Agreement No. 99-0199

Pest Management Evaluation for Clingstone Canning and Fresh Shipping Peaches, Plums and Nectarines

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Contractor Organization: California Tree Fruit Agreement

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Prepared for California Department of Pesticide Regulation

The statements and conclusions in this report are those of the contractor and not necessarily those of the California Department of Pesticide Regulation. The mention of commercial products, their source, or their use in connection with material reported herein is not to be construed as actual or implied endorsement of such products.

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Abstract

In 1999, California produced 891,350 tons of peaches. Clingstone peaches comprise 58% of the total crop and are exclusively utilized for processing which includes canning, juice and baby food. The California fresh shipping freestone peach production represents the remaining fraction, or 42% of the annual tonnage. California also produced 196,000 tons of plums and 276,00 tons of nectarines for the fresh market during 1999.

Clingstone processing peach production in California is localized in Butte, Sutter, Yuba, San Joaquin, Stanislaus, Merced, Tulare, Madera, Kings and Fresno counties where approximately 98% of the total canning peach tonnage is harvested from this area annually. The fresh market stone fruit growing area is approximately 90% concentrated in Fresno, Kings, Tulare and Kern counties for the production of peaches, plums and nectarines. As a result of the geographic, temporal and postharvest handling differences, there are slight variations in cultural and system operations between the processing and fresh shipping production of stone fruit.

The Pest Management Evaluation for Clingstone Canning and Fresh Shipping Peaches, Plums and Nectarines adopted a statewide approach by assessing all cropping aspects for California peaches, fresh market plums and nectarines. Input from fruit growers, packers, Pest Control Advisors (PCAs) and University of California Researchers and Farm Advisors was utilized in the preparation of this document. The evaluation provides current information regarding cultural practices, pests, and system changes that impact the use of fertilizers and pesticides commonly used in the stone fruit industry.

Production

The following production data for clingstone canning and fresh market freestone peaches, plums and nectarines is compiled from the January 2000 Agricultural Statistics Board, NASS, USDA, California Cling Peach Growers Advisory Board and California Tree Fruit Agreement 1999 Annual Report:

Peaches

California ranks first in the U.S. in the production of peaches.
California produces 76% of the total U.S. peach crop.
California produces 95% of the U.S. processed peaches.
California produces 51% of the U.S. fresh market peaches.
891,360 tons of peaches valued in excess of $238 million were produced during the 1999 crop year on approximately 67,000 acres.
Production costs for clingstone peaches (1998) averaged $3,910/acre.
Production costs for fresh market peaches (1992) averaged $6,554/acre.
Clingstone peaches comprise approximately 58% of the total crop in California and are exclusively utilized for processing, which includes canning (including baby food), juice and frozen.
The California fresh shipping freestone peach production represents 42% of the annual tonnage.

Plums

California ranks first in the U.S. in the production of plums/prunes.
California produces 91% of the total U.S. fresh plum/prune crop.
California produces 100% of the U.S. fresh market plums/prunes.
196,000 tons of fresh market plums/prunes valued in excess of $82 million were produced during the 1999 crop year on approximately 41,500 acres.
Production costs for fresh market plums/prunes (1992) averaged $5,185/acre.
Fresh market plums/prunes comprise approximately 21% of the annual tonnage of plums/prunes produced in California.

Nectarines

California ranks first in the U.S. in the production of nectarines.
California produces 100% if the total U.S. nectarine crop.
California produces 100% of the U.S. fresh market nectarines.
276,000 tons of fresh market nectarines valued in excess of $113 million were produced during the 1999 crop year on approximately 36,000 acres.
Production costs for nectarines (1992) averaged $5,816/acre.
Fresh market nectarines comprise approximately 98% of the annual tonnage of nectarines produced in California.

Production Regions

There are two major growing regions in California. The San Joaquin Valley (Fresno, Kings, Merced, Tulare, Kern, Madera, Stanislaus, San Joaquin) and the Northern Region (Solano, Sutter, Yuba, Placer, Butte and El Dorado Counties). The fresh market stone fruit growing areas for peaches, plums and nectarines is approximately 90% concentrated in Fresno, Kings, Tulare and Kern Counties. Roughly 98% of the clingstone canning peaches are produced in the Northern Region. As a result of the geographic, timing of harvest and post-harvest handling differences, there are slight variations in cultural and system operations between the processing and fresh shipping production of peaches, plums and nectarines.

Cultural Practices

California cling and freestone peaches, plums and nectarines are members of a large genus of plants, *Prunus*, which also includes cherries, almonds and apricots (Strand et al., 1999). More than 700 varieties of peaches, plums and nectarines are grown commercially in California. Therefore, the harvesting seasons for peaches, plums and nectarines is prolonged. Clingstone canning peaches are harvested beginning in July through mid September (CCPB, 1998). Freestone fresh shipping peaches begin harvest in late April and continue through late October. Nectarines follow a similar pattern to freestone peaches with a harvest season extending from late April through late September. Plums come off of the tree mid May and are generally finished with harvest early October (CTFA, 1997).

Deep, fine-sandy loam soils with good internal drainage and freedom from alkali or salinity are best for optimum peach, plum and nectarine growth and production. *Prunus* trees will not produce commercially acceptable crops under arid California conditions without supplemental irrigation water (Strand et al., 1999). Most peach, plum and nectarine orchards are furrow or flood-irrigated. However, new orchard plantings are increasingly utilizing micro-jet sprinkler irrigation. No-till cultivation is widely used in the southern San Joaquin Valley of California in mature stone fruit orchards. This entails a herbicide-treated berm in the tree row with weeds in the row middles being controlled by mowing. Fruit thinning is an annual practice and hand labor is preferred over mechanical or chemical options.

Nitrogen and zinc fertilizers are traditionally applied in the summer and fall following harvest. In some instances nitrogen fertilizer may need to be applied in the spring. Generally, it is applied at a rate of 50 to 75 pounds of nitrogen per acre in the form of manure or ammonium nitrate. Zinc sulfate is applied in the autumn at leaf fall at a rate of 10 pounds per acre.

Trees are removed after final fruit harvest in orchards designated for replant. Soil samples are obtained to determine the species complex of nematodes. Systematic soil samples from throughout the field are obtained in the fall when nematode populations are highest. Based on the soil samples, methyl bromide solid fumigation is applied during September through October when soil moisture level is low and nematode populations are highest. New trees are planted from December through February.

Insect/Mite

San Jose Scale (SJS):

Description:

San Jose Scale is a serious pest of canning clingstone and fresh market peaches, plums and nectarines in the southern San Joaquin Valley which causes economic losses every year. The adults, which feed on limbs, twigs and fruit, are small, circular and gray. If the shell-like cover is removed, a bright yellow female body is exposed. Young scale crawlers emerge from beneath the shell and move to the fruit where they cause spotting and pitting. The fruit develops a characteristic red spot discoloration around the insect and may be unsightly enough to cause the fruit to be culled. High populations may seriously weaken or kill fruiting branches and main limbs, thus causing permanent injury to mature trees (Rice, 1998).

In a 1998 survey of growers conducted by CTFA, 50% of those who responded stated they had had some difficulty controlling SJS in the past. In addition, 13% of the respondents stated they had removed orchards due to the inability to control SJS. Based on previous scientific evidence, SJS may be exhibiting resistance to OPs and carbamates in the Southern San Joaquin Valley, placing growers in a cycle of increasing material usage with declining pest control returns and seriously inhibits the implementation of an IPM program (Grafton-Cardwell, 1999).

Chemical Controls:

SJS continues to be controlled through the use of a dormant application of petroleum oil and insecticide. Application coverage is of paramount importance as oils act to smother the pest and must be evenly distributed throughout the tree. Therefore, the spray rig speed must be 2 miles per hour or less. In severe cases of scale, when sticky traps indicate increasing populations of crawlers despite dormant spray application, it may be necessary to apply additional insecticide treatments in early summer and late fall (Rice, 1998).

Narrow Range Oils: Applied to 97% of the acres at a rate of 1-6 gallons per acre. Application during the dormant season provides partial control. Oils are most frequently applied in combination with other pesticides, particularly dormant applications (CDPR, 1997).

Esteem (pyriproxifen): Applied under a US Environmental Protection Agency Section 18 Emergency Exemption Permit as a delayed dormant material to be used in conjunction with narrow range oils. The Emergency Exemption Permit was in effect from 1 December 1999 through 1 March 2000 for application on fresh market peaches, nectarines and plums in Fresno, Kern, Kings, Madera and Tulare Counties. Pyriproxyfen is a reduced risk insect growth regulator compound that is part of Integrated Pest Management (IPM) and Integrated Resistance Management (IRM) programs for the control of SJS. Dormant or delayed dormant application of Esteem affects the overwintering black cap stage of SJS. Since Esteem provides a mode of action that differs from commonly used OPs and carbamate insecticides, it is able to control scale that has become resistant to these conventional materials.

Chlorpyrifos: Applied to 4% of the acres by ground at an average rate of 1.9 lbs. a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 4 days. Chlorpyrifos can only be applied during dormant or delayed dormant period. Labeling does not allow meat or dairy animals to graze in treated orchards (CDPR, 1997).

Diazinon: Generally a dormant spray but is sometimes applied post-bloom. Applied to 38% of the acres by ground at an average rate of 2.5 lbs. active ingredient (a.i.) with a typical PHI of 90+ days and a labeled PHI. There have been documented cases of San Jose Scale resistance (Rice, 1998). Also, this product may induce other pest problems (CDPR, 1997).

Carbaryl: Generally a dormant spray but is sometimes applied post-bloom. Applied to 7% of the acres by ground application at a average rate of 3.5 lbs. a.i. per acre and has a 1-day PHI. It will generally cause mite outbreaks. Use of this chemical has decreased because of signs of resistance and pressure from processors of baby food (CDPR, 1997).

Phosmet: Generally an in-season spray but is sometimes applied as a dormant. Applied to 11% of the acres by ground at an average of 2.5 lbs. a.i. per acre with a typical PHI of 14 days which is the labeled PHI (CDPR, 1997). Timing for control is critical.

Methidathion: Applied to 21% of the acres by ground application at an average rate of 1.5 lbs. a.i. per acre (CDPR, 1997). This chemical is widely used but will probably decrease in use due to signs of resistance of San Jose Scale.

Methyl Parathion: Applied to 21% of the acres with an average rate of 1.42 lbs. a.i. per acre (CDPR, 1997). Use of this chemical has increased because it is inexpensive and there are resistance problems with other alternatives. However, in August, 1999, the labeled use of this material for canning and fresh market peaches, plums and nectarines was lost due to the Food Quality Protection Act (FQPA).

Biological Controls:

In 1999, the California Department of Pesticide Regulation (DPR) awarded CTFA and CCPB Pest Management Demonstration Grant and Pest Management Alliance Grant. The Grants provide $61,325 in matching financial support to the clingstone canning and freestone peach, nectarine and plum industry to conduct research, oversight and information dissemination in the development of an integrated reduced risk system for controlling San Jose Scale, Peach Twig Borer, Oriental Fruit Moth and thrips. An integral portion of the project is to survey for and identify endemic and commercial parasite strains to develop a biological control augmentation program for controlling SJS. Moreover, the project will compare the effect of traditional material use and reduced material use on the long term establishment of SJS natural enemies in an orchard setting. The time-frame for completion of this project is 2002 with grower demonstration plots established in Fresno, Kings and Yuba/Sutter counties in January 2000.

Oriental Fruit Moth (OFM):

Description

This is a serious pest in California. There are usually 4 to 5 generations per year in California, although a sixth generation has been observed in years with warm weather in early spring. They 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 larvae feed in terminals where they complete their development. Larvae cause damage by feeding on developing shoots and fruits. The most severe damage occurs where larvae feed on fruit, causing it to be rated off grade. Larvae burrow deep into the flesh often moving to the stone causing decay (Strand et al., 1999).

Chemical Controls

OFM populations are frequently monitored through the use of pheromone traps to determine if treatment is necessary and to time treatments to maximize the efficacy of chemical control. Traps are placed in orchards mid February and degree-days are accumulated from the beginning of the overwintered adult flight (Strand et al., 1999). Increasingly, pheromone mating disruption is being used to control damage from OFM.

Azinphos-methyl: Applied to 5% of the acres by ground at an average rate of 1.75 lbs. a.i. per acre with a typical 21 day PHI which is the labeled PHI (CDPR, 1997). Resistance has occurred in some orchards in the Sacramento Valley and in the northern San Joaquin Valley (Calif. League of Food Processors, 1998). However, in August, 1999, the labeled use of this material for canning and fresh market peaches, plums and nectarines was lost due to the Food Quality Protection Act (FQPA).

Methomyl: Applied to 1% of the acres by ground at an average rate of 0.80 lb. a.i. per acre with a typical PHI of 4 days which is the labeled PHI (CDPR, 1997). It kills beneficials and/or non target organisms and is not good for an IPM program. It was used in the past as a clean-up material, but the reentry interval has been changed to 4 days, so it is no longer is used for this purpose (Calif. League of Food Processors, 1998).

Phosmet: Applied to 11% of the acres by ground at an average of 2.5 lbs. a.i. per acre with a typical PHI of 14 days which is the labeled PHI (CDPR, 1997). Timing is critical.

Methyl Parathion: Applied to 21% of the acres with an average rate of 1.42 lbs. a.i. per acre (CDPR, 1997). Use of this chemical has increased because it is inexpensive and there are resistance problems with other alternatives. Used only early in season. Some processors do not allow use (Calif. League of Food Processors, 1998). However, in August, 1999, the labeled use of this material for canning and fresh market peaches, plums and nectarines was lost due to the Food Quality Protection Act (FQPA).

Permethrin: is applied to 28% of the acres by ground at an average rate of 0.05 lb. a.i. per acre with a typical PHI of 14 days (Ambush) and 14 days (Pounce) which are the labeled PHIs (CDPR, 1997). There should be caution when using permethrin because of potential secondary pest problems.

Esfenvalerate: Applied to 28% of the acres by ground or air at an average rate of 0.05 lb. a.i. per acre with a labeled PHI of 14 days (CDPR, 1997).

Diazinon: Applied to 38% of the acres most of which is a dormant application (CDPR, 1997). It is applied by ground at an average rate of 2.5 a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 21 days. Timing is critical. Resistance is suspected but has not been documented (Rice, 1998).

Carbaryl: Applied to 7% of the acres by ground at an average rate of 3.5 lbs. a.i. per acre with a 1-day PHI (CDPR, 1997). Use of this product will cause mite outbreaks. Not recommended for routine use and does not fit within an IPM program. Use of this chemical has decreased because of signs of resistance and pressure from processors of baby food. It is the only chemical that can be used under certain conditions because of the 1-day PHI (Calif. League of Food Processors, 1998).

Biological Control

Mating Disruptants: Effective OFM control can be achieved with pheromone dispensers. However, this is the least popular control method mainly due to costs. Disruptants are applied just before or at first moth emergence in spring or roughly around March 1 (Rice, 1998). Replace emitters on product recommendation, usually in 3 months. Two current products are Isomate M-100 applied at a rate of 150 dispensers per acre. Checkmate SF Dual OFM + PTB applied at 150 dispensers per acre. These are applied by hand labor.

Growers and PCAs are reluctant to use pheromone mating disruption due to the potential for secondary pest outbreaks of Oblique Banded Leaf Roller (OBLR), the increased cost of pheromone application and the difficulties some growers have experienced with mating disruption failure to suppress reproduction of the target pest. Due to these barriers in attaining a more widespread acceptance and adoption of pheromone mating disruption, the CCPB, CTFA and DPR funded Demonstration and Pest Management Alliance grants containing a component to examine refining the commercial application rates for pheromone mating disruption. This portion of the projects seeks to increase the soundness of the mating disruption system and restore grower confidence thus increasing routine use of this reduced risk pest management alternative.

Peach Twig Borer (PTB):

Description:

Peach Twig Borer is a severe pest to clingstone canning and fresh market peaches, plums and nectarines, and annually causes severe losses. Adult peach twig borer moths are 0.3 to 0.4 inch long with steel gray, mottled forewings. The bluntly oval eggs are yellow white to orange

and are laid on twigs, leaves, or on the fruit surface. They overwinter 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. Larvae emerge in early spring, usually during the bloom, and migrate up twigs and branches where they attack newly emerged leaves and shoots. 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. Shoot damage is most severe on young developing trees because feeding kills the terminal growth. As fruit matures, it becomes highly susceptible to attack; damage is most likely to occur from color break to harvest. PTB burrows into the flesh but does not reach the pit. Feeding damage however, can increase the incidence of fruit decay (Strand et al., 1999).

Controls

PTB populations are frequently monitored through the use of pheromone traps to determine if treatment is necessary and to time treatments to maximize the efficacy of chemical control. Traps are placed in orchards mid February and degree-days are accumulated from the beginning of the overwintered adult flight (Strand et al., 1999). Increasingly, pheromone mating disruption and *Bacillus thuriengensis* are being used to control damage from PTB.

Diazinon or Methidathion + Oil: Are often applied during the dormant season (CDPR, 1997).

Chlorpyrifos: Applied to 4% of the acres by ground at an average rate of 1.9 lbs. a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 4 days (CDPR, 1997).
Chlorpyrifos can only be applied during dormant or delayed dormant period. Labeling does not allow meat or dairy animals to graze in treated orchards.

Azinphos methyl: Applied to 5% of the acres by ground at an average rate of 1.75 lbs. a.i. per acre with a typical PHI of 21 days which is the labeled PHI. This is a post-bloom application (CDPR, 1997). The use of this material is decreasing due to suspected resistance in PTB. However, in August, 1999, the labeled use of this material for canning and fresh market peaches, plums and nectarines was lost due to the Food Quality Protection Act (FQPA).

Diazinon: Is applied to 38% of the nectarine acres for various different pest. It is applied after the dormant season by ground at an average rate of 2.5 lbs. of a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 21 days (CDPR, 1997). May induce other pest problems.

Carbaryl: Applied to 7% of the acres by ground at an average rate of 3.5 lbs. a.i. per acre with a 1-day PHI. Use of this product will cause mite outbreaks. Not recommended for routine use and does not fit within an IPM program (CDPR, 1997). Use of this chemical has decreased because of signs of resistance and pressure from processors of baby food (Calif. League of Food Processors, 1998). It is the only chemical that can be used under certain conditions because of the 1-day PHI.

Phosmet: Applied to 11% of the acres by ground at an average rate of 2.5 lbs. a.i. per acre with a typical PHI of 14 days which is the labeled PHI. This is a post-bloom application (CDPR, 1997).

Permethrin: is applied to 28% of the acres by ground at an average rate of 0.05 lb. a.i. per acre with a typical PHI of 14 days (Ambush) and 14 days (Pounce) which are the labeled PHIs (CDPR, 1997). There should be caution when using permethrin because of potential secondary pest problems.

Esfenvalerate: Applied to 28% of the acres by ground or air at an average rate of 0.05 lb. a.i. per acre with a labeled PHI of 14 days (CDPR, 1997).

Biological Control:

PTB has about 30 species of natural enemies. Among those commonly found in California are the chalcid wasps, *Paralitomastix varicornis* and *Hyperteles lividus*, the grain or itch mite, *Pyemotes ventricosus* and the native gray ant (Daane, 1996). In some years these natural enemies destroy a significant portion of larvae, but by themselves they generally do not reduce PTB populations below economically damaging levels.

Bacillus thuringiensis: Applied to over 50% of the clingstone canning and fresh market peach, plum and nectarine acres by ground during bloom only; the first at popcorn or early bloom and the second 7-10 days later, but no later than petal fall. Good coverage is essential. Precede this treatment with an oil spray during the dormant season to control SJS and European red mite eggs.

Mating Disruptants: Effective PTB control can be achieved with pheromone dispensers. However, this is the least popular control method mainly due to costs. Disruptants are applied just before or at first moth emergence in spring or roughly around March 1 (Rice, 1998). Replace emitters on product recommendation, usually in 3 months. Two current products are Isomate M-100 applied at a rate of 150 dispensers per acre. Checkmate SF Dual OFM + PTB applied at 150 dispensers per acre. These are applied by hand labor.

Growers and PCAs are reluctant to use pheromone mating disruption due to the potential for secondary pest outbreaks of Oblique Banded Leaf Roller (OBLR), the increased cost of pheromone application and the difficulties some growers have experienced with mating disruption failure to suppress reproduction of the target pest. Due to these barriers in attaining a more widespread acceptance and adoption of pheromone mating disruption, the CCPB, CTFA and DPR funded Demonstration and Pest Management Alliance grants containing a component to examine refining the commercial application rates for pheromone mating disruption. This portion of the projects seeks to increase the soundness of the mating disruption system and restore grower confidence, thus increasing routine use of this reduced risk pest management alternative.

Dormant and in-season sprays are an effective way to control PTB in clingstone canning and fresh market peaches, plums and nectarines.

Omnivorous Leafroller (OLR):

Description:

The Omnivorous Leafroller has increased in importance as a pest of clingstone canning and fresh market peaches, nectarines and plums. The larvae feed on both the foliage and fruit. Damage caused by leaf feeding is usually minor. Feeding on fruit is typically shallow, often around the stem end. In addition, feeding wounds are also sites for the invasion for fungi, and is often seen in a complex with brown rot, which can destroy the fruit completely. Injury can occur spring through fall, as the Omnivorous Leafroller can complete 3 to 5 generations from March through October (Shorey, 1997).

Controls

Diazinon or Methidathion + Oil: Are often applied during the dormant season.

Chlorpyrifos: Applied to 4% of the acres by ground at an average rate of 1.9 lbs. a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 4 days (CDPR, 1997). Chlorpyrifos can only be applied during dormant or delayed dormant period. Labeling does not allow meat or dairy animals to graze in treated orchards.

Azinphos methyl: Applied to 5% of the acres by ground at an average rate of 1.75 lbs. a.i. per acre with a typical PHI of 21 days which is the labeled PHI (CDPR, 1997). This is a post-bloom application. However, in August, 1999, the labeled use of this material for canning and fresh market peaches, plums and nectarines was lost due to the Food Quality Protection Act (FQPA).

Diazinon: Is applied to 38% of the nectarine acres for various different pest. It is applied after the dormant season by ground at an average rate of 2.5 lbs. of a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 21 days (CDPR, 1997). May induce other pest problems.

Carbaryl: Applied to 7% of the acres by ground at an average rate of 3.5 lbs. a.i. per acre with a 1-day PHI (CDPR, 1997). Use of this product will cause mite outbreaks. Not recommended for routine use and does not fit within an IPM program. Use of this chemical has decreased because of signs of resistance and pressure from processors of baby food (Calif. League of Food Processors, 1998). It is the only chemical that can be used under certain conditions because of the 1-day PHI.

Phosmet: Applied to 11% of the acres by ground at an average rate of 2.5 lbs. a.i. per acre with a typical PHI of 14 days which is the labeled PHI (CDPR, 1997). This is a post-bloom application.

Permethrin: is applied to 28% of the acres by ground at an average rate of 0.05 lb. a.i. per acre with a typical PHI of 14 days (Ambush) and 14 days (Pounce) which are the labeled PHIs (CDPR, 1997). There should be caution when using permethrin because of potential secondary pest problems.

Esfenvalerate: Applied to 28% of the acres by ground or air at an average rate of 0.05 lb. a.i. per acre with a labeled PHI of 14 days (CDPR, 1997).

Biological Control:

Bacillus thuringiensis: Applied to over 50% of the clingstone canning and fresh market peach, plum and nectarine acres by ground during bloom only; the first at popcorn or early bloom and the second 7-10 days later, but no later than petal fall. Good coverage is essential. Precede this treatment with an oil spray during the dormant season to control SJS and European red mite eggs.

Codling Moth

Description:

Codling moth has a 0.5 to 0.75 inch wingspan. The tip of each forewing has a coppery tinged, dark brown band that distinguishes codling moth from other moths. Females lay eggs singly on leaves and on fruit. Newly hatched larvae are white with black heads. Mature larvae are 0.5 to 0.75 inch long, pinkish white, with mottled brown heads. Codling moth is very rarely a problem in clingstone canning and fresh market peaches and nectarines (Strand et al., 1999). This pest tends to occasionally occur in plums and prunes.

Controls

Phosmet: Generally an in-season spray but is sometimes applied as a dormant. Applied to 11% of the acres by ground at an average of 2.5 lbs. a.i. per acre with a typical PHI of 14 days which is the labeled PHI (CDPR, 1997). Timing for control is critical.

Methidathion: Applied to 21% of the acres by ground application at an average rate of 1.5 lbs. a.i. per acre (CDPR, 1997). This chemical is widely used but will probably decrease in use due to signs of resistance of San Jose Scale (Rice, 1998).

Methyl Parathion: Applied to 21% of the acres with an average rate of 1.42 lbs. a.i. per acre (CDPR, 1997). Use of this chemical has increased because it is inexpensive and there are resistance problems with other alternatives. However, in August, 1999, the labeled use of this material for canning and fresh market peaches, plums and nectarines was lost due to the Food Quality Protection Act (FQPA).

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Esfenvalerate: Applied to 28% of the acres by ground or air at an average rate of 0.05 lb. a.i. per acre with a labeled PHI of 14 days (CDPR, 1997).

Biological Control:

Bacillus thuringiensis: Applied to over 50% of the clingstone canning and fresh market peach, plum and nectarine acres by ground during bloom only; the first at popcorn or early bloom and the second 7-10 days later, but no later than petal fall. Good coverage is essential. Precede this treatment with an oil spray during the dormant season to control SJS and European red mite eggs.

Cultural Control

Remove abandoned host trees in nearby orchards. Also remove unharvested fruit from nearby host trees. Following harvest, remove unpicked fruit to prevent a large overwintering population (UC IPM Guidelines).

Citrus Cutworm:

Description:

This pest is an economically important pest of plums on an occasional basis and is generally restricted to certain geographic areas of Tulare, Kern and Fresno counties. The larvae feed on leaves, flowers and fruit and a single larva can damage several fruit. It is important to note, the Citrus Cutworm larvae has a single generation per year, therefore feeding damage is limited to a time span of approximately February through May (Grafton-Cardwell, 1997).

Controls:

Phosmet: Generally an in-season spray but is sometimes applied as a dormant. Applied to 11% of the acres by ground at an average of 2.5 lbs. a.i. per acre with a typical PHI of 14 days which is the labeled PHI (CDPR, 1997). Timing for control is critical.

Methyl Parathion: Applied to 21% of the acres with an average rate of 1.42 lbs. a.i. per acre (CDPR, 1997). Use of this chemical has increased because it is inexpensive and there are resistance problems with other alternatives. However, in August, 1999, the labeled use of this material for canning and fresh market peaches, plums and nectarines was lost due to the Food Quality Protection Act (FQPA).

Diazinon: Applied to 38% of the acres by ground at an average rate of 2.5 lbs. active ingredient (a.i.) with a typical PHI of 90+ days and a labeled PHI (CDPR, 1997). There have been documented cases of San Jose Scale resistance (Rice, 1998). Also, this product may induce other pest problems.

Carbaryl: Generally a dormant spray but is sometimes applied post-bloom. Applied to 7% of the acres by ground application at a average rate of 3.5 lbs. a.i. per acre and has a 1-day PHI (CDPR, 1997). It will generally cause mite outbreaks. Use of this chemical has decreased because of signs of resistance and pressure from processors of baby food (Calif. League of Food Processors, 1998).

Biological Control:

Bacillus thuringiensis: Applied to over 50% of the clingstone canning and fresh market peach, plum and nectarine acres by ground only during bloom; the first at popcorn or early bloom and the second 7-10 days later, but no later than petal fall. Good coverage is essential. Precede this treatment with an oil spray during the dormant season to control SJS and European red mite eggs.

Western Flower Thrips

Description:

Western flower thrips are an occasional pest and are attracted to the blooms of peaches, nectarines and plums. Nectarines are the most seriously injured, but peaches and plums can also suffer severe injury if large populations of thrips are present during bloom. In early spring, the nymphs hatch and feed in numbers on tiny fruit, often under the drying calyx or flower parts. Damage is more pronounced in cool seasons when shedding of the calyx is slow. Injury consists of several types including holes or depressions, punctures and scarring in large or small blotches (Strand et al., 1999).

Controls:

Methomyl: Applied to 1% of the acres by ground at an average rate of 0.80 lb. a.i. per acre with a typical PHI of 4 days which is the labeled PHI (CDPR, 1997). It kills beneficials and/or nontarget organisms. May induce other pest problems. It was used in the past as a clean-up material, but the reentry interval has been changed to 4 days, so it no longer is used for this purpose.

Formetanate HCl: Applied to 3% of the acres by ground at an average rate of 0.75 lb. a.i. per acre with a typical PHI of 21 days which is the labeled PHI (CDPR, 1997).

***Spider mites*:**

Description:

If uncontrolled can be a serious pest problem in California. Pacific and two-spotted spider mites overwinter as adult females in protected places on the tree or in the litter, trash and weeds on the orchard floor. Mites become active in early spring 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. Peaches, plums and nectarines can tolerate some mite damage, particularly on water sprouts in the center of trees. Feeding by both species causes a mottling of the leaves, and under severe conditions can cause heavy leaf drop. If defoliation happens early in the season, fruit fails to size properly and limbs and fruit may be exposed to sunburn (Strand et al., 1999).

Controls:

Insecticidal Soap: Applied at various application rates depending on the product. May pose problems with plant phytotoxicity.

Narrow Range Oil: Applied to 97% of the acres at various application rates depending on the product (CDPR, 1997).

Clofentezine: Applied to 8% of the acres by ground at an average rate of 0.10 lb. a.i. per acre with a minimum 21-day PHI (CDPR, 1997). This material is more effective in the early part of the year. It kills eggs and young larval stages most effectively. To delay development of resistance, use only once per season.

Dicofol: Has just been registered for use on peaches and nectarines in California. No use data is available. However, evidence suggests this material kills predators of mites and is therefore not recommended for use. It is applied at 1.3 lbs. a.i. per acre with a typical PHI of 7 days which is the labeled PHI.

Fenbutatin Oxide: Applied to 21% of the acres by ground at an average rate of 0.58 lb. a.i. per acre with a minimum 14-day PHI (CDPR, 1997). This material appears to be most effective when applied early in the season.

Biological Control:

Predators are very important in regulating pest mite populations in orchards. The three major predators are the western predatory mite, six-spotted thrips and the spider mite destroyer, *Stethorus picipes*. All of these predators are adversely affected by certain materials applied for control of other pests, such as oriental fruit moth (UC IPM Guidelines).

Cultural control:

Keeping orchards well irrigated and treating orchard roads, if necessary, to keep dust to a minimum helps to manage mite buildups. Choice of insecticides for other pest problems can influence mite buildup (e.g. carbaryl and pyrethroids) (UC IPM Guidelines).

Secondary Insect Pests

Secondary pests, such as true bugs and aphids, are generally not significant problems and are controlled with existing pest management systems. However, the loss of OPs and the shift to softer programs will likely see and increase in these secondary pests.

True Bugs:

These pests are not usually considered major problems but they can be if neighboring fields contain crops which are hosts. In general, the true bugs of greatest economic interest to the stone fruit industry are the Lygus and the Consperse stink bugs. Adult true bugs are about .20 to .25 inch long. True bugs overwinter as adults in plant debris, in the crown of plants on the orchard floor, and in uncultivated areas outside the orchard. As temperature rises, true bug

adults migrate to irrigated areas where mating occurs. It is believed adults are chiefly responsible for damage to fruit orchards. There may be as many as 6 to 10 overlapping generations per year. Damage by true bugs can be either to the growing shoot tips which can cause them to die or to the fruit which can cause them to be misshapen. Fruit damage is sporadic and does not occur every year; however, in some years severe economic losses can occur. In general, true bug populations are highest in years where there is a loss of lush vegetation growing in and around the orchard (Strand et al., 1999).

Controls:

Formetanate HCl: Applied to 3% of the acres by ground at an average rate of 0.75 lb. a.i. per acre with a typical PHI of 21 days which is the labeled PHI (CDPR, 1997).

Methomyl: Applied to 1% of the acres by ground at an average rate of 0.80 lb. a.i. per acre with a typical PHI of 4 days which is the labeled PHI. It kills beneficials and/or nontarget organisms. May induce other pest problems. It was used in the past as a clean-up material, but the reentry interval has been changed to 4 days, so it no longer is used for this purpose (CDPR, 1997).

Cultural control:

Cover crop manipulation is important in Lygus and stink bug management. Clean cultivation or a weed free orchard floor in lieu of a cover crop will aid in suppressing Lygus. Legumes are major hosts for both species. It is a rare occasion if growers actually treat an orchard with pesticides to gain control of these pests (Strand et al., 1999).

Aphids:

Aphids can be seen on the underside of leaves in the early spring. In particular the mealy plum aphid and leaf curl plum aphid can be found in plums and the green peach aphid is a secondary pest of peaches and nectarines (Strand et al., 1999). Honeydew secreted by the aphids can cause cracking of the fruit. The wounds may become secondarily infected with fungi and render the fruit unfit for consumption.

Aphids are best controlled through the use of an insecticide in the dormant spray to kill overwintering eggs. This is a common grower practice for controlling San Jose Scale as well (Strand et al., 1999).

Weeds

Description:

Weeds are a typical problem especially during the first two years after planting an orchard. When the canopy closes and shades out the middles, weed growth is usually reduced. Generally, there is one pre-emergent application made on the berm surrounding the trees. The pre-emergence herbicide is usually applied in the fall following harvest or is applied in the winter or spring. Weeds in the row middles are generally controlled with repeated post emergent applications, alone or in combination with cultivation. The spectrum of weeds within an orchard

changes so much that loss of the broad spectrum herbicides (glysophate and paraquat) would cause the loss of post emergent weed control in orchards. It would also cause the loss of effective control of perennial weeds (UC IPM Guidelines).

Controls:

Glysophate: Applied to 71% of the clingstone canning and fresh market peach, plum and nectarine acres at a average rate of .5 lb. a.i. per acre by ground application (CDPR, 1997).

Simazine: Applied as a dormant spray with an average rate of 1.0 lb. a.i. per acre by ground application. Potential groundwater contamination. Virtually not used in California due to phytotoxicity (CDPR, 1997).

Paraquat: Applied to 34% of the clingstone canning and fresh market peach, plum and nectarine acres at an average rate of .70 lb. a.i. per acre by ground application. Restricted use material (CDPR, 1997).

Oxyfluorfen: Applied to 21% of the clingstone canning and fresh market peach, plum and nectarine acres at an average rate of .21 lb. a.i. per acre by ground application. Must be used in conjunction with another substance or tactic (CDPR, 1997).

Cultural control:

Frequent discing or harrowing, helps eliminate perennial and broadleaf weeds.

Diseases

Brown rot, green fruit rot, shot hole, rust, and powdery mildew are the most common and devastating fungal diseases of clingstone canning and fresh market peaches, plums and nectarines. Other fungal diseases such as anthracnose and scab occur in California stone fruit growing regions, however, they have not caused economic damage. Root diseases such as *Phytophthora* root rot and *Armillaria* root rot can be problems in wet years when flooding occurs or specific regions, respectively. Bacterial diseases such as crown gall and bacterial blast or canker are also perennial problems in California. Peach leaf spot does not occur in California (Teviotdale, 1997).

Processing clingstone canning peaches: Benomyl and captan are not used much anymore. Growers rely on sulfur to control scab and rust. Iprodione, propiconazole, tebuconazole and myclobutanil are used to control brown rot or blossom blight (Calif. League of Food Processors, 1998).

Fresh market peaches, plums and nectarines: The most commonly applied fungicides in fresh market peaches, plums and nectarines are benomyl, thiophanate-methyl, captan, iprodione, myclobutanil, propiconazole and tebuconazole (Adaskaveg, 1997).

***Brown Rot*:**

Description:

A major perennial problem for *Prunus* in California that is dependent on wind, wetness and warm temperature. Brown rot infections are caused by two airborne fungi, *Monilina fructicola* or *M. laxa.* The disease is favored by high relative humidity and develops very well in moderate to warm temperatures.

Monilina spp. overwinter as mycelium in twigs, peduncles and mummified fruit. The most important source of inoculum are remaining infected flower parts and fruit mummies on which the fungi produce masses of asexual spores beginning in late winter. *M. fructicola* also produces a sexual stage on fallen mummified that functions in producing primary inoculum in the spring. *M. laxa* usually blights blossoms and twigs and occasionally rots ripening fruit. *M. fructicola* is the organism most commonly found in nectarine orchards, and is generally responsible for blossom and twig blight, as well as fruit brown rot outbreaks. Aerial applications are generally not as effective as properly applied ground sprays, but may be necessary when the orchard floor is wet (Michailides, 1997).

Controls:

Iprodione: Applied to 59% of the acres by ground or air at an average rate of 0.75 lb. a.i. per acre with a typical 7 day PHI which is the labeled PHI (CDPR, 1997). Addition of a narrow range oil at 1-2% increases the effectiveness of this material. Label changes made in 1998 do not allow preharvest applications on nectarine. Thus, the fungicide is restricted to blossom and petal fall applications (Teviotdale, 1997)

Captan: Applied to 9% of the acres by ground or air at an average rate of 2.9 lbs. a.i. per acre with a typical 30+ days PHI with a labeled PHI of 0 days (CDPR, 1997). This is mostly used during bloom. Do not apply in combination with, immediately before, or closely following oil sprays (Teviotdale, 1997).

Thiophanate-methyl: Applied to 7% of the acres by ground or air at an average rate of 0.70 lb. a.i. per acre with a typical PHI of 90+ days which has a labeled PHI of 1 day (CDPR, 1997). Mostly used during bloom. Resistance has been documented in the Sacramento and northern San Joaquin Valleys (Adaskaveg, 1997).

Vinclozolin: Applied to 4% of the acres by ground or air at an average rate of 0.75 lb. a.i. per acre with a typical PHI of 30+ day and the labeled PHI is 7 days (CDPR, 1997). Mostly used during bloom. Do not use with or closely following oil sprays. Label changes made in 1998 do not allow preharvest applications on nectarine. Thus, the fungicide is restricted to only blossom and petal fall applications (Teviotdale, 1997).

Chlorothalonil: Applied to 32% of the acres by ground or air at an average rate of 2.4 lbs. a.i. per acre with a typical PHI of 30+ days and the labeled PHI is 0 days (CDPR, 1997). Mostly used during bloom. Do not apply after shuck split and before harvest. Do not use with or closely following oil sprays (Teviotdale, 1997).

Myclobutanil: Applied to 25% of the acres by ground or air at an average rate of 0.13 lb. a.i. per acre with a minimum 7-day PHI (CDPR, 1997).

Benomyl: Applied to 17% of the acres by ground or air at an average rate of 0.75 lb. a.i. per acre with a typical PHI of 90+ day and a labeled PHI of 3 days (CDPR, 1997). Mostly used during bloom. Apply at pink bud only and use a companion fungicide of different chemistry. Resistance has been documented in the Sacramento and northern San Joaquin Valleys (Adaskaveg, 1997).

Cultural control:

Removal of unharvested fruit and mummies from trees and cultivation of orchard floor (to bury mummies) before bloom will help reduce inoculum. Pruning infected twigs also helps reduce the spread of this disease (Michailides, 1997).

Jacket Rot/Green Fruit Rot:

These diseases are caused by a complex of fungi namely *Monilinia* species, *Botrytis cinerea*, and *Sclerotinia sclerotiorum*. Senescent and dead flower parts are colonized by any one or combination of these fungi during wet weather. The flower parts usually dry out and drop off quickly in dry weather as the immature fruit develops. In wet weather the flower tissues remain attached and provide a substrate for these fungi to colonize the developing fruit. Symptoms usually develop one to three weeks after petal fall. Green fruit rot, however, can also occur in years of wet weather and heavy fruit set when non-thinned fruit are in contact with each other (UC IPM Guidelines).

Controls:

In the past, full bloom and petal fall applications of fungicides such as benomyl or iprodione have provided effective control. Recently, with the introduction of newer compounds such as the strobilurins and DMI fungicides, management of this disease is more difficult because these compounds are less effective against *B. cinerea* (Adaskaveg, 1997).

Benomyl: Applied to 17% of the acres by ground or air at an average rate of 0.75 lb. a.i. per acre with a typical PHI of 90+ day and a labeled PHI of 3 days (CDPR, 1997). Mostly used during bloom. Apply at pink bud only and use a companion fungicide of different chemistry. Resistance has been documented in the Sacramento and northern San Joaquin Valleys (Adaskaveg, 1997).

Thiophanate-methyl: Applied to 7% of the acres by ground or air at an average rate of 0.70 lb. a.i. per acre with a typical PHI of 90+ days which has a labeled PHI of 1 day (CDPR, 1997). Mostly used during bloom. Resistance has been documented in the Sacramento and northern San Joaquin Valleys (Adaskaveg, 1997).

Iprodione: Applied to 59%of the acres by ground or air at an average rate of 0.75 lb. a.i. per acre with a typical 7 day PHI which is the labeled PHI (CDPR, 1997). Addition of a narrow range oil at 1-2% increases the effectiveness of this material. Label changes made in 1998 do not allow preharvest applications on nectarine. Thus, the fungicide is restricted to only blossom

and petal fall applications.

Chlorothalonil: Applied to 32% of the acres by ground or air at an average rate of 2.4 lbs. a.i. per acre with a typical PHI of 30+ days and the labeled PHI is 0 days (CDPR, 1997). Mostly used during bloom. Do not apply after shuck split and before harvest. Do not use with or closely following oil sprays.

Captan: Applied to 9% of the acres by ground or air at an average rate of 2.9 lbs. a.i. per acre with a typical 30+ days PHI with a labeled PHI of 0 days (CDPR, 1997). This is mostly used during bloom. Do not apply in combination with, immediately before, or closely following oil sprays.

***Peach Leaf Curl*:**

Description:

Peach Leaf Curl is caused by *Taphrina deformans*, an airborne fungus. About 90% of the clingstone canning and fresh market peach, plum and nectarine acres are treated for this disease. Leaves produced in the spring are deformed, thickened, curled, and colored red or yellow instead of normal green. Severely affected shoots die. Irregular reddish lesions are sometimes seen on the fruit where touched by infected leaves. Badly diseased leaves fall by early summer, and repeated infections debilitate trees and kill branches. Dormant applications are necessary in all stone fruit growing districts. One application in late winter before budswell is sufficient except in areas of high rainfall or where leaf curl has become an increasing problem (Teviotdale, 1997).

Controls:

Chlorothalonil: Applied to 32% of the acres by ground at an average rate of 2.5 lbs. a.i. per acre (CDPR, 1997). Do not use with or closely following oil sprays.

Copper: Applied to 89% of the acres by ground at various application rates depending on the product (CDPR, 1997).

Ziram: Applied to 49% of the acres mostly by ground at an average rate of 6 lbs. a.i. per acre with a minimum 30-day PHI (CDPR, 1997).

***Powdery Mildew (Sphaerotheca pannosa)*:**

Description:

Terminal leaves of shoots are covered in powdery, white fungal growth. Leaves become misshapen and puckered and fruits develop powdery white spots. *S. pannosa* survives as mycelium in bud scales and other Roseaceous hosts. The climate in the San Joaquin Valley is suitable for powdery mildew, particularly during spring when the disease causes the most damage. Growth of the pathogen is favored by cool, moist nights and warm days (UC IPM Guidelines).

Controls:

Benomyl: Applied to 17% of the acres by ground at an average rate of 0.75 lb. a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 3 days (CDPR, 1997). Mostly used during bloom. Resistance to benomyl may develop if this material is used repeatedly. It is important to alternate benomyl with materials of a different chemistry (Adaskaveg, 1997).

Sulfur: Is a preventative treatment and applied at various application rates depending on the product mostly by ground (CDPR, 1997). It is applied to about 40% of the nectarine acres. Do not apply within 3 weeks of an oil application.

Myclobutanil: Applied to 25% of the acres by ground at an average rate of 0.12 lb. per acre with a minimum 1-day PHI (CDPR, 1997).

Thiophanate-methyl: Applied to 7% of the acres by ground or air at an average rate of .70 lb. a.i. per acre with a typical 90+ day PHI and a labeled 1-day PHI (CDPR, 1997). Mostly used during blossom. Apply at pink bud only. Resistance has been documented in the Sacramento and northern San Joaquin Valleys (Adaskaveg, 1997).

Cultural control:

Removal of alternate hosts adjacent to nectarine orchards is suggested as a method to reduce inoculum (UC IPM Guidelines).

***Phytophthora Root and Crown Rot*:**

Description:

Generally, crown rots advance rapidly and trees collapse and die soon after the first warm weather of spring. Leaves of such trees wilt, dry, and remain attached to the trees. Phytophthora infections typically kill young trees because their root systems and crown areas are small compared to those of mature trees. Can also kill mature trees. Periods of 24 hours or more of saturated soil favor Phytophthora infections. Conversely, good soil drainage and more frequent but shorter irrigations reduce the risk of root and crown rot. Also planting trees on a berm reduces the chances of this diseases (UC IPM Guidelines).

Controls:

Fosetyl-al: Applied to less than 1% of the acres by ground at a rate of 5.0 lbs. a.i. per acre (CDPR, 1997). It is used as a post-plant treatment for nonbearing trees only. It is a foliar and soil application material, 60-day intervals (Teviotdale, 1997).

Metalaxyl: Applied to less than 1% of the acres (CDPR, 1997). The fungicide is applied as a soil drench (6 fl oz/1,000 sq ft.) under the tree canopy. The application rate varies with the method of application and size of trees. This is a post-plant application on nonbearing and bearing trees and is only effective as a soil drench. Up to three applications are made from early spring to fall (Teviotdale, 1997).

***Peach rust*:**

Description:

Leaves and fruit of clingstone canning and fresh market peach, plum and nectarine are infected. In recent years, the disease is most severe on cling peaches in Sutter/Yuba Co. of the Sacramento valley but also occurs in counties of the San Joaquin valley. In 1998 there was an unexpected outbreak in Kings county. The fungus overwinters as a mycelium in one-year old twigs. In the spring the fungus forms lens-shaped twig cankers filled with rusty-brown spores. On leaves the disease develops as bright yellow, angular lesions. Rusty-brown sporulation pustules of the fungus develops on the lower leaf surface. Severe infections result in early season defoliation. Direct crop loss can occur from fruit infections that develop as sunken, greenish lesions as fruit ripen. Twig cankers form regardless of weather in the spring however, growing season epidemics are dependent on high rainfall in the spring. The lesions are susceptible to secondary infection by other fugal species such as brown rot (UC IPM Guidelines).

Controls:

Sulfur: Applied in a wettable formulation, is a preventative treatment. Various application rates are used but 20 lb/A is commonly used for rust management (CDPR, 1997). Do not apply within 3 weeks of an oil application.

Tebuconazole, Propiconazole, Myclobutanil, and Abound have been shown to be effective.

Cultural control:

Practices have not been developed, however, disease is most severe in lowland areas and high density orchards with poor air-circulation and long wetness periods from dew or rain (UC IPM Guidelines).

***Shot hole*:**

Lesions on twigs develop as purplish spots that expand and turn brown with a tannish center. Spores develop in the center of the lesion. Infected buds are dark brown to black and sometimes covered with gummy exudate. Leaf and fruit infections are circular. On leaves the lesions are chlorotic and commonly abscise. On fruit, lesions are corky and raised (UC IPM Guidelines).

Controls:

Copper: Applied to 89% of the acres by ground at various application rates depending on the product (CDPR, 1997). Copper is applied as a dormant application in late November and early December.

Chlorothalonil: Applied to 32% of the acres by ground at an average rate of 2.5 lbs. a.i. per acre (CDPR, 1997). Chlorothalonil is applied as a dormant spray in late November or early December. It is also effective in protecting leaves and immature fruit with spring applications (Teviotdale, 1997).

Captan: Applied to 9% of the acres by ground or air at an average rate of 2.9 lbs. a.i. per acre with a typical 30+ days PHI with a labeled PHI of 0 days (CDPR, 1997). This is mostly used during bloom. Do not apply in combination with, immediately before, or closely following oil sprays. It is also effective in protecting leaves and immature fruit with spring applications (Teviotdale, 1997).

Iprodione: Applied to 59% of the acres by ground or air at an average rate of 0.75 lb. a.i. per acre with a typical 7 day PHI which is the labeled PHI (CDPR, 1997). Addition of a narrow range oil at 1-2% increases the effectiveness of this material. Label changes made in 1998 do not allow preharvest applications on nectarine. Thus, the fungicide is restricted to only blossom and petal fall applications. It is also effective in protecting leaves and immature fruit with spring applications (Teviotdale, 1997).

Ziram: Applied to 49% of the acres mostly by ground at an average rate of 6 lbs. a.i. per acre with a minimum 30-day PHI (CDPR, 1997). It is effective in protecting leaves and immature fruit with spring applications.

***Crown gall*:**

Description:

Is caused by the bacterial pathogen *Agrobacterium tumefaciens*. Galls commonly occur on roots, crowns, and stems. Smooth, young galls enlarge to become woody tumors with irregular surfaces. The disease can occur on nursery, young, or mature trees. Soil temperature of 22 C and moisture of 60% is most favorable for disease development. Soil fumigants are used in nursery operations but are not completely effective in managing the disease. Sodium hypochlorite is used to disinfect equipment used during planting by nursery and orchard operations (UC IPM Guidelines).

Biological Control:

Biological control using a strain of *A. radiobacter*, (e.g, Galltrol) is used during planting of trees at orchard sites (UC IPM Guidelines).

***Bacterial Canker (Pseudomonas syringae)*:**

An average of 2-5% of the clingstone canning and fresh market peach, plum and nectarine acres are treated for this disease. There are higher incidence of bacterial canker in sandy field and during cold wet winters. The colder the temperature the higher the incidence of this disease. Symptoms are most obvious in spring, and include limb dieback with rough cankers and amber colored gum. There may also be leaf spot and blast of young flowers and shoots. Frequently, trees sucker from near ground level; cankers do not extend below ground. *P. syringae* survives on plant surfaces, is spread by splashing rain, and is favored by high moisture and low temperatures in spring. Vigorous trees are less susceptible to bacterial canker, while young trees, 2 to 8 years old, are more affected. This disease if left uncontrolled will kill young trees. Dormant copper is used with some success (UC IPM Guidelines).

Controls:

Cultural control:

Delayed pruning may help. Lovell peach rootstock is usually more tolerant than others. In light, sandy soils and in some heavy soils, control has been achieved with preplant fumigation for nematodes. There is no known reliable chemical control for bacterial canker. Therefore, good practices that promote tree health and vigor may help deter bacterial canker. In addition, planting of trees in sandy soils may increase the overall risk of infection due to the link between this soil type, high ring nematode populations and increased incidence of the disease (McKenry, 1998).

Vertebrates

A number of vertebrate species may move into or live near stone fruit orchards. The potential for damage by vertebrates varies from region to region. Orchards located near rangeland, wooded areas or other uncultivated areas are more likely to be invaded or re-invaded by certain vertebrates, such as rodents. Predators, diseases and food sources all may influence vertebrate populations. Predators such as coyotes, foxes, snakes, hawks and owls feed on rodent and rabbit species. However, growers cannot rely on predators to prevent rodents from becoming agricultural pests (Strand et al., 1999).

Pocket Gophers:

Description:

Pocket gophers and ground squirrels are important vertebrate pests. They gnaw on root systems and girdle trees below the soil line. Their burrows run through the orchard, diverting water and contributing to soil erosion.

Controls:

Strychnine: Strychnine bait is applied at label rates to control rodents. Bating is by hand and is one of the most effective control mechanisms. Single dose baits can also be placed in traps and in burrows (Strand et al., 1999).

Biological Control:

Owl Boxes: Occasionally, owl boxes are set up in orchards to help control gophers.

Cultural Control:

Monitoring: Growers monitor for gophers by inspecting trees near the borders of the orchard where gophers may move in from adjacent fields (Strand et al., 1999).

Trapping: Trapping by hand from is the most effect control mechanism for small populations of rodents. Traps are placed in the main tunnel between two fresh mounds. Growers check the traps daily (Strand et al., 1999).

Habitat Reduction: Reducing natural shelters for animals will discourage populations from increasing and will therefore minimize damage. Piles of brush or wood can shelter rodents. Excessive weeds in or about tree rows provide food for pocket gophers.

Nematodes

Nematodes are microscopic roundworms that live in diverse habitats. Plant parasitic nematodes live in soil and plant tissues and feed on plants by puncturing and sucking the cell contents with a mouthpart called a stylet. Of the several genera of plant parasitic nematodes detected in California orchard soils, root knot, ring, lesion, and dagger nematodes are considered to be the most important (UC IPM Guidelines and McKenry, 1997).

Root knot nematode: This nematode is not a problem if Nemaguard rootstock is used. Feeding by root knot nematodes can impair root functions such as uptake of nutrients and water. Root knot nematodes have been implicated in nectarine disease complexes with fungi and bacteria; for example, *Meloidogyne javanica* has been reported to increase the incidence of crown gall on nectarine roots. Symptoms of root knot infestation are reduced vigor and yield, patches of unevenly sized trees, and characteristic galls on roots.

Ring nematode: Infestation impairs development and function of nectarine roots which reduces tree vigor and predisposes trees to bacterial canker.

Lesion nematodes: Penetrates roots and causes damage by feeding and migrating through the root tissues. Lesion nematode infestation reduce overall root presence and may cause reddish brown lesions on roots that later turn dark and ultimately black.

Dagger nematodes: Feed from outside the roots, but can reach the vascular tissues with their long stylet and are capable of reducing vigor and yield of trees. The main damage caused by the dagger nematode is that it vectors a strain of tomato ringspot virus that causes peach yellow bud mosaic which debilitates and can kill trees. Symptoms of dagger infestation include reduced growth and vigor.

Controls:

Methyl Bromide: Preplant application by ground at a rate of 300-600 lbs. a.i. per acre. Use the higher rates for fine textured soils. Methyl bromide fumigation kills 99% of all nematode species but populations will gradually begin to rebuild over a two year period. This period allows the tree time to develop a healthy root system that can ultimately withstand or tolerate some nematode damage when populations rebound (McKenry, 1998).

Metam Sodium: Preplant application. Applied to less than 1% of the acres at 300 lbs. per acre. Metam sodium can reduce populations of nematodes if applied properly, but it does not penetrate plant roots very well and it is very difficult to get 4-5 feet down from the surface. Before applying this material, thoroughly cultivate the area to be treated. After cultivation and about one week before treatment, pre-irrigate the field with 6-8 acre--inches of water. After treatment, do not plant for 30 days, or 60 days if soil is high in organic matter or cold (below 50 F) (McKenry, 1997).

Fenamiphos: Applied to 2% of the acres as a post-plant application at an average rate of 2.75 a.i. per acre with a typical PHI of 90+ days and a labeled PHI of 45 days. Make initial application in fall. All applications should include drip irrigation or low volume sprayer to move the material into the root zone. Low use due to costs and efficacy (McKenry, 1997).

Cultural control:

Before fumigating, remove old trunks and large roots brought to the surface by ripping and fallow or plant green manure cover crops for 1-2 years. In addition, planting nursery certified nematode free and nematode resistant rootstock, such as Nemaguard and Nemared, is also common. However, in sandy soils or in areas with a known history of bacterial canker, these alternative methods are less efficacious and stunted plant growth and reduced tree vigor may be evident (UC IPM Guidelines).

Post Harvest

Post-harvest management of brown rot, gray mold, and *Rhizopus* rot is dependent on integrated pest management programs for fresh market peaches, plums and nectarines only. Rapid cooling and cold temperature management during packing and shipping of fruit is a critical practice for shipping fruit to fresh markets. Sanitation practices are also an integral part of post-harvest handling of fruit. Fruit washes with neutral cleaners, chlorine or other sanitizing agents remove fungal spores from fruit surfaces and reduce the potential for contamination of other fruit. Sterilants are also used to clean equipment after fruit are processed to again reduce inoculum levels on the equipment and to prevent re-contamination of fruit. Sorting lines that remove injured or bruised fruit also reduce the potential of decay from spreading fruit to fruit in packed boxes. Fungicides for management of brown rot, gray mold, Rhizopus rot, and other decays are also effectively used by packers who use mechanical post-harvest packing equipment (e.g., a washer/waxer). Currently, dicloran (Allisan) is the only fungicide fully registered on fresh market stone fruit crops for management of decays caused by *Rhizopus stolonifer* and *Botrytis cinerea*. There are no current efficacious post-harvest fungicides for brown rot registered for use in fresh market peaches, plums and nectarines. Iprodione use is allowed in packing sheds which may still have inventory from before the voluntary inactivation of the registration of this material by the manufacturer. In 1997, a Section 24 C was obtained for thiophanate-methyl (Topsin-M) for management of brown rot and gray mold. Due to resistant populations of Monilinia species to benzimidazole fungicides, a Section 18 emergency registration was obtained for fludioxonil (Medallion 50WP) in the 1998 season, again in 1999. This a broad spectrum, reduced risk fungicide that is very effective at low rates (8 oz product/100 gal of water) in managing all the major post-harvest decay fungi of fresh market peaches, plums and nectarines. It is important to note early harvested varieties of fresh shipping stone fruit are less likely to develop post-harvest brown rot infections than varieties that are harvested later in the season due to lower inoculum levels (Adaskaveg, 1998).

Challenges to Implementing Change

By far the greatest barrier to implementing reduced risk practices is information dissemination and grower education. The fresh shipping stone fruit industry is working to be proactive in this arena by financing CTFA in publishing a quarterly research newsletter and annual research report, maintaining a website with a research page, and sponsoring several tree fruit research

days in conjunction with the University of California. The Cling Peach industry has a quarterly report of which a large portion is dedicated to reporting research projects. The Peach Association's website and monthly newsletter are also used to facilitate communication with growers.

Regulatory barriers also threaten the adoption of reduced risk alternatives. The prohibitive cost for chemical companies to research the efficacy and feasibility of "softer" pesticides can be an impediment to timely registration. Therefore, CTFA continues to fund USDA IR-4 and University of California research to facilitate data collection and reduce the monetary burden on those companies developing viable chemical alternatives and biological approaches.

In addition, technical challenges, such as pesticide resistance, continue to present problems for the cling canning peach and fresh shipping peach, nectarine and plum industry. There is increasing evidence to suggest San Jose Scale may be resistant to organophosphates (Grafton-Cardwell, 1999). Coupled with difficulties in obtaining appropriate tree coverage with dormant spray, some areas in Fresno and Tulare counties are experiencing problems in controlling this pest. This may lead to increased applications of organophosphates and carbamates in order for a grower to gain control over rising pest populations. San Jose Scale is unique in that a severe infestation can eventually cause the death of trees, even in young orchards (Rice, 1998). Therefore, this particular pest has the potential of causing tremendous economic damage if it is not managed. Dormant sprays in peaches are also used to kill overwintering Peach Twig Borer. There is also some indication of resistance in Peach Twig Borer to dormant sprays.

The use of a dormant diazinon spray presents water quality challenges. The California Department of Pesticide Regulation has called for a voluntary dormant spray reduction/alternatives to diazinon use on a statewide basis from the agricultural community to reduce the incidence of diazinon in California watersheds. The fresh shipping stone fruit industry is aware of the potential for regulatory intervention on this issue and is examining viable alternatives to organophosphate dormant spray. The cling peach industry has funded for two years a project to examine alternatives to reduce dormant sprays. However, there are no alternatives currently registered for use to control San Jose Scale, the primary pest targeted when using an organophosphate dormant spray.

The implementation of the Food Quality Protection Act will have a profound effect on pest management for growers of peaches, plums and nectarines. The most commonly used pesticides, namely organophosphates and carbamates, are Group 1 listed chemicals under the Act and were slated for reevaluation by August 1999. The industry expects to lose a portion of the chemicals currently registered for use and continues to fund research, through the California Tree Fruit Agreement (CTFA) and the California Cling Peach Growers Advisory Board, to have viable pest management alternatives in place.

Innovation

The clingstone canning and fresh market stone fruit industry is striving to bridge informational gaps in key pest management systems. In 1998, surveys were sent out by CTFA and CCPB to glean information from clingstone canning and fresh market peach, plum and nectarine growers regarding key pest management needs and research gaps. The survey was a direct result of

the partnership formed by the CCPB and CTFA to complete the 1998 Pest Management Evaluation in which systems clearly in need of further study were highlighted. Specifically, the focus of the survey was SJS, PTB, OFM and thrips management practices and evaluating the adoption of reduced risk practices. The data was analyzed to determine areas of potential concern, such as pesticide resistance, and was used by both the CCPB and CTFA Research Subcommittees when evaluating projects for recommendation of funding for the 2000 research season.

Moreover, the CCPB and CTFA have formed another partnership as a result of the 1998 Pest Management Evaluation. In an effort to reduce pesticide risk, for clingstone canning and fresh market peach, plum and nectarine growers throughout the state of California, and with funds from the California Department of Pesticide Regulation (DPR) under a Demonstration and Pest Management Alliance Grant, the CCPB and CTFA is evaluating and disseminating information on sustainable pest management practices for SJS, PTB OFM and thrips. Conventional use of organophosphates (OPs) and carbamates to control these pests account for approximately 80% of pesticide applications in stone fruit orchards annually. The partnership seeks to develop a comprehensive pest management program to reduce or eliminate the need for the use of OPs and carbamates to control these pests. The objectives are to 1) test the efficacy of new reduced risk insecticides and oils, including insect growth regulators, to abate the application of OPs for either dormant or in-season control, 2) survey and identify endemic/commercial parasite strains and develop a biological control augmentation program for controlling SJS, 3) promote increased use of pheromone mating disruption for PTB and OFM through a comprehensive evaluation of recommended application rates for commercially available products, thus reducing system failure.

The cling peach and fresh shipping stone fruit industry subsidizes research, through CCPB and CTFA, to examine and implement reduced risk pest management practices. Long term projects to screen new rootstocks for resistance to Bacterial Canker and nematodes is ongoing with research field trials. In addition, work continues on examining alternatives to the use of methyl bromide as a preplant fumigant for controlling nematodes. Currently, a Vapam plus Telone drench has been identified as an economic and suitable nematode control replacement for methyl bromide. However, this treatment is currently not registered for use and commercial field trials have yet to be completed.

Reduced risk fungicides and biological control in the orchard continue to be a priority for the industry as is reflected in the research efforts of CTFA. *Trichoderma* and yeast were examined for efficacy against latent brown rot infection in 1999. Early detection models were evaluated using brown rot specific DNA primers and proved to predict potential infection before disease symptoms were evident. Residue work was completed for fludioxinil for this reduced risk fungicide and CTFA will seek a Section 18 registration for fresh shipping peaches, nectarines, and plums in 2000.

The cling peach industry for several years has been funding research on analyzing potential biochemical markers that appear to co-segregate with resistance to brown rot. This resistance is being incorporated into advanced experimental lines (Bostock, 1997). CCPB has funded research since 1995 on Peach Rust. One of the main focuses of this project is predicting the conducive environmental conditions of disease development and effective timing of spring applications of fungicides.

Finally, there is increasing grower implementation of reduced risk management strategies for the control of pathogens and pests in the clingstone canning and fresh market peach, plum and nectarine industry. Increasing costs, secondary pest outbreaks and potential loss of traditional chemicals for control has prompted growers to try alternative methods. Specifically, pheromone mating disruption to suppress lepidopteran larval populations has gained general acceptance and is used by growers. The installation of monitoring traps for SJS and lepidopteran species has maximized the effectiveness of those sprays that are necessary and decreased the incidence of unnecessary "routine calendar" insecticide sprays. Universal use of nematode resistant rootstock, such as Nemaguard and Nemared, has curtailed the need for methyl bromide fumigation. Growers are also sampling for nematode species complexes to determine if the need for pre-plant fumigation actually exists. Each of these common practices reduces pesticide risk by initiating an overall system change from habitual to minimal insecticide use.

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