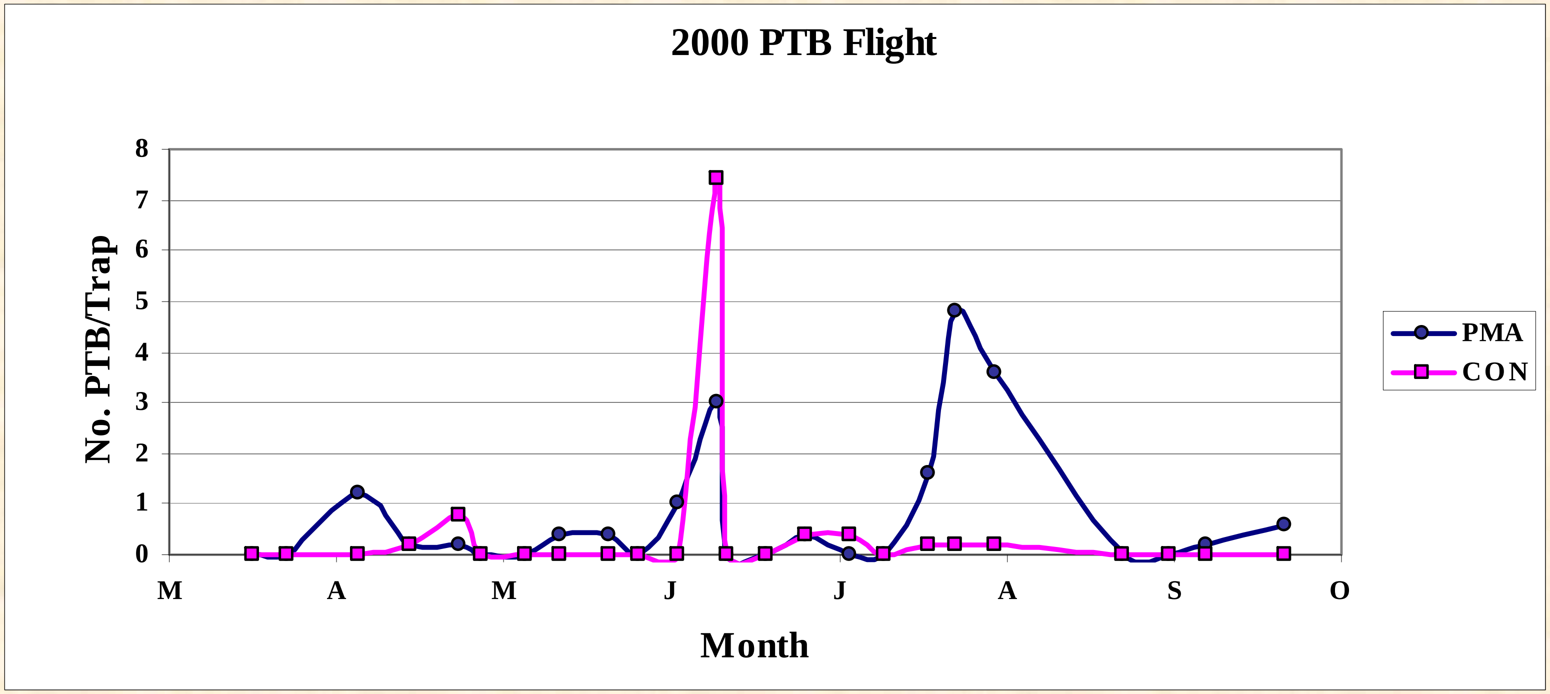
OFM: 2002 Seasonal Flight Dynamics



PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 12 varieties monitored in 2002.

Because of the successes of mating disruption programs, our growers opted to use OFM mating disruption on all their acreage. As a result, differences between PMA and CON trap catches are fairly negligible.

PTB: 2000 Seasonal Flight Dynamics



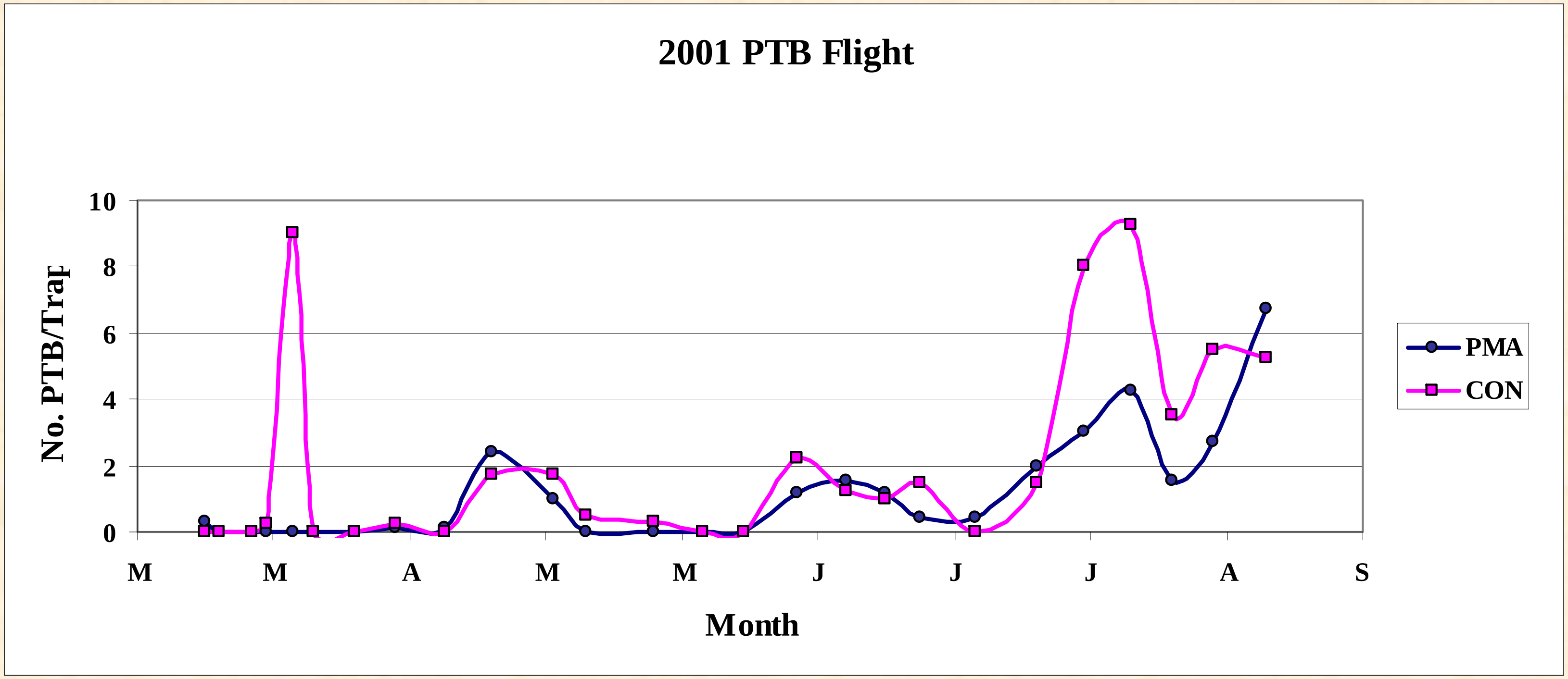
PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 5 varieties monitored in 2000.

The trap catches may appear at first to have pronounced “spikes,” but the actual number of PTB/trap is not very high (the y-axis range is 0 to 8). PTB populations in recent years have been exceedingly low, which may be the result of the pyrethroid application in winter and the bloomtime spray.

Seasonal Flight Dynamics

Table of Contents

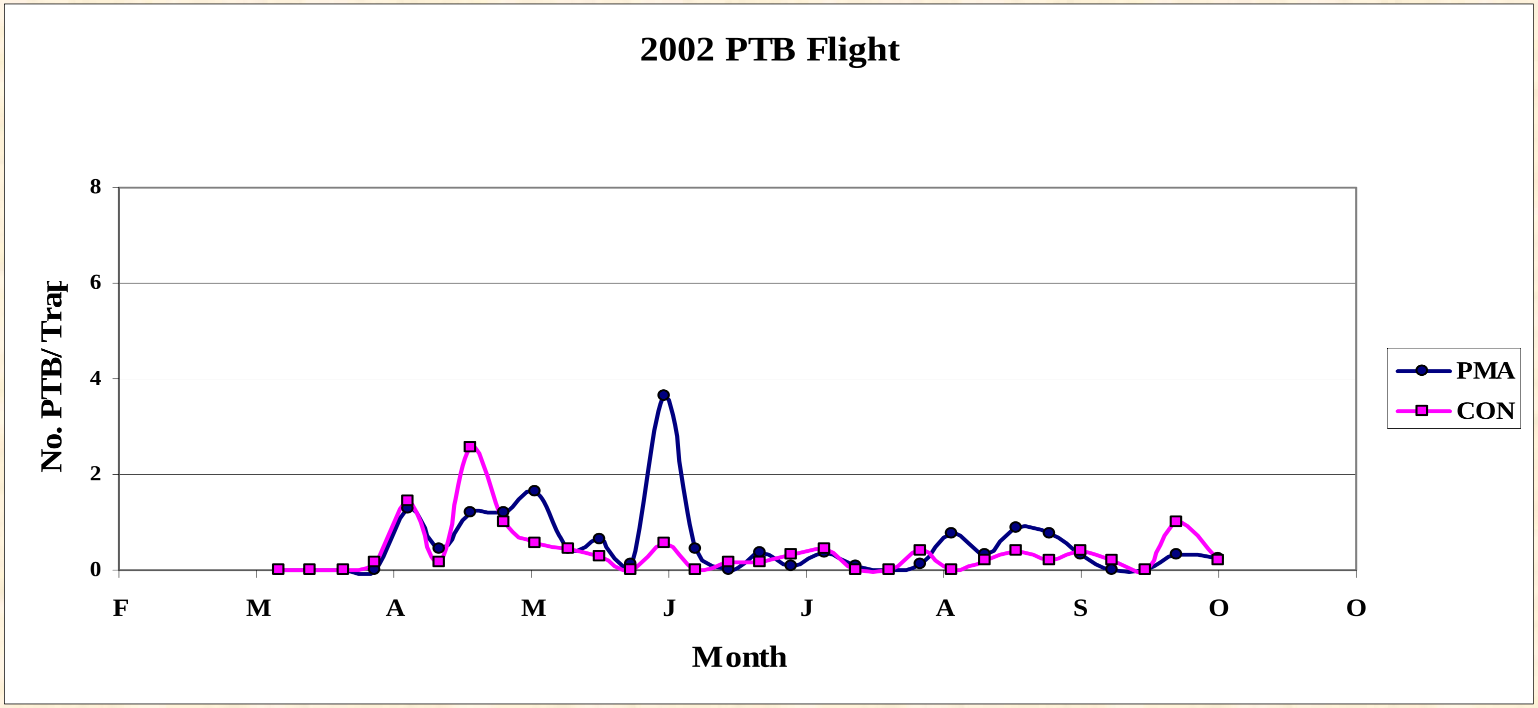
PTB: 2001 Seasonal Flight Dynamics



PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 11 varieties monitored in 2001.

The trap catches were greater in the Conventional blocks in 2001, which is likely the result of a new pheromone dispensing system used in the PMA blocks. Known as “puffers,” this technology emits aerosolized PTB pheromone into the orchard. During the early and late-season flights, the puffers appear to have had a substantial impact on male PTB.

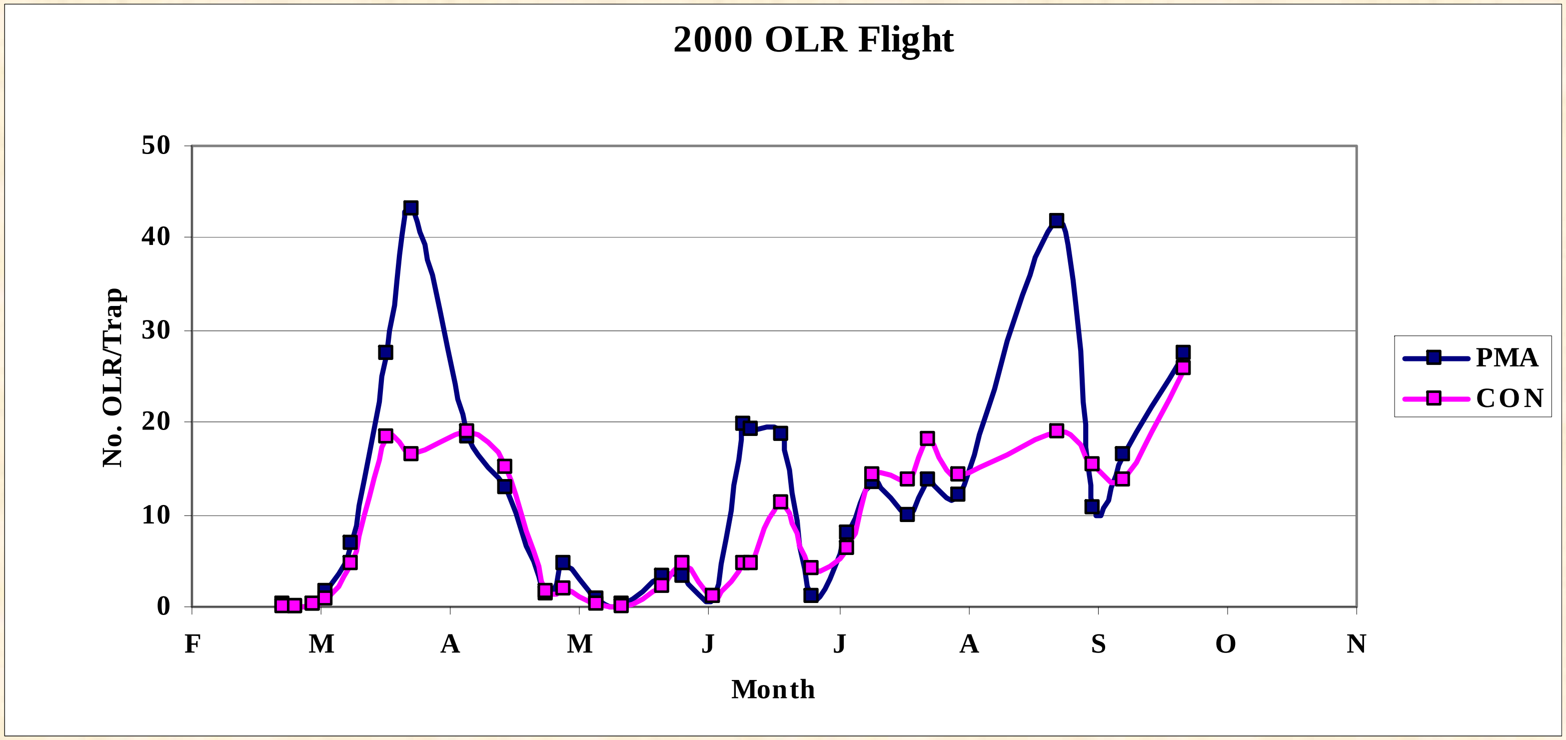
PTB: 2002 Seasonal Flight Dynamics



PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 12 varieties monitored in 2002.

The trap catches in 2002 were again very low. Puffers were installed in some, but not all orchards. Overall, trap catches were very similar in PMA and CON blocks. The early-June spike in PMA average was still less then four moths/trap. Spray programs appear to be working very well to keep overwintering PTB in check.

OLR: 2000 Seasonal Flight Dynamics



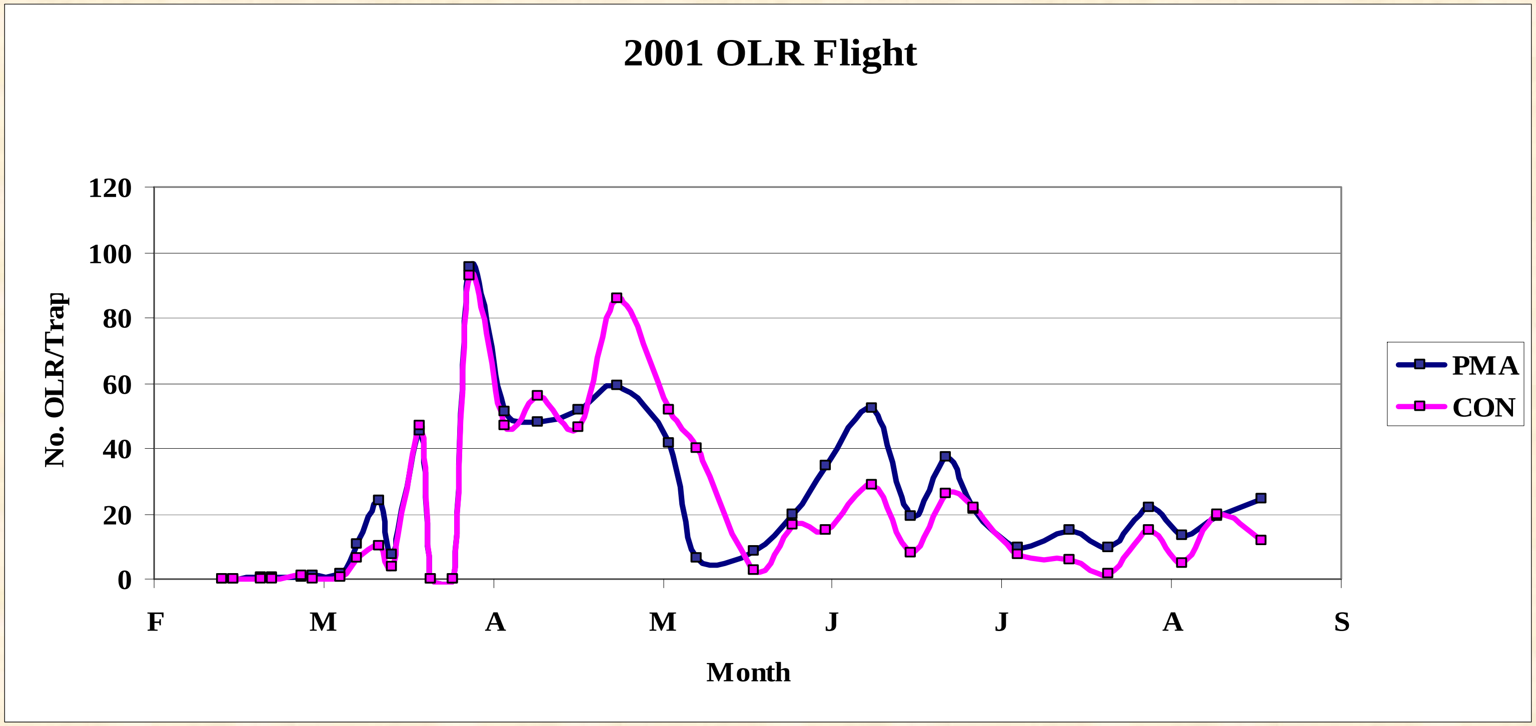
PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 5 varieties monitored in 2000.

Each year, relatively large numbers of OLR are caught in both the PMA and CON blocks. However, the high populations have not resulted in yield losses. After the first three generations of OLR in 2000, the PMA blocks had significantly more OLR but not a proportional increase in fruit damage at harvest. OLR is generally considered a secondary pest problem, but it can cause direct damage.

Seasonal Flight Dynamics

Table of Contents

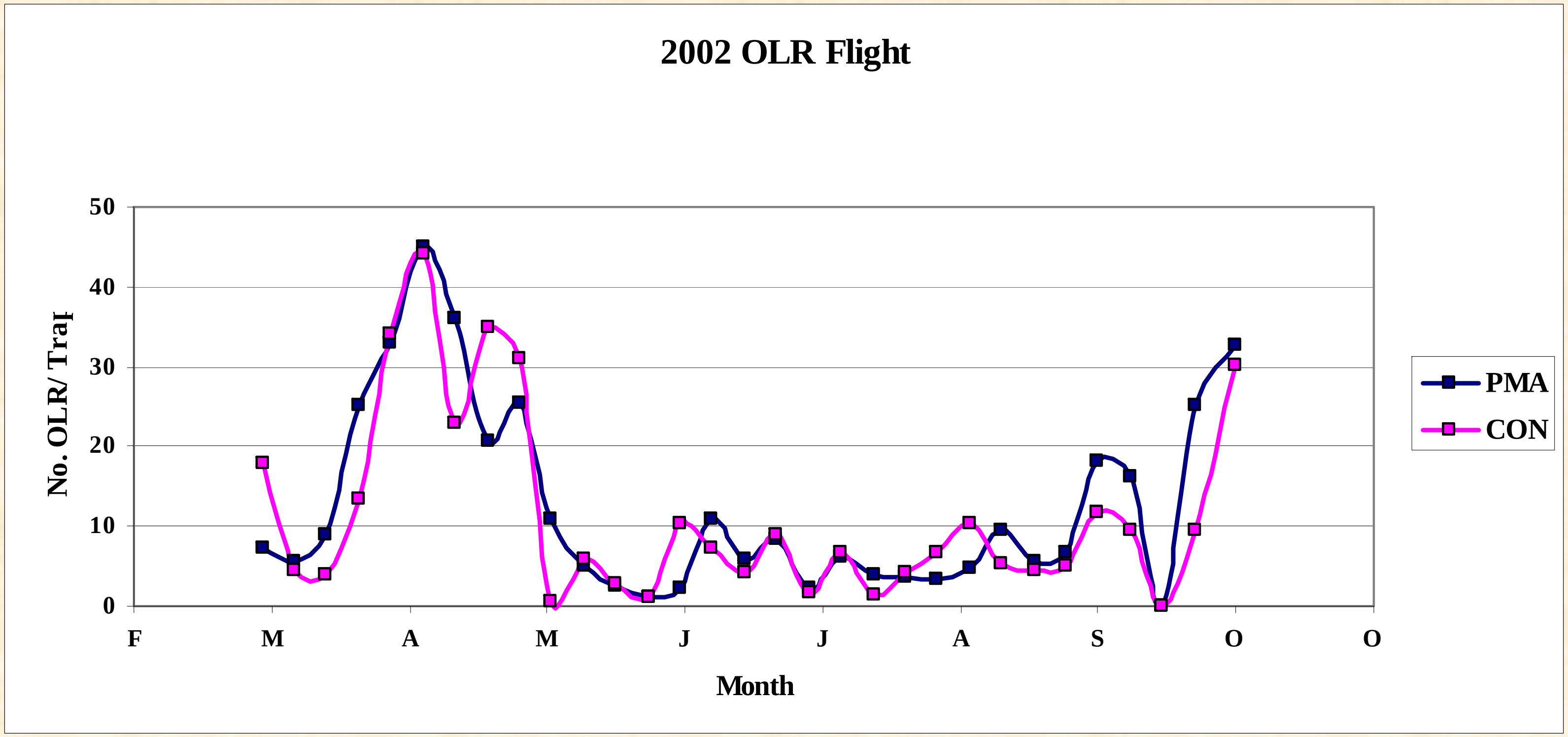
OLR: 2001 Seasonal Flight Dynamics



PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 11 varieties monitored in 2001.

It appeared that, on average, the PMA blocks were very similar to the CON blocks. This is an indication that the reduced-risk materials do play a role in suppressing "background" populations pests. Treatments are generally not timed specifically to hit OLR, so suppression to any degree is attributable to the residual activity of the insecticide.

OLR: 2002 Seasonal Flight Dynamics



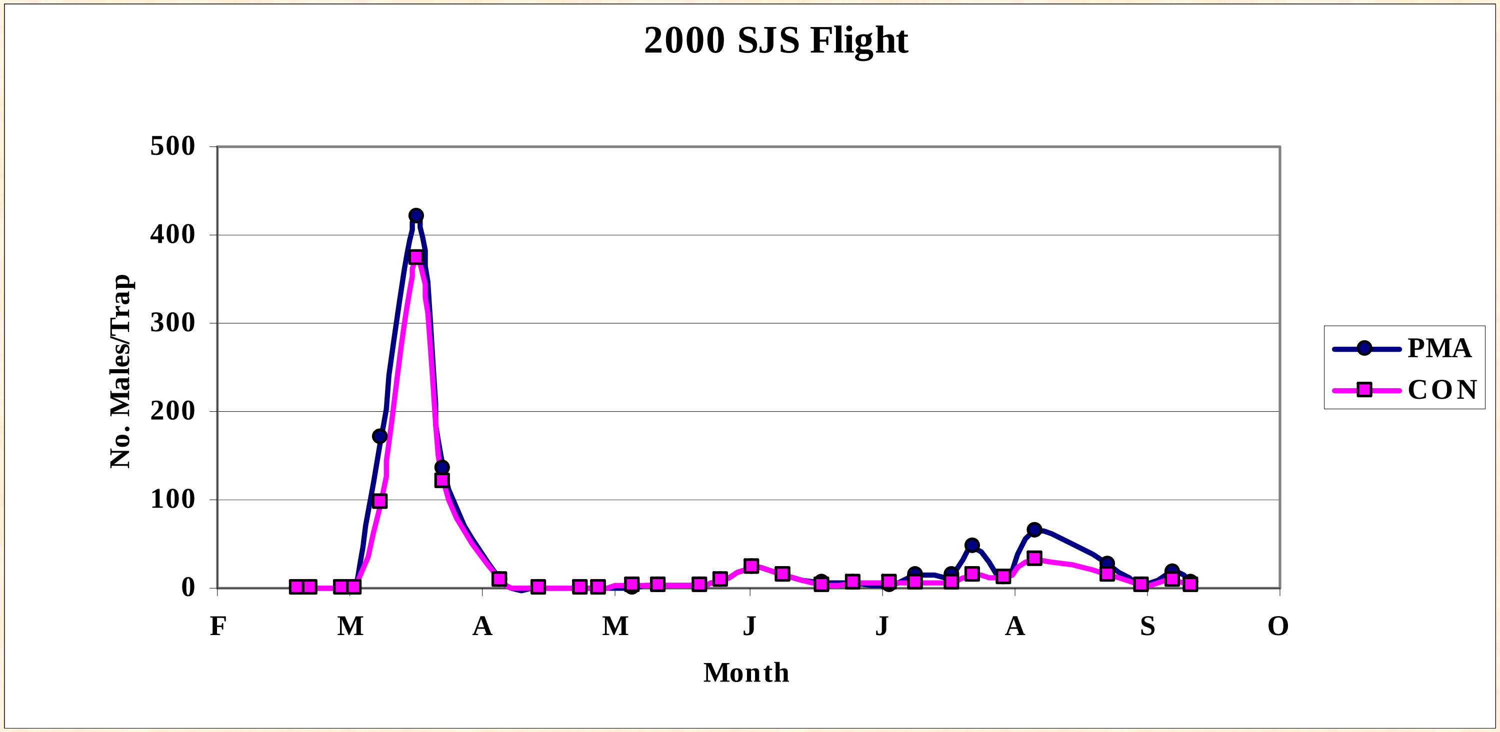
PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 12 varieties monitored in 2002.

For the second year in a row, populations of OLR were very similar between the PMA and CON blocks. Efficacy of reduced-risk materials compares favorably with conventional materials.

Seasonal Flight Dynamics

Table of Contents

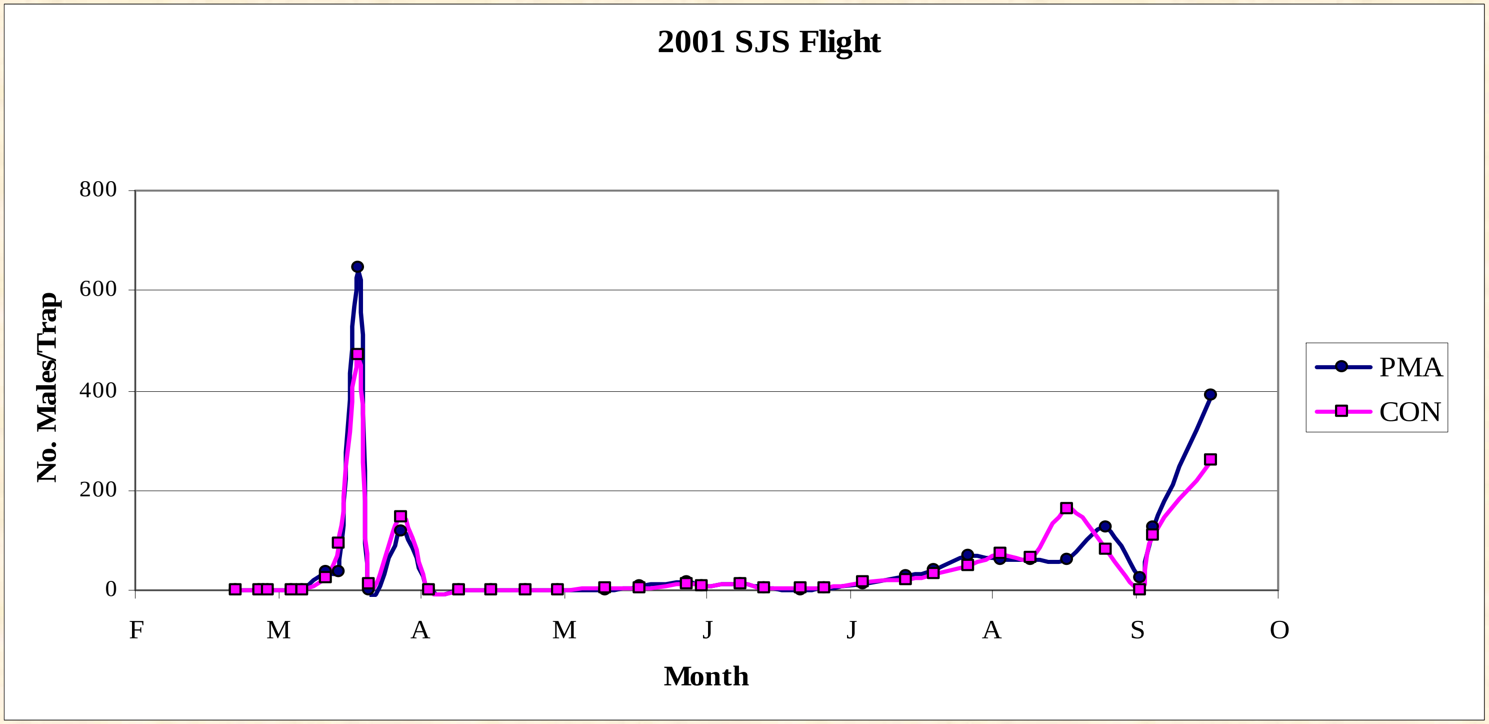
SJS: 2000 Seasonal Flight Dynamics



PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 5 varieties monitored in 2000.

In 2000, we found tremendously high SJS populations in several blocks, but average yield losses due to scale were small (less than 0.4%) in PMA and CON blocks. This emphasizes the importance of biological knowledge of a pest, as well as shoot sampling in the spring to determine their distribution in the orchard..

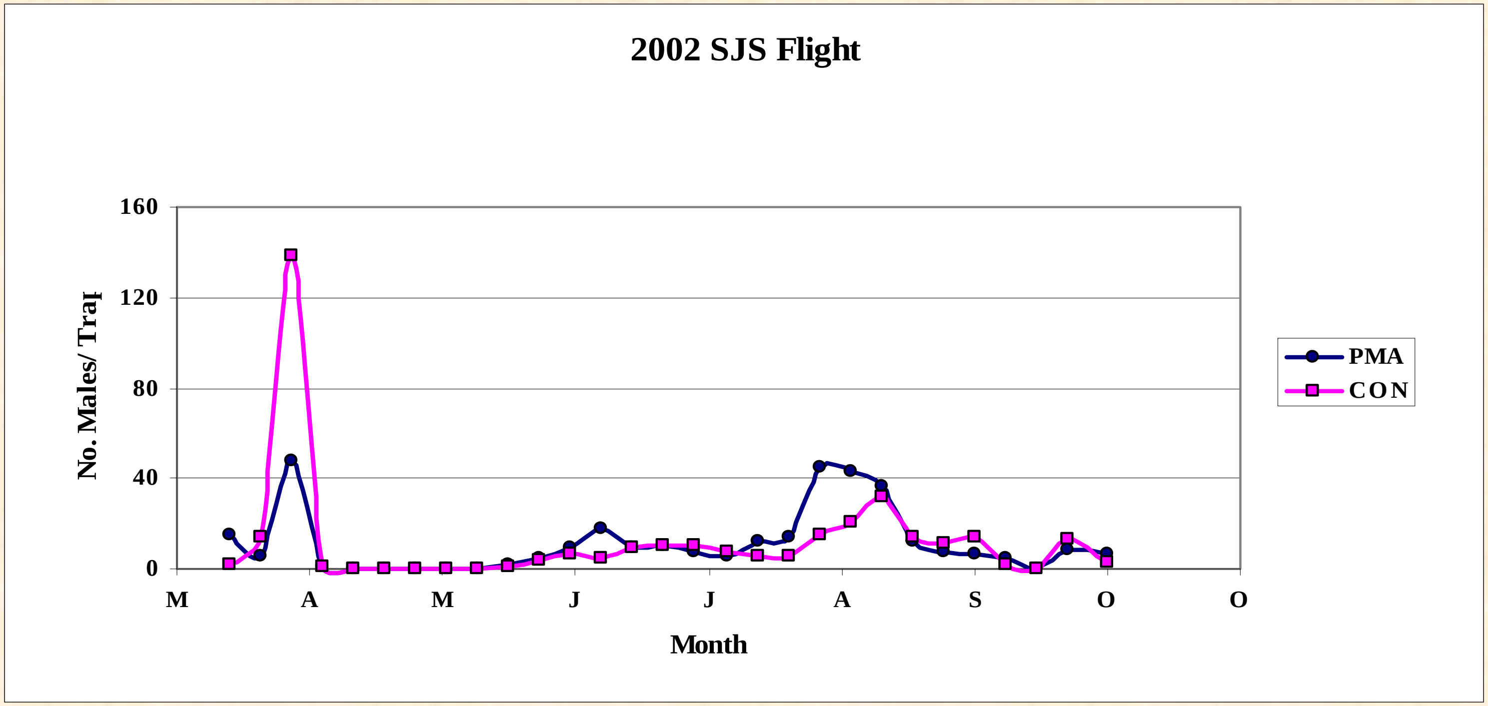
SJS: 2001 Seasonal Flight Dynamics



PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 11 varieties monitored in 2001.

San Jose scale populations can be immense in an orchard, yet the grower experiences little or no damage due to SJS. Trap catches provide a glimpse of the approximate size of the population, but they do not explain how the scale are distributed within the tree canopy. It is, therefore, difficult to assess the damage potential based on the trap counts. In 2001, the spring emergence of SJS was much larger in PMA blocks, yet damage at harvest in PMA blocks was very low, and slightly less than that of the CON blocks.

SJS: 2002 Seasonal Flight Dynamics



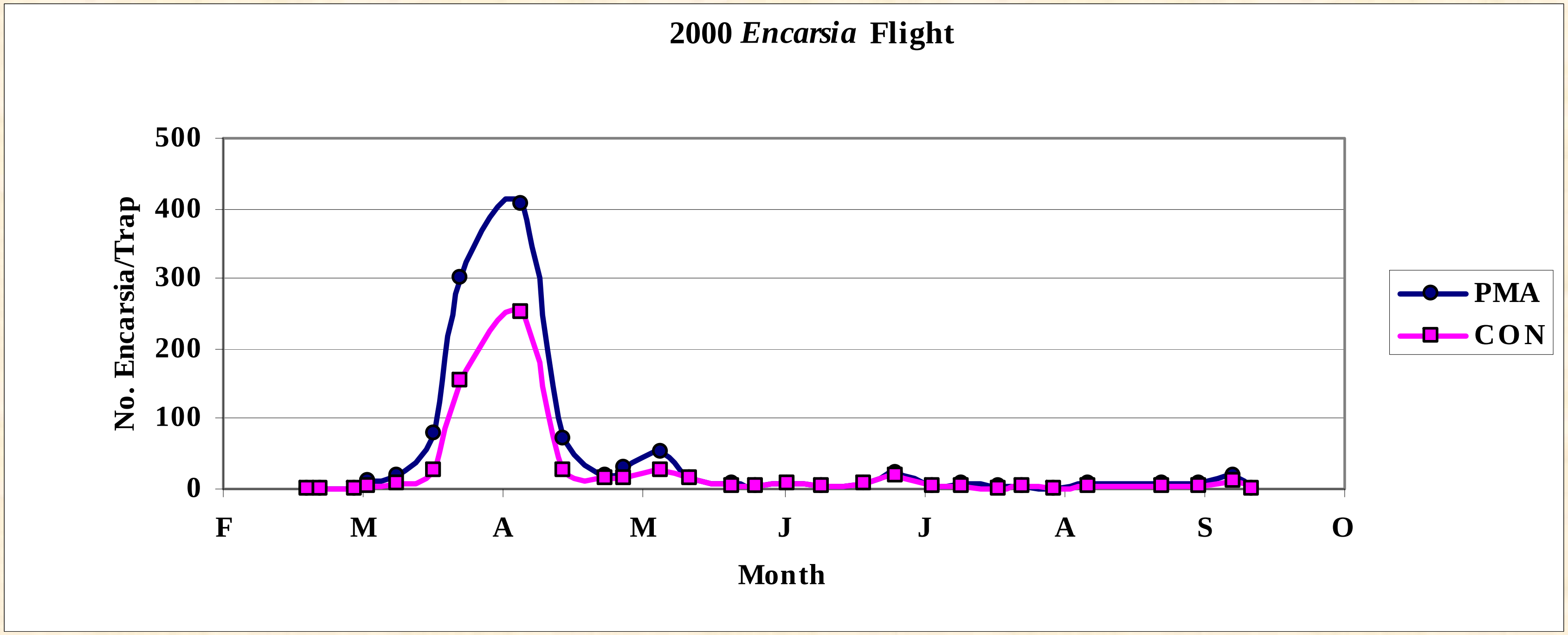
PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 12 varieties monitored in 2002.

In 2002, SJS numbers had dropped substantially in all blocks. Numbers were especially low in the PMA blocks, which may be attributable to a build-up of parasitoids, effective dormant oil treatments, or both. Despite the low trap counts, there was slightly higher fruit damage due to SJS in the PMA blocks.

Seasonal Flight Dynamics

Table of Contents

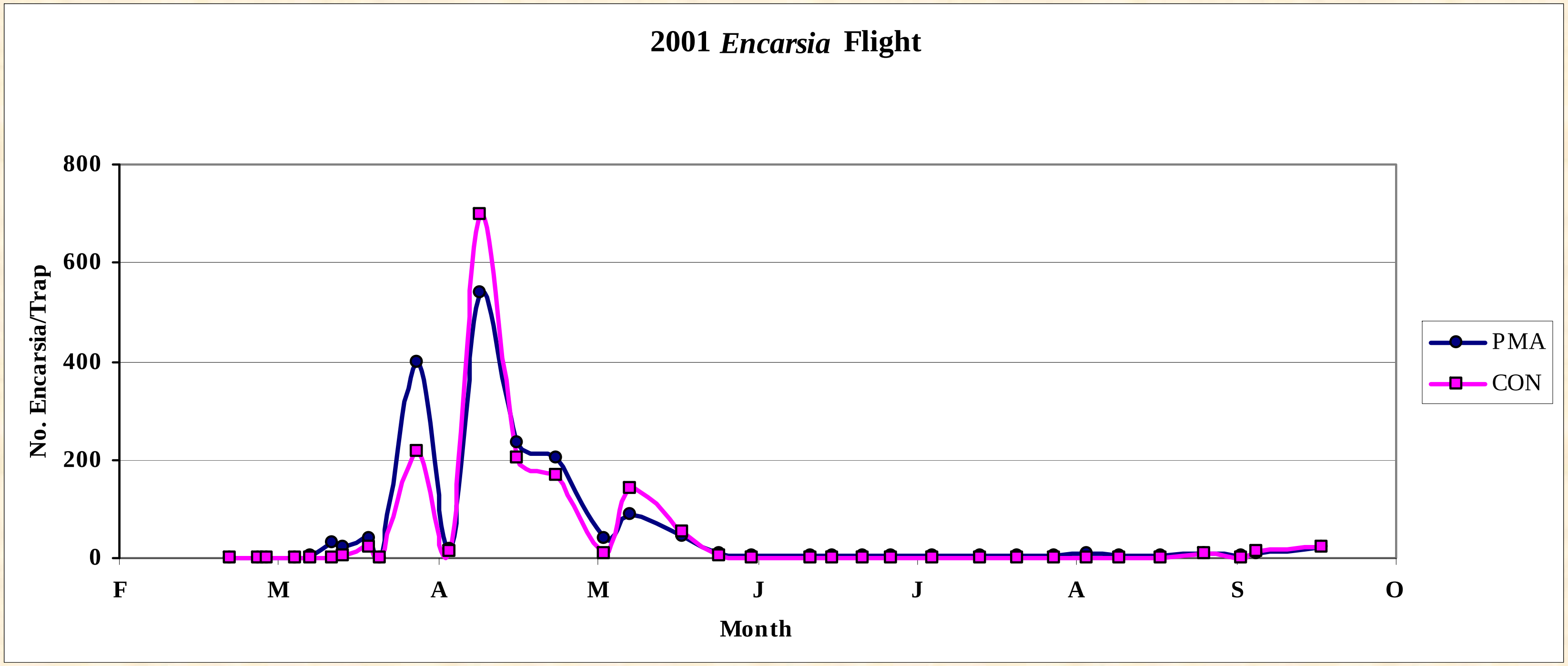
Encarsia: 2000 Seasonal Flight Dynamics



PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 5 varieties monitored in 2000.

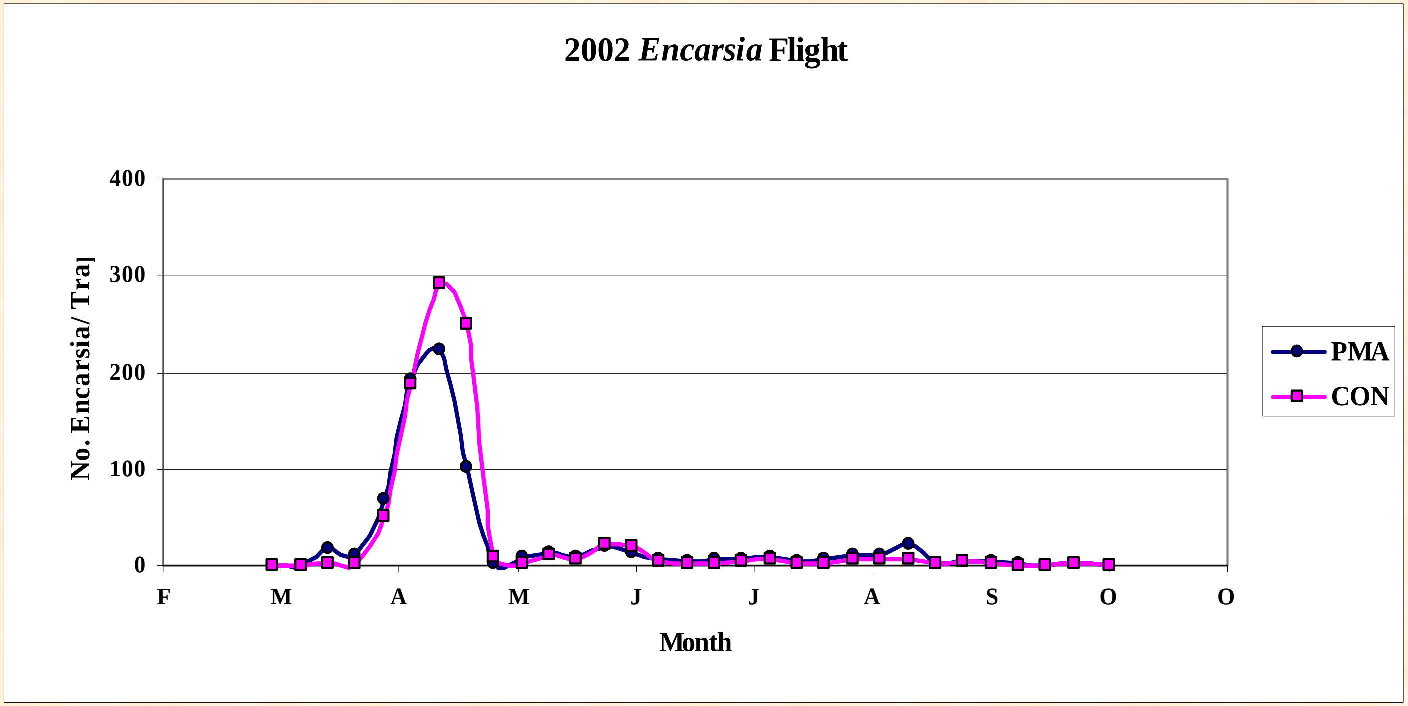
Encarsia perniciosi is an internal parasitoid of SJS. It is very host-specific and prolific, which means it is good at finding and reproducing quickly in SJS. *Encarsia* is easily spotted on the pheromone traps that are used to monitor SJS. Chapter Seven discusses in greater detail the role and value of the parasitoids of SJS.

Encarsia: 2001 Seasonal Flight Dynamics



PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 11 varieties monitored in 2001.

Encarsia: 2002 Seasonal Flight Dynamics

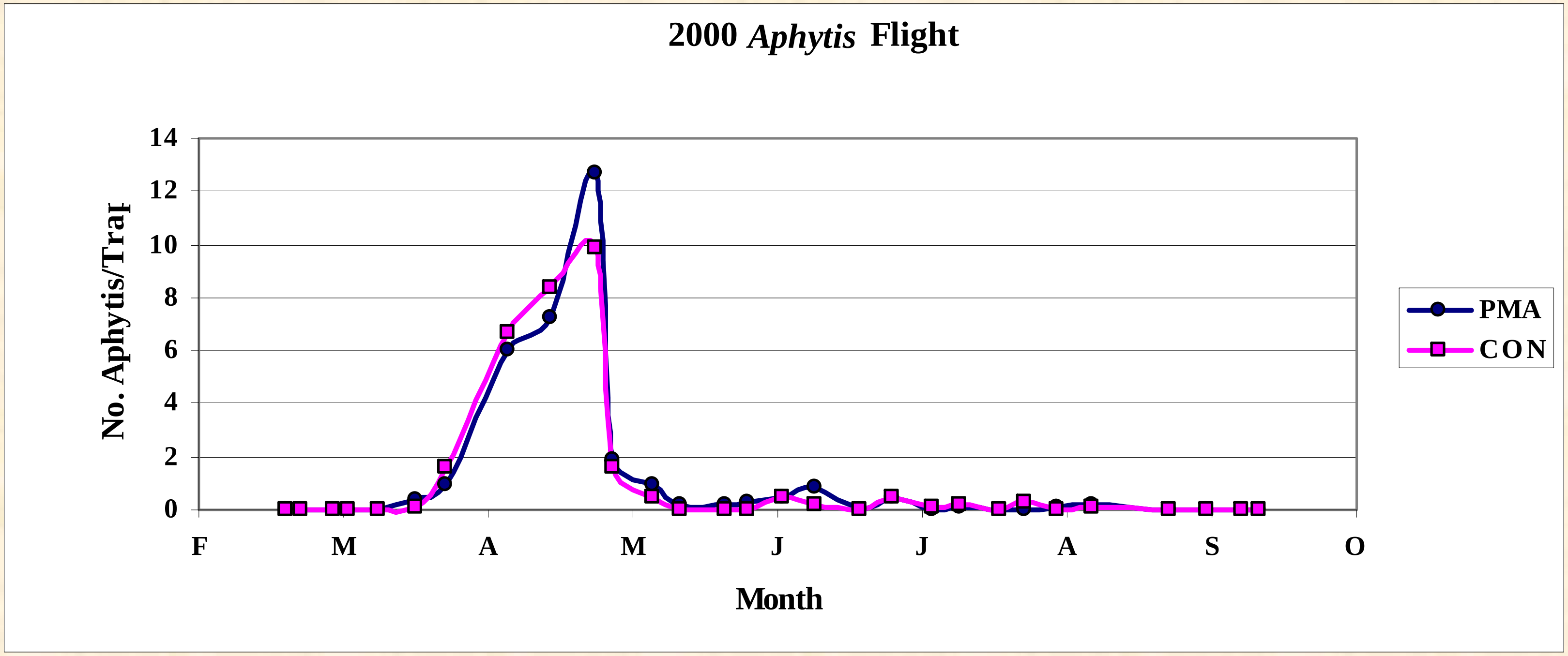


PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 12 varieties monitored in 2002.

Seasonal Flight Dynamics

Table of Contents

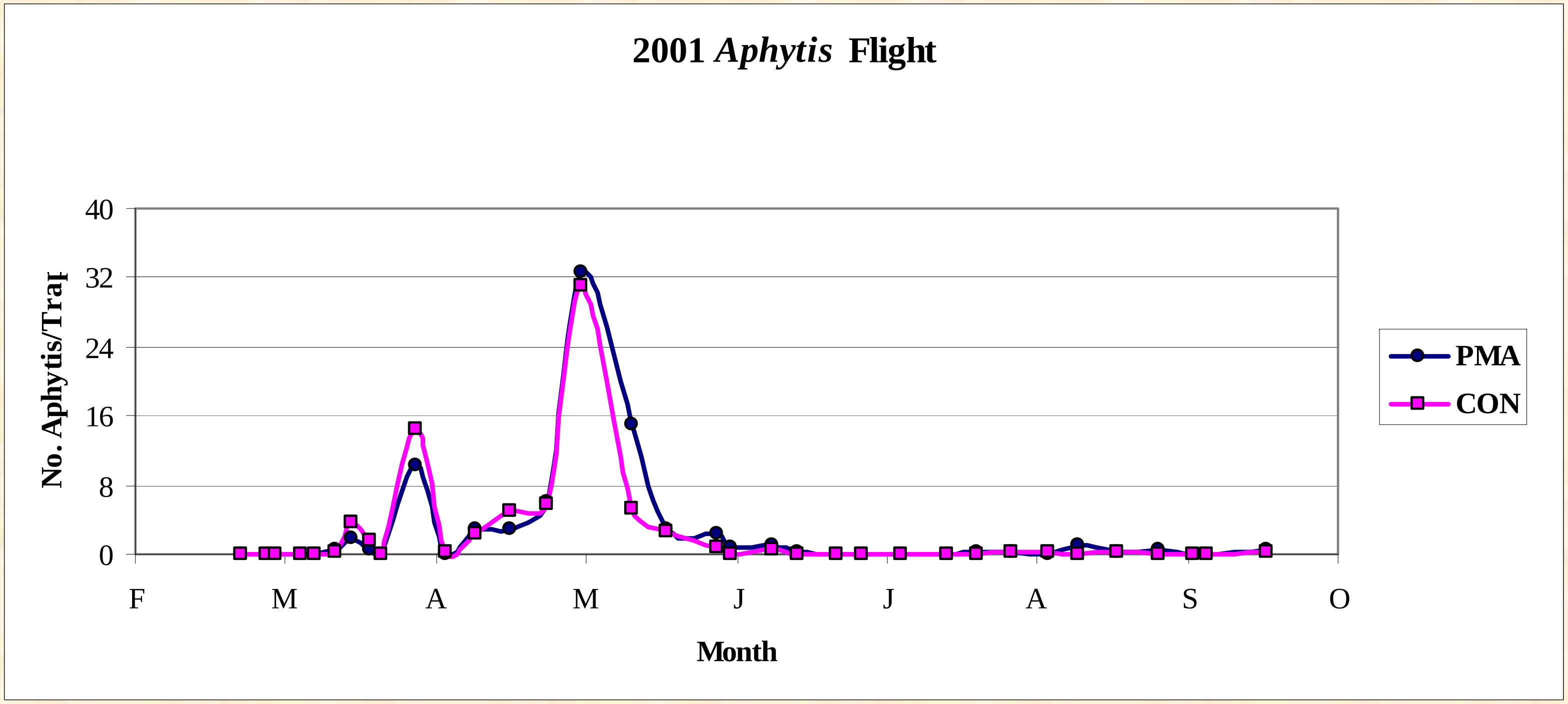
Aphytis: 2000 Seasonal Flight Dynamics



PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 5 varieties monitored in 2000.

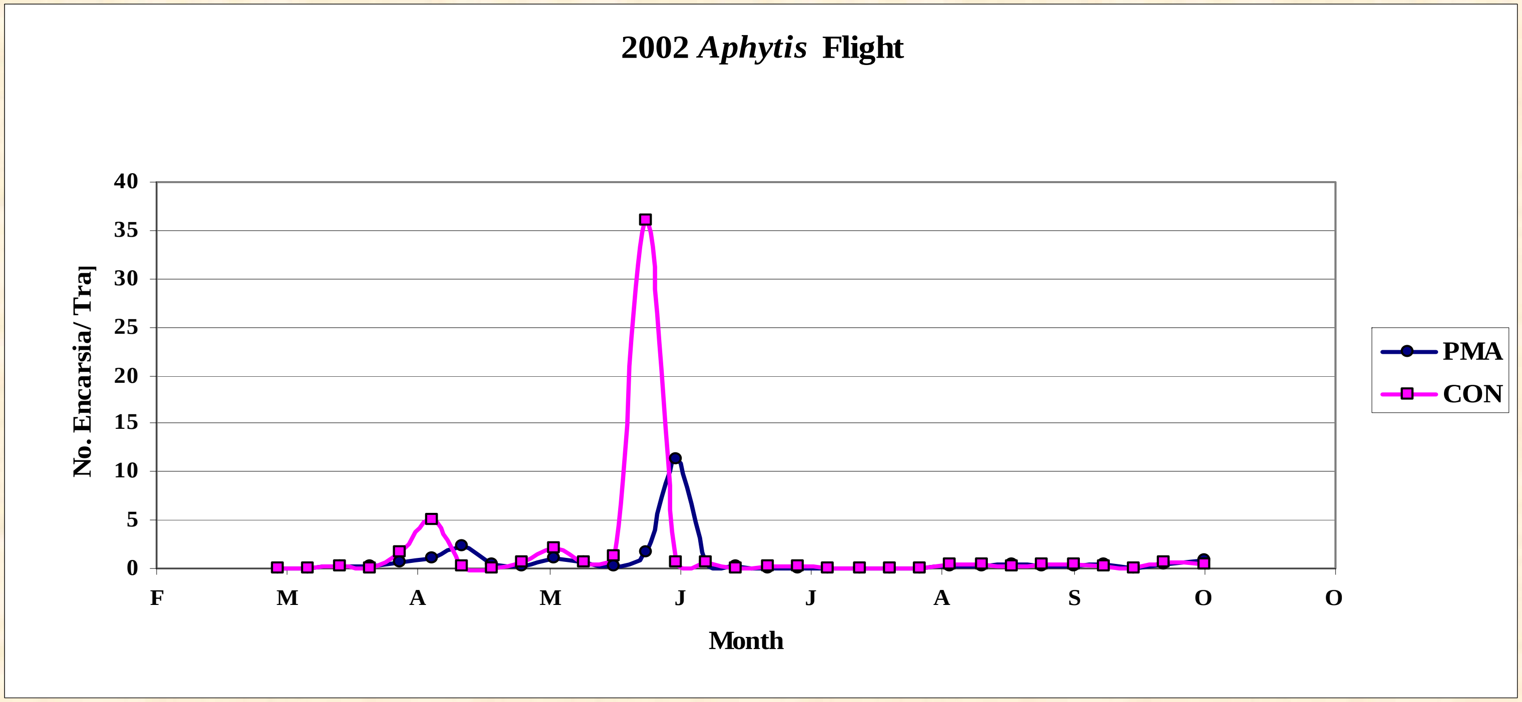
Aphytis is a group of external parasitoids of SJS, which means they kill SJS by feeding on them from outside the scale body. It is not as host-specific as *Encarsia*, but this parasitoid preys upon many SJS before it lays an egg on any scale. *Aphytis* is easily spotted on the pheromone traps that are used to monitor SJS. Chapter Seven discusses in greater detail the role and value of the parasitoids of SJS.

Aphytis: 2001 Seasonal Flight Dynamics



PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 11 varieties monitored in 2001.

Aphytis: 2002 Seasonal Flight Dynamics



PMA and CON are the respective designations for reduced-risk and conventional blocks. In the graph above, each line consists of the mean trap catches for the 12 varieties monitored in 2002.

Chapter Five
Harvest Quality and Insecticide Costs

Table of Contents

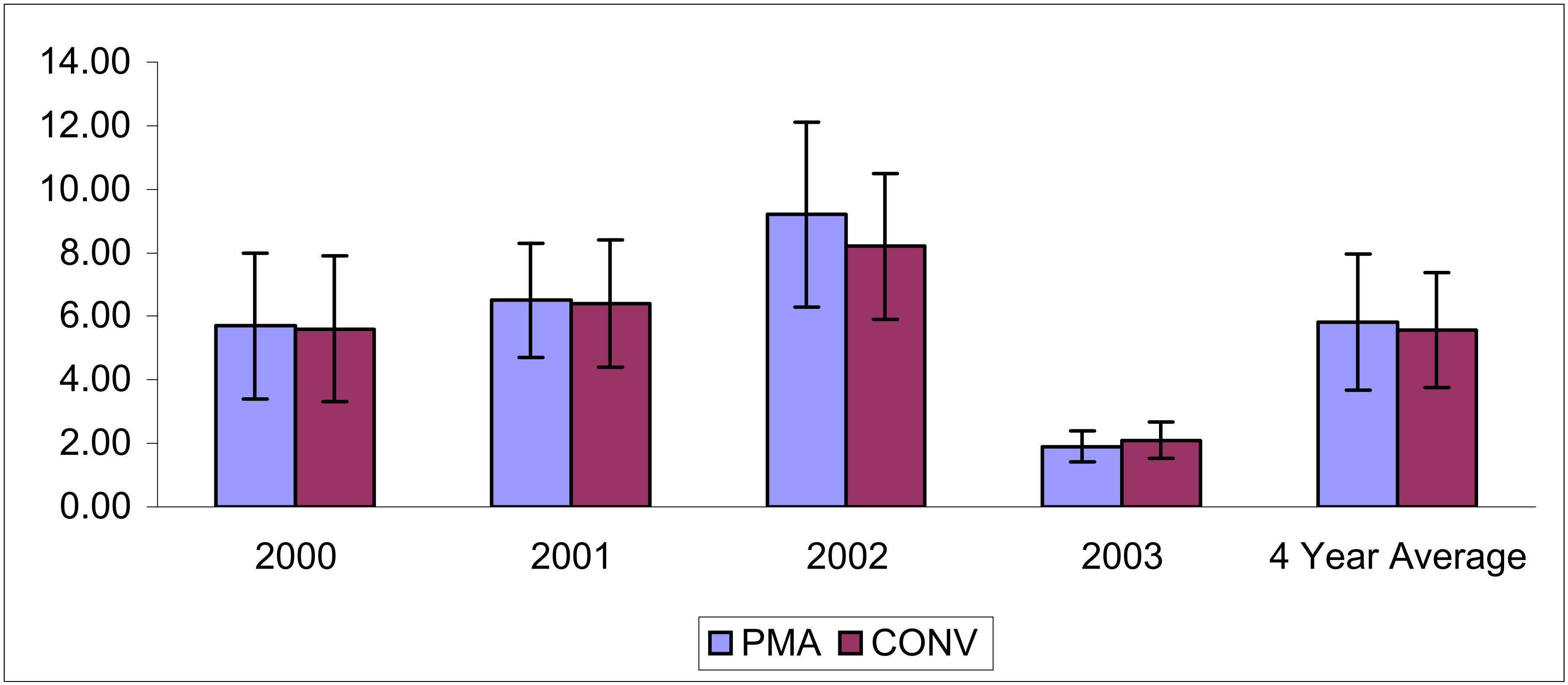
Insect Damage

Each year, insect damage was measured at harvest by examining fruit in the harvest bins. At least 500 fruit per block were examined, and when unmarketable fruit was found, the damage was identified and counted.

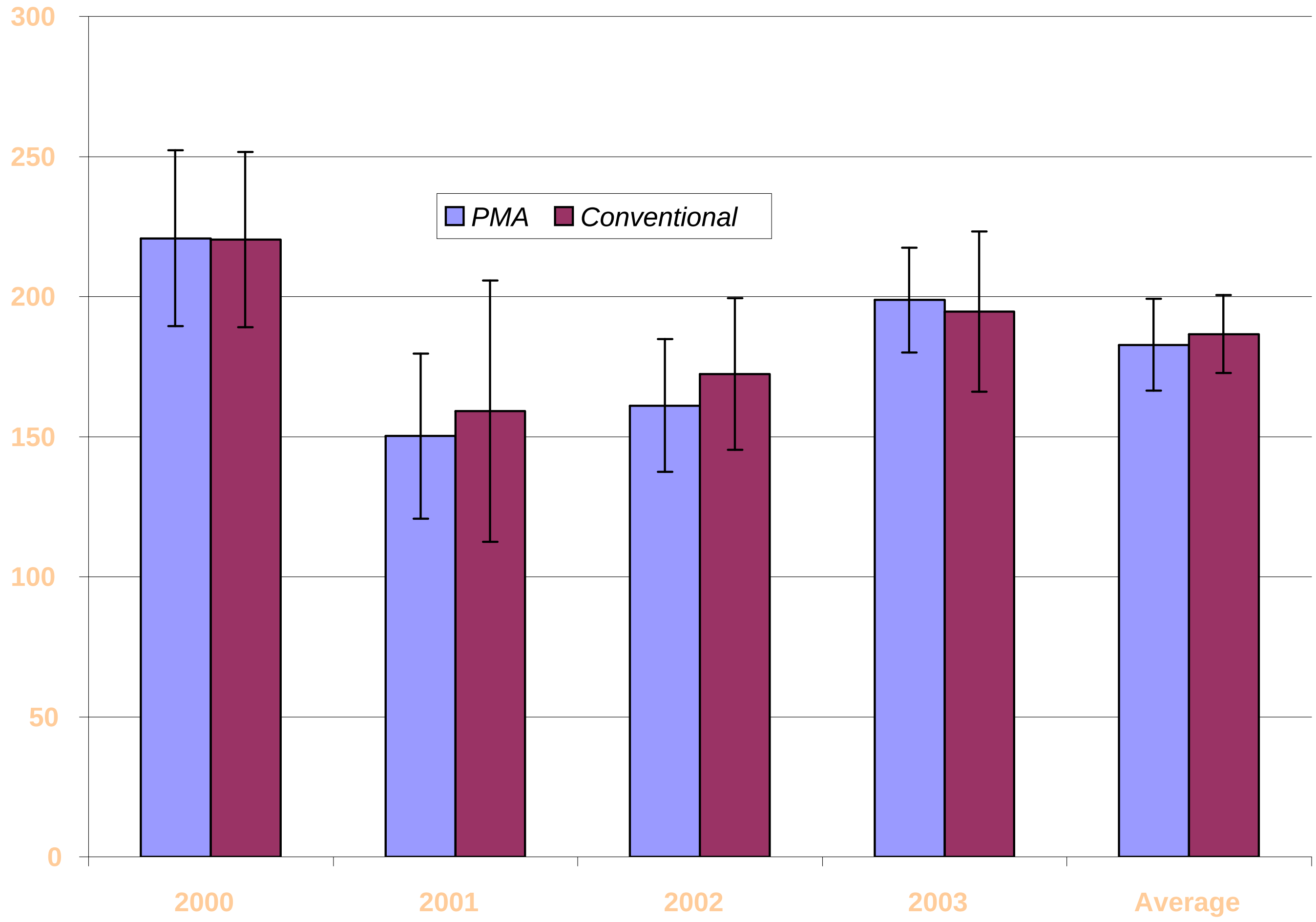
Harvest quality and associated insecticide use was tabulated each year and is presented here to show that reduced-risk programs can sustain quality yields beyond the first year or two.

Table of Contents

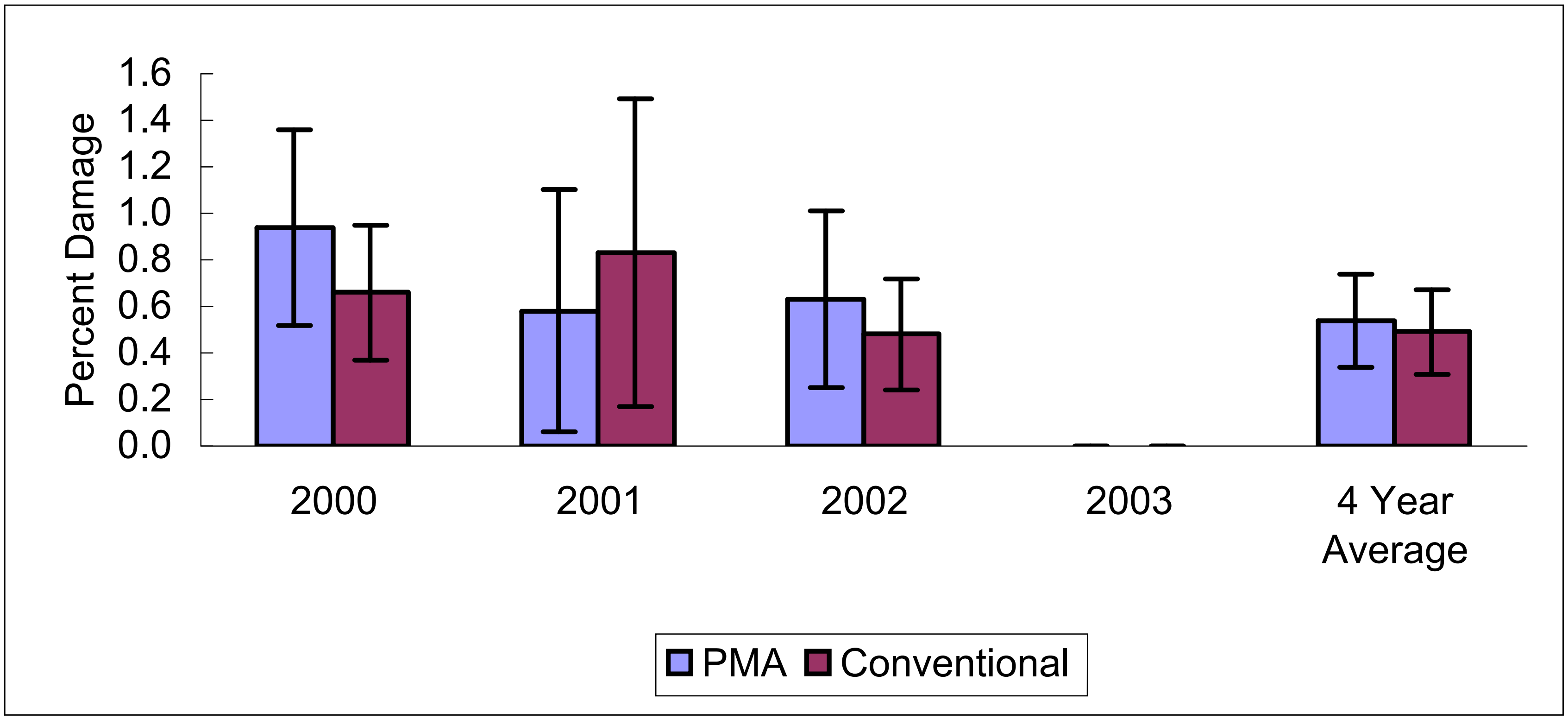
Percent insect damaged fruit in San Joaquin Valley



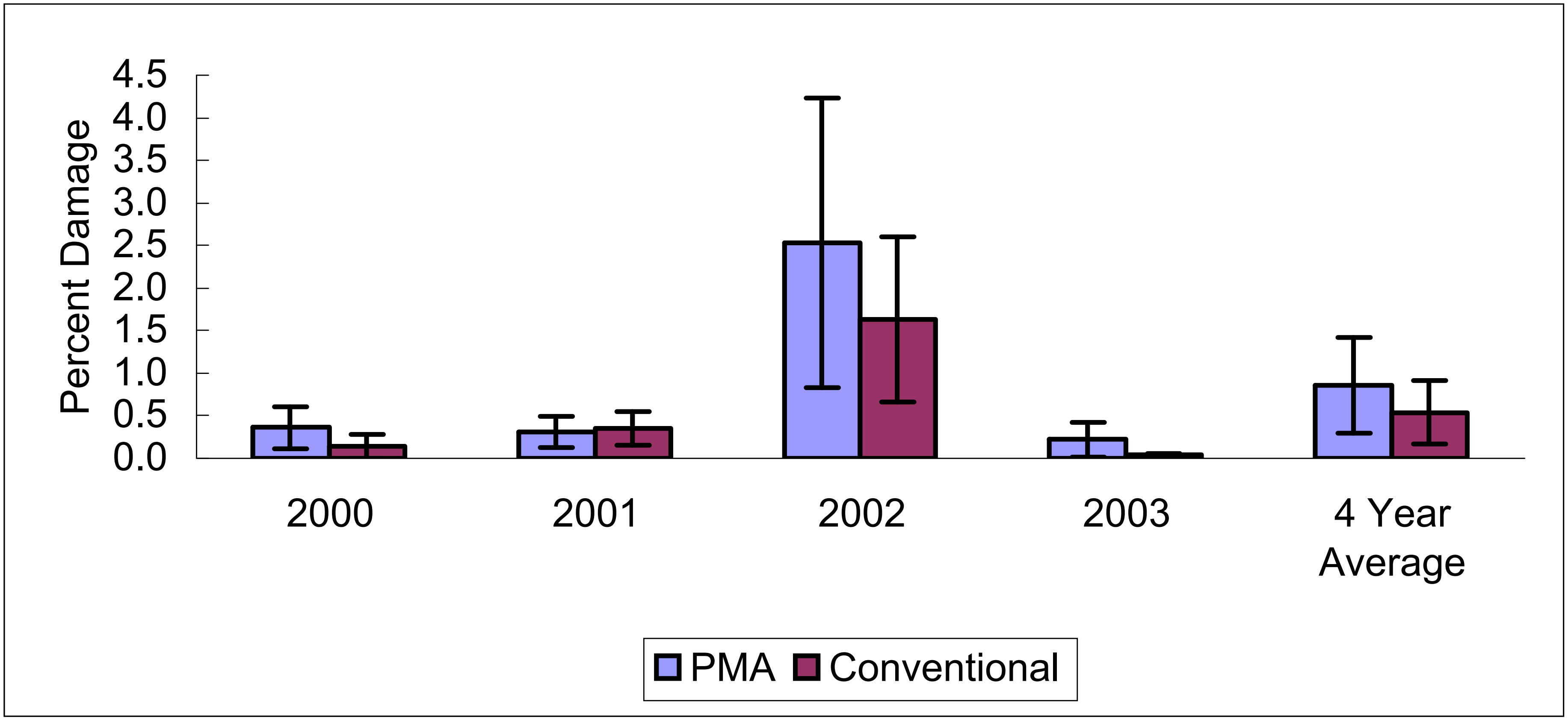
Cost of Pest Managment Materials San Joaquin Valley



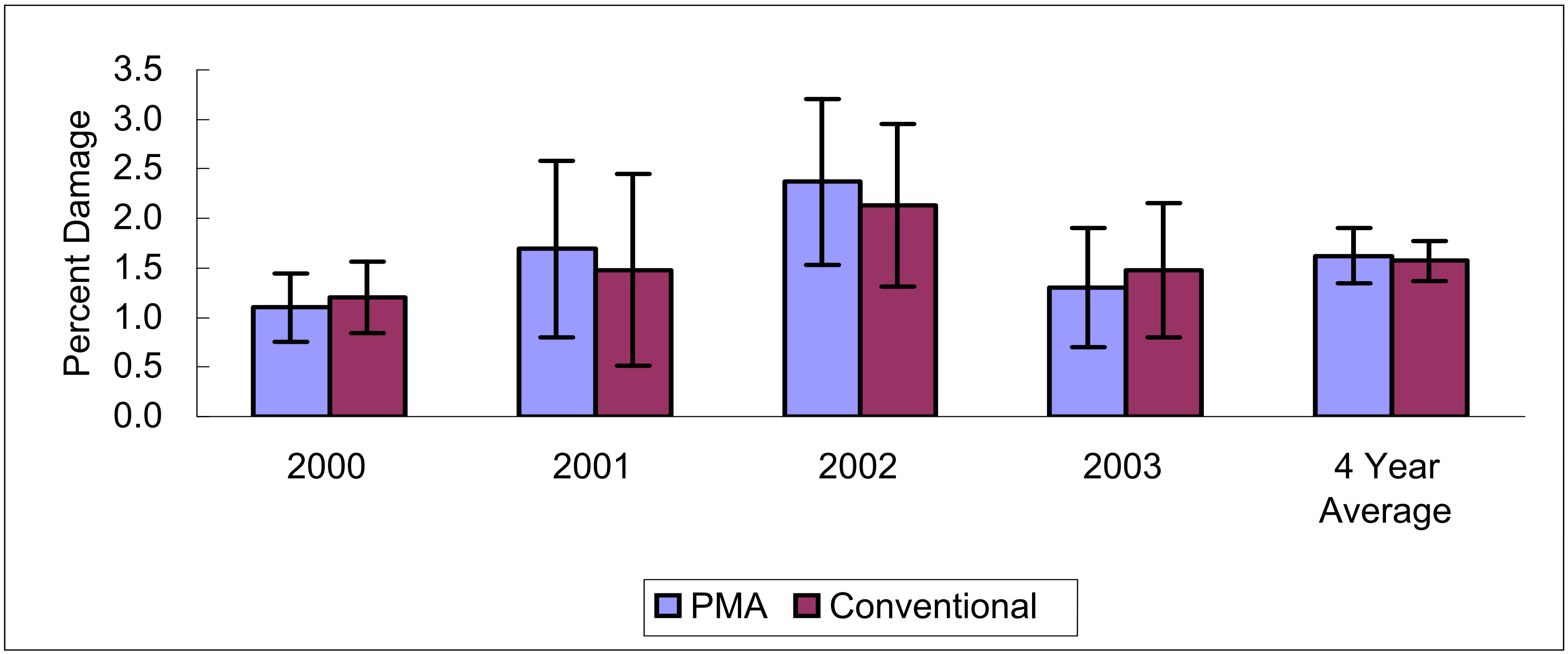
Percent Oriental fruit moth infested fruit
San Joaquin Valley



Percent San Jose Scale damaged fruit
San Joaquin Valley

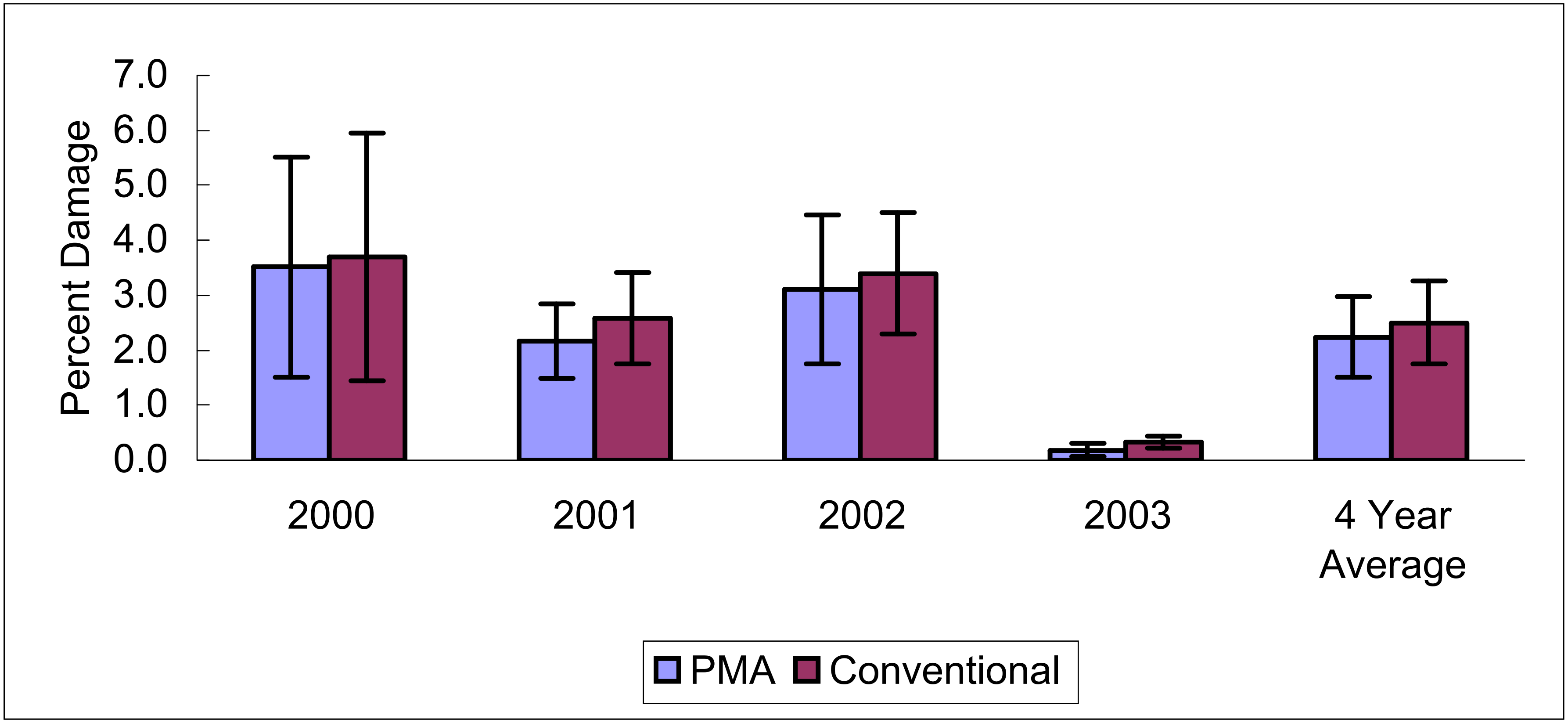


Percent Katydid damaged fruit
San Joaquin Valley

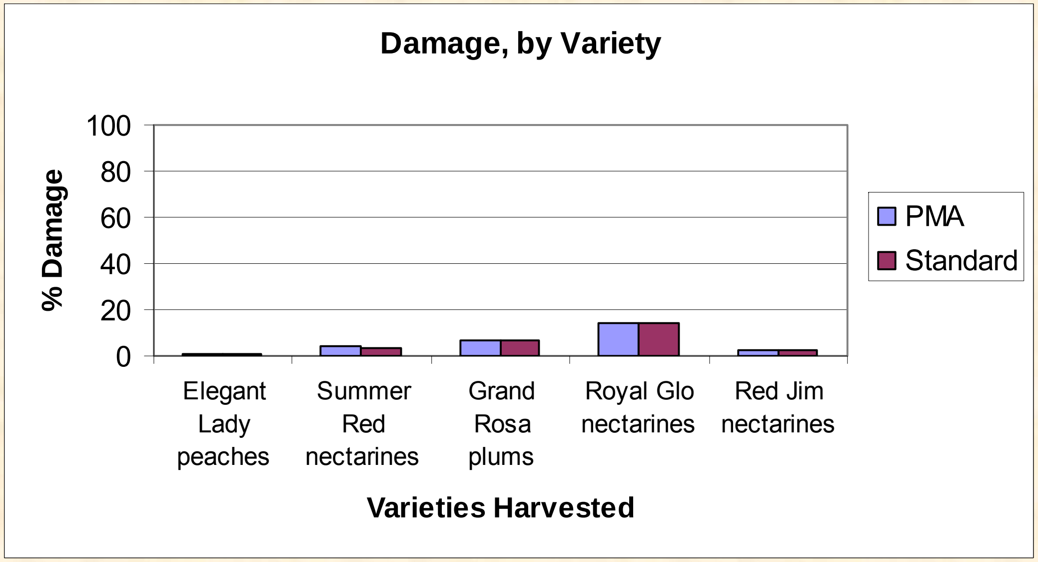


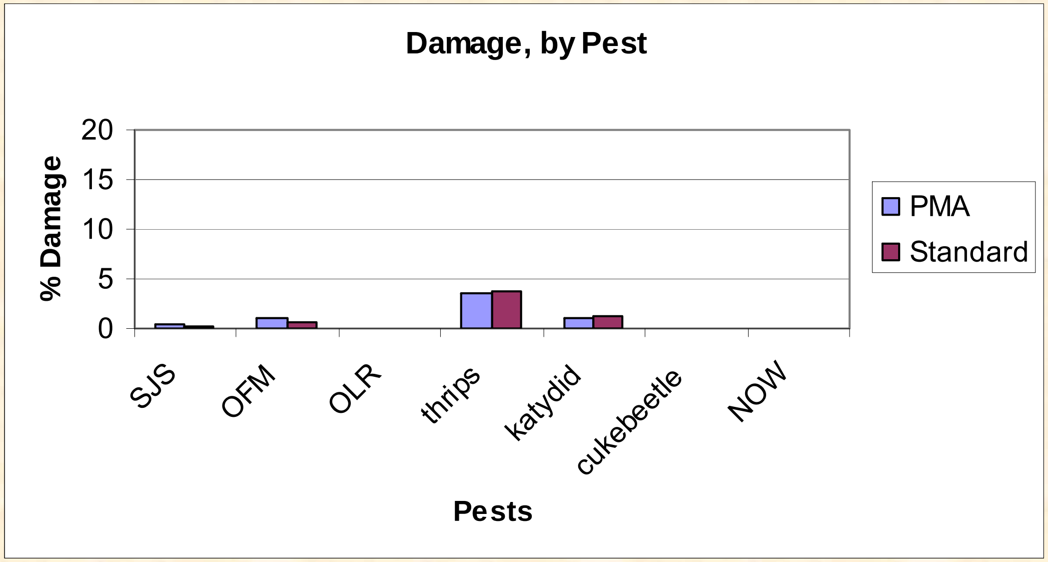
Percent Western flower thrips damaged fruit

San Joaquin Valley



Harvest 2000



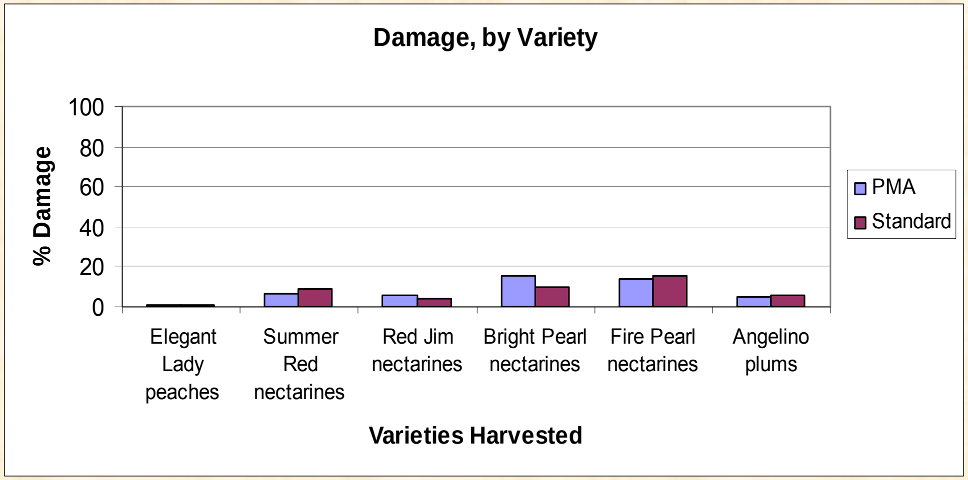


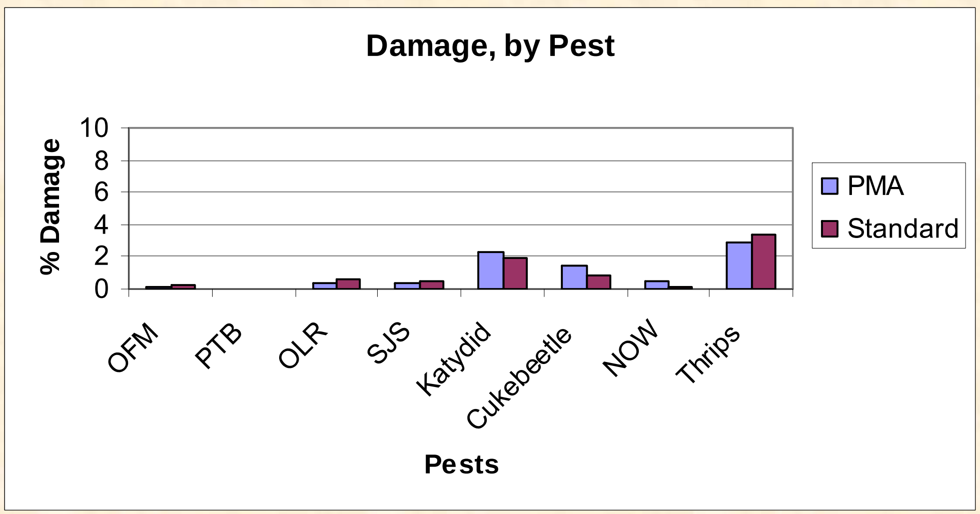
The harvests in 2000 were marred somewhat by thrips and katydids.

The 'Royal Glo' nectarines are a very early variety, and they were damaged significantly by thrips a week before harvest.

Table of Contents

Harvest 2001



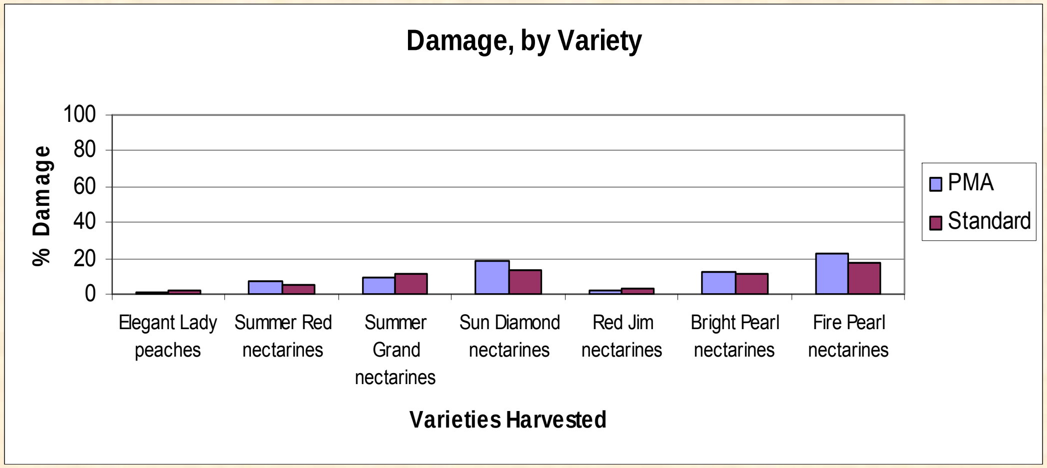


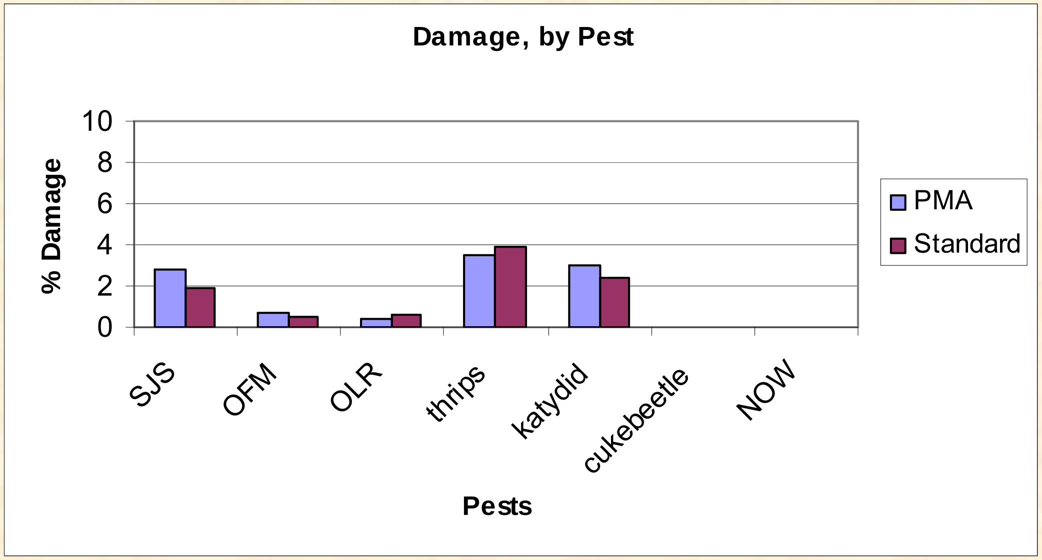
Harvests in 2001 were marked again by katydid and thrips damage, but an old pest also emerged. Western spotted cucumber beetles caused substantial damage.

Late-season nectarines suffered the most from the katydid, thrips, and cukebeetle damage.

Table of Contents

Harvest 2002





Harvests in 2002 were noteworthy for the SJS emergence in several blocks. And for the third year in a row, thrips and katydids caused damage in PMA and Conventional blocks.

Late-season nectarines suffered the most from the katydid, thrips, and San Jose scale damage.

Table of Contents

A Few Take-Home Messages

- Mating disruption worked well, but may need to be done in conjunction with in-season sprays.
- Continue checking shoot strikes and fruit while checking traps in mating disrupted blocks. You can't assume that trap shut-down gives complete mating shutdown.
- SJS distribution important: check shoots in winter after dormant apps to see whether scale are out toward buds
- Success® works well for thrips and katydids, but not as well for OFM.
- Katydids found in the field are predominantly fork-tailed bush katydid. They lay eggs within leaves, which means the first generation nymphs hatch in the trees, while overwintered eggs hatch on the ground and crawl up into the tree. Monitor and treat if necessary with Success by mid- to late-April.
- Two major obstacles to adoption of IPM and reduced-risk materials--fear of harvest losses and/or extra costs associated with monitoring.

Chapter Six

Extension with a Capital "E"

Table of Contents

The Approach

An important element of the PMA extension approach was creating a forum for grower-to-grower discussion. Our growers and their PCAs spoke at almost every event we held.

In fact, many of the meetings were hosted by our growers.

Table of Contents

Extension

In the four years of the Stone Fruit PMA Project, over 30 extension meetings/field days/seminars were held. It is estimated that audiences totaled 2000 attendees.

Demonstration Key to Implementation

In addition to having our PMA growers lead by example in their production methods, we also demonstrated our scouting methods.

Often, we discussed how to sample for mites, how to check shoot strikes, how to hang traps, and how to distinguish katydid feeding from worm feeding.

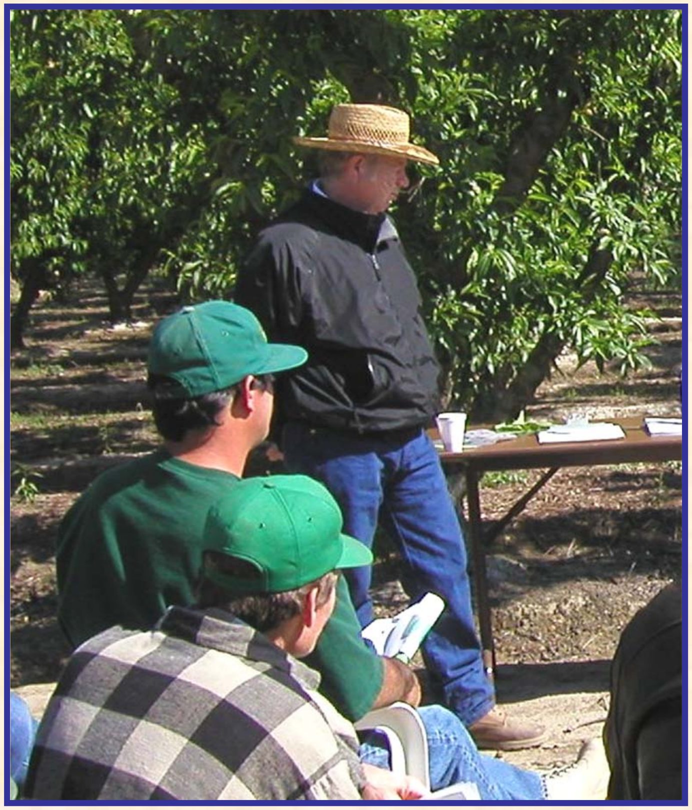
Table of Contents

Diverse Resources for the Grower Community

Topics were often presented by UC, EPA, and DPR personnel, but discussions were guided by audience questions about timely issues.

Table of Contents

Commodity Group Support



- Publications
- Mass-mailings
- Media events
- PBS Documentary
- Many free lunches and breakfasts for the stone fruit growing community.

Table of Contents

New Technologies Presented

Pheromone Mating Disruption materials and equipment.

New insecticide efficacy information (spinosad, azadirachtin, horticultural oil).

New sampling techniques for stone fruit pests.

Biological information on new pest problems such as katydids and cucumber beetles.

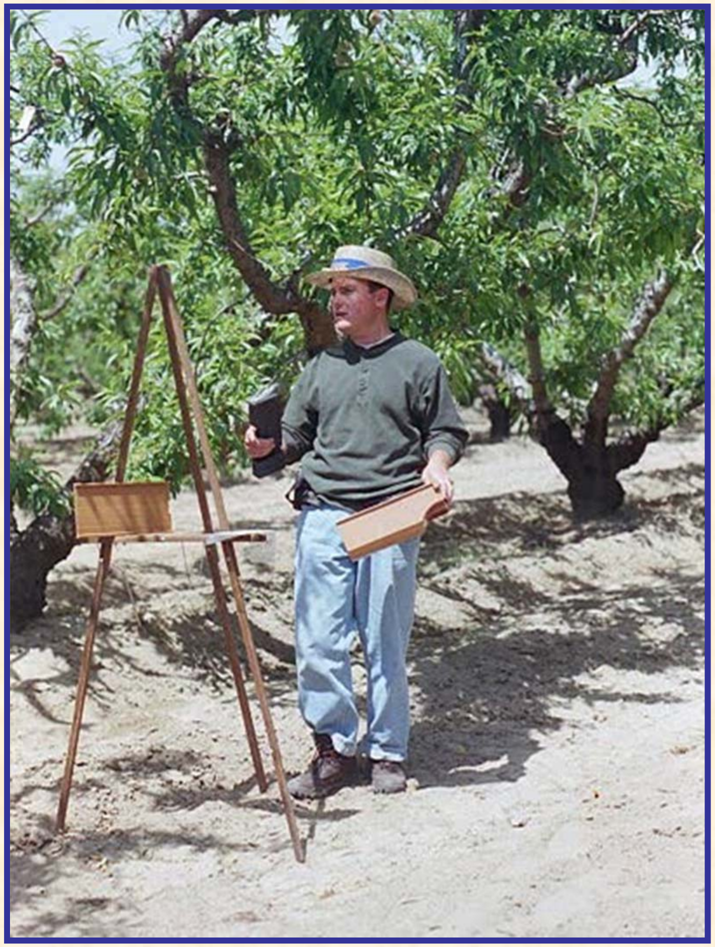


Table of Contents

Coverage in Local and National Press

Click HERE for article in *The Grower*

Table of Contents

Chapter Seven
Parallel Projects

Parallel Projects

As the PMA Demonstration Project got underway in 2000, pertinent questions soon began to arise, such as how well a certain material worked or the significance of a given insect.

To answer the more pressing questions, projects were set up in-parallel with the work being done on the PMA project.

The parallel projects focused on the biology of katydids, the efficacy of Success for katydid control, and the role of parasitoids in controlling SJS.

Table of Contents

Observations of Katydid Biology in the San Joaquin Valley

Fork-tailed bush katydids have a spring generation (April egg-hatch), followed by egg-laying in June-July. A portion of these eggs hatch in mid-summer (July-August), while the rest hatch the following spring.

The factors mediating this difference are not yet known.

Angularwinged katydids tend to emerge about a month later (May egg-hatch) than forktails. They also require longer to develop to maturity. Angularwinged katydids have a single generation per year in the San Joaquin Valley.

Feeding by the smaller nymphs of both species tends to be on the upper sides of leaves, in the middle of the leaf as opposed to the edge. In spring, this type of feeding differentiates katydid leaf damage from that of cutworms and various other caterpillars. Larger katydid nymphs and adults will feed readily at the leaf edge.

Table of Contents

Katydid Oviposition

Fork-tailed bush katydids oviposit within the leaves of stone fruit trees by first chewing at the edge of a leaf, and then slowly working the ovipositor into the leaf at the point of the feeding injury. During this process, the abdomen of the female was observed to be strongly arched under her such that the ovipositor made contact with the labium ("chin") of the female. This contact seemed to help guide and/or leverage the ovipositor as the egg was inserted into the leaf.

Angularwinged katydids chew at the bark of branches or tree scaffolds, which seems to somehow prepare the substrate for their eggs. Their eggs are laid in two rows of overlapping eggs which form a long "tent." The eggs are large, gray and highly visible to the casual observer.

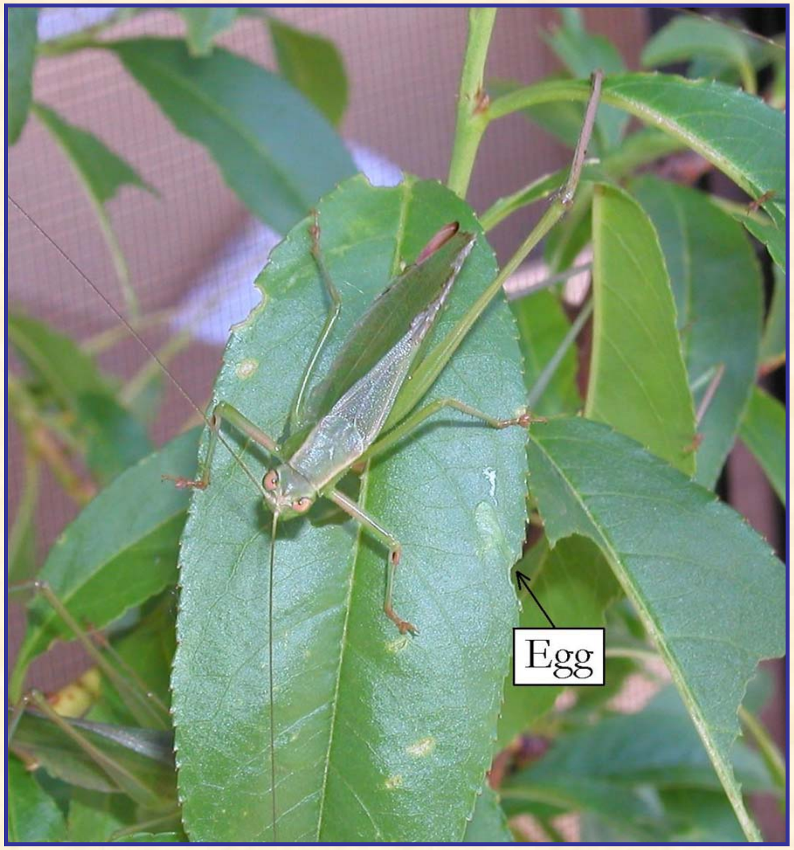


Table of Contents

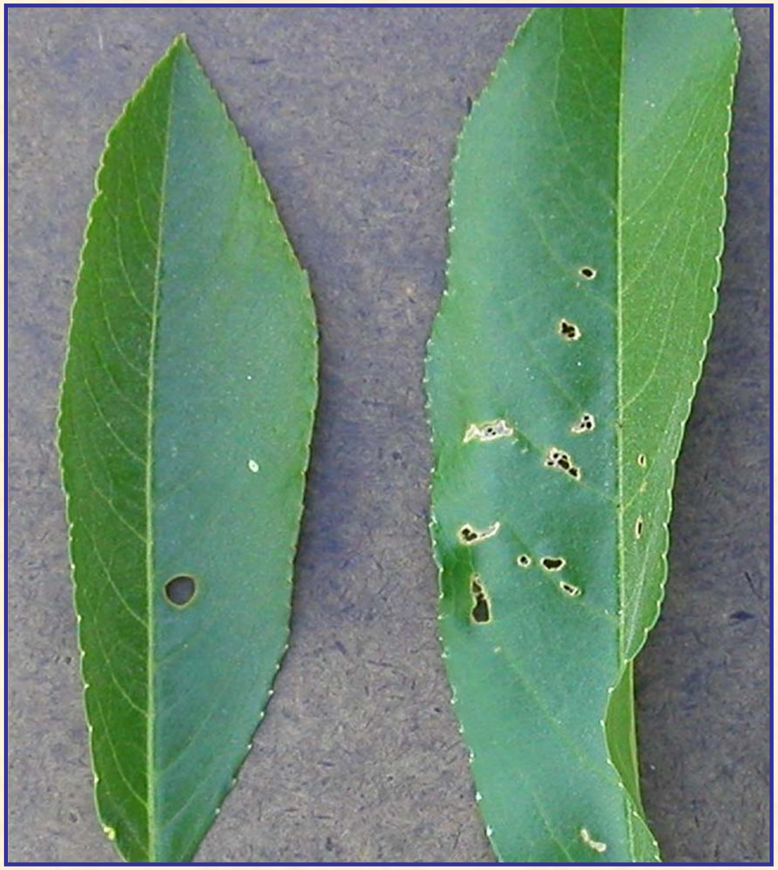
Signature Nymphal Feeding Damage

Table of Contents

What Isn't Katydid Damage

Fungus or fertilizer burn, but not katydid damage. Note brown "disk" hanging from edge.

Typical caterpillar feeding. Katydids eat smaller quantities before moving on.



Contrast: on the left, not katydid damage.
on the right, definite katydid feeding.

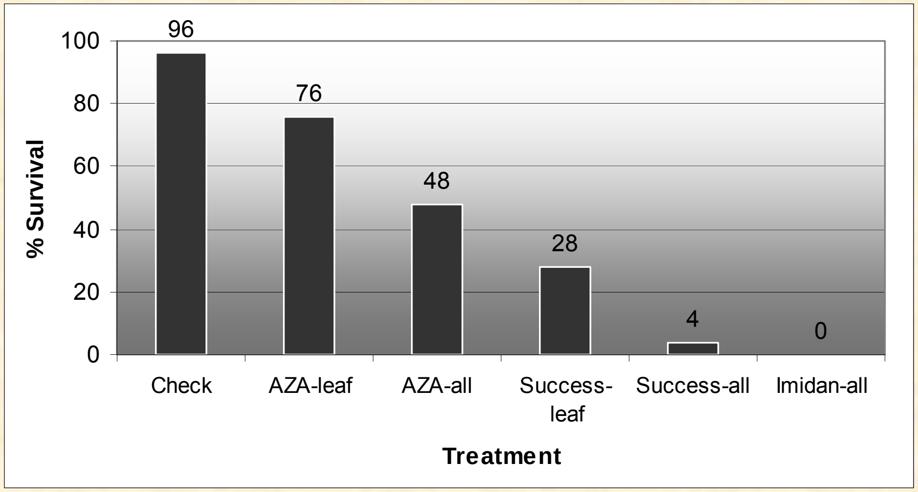
Table of Contents

Katydid Insecticide Trials

Phosmet, spinosad, azadirachtin, and a water-only check were assayed at UC KREC for their insecticidal activity on katydids caged on nectarine saplings. Treatment effects were measured in terms of surviving katydids at 1, 2, 4, and 7 days-after-treatment. Results from the trial indicate that nymphal (3rd-4th instar) fork-tailed bush katydids were readily killed by phosmet and spinosad within 48 h of treatment, while azadirachtin (AZA) caused significantly less mortality after 7 days.

On the commercial acreage, katydid mortality levels were measured pre- and post-treatment in ten nectarine and two peach blocks. Katydid counts were conducted between six and ten days post-treatment. Mortality levels were similar among the three insecticides, with substantial control achieved across all treated blocks. Untreated blocks had significantly higher katydid populations.

48 hrs post-treatment



One Week

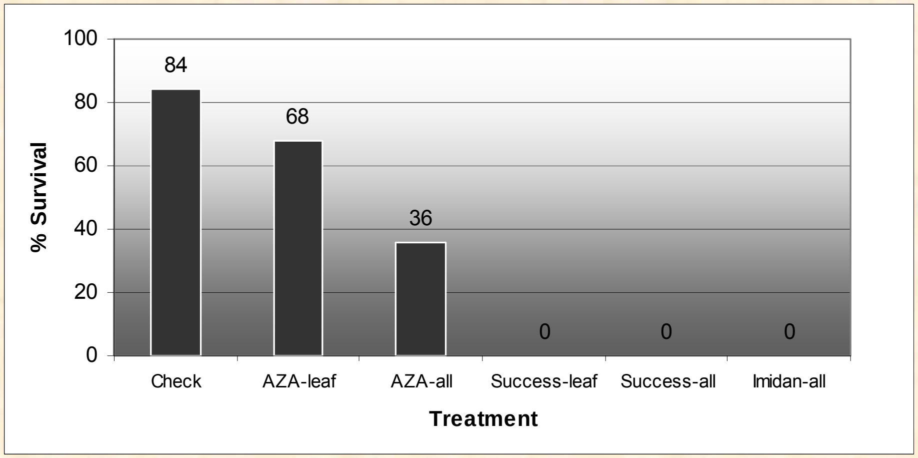
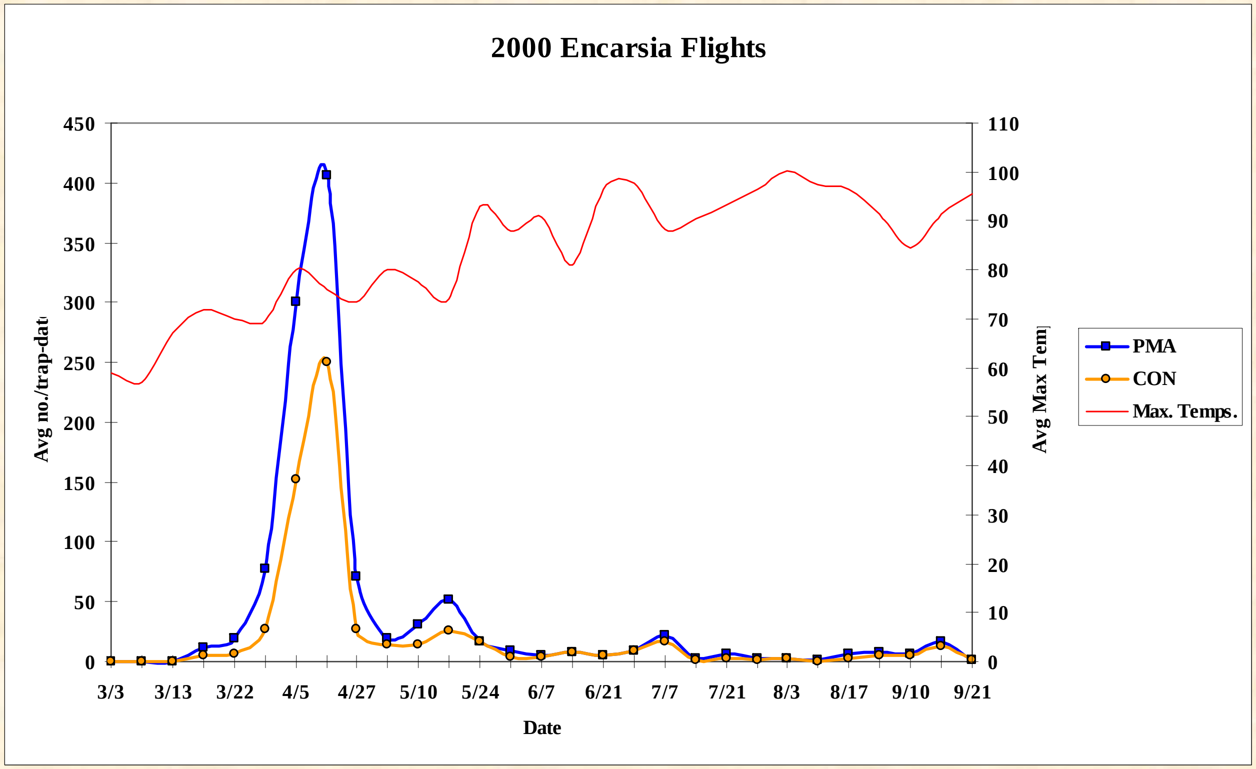


Table of Contents

San Jose Scale Parasitoids



In 2000, our trapping data in the PMA blocks showed a marked increase in parasitoid numbers, compared to the Conventional blocks.

Table of Contents

Parasitism Trials

To determine if the pesticide programs being used were affecting parasitoid activity, we set up sentinel SJS colonies on saplings and put the potted saplings in the fields we were monitoring.

Table of Contents

Encarsia and *Aphytis*

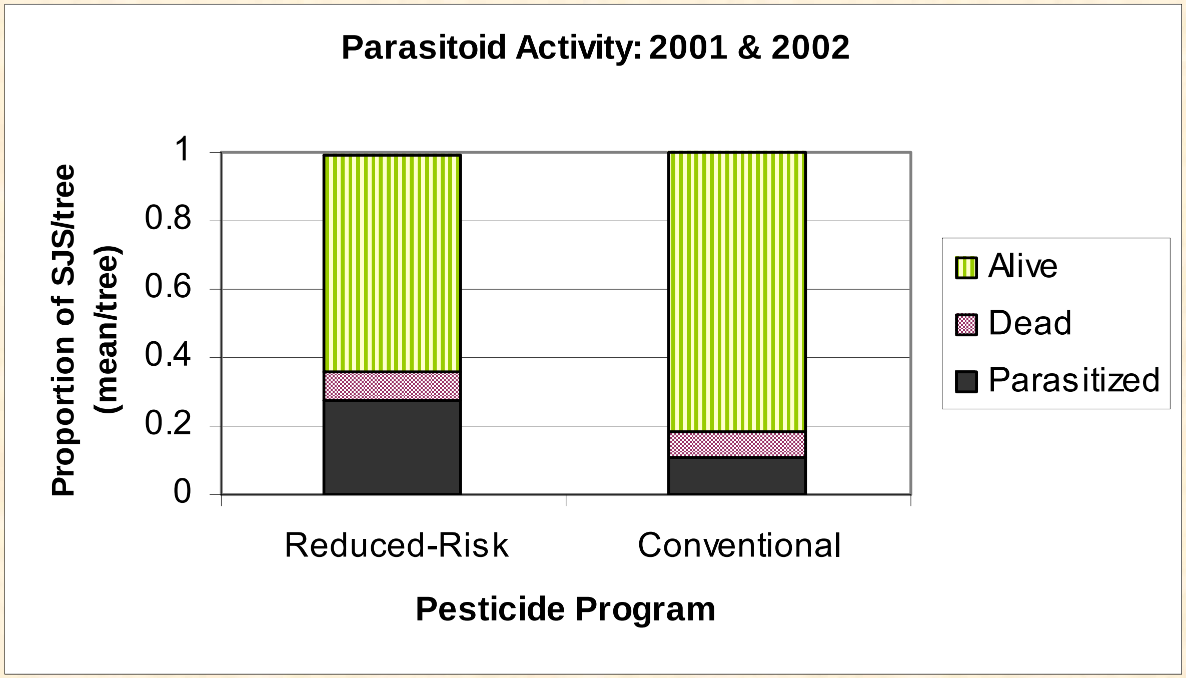
Encarsia pupa inside SJS body

Aphytis pupae and larvae on SJS bodies

Then the saplings were brought back and dissected for signs of parasitism.

Table of Contents

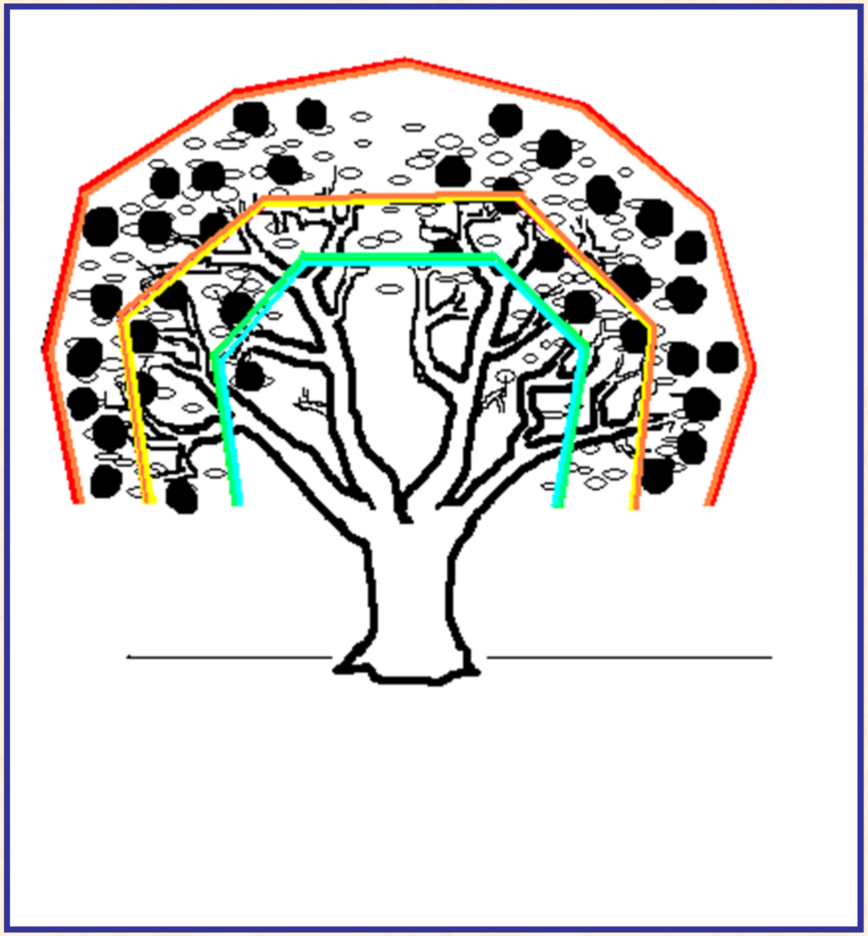
Results of Parasitism Studies



Results of this two-year study indicate that total parasitoid activity was significantly higher in the reduced-risk blocks, compared to the conventionally managed blocks. It is likely that the reason for this phenomenon is the detrimental effect of broad-spectrum, persistent OPs on the parasitoids as they search for SJS.

Table of Contents

Hypothesis On SJS Distribution



Dormant applications of insecticide usually kill the SJS on the outer parts of the canopy.

Most SJS survive on the inner, more protected parts of the scaffold, probably in cracks and breaks in the bark.

By late-April, the trees have set their fruit, and the first crawlers begin moving up and out, toward the developing fruit.

By mid-June, the second generation of crawlers begin moving up and out, getting closer to the bulk of the fruit.

Table of Contents

Implications for Growers

Harvest date relative to crawler emergences.

If fruit isn't harvested by mid- to late-June, then it will be exposed to a second generation of crawlers.

Late-season fruit are especially vulnerable to SJS damage.

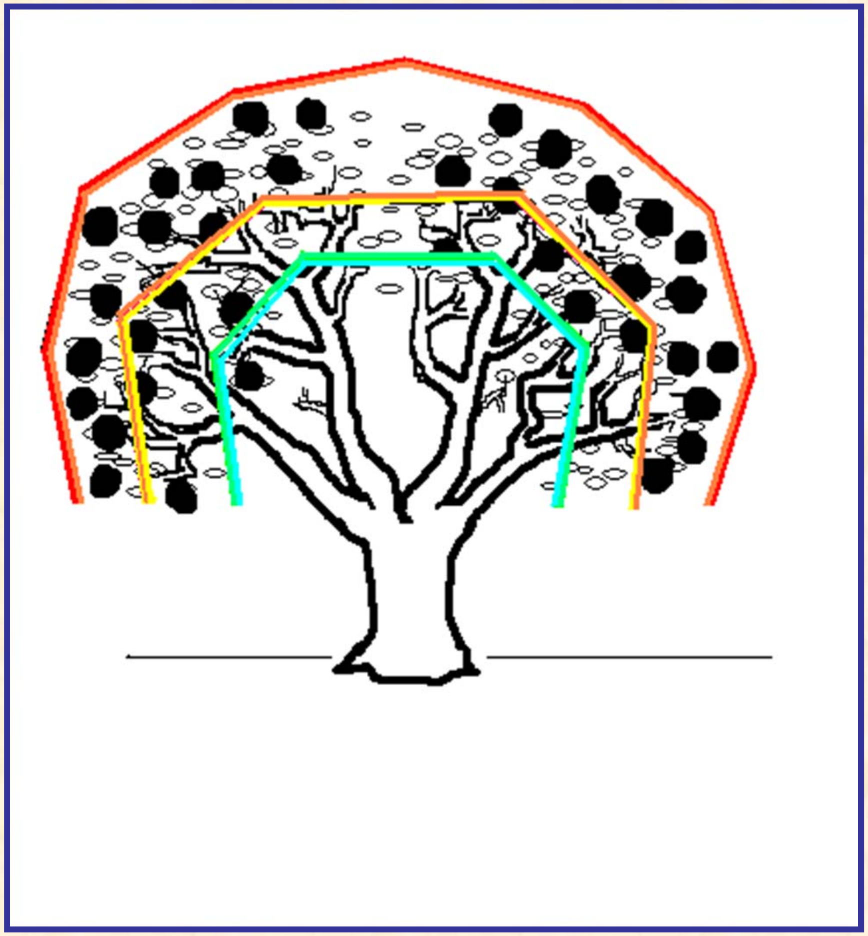


Table of Contents

Appendix

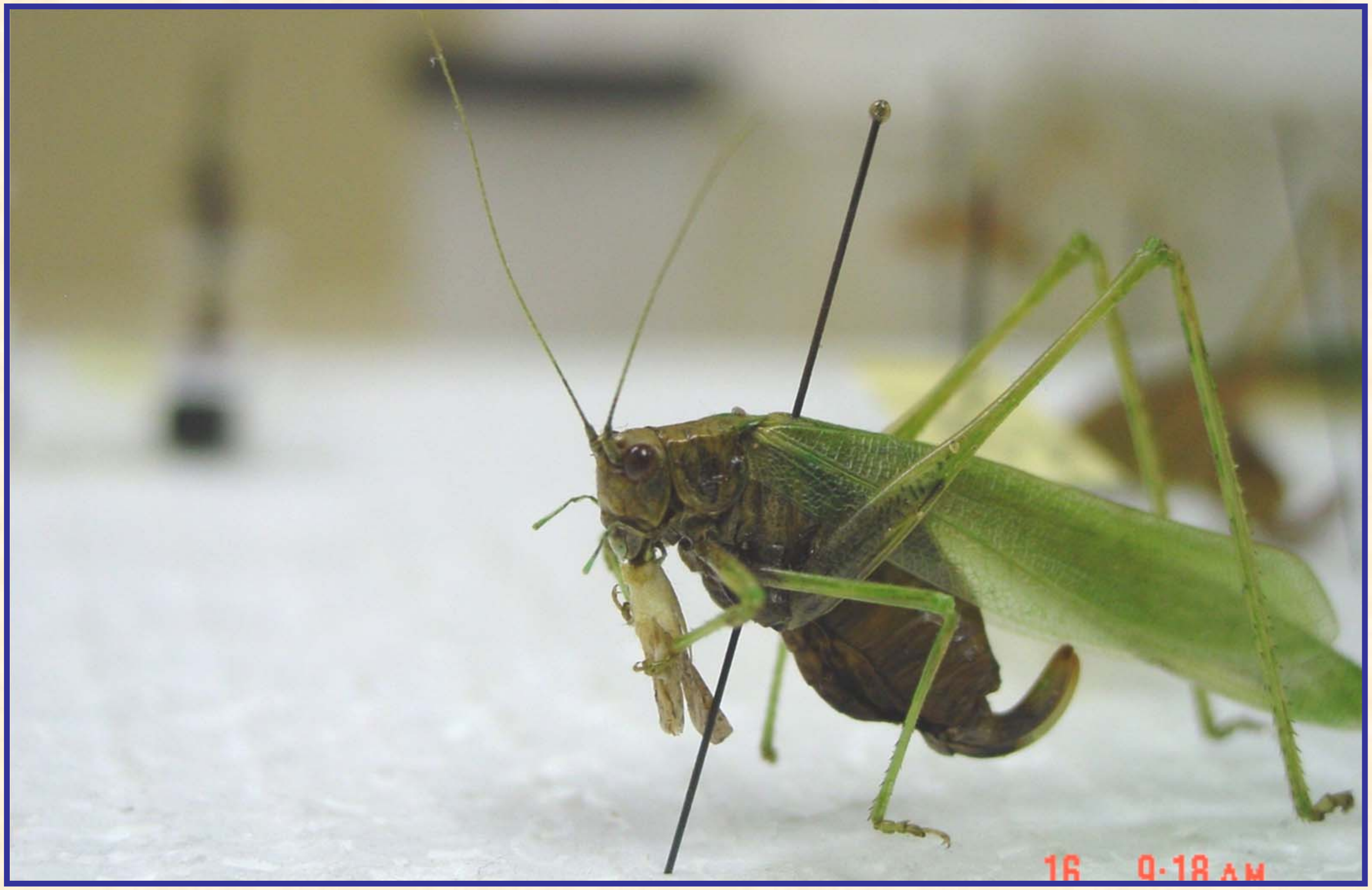


Table of Contents

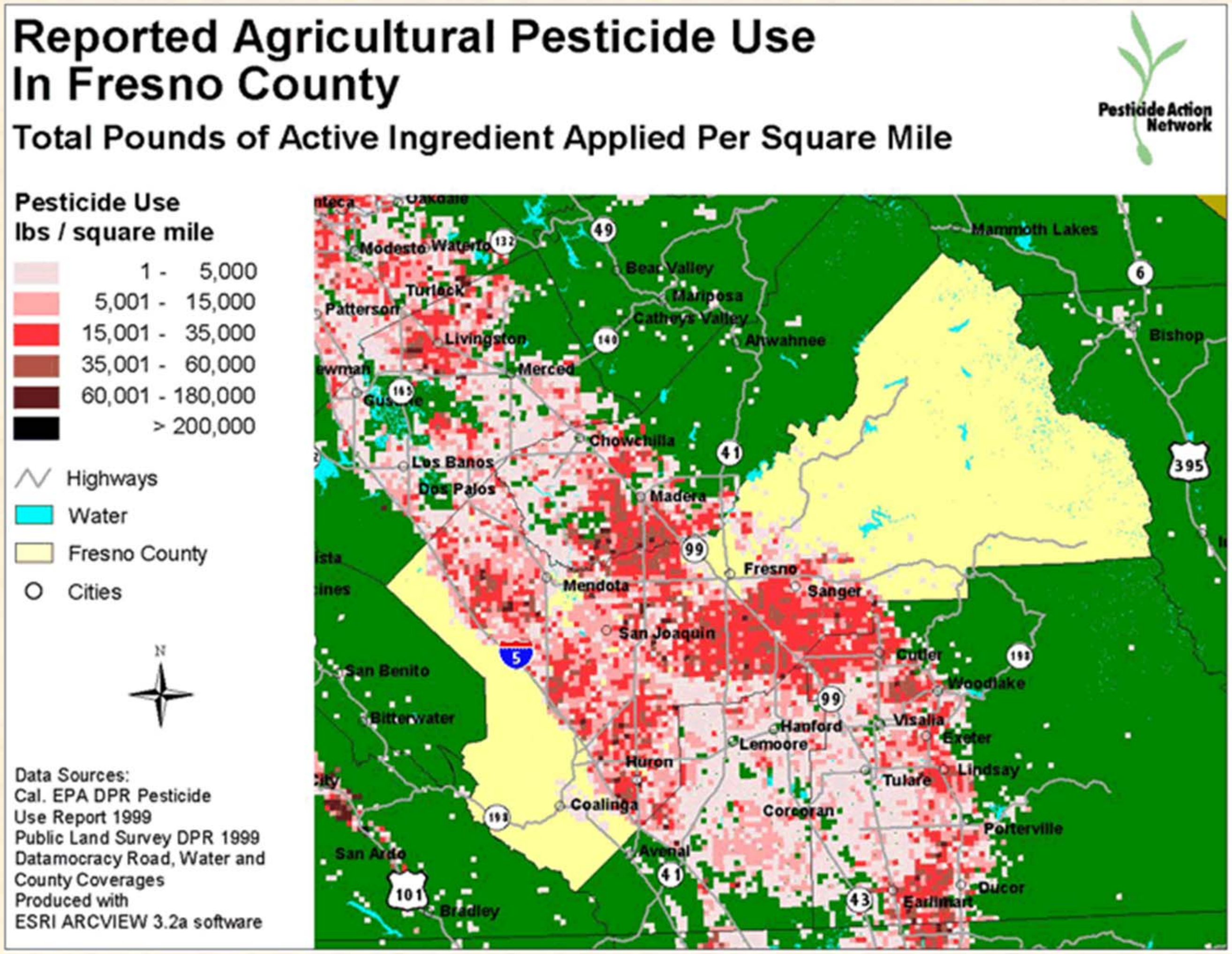
Online References

- San Jose scale resistance to OPs: http://www.uckac.edu/ppq/PDF/96apr.pdf

- Oriental Fruit Moth, resistance to OPs: http://www.uckac.edu/ppq/PDF/93apr.pdf

- Peach Twig Borer, resistance to pyrethroids: http://www.ipm.ucdavis.edu/PMG/r3300211.html

Central San Joaquin Valley



Back to CDPR Data

Table of Contents

The Food Quality Protection Act (FQPA) Background

In 1996, Congress unanimously passed landmark pesticide food safety legislation supported by the Administration and a broad coalition of environmental, public health, agricultural and industry groups. President Clinton promptly signed the bill on August 3, 1996, and the Food Quality Protection Act of 1996 became law (P.L. 104-170, formerly known as H.R. 1627).

EPA regulates pesticides under two major federal statutes. Under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), EPA registers pesticides for use in the United States and prescribes labeling and other regulatory requirements to prevent unreasonable adverse effects on health or the environment. Under the Federal Food, Drug, and Cosmetic Act (FFDCA), EPA establishes tolerances (maximum legally permissible levels) for pesticide residues in food.

For over two decades, there have been efforts to update and resolve inconsistencies in the two major pesticide statutes, but consensus on necessary reforms remained elusive. The 1996 law represents a major breakthrough, amending both major pesticide laws to establish a more consistent, protective regulatory scheme, grounded in sound science. It mandates a single, health-based standard for all pesticides in all foods; provides special protections for infants and children; expedites approval of safer pesticides; creates incentives for the development and maintenance of effective crop protection tools for American farmers; and requires periodic re-evaluation of pesticide registrations and tolerances to ensure that the scientific data supporting pesticide registrations will remain up to date in the future.

Reprinted from US EPA website: http://www.epa.gov/oppfead1/fqpa/backgrnd.htm

Back to FQPA

Table of Contents

A SOFTER SIDE OF PEST CONTROL

Demonstration hopes to show stone fruit growers that non-disruptive techniques pay

By Vicky Boyd, Editor

Ever since Robert Jackson was first introduced to mating disruption for apple codling moth in the late 1980s, he has slowly been easing into a softer approach with his stone fruit pest control.Although the program, which relies on non-disruptive pesticides, dormant oil sprays, mating disruption and beneficial insects, is not a silver bullet, the Tulare County, Calif., area fruit grower believes it is the future.

“Half of me really enjoys farming this way—working with creation rather than against it,” Jackson says. “The other half believes we will see the elimination of most of the OPs (organophosphates), and I want to be a step ahead of the curve. “I’ve always taken the approach, and still do today, that if I come across an economically damaging level of any insect, I will spray. That is the bottom line because I can’t risk my farm.”Jackson isn’t alone, either. Already, two out of three California stone fruit growers are using some type of reduced-risk materials or practices, according to a recent California Tree Fruit Agreement (CTFA) study.But a group calling itself the Pest Management Alliance wants to take the practices to the next level.Through a collaboration of growers, University of California Cooperative Extension, the California Department of Pesticide Regulation, CTFA and the California Cling Peach Board, the alliance is comparing participants’ standard pest-control program to a softer approach in side-by-side demonstrations. The U.S. Environmental Protection Agency also is helping fund the program.

The PMA approach is not intended to replace all OPs, but rather to demonstrate that viable alternatives exist and can be successfully incorporated into the pest control arsenal, says PMA coordinator Shawn Steffan, who works at the Kearney Agricultural Center near Parlier, Calif.The use of OPs, carbamates and pyrethroids certainly can be reduced in California stone fruit orchards, he says, but it is up to growers and pest control advisors to make the effort to do so.In the end, alliance members want to show other growers that a reduced-risk approach is agronomically feasible, says Gary Van Sickle, CTFA research director in Reedley, Calif.The program will run for at least four years to account for environmental variables that could affect pest pressures.“One of the criticisms by growers is, ‘you can do it for a year or two, but can you do it for a longer period of time?’” Van Sickle says. “We want to do this over a certain length of time to show them they can do it.”

Back to News Coverage

Table of Contents

A SOFTER SIDE OF PEST CONTROL, continued

Putting it to the test

During the 2001 growing season, Jackson and six other growers with 12 peach, plum and nectarine varieties in the San Joaquin Valley and one grower with seven peach varieties in the Sacramento Valley participated.In the San Joaquin Valley, the PMA approach involved using 8 gallons of horticultural oil in 400 gallons of water for dormant control of San Jose scale. During the growing season, spinosad (Success) was used around petal fall for thrips, mating disruption for Oriental fruit moth, in-season applications of *Bacillus thuringiensis (Bt)* and/or spinosad for OFM, peach twig borer and/or katydids. The program also included optional late-season applications of methomyl (Lannate) or phosmet (Imidan).

You can bank on it

Through two years of the demonstrations, the average costs and fruit damage for the San Joaquin Valley blocks are comparable.But in the three blocks of canning peaches in the Yuba County area, the PMA blocks averaged about $161 per acre compared to about $50 for the conventional blocks in 2001.Janine Hasey, a UCCE farm advisor for Yuba and Sutter counties, says the area growers' heavy reliance on less-expensive pyrethroids is a reason for the cost disparity.The participating grower used mating disruption early in the season, then returned with one or two pyrethroid sprays later. A season-long pheromone program could run as high as $100 per acre alone. Canning peaches also tend to ripen later in the season than some of the early- and mid-season fresh-market varieties, exposing them to increased pest pressure.Nevertheless, Hasey says the program is still weaning growers away from the harsher OPs and carbamates. If you don't put on additional pheromones and come back and spray with a pyrethroid, you are still reducing the pesticides, just not as much," she says.In addition, the participating grower didn't have a mite problem during the 2001 season and didn't have the miticide costs that many of the area's other conventional growers did. That would have put the conventional cost at about $100 per acre.

A mind-set change

Jackson has been able to control OFM using only mating disruption on his early varieties. On the later varieties, he's used a combination of mating disruption and sprays, such as phosmet, which are easier on the beneficials. For PTB, he uses two applications of *Bt*.In the end, the pest control costs over his entire 300 acres of stone fruit balance out."Mating disruption cost me more on the early fruit, but it reduced the pressure and the amount of spraying that I had to put on my late fruit," Jackson says.

A need for vigilance

Because the PMA program relies on several pest control products with a narrow application window, Steffan says PCAs and growers have to be vigilant about pest monitoring. Take a *Bt* or spinosad product, for example. Both materials have about a one-week residual compared to the much longer-lived OPs, carbamates and pyrethroids, Steffan says.Day-degree models, available on the Internet, let growers and PCAs know the growth stage of insect populations so they can target pesticide applications when they'll be most effective.Jackson agrees and says one of the keys is the PCA."You definitely have to have a good PCA monitoring things," he says. "You either need to be the expert or the PCA you work with has to be very familiar with the approach."Jackson also doesn't advocate switching suddenly from conventional practices to the softer approach. Instead, he suggests easing into the program so you can learn how each technique works and build your comfort levels.

Unexpected visitors

One unexpected problem some growers have begun seeing is an increase in secondary pests, such as the fork-tailed bush katydid, Steffan says.In the past, the dormant or in-season OP sprays controlled the pests. Without the OPs, however, the pests are becoming more of a problem.Jackson has learned to watch the grassy middles in his orchards for hatching katydids. In the younger life stages—up to fourth instar—the pest can be controlled with spinosad. When the nymphs are still small, the Tulare County grower sprays the ground cover. He has even experimented with neem oil in mid-summer on adults with some success."You have to keep constant vigilance," Jackson says. "It seems that we run into something every year, but I feel we have made progress."

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