A Pest Management Strategic Plan for Peach Production in California

The California Tree Fruit Agreement (CTFA)

The California Canning Peach Association (CCPA)

The California Minor Crops Council (CMCC)

The California Minor Crops Council received major funding for this project from the EPA Region 9 Agricultural Initiative and the USDA Cooperative States Research, Education, and Extension Service (CSREES) Pest Management Alternatives Program (PMAP). CMCC received additional support from the California Tree Fruit Agreement, the California Canning Peach Association and the California Pest Management Center at UC Davis. We gratefully acknowledge the contributions of all of these organizations and their participation in this process.

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EXECUTIVE SUMMARY

New safety standards set forth by the 1996 Food Quality Protection Act (FQPA) will impact certain crop protection tools used by the agricultural community. To help transition to "Reduced Risk" pest management, the USDA has requested that all commodities develop Pest Management Strategic Plans (PMSPs) to identify growers' critical research, registration, and educational needs. "Reduced Risk" broadly describes pest management techniques and tools that have low inherent toxicities and minimal impact on the environment. Pest management practices and products should be safe for both consumers and field workers, and crop protection tactics should have little or no impact on air, soil, or water quality.

In accordance with the goals of FQPA, California peach producers have reduced their use of organophosphate insecticides significantly over the last five years. The successful transition to reduced risk materials has been facilitated by collaborative efforts on the part of growers, PCAs, industry, processors, research, extension and agency personnel. Even with these improvements, however, it needs to be pointed out that major pest management challenges continue to exist for peach growers, and that certain pest situations will probably necessitate the use of chemical insecticides to protect the crop. Improved cultural practices, pheromones, and microbial insecticides (e.g., Bt) are widely used, but in general, there have been no major commercial developments in the area of biological control that have allowed our growers to move completely away from the use of chemicals for all pest categories.

For California peach production, the important pesticides methyl parathion and azinphos-methyl (Guthion®) are examples of products already cancelled or restricted due to FQPA safety standards. The loss of these and other valuable crop protection tools and the widespread reductions in funding for Land Grant University research and extension programs require that all resources be used in the most efficient manner possible to address industry priorities.

This strategic plan includes an overview of peach production, seasonal pest occurrences, and integrated pest management techniques throughout California for fresh market and processing varieties. This plan addresses both current and emerging pest management needs; it is a working document and will need to be updated periodically. Efficacy ratings of various pest control techniques (chemical and non-chemical) used in peach production have been summarized from input made by growers, pest control advisors, and other experts involved in field activities. It should be noted that the mention of specific trade names in this document is not an endorsement of any particular product.

This strategic plan will receive periodic updates and serves principally as a guideline to direct future pest management efforts related to California peach production. Important documents that provide a basis for this strategic plan are UC Publication 3389 (*Integrated Pest Management for Stone Fruit*) and the *Crop Profile for California Peaches* which can be found at http://pestdata.ncsu.edu/cropprofiles. They provide a complete review of cultural and pest management practices for California peaches.

A list of industry experts (growers, pest control advisors, industry representatives, and university research and extension personnel) is included in this document to serve as a reference for those needing more detailed information regarding California peach production.

Stakeholder Recommendations

As a result of the PMSP planning meeting held in September 2002 and revisions to this document in 2003, the Peach Work Group identified the following research, regulatory, and educational priorities. These critical areas were presented by various segments of the peach industry in California.

Research Priorities

Finding effective solutions to insect and disease control is the most immediate and serious concern of peach growers in California. Alternatives to using organophosphate insecticides and methyl bromide are extremely important to the continued development of integrated pest management systems. Risk mitigation measures to reduce human and environmental exposure to pesticides should be developed. Advanced application technologies for new products should be a focus of agricultural engineering research. The university research and extension programs will remain critical to identifying and adopting new technologies for pest management in California peach production.

- Develop new control methods for pre- and post-harvest disease control
- Develop methyl bromide alternatives for quarantine treatments
- Develop methyl bromide alternatives for peach nursery and pre-plant treatments
- Develop alternatives to oils for insect and mite control
- Develop best management practices (BMPs) and mitigation measures for environmental issues
- Assess economic and environmental costs of all pest management tools
- Improve application technology, especially for newer materials
- Maintain or enhance university research programs for IPM
- Provide access to research funding directly through commodity organizations (CTFA, CCPA, etc.) in addition to continued support of the Land Grant University system for research and extension activities
- Develop disease resistant rootstocks

Regulatory Priorities

The peach industry needs new products registered to replace organophosphate, carbamate, and oil insecticides. A prescriptive-use system for certain organophosphates and other insecticides should be developed for these tools to remain available to growers in critical need situations. Harmonization between Cal/EPA and US-EPA should be encouraged to facilitate timely registration of reduced risk products. In addition, all registrants should ensure that all new product registrations are in compliance with provisions of NAFTA, Codex, and all importing countries.

- Harmonize the Cal/EPA and US EPA review process to hasten new product registrations
- Retain key products which are complementary to current IPM tactics and which address resistance management concerns
- Establish prescriptive uses for certain key pest management tools (e.g., organophosphates, carbamates, etc.) to complement IPM tactics and to serve as backup products in critical pest management situations
- Register organophosphate and carbamate alternatives as soon as possible; utilize the IR-4 priority system for research on reduced risk materials
- Develop best management practices (BMPs) and environmental mitigation measures to address air and water quality concerns and other issues related to natural resources management
- Identify potential trade irritants as early as possible in the research and registration process; ensure there are no conflicts with provisions of NAFTA or Codex

Educational Priorities

The public, including regulators and consumer groups, must be educated about the use of Integrated Pest Management (IPM) in California peach production and how this system optimizes food production while minimizing risks to workers and the environment. Growers need to be educated on new materials and the most efficient manner in which these can be applied. University programs in the areas of research and education, particularly agricultural engineering, should be enhanced to provide adequate technology transfer of reduced risk pest management practices. Finally, the public should be reminded that eating California peaches is an important part of a healthy lifestyle and that this produce is grown under the highest standards of safety and quality in the world.

- Conduct resistance management training for all pest categories
- Educate the regulatory community on the need for all pest management tools including traditional organophosphate pesticides, which are a critical component of a reduced risk pest management program
- Educate applicators/growers on safe and efficient application techniques
- Educate growers, PCAs, and commodity members on the use of best management practices (BMPs)to protect and improve water and soil quality
- Educate the public on the nutritional values of California grown peaches and their high level of food safety and quality

The California peach industry appreciates the support of EPA, USDA, CDPR, and the University of California Land Grant system throughout the development of this strategic plan. We look forward to the valuable assistance provided by these agencies and institutions as we develop solutions for the many issues facing the California peach industry.

The California Minor Crops Council received major funding for this project from the EPA Region 9 Agricultural Initiative, and the USDA Cooperative States Research, Education, and Extension Service (CSREES) Pest Management Alternatives Program (PMAP). CMCC received additional support from the California Tree Fruit Agreement, the California Canning Peach Association, and the California Pest Management Center at UC Davis. We gratefully acknowledge the contributions of all of these organizations and their participation in this process.

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August 2003

A PEST MANAGEMENT STRATEGIC PLAN FOR CALIFORNIA PEACHES

1. CALIFORNIA PEACH PRODUCTION OVERVIEW

Peaches are grown throughout the world. The leading peach-growing countries in order of production are China, the United States, Italy, and Greece. Peaches are the third most extensively grown temperate fruit in North America, after grapes and apples. Most of the U.S. production occurs on the west coast in California, and on the east coast from New Jersey to Florida. Ontario leads the Canadian provinces in peach production, producing about 85 percent of Canada's total crop.

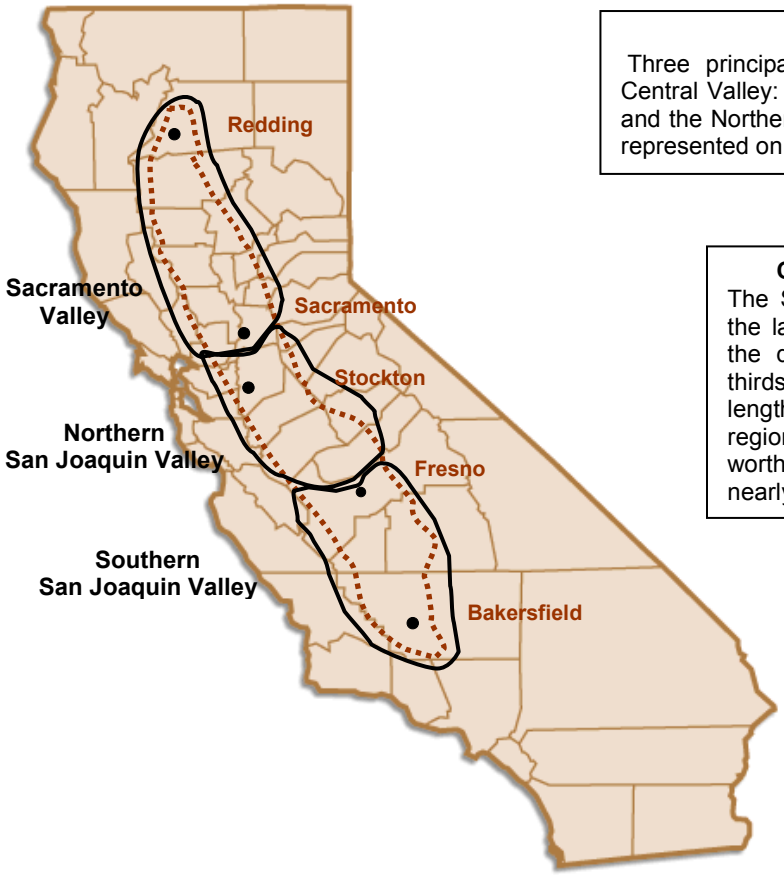
The top three states in peach production are California, South Carolina, and Georgia. About three-fourths of the peaches grown in the United States are grown in California. Clingstone cultivars make up about two-thirds of California's peach crop. While California's rate of production varies little, weather conditions affect production in other peach-growing states.

For 2001, USDA data show that the United States had 152,000 acres of peach trees in production and the peach crop was valued at nearly $496 million.

- California growers produced about 70% of US peaches
- California peach production totaled 894,032 tons on approximately 71,000 acres, with an average yield of 13.3 tons/acre
- Approximately 45% of California peaches are sold in the fresh market and 55% are used by the processing industry
- Although most California peaches are consumed in domestic markets, about 22% of the fresh crop is exported, mainly to Mexico, Taiwan, Columbia, and the U.K.
- California's peach industry has reduced its use of organophosphate (OP) insecticides by over 50% since the late 1990s
- Major alternatives to OP use have included the use of pheromones, insect growth regulators, and reduced risk pesticides
- California peach producers face major transition issues to achieve reduced risk pest management including
    - Availability of efficient and economical pest management tools
    - Methyl bromide alternatives
    - Timely registration of new materials
    - Consistently effective biological control methods
    - Technology transfer
    - Trade irritants

The main peach production areas in California are shown below in Figure 1. Appendix 2 contains seasonal profiles of peach crop development, cultural practices, and pest management activities.

Fig. 1: Peach Production Regions in California



The Peach Industry

Three principal growing regions exist within the Central Valley: the Sacramento Valley in the north, and the Northern and Southern San Joaquin Valley, represented on the map by solid black lines.

California's San Joaquin Valley

The San Joaquin Valley (SJV) is part of the larger Central Valley (represented by the dotted line). The SJV covers two-thirds of the Central Valley's 450-mile length and 50-mile width. This particular region produces over 250 different crops worth more than $14 billion annually; nearly six million people live in this area.

Differences in the Major Peach Production Areas of California

Characteristics	S. San Joaquin Valley	N. San Joaquin Valley	Sacramento Valley
Soil types	Sand/Loam/Clay	Sandy loam/ Loamy sand	Loamy clay
Bloom period	Feb. – Mar.	Late Feb. – March	Late Feb. – March
Dormancy (length)	Shortest	Longer	Longest
Annual rainfall	6 – 9”	10 – 13”	18 – 20”
Temperatures	Higher maximums	Moderate	Higher maximums
Chilling hours required*	700 – 900	700 – 1200	700 - 1100

*The amount of cold needed by a plant to resume normal spring growth following the winter period is commonly referred to as its "chilling requirement." Plant species and varieties vary widely in their winter cold requirement.

Peach Varieties in California

Fresh Market Peaches

- Freestone – those peaches which have flesh easily and completely separated from the stone or pit. Freestone peaches are distributed throughout the season, from early to late. The early varieties which mature prior to mid-June tend to be semi-freestone, meaning the pit will cling until the fruit is "dead ripe"
- Approximately 200-250 varieties of fresh market peach are produced in California. About 75 of these comprise over 90% of the volume shipped
- 6-8% of the fresh market peach acreage is replanted each year to new varieties to keep up with consumer demands and changing tastes
- Newly planted trees reach minor production in about two years and full production about 5-6 years after planting
- Recently, white fleshed peach varieties have increased to about 20% of all peaches, and "subacid" varieties are increasing significantly. Subacid peaches have a low acid concentration
- Almost 95% of the fresh market varieties have been bred by private breeders. There have been a small number of releases from the USDA-ARS; UC is not involved in fresh market peach breeding

Processing Peaches

- Clingstone – those peaches in which the flesh is not easily separated from the stone or pit. Clingstone peaches have a firmer flesh that makes them ideal for processing and storage
- More than 80 varieties are grown in California with 15 varieties making up more than 80% of the volume used by the industry
- Compared to fresh market varieties, there is much less orchard rotation; a cling orchard will stay in production for 15-20 years
- Recently, varieties are being bred for earlier and later ripening to expand the regions and seasons of production
- Most clingstone varieties are produced through the UC program with two new varieties being released in the last 20 years

Harvest Timing in Fresh Market vs. Cling Peach Varieties

Fresh Market Peaches	Cling Peaches
April through October	July through mid-September

Stages and Approximate Length of Time for California Peach Development *

Dormancy	Bloom	Fruit Development	Harvest	Storage
~3 mo.	3-4 wks.	45-180 days	7-20 days	14-28 days

* Extremely variable according to variety, location, and season

Pests in California Peach Production: Overview of Key Organisms

The following section lists the most important pests of peaches that will be the main issues dealt with throughout the strategic plan. For more detailed information on these and other pests of peaches, the reader is directed to the *Crop Profile for California Peaches* at website http://pestdata.ncsu.edu/cropprofiles/docs/capeaches.html (January 1999), and UC Publication 3389, *Integrated Pest Management for Stone Fruit*, 2002.

Chemical pest management products as well as biological and cultural pest management tools will be mentioned throughout this portion of the strategic plan; to find information on specific chemicals, please refer to Appendices 4-9 which include a complete listing of all products by their chemical name and trade name.

Insects

In recent years, **major shifts in insect problems** in terms of species causing economic damage have been observed. This is in great part explained by the shift away from organophosphate insecticides to reduced risk materials that typically have a narrower spectrum of activity. Pests which were formerly considered occasional or secondary pests, such as katydids, oblique-banded leaf roller (OBLR), and others, are now of increasing importance in integrated pest management programs. Several of these species will be mentioned throughout the strategic plan.

San Jose scale (SJS) is a pest that causes some economic loss each year. Damage may be done directly to fruit (cosmetic) and under high population densities, scale infestations can cause limbs and branches to die back, thus causing permanent injury to the trees. A variety of insecticides is used for this key pest; oils are often used with or in place of insecticides at various times throughout the year (e.g., in season, during dormancy, etc.) to reduce scale populations. Biological control for SJS is not commercially available.

Oriental fruit moth (OFM) in the larval stage causes direct damage to the developing fruit. This pest is troublesome because it has several generations per year. Insecticides and mating disruption pheromones are used to reduce damage from Oriental fruit moth.

Peach twig borer (PTB) can be a pest to both fruit and branches and may cause severe losses to peaches. Shoot damage is a problem only on young trees. Some biological control of PTB is available; however, the 30+ species of PTB parasites do not significantly reduce PTB infestations in trees before damage has occurred. Microbial insecticides (Bts) are widely used for PTB and are often part of an overall IPM program which includes dormant sprays. Several insecticides are used for PTB, although among these are organophosphates that may not be available in the future. Tebufenozide (Confirm®) and spinosed (Success®) provide good control.

Omnivorous leaf roller (OLR) has become a more important pest of peaches in recent years causing damage by feeding on the foliage and the fruit. Fruit feeding can also lead to secondary problems with brown rot organisms, leading to complete loss of fruit.

Spider mites can cause severe problems in peaches by leaf feeding, which can ultimately lead to leaf shed and poor fruit sizing. In addition to yield loss, loss of leaves due to spider mite feeding can lead to sunburn of peach trees. There are several species of mites found in peaches: **two-spotted, Pacific,** and **European red mites**. Predators are extremely important sources of biological control of spider mites, but are often adversely affected by materials used for the control of other pests. Insecticidal soaps are used with moderate success; oils and miticides can effectively control mite populations.

Diseases

Brown rot, the most common and devastating fungal disease of peaches, is caused by two airborne fungi. Development of this disease is dependent upon wind, moisture, and temperatures. Blossoms, fruit, and twigs may be impacted by this disease. Orchard sanitation to remove or bury mummies (old, diseased fruit) may help reduce inoculum. Fungicides are used to reduce losses due to brown rot.

Jacket rot and **green fruit rot** are caused by a complex of fungi including *Monilinia*, *Botrytis*, and *Sclerotinia*. Applications of fungicides during early bloom and full bloom assist in managing losses to these diseases.

Root diseases such as ***Phytophthora* root rot** and ***Armillaria* root rot** can be a problem in areas prone to wetness for a long period of time**.** Proper planting, good drainage, and short irrigations help limit losses to root diseases.

Peach leaf curl must be managed every year.

Powdery mildew is favored by cool, moist nights and warm day time temperatures; the disease weakens the tree and reduces yields. Fertilizer management and removal of alternate hosts help to reduce losses to powdery mildew and several fungicides are used as preventative controls of this disease.

***Verticillium* wilt** is caused by a soil-borne fungus; the disease, although rare, is most severe in young orchards planted where *Verticillium* wilt susceptible crops, such as tomato or cotton, were previously grown.

Weeds

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 somewhat reduced. The spectrum of weeds within an established orchard varies throughout the year. A complex of **annual grasses**, **broadleaves**, and **perennial weeds** is the target of all weed control programs. Certain weeds such as **flaxleaf fleabane** have become particularly troublesome in recent years and are difficult to control with currently available herbicides. The reduced availability of methyl bromide as a pre-plant fumigant will also lead to changes in the weed spectrum in orchards and management techniques will have to evolve over the next several years to make up for the loss of this effective product.

In a typical season, pre-emergence herbicides are applied in the fall following harvest and then contact herbicides are used as needed throughout the growing season. Cultivating with a tractor and hand weeding are also used as weed control techniques. In recent years, more attention has been given to cover crop management in terms of species selection and suitability for use in orchard systems; this practice has reduced the number of applications of herbicides to California peach orchards.

Nematodes

Three major species of nematodes are found in peaches: **root knot, ring,** and **lesion nematodes**, although **root knot nematodes** are not considered a problem if nematode-resistant rootstock is used. Plant parasitic nematodes move from the soil environment onto the root tissues and feed by puncturing the roots and sucking the cell contents of the roots. Nematode damage interferes with nutrient and water uptake and certain diseases may be vectored by nematodes. Soil conditions and application procedures determine efficacy of nematicides, which may be quite variable. The loss of methyl bromide and restrictions on other fumigants present significant concerns for plant health and nematode management in peaches. For new orchards, the use of certified nematode-free and nematode-resistant rootstocks will be increasingly important.

Vertebrates

Rodents and other vertebrates can cause significant damage to peach trees themselves, or may interfere with irrigation and other cultural activities. **Rabbits, voles, gophers, squirrels,** and **deer** are the most troublesome species and **birds** are pests which impact established orchards. Sites which are adjacent to unmanaged ground or pastures will harbor more vertebrate pests, but monitoring and implementing control actions may discourage the buildup of populations within orchards. Control tactics for vertebrate pests include the use of barriers, traps, frightening tactics, and lethal control. Care must be taken not to violate any endangered species restrictions in specific areas.

The pests that cause the most significant losses to California peach growers are listed below.

	S. San Joaquin Valley	N. San Joaquin Valley	Sacramento Valley
Insects*	SJS, OFM, PTB, OLR, katydids, mites	SJS, OFM, PTB, OLR, mites	SJS, OFM, PTB, OBLR, mites
Diseases	Brown rot, Leaf curl, *Phytophthora*, Oak root fungus	Brown rot, Leaf curl Shot hole, Powdery mildew, *Phytophthora*, Oak root fungus, Canker	Brown rot, Leaf curl, Powdery mildew Oak root fungus
Weeds**	Fleabane	Fleabane	Johnsongrass
Nematodes	Root knot, ring, lesion	Root knot, ring, lesion	NA

* SJS = San Jose Scale, OFM = Oriental Fruit Moth, PTB = Peach Twig Borer
OLR = Omnivorous Leaf Roller, OBLR = Oblique-banded Leaf Roller
** Note: The species listed are the most difficult to control. Currently used cultural practices and herbicides provide commercial control of all other weeds

Pest Management Issues in Fresh Market vs. Processed Peach Varieties

PESTS	Fresh Peaches	Processing Peaches ("Clings")
Scales	Major issue	Minor issue; some cosmetic damage tolerated since the skin is removed during processing
Worms	No worm damage tolerated	Minor issue; some cosmetic worm damage tolerated since the skin is removed during processing
Mildew	No mildew is acceptable	Minor issue; some cosmetic mildew damage tolerated since the skin is removed during processing

2. PEST MANAGEMENT FOR NEW PEACH ORCHARDS

Selecting the proper orchard site and ensuring that young trees are well established will impact productivity over the lifetime of the orchard. Reviewing site history, including previous crops, neighboring crops, cultural practices, pesticide use, and soil conditions, will assist the grower in deciding on optimal sites for new orchards. Once a site has been selected, appropriate insect, weed, nematode, and disease control measures need to be considered. Precautions must also be taken to prevent damage to young trees by vertebrate pests.

Of great importance is the selection of well-adapted varieties for all production areas and conditions. In addition, selection of appropriate rootstock and use of certified planting stock will help the grower avoid specific disease and nematode problems.

Cultural Activities

- Mechanical cultivation – ground preparation
- Fumigation – on about 50-60% of the ground to be used for new plantings, but this is rapidly declining
- Planting
- Trunk painting (white-washing) and wrapping
- Pruning – first year in the spring; then annually in the winter and summer
- Irrigation – furrow and flooding is the most common type of irrigation

INSECTS

In non-bearing orchards fruit does not need to be protected; therefore, fewer in-season sprays are used on young trees than on producing trees. Mites can be serious problems on young trees and miticides such as Agrimek®, Omite®, Vendex®, or Nexter® may be used. Peach twig borer treatments include Bts, pyrethroids, spinosad, Sevin®, and organophosphates. Western flathead borer is controlled by white-washing the tree trunks. Grasshoppers and Lygus bugs are considered occasional pests in young orchards. These occasional pests are controlled by methomyl and spinosad.

Work Group Recommendations for Insect Management in New Orchards

Research	• Develop economic thresholds for mites • Evaluate efficacy and cost effectiveness of using pheromones in non-bearing orchards
Regulatory	• Register miticides for non-bearing orchards
Educations	• No recommendations at this time

WEEDS

Weeds can be highly competitive with young orchards and care should be taken to manage populations. While most orchards were fumigated in the past, increasing numbers of new plantings will need to rely on new techniques to provide control of weeds and other soil-borne pests. Methyl bromide has provided excellent broad spectrum control of these pests, including weeds, but the only currently available alternatives, Vapam® and Telone®, are limited in weed control spectrum. In addition each has separate regulatory issues. Vapam® is more difficult to use and requires consistent soil moisture conditions to have optimal efficacy. Telone® can provide good weed control; however, local caps on the usage of this material due to air quality concerns limit the availability of this tool.

While several herbicides are registered for non-bearing orchards, no one product will control all species. Prowl® and Surflan® provide good control of grasses, but do not control many key broadleaf weed species. Surflan® also has been reported in recent years to be available only in limited supplies due to production issues. Goal® is a very good broadleaf material, but is expensive and does not control grasses. Paraquat is a good burn-down material but lacks residual control.

The following weeds are of concern in young peach orchards in California:

• Annual bluegrass	• Curly dock	• Mallow
• Annual grasses	• Filaree	• Mustards
• Bermuda grass	• Fleabane	• Nutsedge
• Bindweed	• Johnsongrass	• Purslane

Work Group Recommendations for Weed Management in New Orchards

Research	• Evaluate new pre-emergence herbicides • Develop methyl bromide alternatives for fumigation • Develop “seed bank” based herbicide recommendations • Develop new sprayer technology (precision ag, etc.) to improve herbicide placement and efficacy
Regulatory	• Develop township cap relief for Telone® and increase label rates for efficacy • Develop restriction relief /buffer zones for Vapam® • Encourage and facilitate registration of methyl bromide alternatives
Education	• Educate growers on proper application conditions and restrictions for Vapam® and Telone® • Educate growers and PCAs on new sprayer and application technologies which are commercially available

DISEASES

There are several diseases for which management begins during orchard establishment. Care must be taken at this point in the life of the peach trees. Disease at this stage will impact long-term commercial productivity.

Site selection and preparation for planting including the planting design (e.g., square, diamond, etc.), planting density, or planting height (e.g., use of berms) will determine microclimate conditions during the life-span of the orchard. Major diseases to consider during this stage include: *Phytophthora* root rot, *Armillaria* root rot (oak root rot) *Verticillium* wilt, bacterial canker, and crown gall. Many of these diseases can be managed by fumigation and proper site selection following non-host rotation crops or fallow fields. Replacements for methyl bromide are needed and include iodomethane, propargyl bromide, sodium tetrathiocarbonate, and metam sodium.

Alliete® and Ridomil® provide fair to good control of *Phytophthora* root rot and crown rot dependent upon disease pressure. Planting on berms and insuring proper soil conditions at planting where *Phytophthora* is a concern will aid in reducing this disease. Root stock selection is also an important consideration for reducing disease loss to these pests.

Enzone® may provide only poor to fair control of oak root fungus (*Armillaria*). Bacterial canker is managed by selecting proper root stock and controlling ring nematodes. Delaying pruning until after flowering in the northern and central San Joaquin Valley may help reduce incidence of canker. Proper irrigation and fertilization will enhance tree vigor and help to reduce the onset of several diseases in young trees.

A complex of viruses can infect young trees. The best way to avoid this complex of diseases is to use certified nursery stock. This is especially important for processing (cling) varieties. Replant disease has traditionally been avoided by using methyl bromide fumigations. Leaving ground fallow also reduces this problem; however, this is obviously not an economic option for most growers.

Work Group Recommendations for Disease Management in New Orchards

Research	• Develop techniques or products to manage the replant problem • Evaluate new methods of nematode control • Develop disease resistant root stock • Evaluate microbial antagonists and other biological products • Evaluate systemic alternatives
Regulatory	• Register new nematicides as soon as possible due to impending loss of methyl bromide
Education	• No recommendations at this time

NEMATODES

Plant parasitic nematodes move from the soil environment onto the root tissues and feed by puncturing the roots and sucking the cell contents. Nematode damage interferes with nutrient and water uptake and nematodes may vector certain diseases. Soil conditions and application procedures determine the efficacy of nematicides, which may be quite variable. The loss of methyl bromide as a fumigant for new orchards presents significant concerns for plant health and nematode management in peaches. Township caps on the use of Telone® are also a concern and must incorporated into pest management decisions.

Three major species of nematodes are important in peaches: root knot, ring, and lesion nematodes. Besides maintaining good tree vigor with proper irrigation and fertilization, two nematicides are effective controls. Nemacur® provides good to excellent control when used in low volume irrigation systems, but the use of this product is being phased out in 2005. Enzone® provides poor to fair control and is most effective when used with drip irrigation systems.

Work Group Recommendations for Nematode Management in New Orchards

Research	• Evaluate DiTera® and other nematicides for nematode control • Develop nematode resistant root stocks • Develop new nematicides (chemical and biological)
Regulatory	• Closer coordination between CDPR and US EPA • Educate regulators on benefits of chemical pre-plant pest management and the role these chemicals play in IPM, and reduction of the overall pesticide load in the environment
Education	• No recommendations at this time

VERTEBRATE PESTS

Rodents and other vertebrates can cause significant damage to young trees themselves, or may interfere with irrigation and other cultural activities. Rabbits, voles, gophers, squirrels, and deer are the most troublesome species, and birds are pests in established orchards. Sites adjacent to unmanaged ground or pastures will harbor more vertebrate pests, but monitoring and implementing control actions may discourage the buildup of populations within orchards. Control tactics for vertebrate pests include the use of barriers, traps, frightening tactics, and lethal control. Care must be taken to not violate any endangered species restrictions in specific geographies.

Damage from rabbits and voles can be managed using trunk protectors. Weed management can also reduce habitat for voles and reduce damage potential from this pest. Squirrel populations can be managed with traps or with lethal control including explosive devices, anticoagulant baits, and aluminum phosphide. Tools to manage gophers include flood irrigation to disrupt and collapse tunnels and strychnine for lethal control. Owl boxes are often placed near orchards to encourage nesting by owls which will serve as predators of vertebrate pests. Deer and coyotes can be controlled using lethal measures, including the use of guns.

Work Group Recommendations for Vertebrate Pest Management in New Orchards

Research	• Develop new management tools for squirrels • Evaluate efficacy of propane/oxygen blasting devices • Evaluate effectiveness of owl boxes
Regulatory	• Work with CDFA to register and develop distribution systems for vertebrate controls (as in the past)
Education	• Provide new product and technique training for growers and PCAs on an annual basis

3. PEST MANAGEMENT FOR ESTABLISHED PEACH ORCHARDS

FALL

(After harvest – may be from September through November)

Cultural Activities

• Pruning	• Irrigation
• Nematode Control	• Mowing and middles management
• Tree Removal	• Planting cover crops
• Fertilizing/adding micronutrients post-harvest	• Weed control

INSECTS

San Jose scale is the major insect of interest in the fall, particularly for late-harvested varieties. Oil provides fair to good control of this scale, and the addition of organophosphates and carbamates increases scale control. Spur sampling is an aid for predicting scale populations.

Various lepidopterous pests, including OFM, PTB, and fall webworm, can occasionally be found in damaging numbers; there is a lack of products labeled for pests occurring in the fall.

Work Group Recommendations for Insect Management in Fall

Research	• Establish biological parasite for OFM • Develop spur sampling techniques and economic thresholds for SJS • Extend mating disruption for OFM • TMDL (total maximum daily load) management
Regulatory	• Relax restriction on diazinon applications because the fruit is gone and there are few, if any, residues or worker issues
Education	• Provide training on the use of mating disruption techniques and potential problems for late season varieties and for OFM control

WEEDS

Most fall activities attempt to control weeds before the cold winter months. Orchard floor management helps to control frost damage in winter and spring. Winter annual weeds are generally not as troublesome as summer and perennial weeds. Cultivation, chemical mowing, and pre-emergence herbicides are the most extensively used tools for weed management during the fall. The following weeds are of most concern in peach orchards in California:

• Annual bluegrass	• Filaree	• Mustards
• Annual grasses	• Fleabane	• Nutsedge
• Bermuda grass	• Johnsongrass	• Puncturevine
• Bindweed	• Lambsquarter	• Purslane
• Curly dock	• Mallow	

Work Group Recommendations for Weed Management in Fall

Research	• Evaluate new pre-emergence herbicides • Evaluate new chemistries for fleabane control • Find Simazine® replacement material • Evaluate FMC Corporation's Shark® (carfentrazone ethyl) followed by Roundup® for bindweed control • Develop methyl bromide alternatives for fumigation • Coordinate research efforts of UC researchers, ARS, CSU, registrants, and commodity groups so that efforts are not duplicated
Regulatory	• Gramoxone® (paraquat dichloride) re-entry restrictions are inconsistent – need to shorten pre-harvest intervals (PHIs) • Develop township cap relief for Telone® and increase label rates for efficacy • Develop restriction relief /buffer zones for Vapam® • Register Simazine® replacement material • Request registrants make PHIs more consistent throughout stonefruit commodities • Increase Gramoxone® applications allowed per year; currently have only 3 • Change REI on Gramoxone® so that it does not exceed 48 hours • Encourage and facilitate registration of methyl bromide alternatives • Register Visor® (thiazopyr) and Chateau®
Education	• Educate growers on proper application conditions and restrictions for Vapam® and Telone® • Increase awareness for monitoring and weed identification • Educate growers and PCAs on environmental awareness for air quality and TMDL runoff issues; provide training on mitigation techniques • Train on the proper timing of deep irrigation to manage weed cycles

DISEASES

Once a peach orchard has become established, a number of diseases will need to be managed during the fall and winter period. For help with diseases such as brown rot, “clean picking” or after-harvest fruit and mummy removal needs to be effectively practiced.

Phytophthora can be a problem in some years in orchards where flooding may occur. Problems with bacterial canker are reduced if trees are kept vigorous to avoid disease.

The potential of other diseases such as rust and powdery mildew to cause problems in the following spring and summer can be monitored during the fall season. For example, high levels of rust in the fall are indicative of high risk for rust in the following spring.

Work Group Recommendations for Disease Management in Fall

Research	• Evaluate sulfur and liquid lime sulfur for late fall powdery mildew control • Evaluate peach varieties for reduced susceptibility to shot hole • Evaluate rust control alternatives and timings • Test new materials for late fall diseases, particularly shot hole and leaf curl
Regulatory	• Emphasize the value of older chemistry in orchard disease management and IPM programs
Education	• Educate growers and PCAs on the value of older chemistry in IPM of diseases • Educate growers and PCAs on monitoring for rust, rust control alternatives, and timings • Provide training for growers and PCAs to increase awareness of the resistance problem and how it can be managed • Provide training on proper irrigation timings and techniques as tools for managing disease

WINTER

(Dormancy through bud break – approximately November through January or February)

During cool weather and shorter days of fall and winter, the trees are in a resting phase called dormancy. Buds must be exposed to a minimum amount of chilling in order to complete dormancy and achieve maximum bloom (i.e, chilling requirement) and this varies according to variety. Buds that formed the previous season continue to develop slowly even in the cold winter months.

Cultural Activities

• Pruning	• Replanting trees	• Irrigation
• Apply dormant sprays	• Tying trees	• Orchard floor management
• Mummy removal	• Vertebrate pest management	• Pest monitoring & trapping

INSECTS

Several pests are managed in part by means of control measures taken during the dormant season. Chemical and oil applications target over-wintering populations of several insects and mites. Almost all orchards receive at least one application of dormant spray during the fall or winter. Oils used with organophosphate insecticides have been highly effective in controlling pest populations of San Jose scale and several other insect and mite pests. Currently used OP products include chlorpyrifos, diazinon, and methidiathion. Non-OPs used during the dormant period include carbaryl, oils, pyrethroids, and pyriproxyfen. Due to product cancellation because of FQPA and concerns about orchard runoff, the use of OPs has been significantly reduced in recent years.

San Jose scale is the major insect controlled by applications in dormant peach orchards. Oil provides fair to good control and the addition of organophosphates provides excellent control at this time. The addition of carbamates to oil provides fair to excellent control. Esteem®, an insect growth regulator, provides excellent control of San Jose scale.

Peach twig borers (PTB) and omnivorous leaf rollers (OLR) are effectively controlled with a pyrethroid (Asana® or Pounce®) or an organophosphate with oil such as Imidan®, diazinon, Lorsban® or Supracide® with oil. Success®, a reduced risk product, provides good control of PTBs. Sevin® is occasionally used, but its performance is considered weak. Ants may provide some natural control of emerging twig borers at this time during the season.

Codling moth is not a major problem, but it is important to monitor for this pest and ensure that levels are kept down by removing abandoned host trees and removing un-harvested fruit from the trees. Organic growers may also use mating disruption at this time to reduce numbers.

Aphids can be effectively controlled by oils during the cooler months of the year. Efficacy of oils is reported to be excellent, except on aphid eggs. European red mites are also effectively controlled with oils.

Work Group Recommendations for Insect Management in Winter

Research	• Evaluate the oil/water ratio for optimal scale control • Evaluate and develop effective, economical alternatives that have a safer environmental spectrum • Evaluate cryolite as a dormant season application timing for PTB
Regulatory	• Check on the registration status of Applaud® • Maintain availability of diazinon for dormant applications
Education	• Continue grower education on alternatives to organophosphates, carbamates, and other reduced risk practices such as pheromones • Emphasize resistance management/alternating materials, especially for SJS • Provide training on the use of spur sampling as a tool in SJS management • Educate growers and PCAs on the need for leaf clean-up to control katydids • Provide training on pruning and the need to avoid pruning during excessively wet periods • Educate growers and PCAs on OP runoff issues and provide training on mitigation measures (TMDL) • Provide training on resistance management, especially for scale control

WEEDS

Orchard floor management helps to control frost damage in the winter and spring. Winter annual weeds are generally not as troublesome as summer and perennial weeds. Cultivation, chemical mowing, and pre-emergence herbicides are the most extensively used tools for weed management at this time. According to the weed spectrum present, the following herbicides are used: Roundup®, Princep®, Gramoxone®, Goal®, Solicam®, Surflan®, and napromamide. The work group recommendations for management of weeds during the winter are the same as those indicated for the fall season on page 16 above.

DISEASES

Winter disease management is similar to fall disease management, although practices are often delayed due to weather. Cultural practices such as sanitation continue to be important for diseases such as brown rot where “clean picking” or after-harvest fruit and mummy removal needs to be effectively practiced.

Phytophthora can be a problem in some years in orchards where flooding may occur.

The potential of other diseases such as rust and powdery mildew to cause problems in the following spring and summer can be monitored during the winter season. Pre-bloom applications of lime sulfur are very effective in controlling powdery mildew.

The work group recommendations for management of diseases during the winter are the same as those indicated for the fall season on page 17 above.

SPRING

(Bloom through jacket split - approximately January through March)

Jacket split is the period when the tiny developing fruit actually splits the calyx. The timing of this period is highly variable depending on weather, growing region, and variety. Check the seasonal cultural charts in Appendix 2 for general differences between the northern and southern production regions. During this specific time in the development of the crop, it is very important to protect the yield and quality of the very young fruit.

Cultural Activities

• Fungicide spray applications	• Apply mating disruption dispensers
• Roping trees	• Orchard floor management
• Planting replacement trees	• Some blossom thinning
• Trap placement and monitoring	• Irrigating
• Final pruning	• Monitoring of all orchard pests

Pollination: although bees are not required to set a peach crop, care must be taken to avoid disrupting bees and other pollinating insects during bloom. Caution must therefore be exercised when selecting and applying pesticides during this critical time. Several products are prohibited entirely during bloom, while others can be applied only at night to avoid foraging bees. Product application timings should be made accordingly and in compliance with local regulations concerning notification.

INSECTS

Applications of the microbial insecticide *Bacillus thuringiensis* (Bt) are used during bloom to control lepidopterous pests. One or two applications of Bt will help to keep over-wintering peach twig borer and other caterpillar pest levels below economic levels. The use of a selective material like Bt has a great advantage in that it is not disruptive to beneficial organisms. Monitoring peach orchards to determine when larvae are emerging and timing applications of Bt is critical to efficacy, since the material must be directly consumed to have a lethal effect. In addition, applications using ground-based sprayers will ensure coverage throughout the tree canopy.

Peach twig borer (PTB) and the oblique-banded leaf roller (OBLR) are very effectively controlled with Bt. Although there are many species of natural enemies of PTB, their activity is generally not effective in reducing PTB populations below economically damaging levels. Success®, a new reduced-risk insecticide, provides excellent control, but cost and resistance are issues. This product must be used at night because of bee toxicity. Diazinon and other OPs (e.g., Lorsban®, Supracide®, and Imidan®) and pyrethroids provide good to excellent control of PTB and OBLR, but these products cannot be used after petal fall and must also be used at night because of concern about bees. Pyrethroids can also cause mite flare-ups. Confirm®, an IGR, works very well for PTB control.

San Jose scale is generally managed at this time as a result of dormant applications made in the fall or winter. Oils in combination with an organophosphate insecticide (Lorsban®, diazinon, and Supracide®) are occasionally applied during this time period, but this is not common.

Oriental fruit moth (OFM) is treated at this time of year with pheromones to confuse the pest and disrupt mating. Products which are effective for this use include IsoMate® M-100, IsoMate® M-Rosso, and Checkmate®. Mating disruption is the only pest management option used for OFM during this season, but growers and PCAs have been reluctant in the past to use mating disruption due to the potential for secondary pest outbreaks. Insecticides used for OFM control are Lannate®, Imidan®, Asana®, Thiodan®, and Sevin®.

Spider mites need to be closely monitored at this time of year. Predators such as the Western predatory mite, six-spotted thrips, and the spider mite destroyer, *Stethorus picipes*, are very important in moderating mite populations. These beneficial organisms should be preserved as much as possible. Insecticidal soaps and oils are effectively used for mite control at this time of the year. Kelthane®, Agri-mek®, and Nexter® are effective in controlling motiles; Apollo® and Savey® are effective ovicides. Pyrethroids such as Asana® should be kept as a control option; however, it is widely recognized these products are highly disruptive to beneficials and may flare mite populations.

Thrips are only occasional pests of peaches and good to excellent control of this pest is achieved with Success®. Carzol® also provides good to excellent control of thrips; however, use of this product may flare mites and long re-entry interval prevents much use. Proper management of orchard floor vegetation is an effective means by which to provide some control of the movement of thrips into peach orchards.

True bugs, *Heteroptera* (Lygus, stink, and plant bugs), are an occasional problem; manipulation of cover crops is an important consideration in management of these pests. If true bug densities are high, clean cultivation or a weed free orchard floor may be needed to suppress Lygus bugs. Carzol® and Lannate® provide good control of true bugs, but populations are highly migratory and thus difficult to control.

Codling moths may be an occasional problem in peach orchards. Several products may be effectively used for codling moth control: Supracide®, Imidan®, Asana®, and Success®. The efficacy of using mating disruption in peaches is not well understood and therefore not widely used.

Citrus cutworm is an occasional pest in orchards adjacent to citrus; this pest is moderately controlled using Bt sprays. Imidan®, Sevin®, and Success® all work fairly well, although Success® is a very expensive product to use.

Katydids have become a more important pest in recent years. It is thought that organophosphates previously used had kept this pest in check; now that softer materials are being used for SJS and PTB, katydids have caused serious damage in peach orchards. Imidan® and Success® work fairly well to control katydids; azadirachtin is an alternative for organic growers.

Work Group Recommendations for Insect Management in the Spring

Research	• Develop reduced risk contact herbicides which are safe for bees • Evaluate fipronil for thrips and true bugs • Evaluate Assail® (acetamiprid) and Avaunt® for control of OFM, PTB, codling moth, thrips, and scales • Evaluate resistance to IGRs and pyrethroids, and develop resistance management programs • Continue mating disruption research to improve efficacy • Evaluate cover crop interactions with thrips • Evaluate new IGRs • Evaluate Acramite® (bifenazate) for best rate to use
Regulatory	• Register Confirm®, Agrimek® and Intrepid®
Education	• Conduct technology transfer meetings to integrate new materials into new IPM programs • Conduct training on the use of mating disruptions • Educate APHIS on systems approaches to insect pest management • Provide training on Acramite® use rates • Provide training on resistance management

DISEASES

Brown rot, green fruit rot, rust, and powdery mildew are the most common and troublesome diseases of peaches during bloom, petal fall, and leaf emergence in California. Thus, management programs continue at bloom through petal fall and leaf emergence.

Commonly used treatments include sulfur, Rovral®, Rally®, Break®, Vanguard®, and Elevate®. Captan and Topsin-M® are also used on fresh market peaches. Although none of these fungicides is effective against all of these diseases, they have overlapping spectrums of activity. Other diseases such as anthracnose and scab sometimes occur; however, damage caused by these diseases is generally not severe. *Phytophthora* and *Armillaria* root rots can be problems in wet spring seasons. All disease controls are rated in the Appendices; the UC IPM guidelines also have this information at http://www.ipm.ucdavis.edu/PMG/crops-agriculture.html.

Intensive monitoring of peach orchards and a thorough knowledge of conditions promoting disease development are critical to controlling pathogens in peach orchards. Sanitation practices help to eliminate sources of inoculums for some of these diseases, but the most effective disease management is accomplished with carefully timed fungicide applications. It is important to rotate these chemistries in order to preserve these products and avoid the buildup of resistance

Work Group Recommendations for Disease Management in Spring

Research	• Evaluate additional systemic brown rot materials • Develop additional multi-site modes of action materials • Develop more reduced risk fungicides • Improve timing for fungicide applications • Evaluate new rootstocks for improved bacterial control • Evaluate biocontrols for oak-root fungus
Regulatory	• Register new reduced risk fungicides
Education	• Continue education for disease resistance • Provide training on fungicide application timing • Provide training on alternatives such as Serenade® and Trilogy®*

* **Trilogy:** natural extract of neem oils derived from seeds of the neem tree. Used as a preventative at low rates by coating the plant surfaces thus preventing fungal spore germination, or as a curative to kill fungal hyphae on the plant surface. Prevents and controls powdery mildew, *botrytis*, anthracnose, downy mildew, leaf spot, rust, *Alternaria*, and blight

IN-SEASON

(Fruit development through harvest – April to October)

Pest problems experienced as the crop develops are highly variable depending on weather, growing region, and variety. Please refer to the seasonal cultural activities and pest management charts for general differences between production regions (Appendices 2 and 3). Scouting for insects and diseases is critical at this time of year and degree day models are very useful in timing insecticide treatments if economic thresholds have been reached. Insect management tools include biological control, cultural practices, pheromone mating disruption, and the use of microbial and chemical insecticides. Disease management tools include fertilizer and irrigation management, sanitation, and the use of fungicides.

Fruit trees are girdled to increase yields, improve set, enlarge fruit size, and advance maturity. Girdling is performed by removing a strip of bark from around the trunk or base of each scaffold limb with a grape girdling knife. The cut is usually made 1/8 to 3/16 inch wide and only as deep as the cambium layer. This temporarily disrupts the downward flow of carbohydrates and apparently makes them more available for fruit growth and development. Girdling is generally carried out in California on early maturing (ripening before mid-June) peach and nectarine trees from early to late April, about 4-6 weeks before harvest.

Cultural Activities

- Girdling
- Fertilizer applications
- Cultivation
- Thinning
- Irrigation
- Harvesting
- Pruning

INSECTS

Mating disruption has been an effective tool for managing peach twig borer (PTB), providing from good to excellent control on low to moderate populations. It is important to note that when populations are high and/or peach orchards are located near almond orchards, mating disruption alone will not control PTB and chemical applications are likely. Imidan® provides good to excellent control, but there are PHI and ERI issues for workers. Success®, a new reduced risk material, has excellent efficacy on PTB and Bt is also a good insect control tool. Pyrethroids such as Pounce® and Ambush® give good control of PTB, but are very harsh on beneficials and may cause mite flare-ups. Asana®, another pyrethroid, provides good to excellent control, but there is concern that PTB populations are becoming tolerant of this material.

San Jose scale (SJS) is an occasional in-season pest of peaches and should be treated only if populations are extremely high.

There are several good control options for in-season mite problems. Care needs to be exercised to manage plant stress during the hot summer months and to reduce dust in and around orchards which promotes mite problems. Oil is an excellent miticide if applied early. Agrimek® and Acramite® are excellent miticides. Savey®, an ovicide, also provides excellent control. Apollo® is also a very good ovicides; however, prohibitive PHI issues limit the use of this product. Trilogy® provides good control, but may be incompatible with sulfur applications. The efficacy of a new miticide, Nexter®, is reported to be good based on initial results. The performance of Kelthane® is reported to be only fair as compared to these newer materials; Vendex® is considered a poor miticide.

The larval pests oblique-banded leaf roller (OBLR) and omnivorous leaf roller (OLR) are both well controlled by Success® and pyrethroids; timing is especially critical when using pyrethroids. Bt and Imidan® also provide good control of OBLR and OLR. Confirm® , an IGR, also is an excellent materials.

Katydids can cause major cosmetic damage to peaches and therefore this pest should be closely monitored throughout the season. Sevin® and Imidan® provide excellent control of this species. Success® is also a very good material but needs to be applied prior to the adult stage; Success® has too short a residual to control katydids because these eggs hatch over a long period of time. Pyrethroids provide good control of young katydids; azadirachtin is fairly good on nymphs and is a useful tool in organic peach production.

Occasional In-season Pests:

Mating disruption is a good control for oriental fruit moth (OFM). Pyrethroids are particularly effective for this lepidopterous pes;, however, some tolerance problems are being reported. Mite flare-ups are possible using these materials. Lannate® and Sevin® are good materials, but Sevin® in particular is extremely disruptive to beneficials and can cause mites to flare up.

Codling moths may be an occasional problem in peaches now. Using mating disruption in peaches is not recommended at this time of the season. Several products may be effectively used for codling moth control: Supracide®, Imidan®, Thiodan®, Asana®, and Success®.

Thrips are only rarely pests of peaches and good to excellent control of this pest is achieved with Success®. Carzol® provides good to excellent control of thrips; however, long reentry interval prevents much use. Proper management of orchard floor vegetation is an effective means by which to provide some control of the movement of thrips into peach orchards. Lannate® is an extremely important insecticide for control of thrips in-season.

Stinkbugs and Lygus (true bugs), when present, can be very serious. Carzol® provides excellent control of true bugs, and the pyrethroids Asana® and Pounce® both have good efficacy. Lannate®, Thiodan®, and Sevin® also provide good control; Imidan is an option later in the season. Cover crop management is a good way to reduce the potential buildup of these pests near orchards; monitoring of all alternate hosts should be done regularly.

Flat-headed borers can be a problem, especially in certain areas. Lorsban® or Asana® are directed at the trunk for control; Thiodan® is also used to control borers.

Good control of aphids is provided by Thiodan®, Lannate®, and the pyrethroids. M-Pede® is reported to have fair to good efficacy on aphids.

Work Group Recommendations for Insect Management In-Season

Research	• Evaluate resistance development potential with Success® • Monitor resistance levels in field populations of insects and mites to all currently used insecticides and miticides • Study secondary pest biology and management (e.g., katydids) • Continue research on mating disruption and reducing costs of these products • Evaluate and improve the field stability of sprayable pheromones • Re-evaluate degree day application timing for IGRs to improve efficacy • Conduct research on basic pest biologies to increase the effectiveness of all pest management tools • Enhance and develop trapping techniques for key insect pests • Determine how the field persistence of microbial insecticides can be increased • Evaluate and commercially develop insecticides with low PHIs • Evaluate the efficacy of Dimilin®, Confirm®, Intrepid® and other IGRs for control of PTB and katydids
Regulatory	• Obtain in-season registration for Esteem® and Applaud® • Resolve PHI and REI issues associated with Imidan® • Retain OPs and carbamates as tools to fit within a systems approach; register OP and carbamate alternatives as soon as possible • Develop “prescriptive use” or “critical use exemption” programs for use of “old” chemical tools in certain extreme and critical situations when reduced risk programs are not effective or severe infestations of pests occur • Reduce PHIs to 7 to 10 days; 21-day PHIs render products useless in IPM programs
Education	• Provide resistance management education • Continue to educate growers on reduced risk options including mating disruption, use of microbials, etc. • Provide training on the great need for monitoring throughout the year for all pests; stress the importance of this practice to coordinating the pest management activities for multiple pests • Provide training on timing and methodology of applications for maximum control of orchard pests • Educate regulators on the need for 7 to 10 day PHIs in IPM programs

WEEDS

As methyl bromide is phased out over the next several years, weed control will become more of a concern to peach growers, especially with perennial weed species. Herbicides commonly used at this time of year include: Roundup®, Princep®, Gramoxone®, Goal®, Solicam ®, and Surflan®.

Biological control of puncturevine, a warm-season weed, is accomplished with the puncturevine weevil that feeds on developing seed pods on the plant, thus preventing reproduction and spread of this weed.

For in-season weed control, there is a need for additional contact herbicides.

The following weed species are of concern in peach orchards in California at this time:

• Annual Bluegrass	• Filaree	• Mustards
• Annual grasses	• Fleabane	• Nutsedge
• Bermuda grass	• Johnsongrass	• Puncturevine
• Bindweed	• Lambsquarters	• Purslane
• Curly dock	• Mallow	

Work Group Recommendations for Weed Management In-Season

Research	• Develop improved technologies for drip systems, chemigation, and subsurface irrigation • Develop guidelines for spot treatments of herbicides • Conduct needed research to shorten the PHIs for Roundup® and Gramoxone® • Evaluate Gramoxone® and Rely® for fleabane control (alone and in tank mix) • Develop weed control tactics suitable for use in organic production (e.g., mulches)
Regulatory	• Shorten PHI for Roundup® through existing IR-4 project • Reduce the PHI for Gramoxone® • Check PHI status of Rely®, Visor®, and Chateau® • Work to make labels more realistic in terms of grower practices; need products with PHIs of less than 7 days
Education	• Provide education on the need for monitoring and proper weed identification • Provide training on the timing of post-emergence herbicide applications • Provide updates on new application techniques for herbicides

DISEASES

Brown rot is the most troublesome in-season disease of peaches; without appropriate pre-harvest management practices, the disease can cause significant losses in storage.

Brown rot may be treated with Break®, Rally®, tebuconazole, fenbuconazole, cyprodonil, thiophanate-methyl, and fenhexamid. Sulfur and Rally® are excellent materials for brown rot control. Most brown rot fungicides are sterol biosynthesis inhibitors (SBIs); because these products target a very narrow spectrum of activity, there is a very high potential for resistant populations to develop if these compounds are overused.

Good control of powdery mildew is provided by many fungicides including Break® and Topsin-M®. Sulfur is also very effective for this disease.

Root and trunk diseases such as *Phytophthora* root rot, crown rot, crown gall, and wood decay fungi continue to be problems year round. Proper irrigation is an important cultural method to manage these diseases. Ridomil® is beneficial for managing *Phytophthora* root rot. For crown gall, it is recommended to disinfect equipment with sodium hypochlorite. For bacterial canker, it is recommended to promote vigorous trees to withstand or resist the onset of this disease.

Work Group Recommendations for Disease Management In-Season

Research	• Study pit hardening/powdery mildew relationship to optimize control • Evaluate biocontrols (e.g. *Trichoderma* spp.) for oak root fungus • Evaluate additional systemic brown rot materials • Evaluate and develop additional multi-site mode of action materials • Evaluate and develop more “reduced risk” fungicides • Improve timing for fungicide applications • Evaluate new rootstocks for improved bacterial control
Regulatory	• No needs currently identified
Education	• Provide resistance management training for fungicide use

NEMATODES

Nematodes in peach orchards are not normally managed in-season. There are very few products registered and many of these are under intense regulatory scrutiny. Fenamiphos, also known as Nemacur®, will be phased out by 2005 and oxamyl (Vydate®), a carbamate, is also at risk. Other materials, such as metam sodium (Vapam®, pre-plant only), have limited efficacy according to soil texture, depth of root systems, and soil moisture content.

Work Group Recommendations for Nematode Management In-Season

Research	• Evaluate DiTera® for nematode control • Evaluate alternatives to Nemacur® • Evaluate the use of mulching techniques for nematode control • Conduct more research on Enzone® to improve efficacy and consistency of activity on nematodes
Regulatory	• Register alternatives to Nemacur®
Education	• Continue updates on need for nematode management and provide information on new products and techniques

VERTEBRATE PESTS

Birds, particularly jays and crows, can cause significant loss to crop yield and quality by feeding directly on ripening peaches. Birds are more of a problem to fresh market peach varieties than they are to canning varieties. Monitoring for birds when fruit starts to ripen is critical to knowing when to implement control measures. Tactics to reduce bird visitation and damage to peaches includes frightening, trapping, or use of protective netting. Lethal control may be necessary in certain cases, but growers must first check with the Department of Fish and Game before taking this action.

Currently, there are no research, regulatory, or educational recommendations pertaining to in-season management of birds or other vertebrate pests.

POST-HARVEST
(May through October)

DISEASES

Good post-harvest disease management starts with healthy peaches which have healthy firm flesh and skin free of physical injury and inoculum. Most post-harvest losses can be traced back to problems with in-season care and handling of the fruit. Thus, it is extremely important that growers make every effort to use sound field practices during the season. This is a critical issue because an increasing amount of the peach crop is destined for the export market and must have good shelf life to be marketable.

Several organisms can cause post-harvest losses of peaches, but two species of brown rot organisms, *Monilinia* and *Sclerotinia,* are the most important. Inoculation occurs during the season, often during bloom and fruit development, and the organisms may become active during the post-harvest stage. These diseases can develop when temperature and humidity are favorable or if overripe fruit is harvested.

Brown rot, gray mold, and *Rhizopus* rot are the most important post-harvest decays of peaches in California. Gray mold causes damage in fruit stored at low temperatures and most infections occur from harvesting and handling wounds. Mucor decays and sour rot (*Geotrichum* sp.) are becoming increasingly problematic. Currently, dichloran (Botran® 75W, Allisan® 75W) is the only fully registered post-harvest fungicide for stonefruit. Rovral® 50WP was highly effective against all major decays, but this registration was canceled in 1996. Other materials previously registered include the benzimidazoles (e.g., benomyl, thiophanate-methyl) and DMIs (e.g., Funginex®). New materials are currently being evaluated by the University of California and some are in the IR-4 registration process.

Registration has been obtained for Scholar® 50WP for post-harvest disease control in all stonefruit. This product provides good to excellent control of brown rot and other diseases (gray mold, blue mold, *Rhizopus*, and *Mucor* rot); however, the activity of this product is somewhat limited because it is not systemic. The reduced risk fungicides fludioxonil and fenhexamid are currently being registered through the IR-4 program. Chlorine as a post-harvest disease control method provides only contact activity with no residual. Ozone stops sporulation of these diseases, but has no curative effects. UV light provides little or no control.

As with other diseases discussed, good sanitation is the best management strategy against *Cladosporum* and sour rot, which cause fruit decay.

Work Group Recommendations for Disease Management Post-harvest

Research	• Develop systemic fungicides to provide consistent disease control and avoid resistance • Develop alternatives for post-harvest fungicide use; e.g., heat treatments, ethanol, irradiation, etc. • Study pest biologies to optimize disease management • Develop technologies to increase field persistence of microbial materials
Regulatory	• Establish Codex MRL for Scholar® • Fast track alternative registrations for fungicides
Education	• Continue education on the importance of safe handling and sanitation in the field and packing houses • Provide resistance management training to maintain efficacy of all new and existing fungicides • Educate growers, PCAs, and packing house personnel on the use of best management practices (BMPs) as they relate to post-harvest disease control

INTERNATIONAL ISSUES

A significant portion of the peach crop is shipped to international markets. The major markets are Taiwan, Canada, and Mexico. Some destinations, such as Mexico and Canada, require the shipped fruit to be fumigated with methyl bromide for arthropod control. The pest targeted is dependent on the market destination, but usually is OFM or codling moth. Because export shipments can account for 50-60% of the gross crop dollar value, it is very important to prevent pest problems in the field and to ensure that no organisms are present in product bound for the export market. In addition, it is extremely important that U.S. registrations be harmonized with the requirements of all importing countries to avoid situations that might limit trade opportunities for U.S. produce (i.e., avoid "trade irritants").

Research	• Encourage registrants to develop residue data and export tolerances for new products prior to U.S. registration • Evaluate new fumigants for pre-shipment quarantine treatments (methyl bromide alternatives) • Establish new quarantine protocols that are not based on use of methyl bromide • Conduct research on population threshold issues that are important phytosanitary issues
Regulatory	• Register alternatives to methyl bromide for pre-shipment quarantine fumigation treatments • Establish new quarantine protocols that are not based on use of methyl bromide • Encourage registrants to establish export tolerances for new products prior to registration • Harmonize registrations between the US EPA and importing countries • Harmonize US EPA registration requirements with the Maximum Residue Limits (MRL) and Codex systems used in other countries. • Ensure that all quarantine protocols are harmonized between the US EPA and importing countries • Request that FDA maintain a current log of international registrations
Education	• Educate and encourage registrants to develop tolerances in compliance with foreign markets prior to full U.S. registration • Educate commodity groups on new quarantine methods and protocols • Encourage US EPA and USDA FAS (Foreign Agricultural Service) to work with Codex to expedite international registrations so that newer and safer products may be used in the U.S. without fear of trade irritant issues • Educate foreign regulatory agencies on population threshold issues (e.g., that one moth or larva found in a shipment will not create a breeding population, etc.)

FOOD SAFETY ISSUES

The job of producing high quality, safe peaches in California begins before the fruit is planted and continues until it reaches the consumer's hand. Working closely with the University of California, California's peach industry continually studies growing practices, pest control, irrigation, fertilization, and post-harvest handling. As part of this research, the California peach industry has taken an active role in studying issues pertaining to microbial safety for this particular fruit. To date, there has been no association of fresh peaches with any reported illness or outbreak, and University laboratory data support the current view of a "low-concern status" for peaches relative to microbial food safety.

Despite this clear record, the California peach industry has taken measures to develop a comprehensive quality control program, which requires an audit of farming and packing house operations. In addition, for fresh peaches, an effective trace-back program is in place and has been in existence for decades. This trace-back program utilizes third-party mandatory inspection conducted by the Federal-State Shipping Point Inspection Service to ensure quality and safety. Under this program, each box of fruit is marked with an inspection stamp indicating date packed and shipper identification. In repeated tests, this stamp has allowed fruit to be traced in a matter of minutes from retail locations throughout North America to the orchard in which the fruit was grown.

As with any produce item produced in California, peaches are subject to very stringent state and federal regulations governing the use and application of pesticides, with severe penalties for violations. Fruit is routinely checked for pesticide residue by third-party government inspectors. These efforts and more make California peaches safe and wholesome products for consumers throughout the world.

Research	• None at the present time
Regulatory	• Conduct self audits to ensure product safety (note: retailers require third-party audit) • Comply with good agricultural practices (GAP) and other food safety programs as established for the peach industry
Education	• Provide training on the importance of clean water and personal hygiene in packing operations

4. CRITICAL ISSUES FOR THE CALIFORNIA PEACH INDUSTRY

The following issues were identified by the Peach Work Group as being the most critical to the sustained viability of the California peach industry.

Research	• Develop new control methods for pre- and post-harvest disease control • Develop methyl bromide alternatives for quarantine treatments • Develop methyl bromide alternatives for peach nursery and pre-plant treatments • Develop alternatives to oils for insect and mite control • Develop best management practices (BMPs) and mitigation measures for environmental issues • Assess economic and environmental costs of all pest management tools • Improve application technology, especially for newer materials • Maintain or enhance university research programs for IPM • Provide access to research funding directly through commodity organizations (CTFA, CCPA, etc.) in addition to continued support of the Land Grant university system for research and extension activities • Develop disease resistant rootstocks
Regulatory	• Harmonize the Cal/EPA and US EPA review process to hasten new product registrations • Maintain oil registrations or find suitable replacements for insect and mite control • Retain key products which are complementary to current IPM tactics and which address resistance management concerns • Establish prescriptive uses for certain key pest management tools (e.g., organophosphates, carbamates, etc.) to complement IPM tactics and to serve as backup products in critical pest management situations • Register organophosphate and carbamate alternatives as soon as possible; utilize the IR-4 priority system for research on reduced risk materials • Develop best management practices (BMPs) and environmental mitigation measures for environmental issues • Identify potential trade irritants as early as possible in the research and registration process; ensure there are no conflicts with provisions of NAFTA or Codex
Education	• Conduct resistance management training for all pest categories • Educate the regulatory community on the need for all pest management tools including traditional organophosphate pesticides, which are a critical component of a reduced risk pest management program • Educate applicators/growers on safe and efficient application techniques • Educate growers, PCAs, and commodity members on the use of best management practices to protect and improve water and soil quality • Educate the public on the nutritional values of California grown peaches and their high level of food safety and quality

REFERENCES

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California Department of Pesticide Regulation Pesticide Use Report, 1999-2001, website http://www.cdpr.ca.gov/dprdatabase.htm

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APPENDICES

1. 2001 California Peach Production Statistics

COUNTY	HARVEST ACREAGE	YIELD (Tons/Ac.)	PRODUCTION (Tons)	TOTAL VALUE ($)
Clingstone Peaches				
Butte	2,300	14.4	33,120	7,320,000
Fresno	1,294	17.9	23,200	5,498,000
Kings	1,044	18.9	19,752	4,643,000
Madera	940	10.3	9,654	2,133,000
Merced	3,651	18.0	65,826	15,526,000
San Joaquin	2,030	20.0	40,600	9,541,000
Stanislaus	6,500	18.3	119,000	28,560,000
Sutter	9,301	16.3	151,141	35,820,400
Tulare	1,168	16.0	18,700	4,376,000
State Subtotals	28,228	**Average** 17.0	480,993	113,417,400
Freestone Peaches				
Fresno	13,246	8.5	113,000	90,739,000
Kings	2,513	8.0	19,978	11,044,000
Madera	870	10.8	9,361	3,342,000
Merced	1,758	16.1	28,216	6,149,000
Riverside	65	2.1	137	159,000
San Joaquin	876	9.9	8,670	5,133,000
Solano	299	1.3	381	258,100
Stanislaus	1,500	11.6	17,400	5,394,000
Sutter	86	3.6	312	109,800
Tulare	12,590	7.2	90,900	50,475,000
State Subtotals	33,803	**Average** 8.5	288,355	172,802,900
Unspecified Varieties				
Contra Costa	141	3.5	495	617,000
El Dorado	110	2.5	275	440,000
Kern	1,903	9.6	18,300	16,334,000
Los Angeles	1,300	16.5	21,450	17,739,000
Placer	115	3.5	403	398,500
Yuba	5,390	15.5	83,761	19,265,000
State Subtotals	8,959	13.9	124,684	54,793,500
STATE TOTALS	**70,990**	Average **13**	**894,032**	**341,013,800**

Source: County Agricultural Commissioners' Data (USDA/NASS/CASS)

Note that the *CDFA Resource Directory – 2002* contains additional production statistics which may be seen at their website (http://www.cdfa.ca.gov/publications.htm).

2. Crop Development, Cultural Practices, and Pest Management Activities in California Peaches

Sacramento Valley

Crop Development	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Dormancy	■											■
Bud Break		■	■									
Bloom		■	■	■								
Pollination			■	■								
Fruit Development			■	■	■	■	■	■				
Harvest							■	■	■			
Post-harvest	■	■	■	■	■		■	■	■	■	■	■
Storage	■	■	■	■	■		■	■	■	■	■	■
Cultural Practices	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Cultivation	■	■	■	■	■	■	■	■	■	■	■	■
Irrigation				■	■	■	■	■	■	■		
Pruning	■	■	■	■							■	■
Thinning					■	■						
Frost Protection			■	■								
Girdling				■								
Fertilizer Application		■	■	■					■	■		
Pest Management Activities	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Soil Sampling	■	■	■	■	■	■	■	■	■	■	■	■
Scouting		■	■	■	■	■	■	■				
Insecticide Applications	■	■	■	■	■	■	■	■				■
Dormant Applications	■	■										■
Fungicide Applications		■	■									
Use of Pheromones		■	■	■	■	■	■	■				
Herbicide Applications		■	■	■	■	■	■	■	■			
Nematicide Applications	■	■								■	■	■
Vertebrate Control	■	■	■	■	■	■	■	■	■	■	■	■

Data based on collective field observations and experiments

2. Crop Development, Cultural Practices, and Pest Management Activities in California Peaches (continued)

Northern San Joaquin Valley

Crop Development	J	F	M	A	M	J	J	A	S	O	N	D
Dormancy												
Bud Break												
Bloom												
Pollination												
Fruit Development												
Harvest												
Post-harvest												
Storage												
Cultural Practices	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Cultivation												
Irrigation												
Pruning												
Thinning												
Frost Protection												
Girdling												
Fertilizer Application												
Pest Management Activities	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Soil Sampling												
Scouting												
Insecticide Applications												
Dormant Applications												
Fungicide Applications												
Use of Pheromones												
Herbicide Applications												
Nematicide Applications												
Vertebrate Control												

Data based on collective field observations and experiments

2. Crop Development, Cultural Practices, and Pest Management Activities in California Peaches (continued)

Southern San Joaquin Valley

Crop Development	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Dormancy												
Bud Break												
Bloom												
Pollination												
Fruit Development												
Harvest												
Post-harvest												
Storage												
Cultural Practices	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Cultivation												
Irrigation												
Pruning												
Thinning												
Frost Protection												
Girdling												
Fertilizer Application												
Pest Management Activities	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Soil Sampling												
Scouting												
Insecticide Applications												
Dormant Applications												
Fungicide Applications												
Use of Pheromones												
Herbicide Applications												
Nematicide Applications												
Vertebrate Control												

Data based on collective field observations and experiments

3. Seasonal Pest Occurrence in California Peaches

Sacramento Valley

Insects and Mites	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
San Jose Scale	■		■	■	■	■	■	■				■
Peach Twig Borer				■	■	■	■	■	■			
Aphids	■					■	■	■	■			
European Red Mite	■											■
Fruit Tree Leaf Roller												
Oblique-Banded Leaf Roller				■	■	■	■	■				
Thrips			■	■	■	■	■	■	■			
Stinkbugs				■	■							
Oriental Fruit Moth		■	■	■	■	■	■	■	■			
Codling Moth						■	■					
Prune Limb Borer												
American Plum Borer												
Mites					■	■	■	■	■	■		
Katydids												
Omnivorous Leaf Roller												
Diseases	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Bacterial Canker			■									
Armillaria Root Rot (Oak Root)	■	■	■	■	■	■	■	■	■	■	■	■
Brown Rot		■	■	■	■	■	■	■	■			
Jacket Rot			■									
Green Fruit Rot				■	■	■	■	■				
Powdery Mildew				■	■	■	■	■	■			
Phytophthora Root & Crown Rots	■	■	■	■	■	■	■	■	■	■	■	■
Shot hole	■			■	■	■	■	■	■		■	■
Crown Gall	■	■	■	■	■	■	■	■	■	■	■	■
Peach Rust				■	■	■	■	■	■			
Weeds	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Johnsongrass			■	■	■	■	■	■	■	■		
Bermuda grass		■	■	■	■	■	■	■	■	■	■	
Annual grasses	■	■	■	■	■	■	■	■	■	■	■	■
Mustards		■	■	■	■							
Nematodes	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Root Knot Nematode												
Ring Nematode	■	■	■	■	■	■	■	■	■	■	■	■
Lesion Nematode	■	■	■	■	■	■	■	■	■	■	■	■
Dagger Nematode												
Vertebrates	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Rabbits												
Voles												
Gophers				■	■	■	■	■	■			
Deer				■	■							
Squirrels												
Birds				■	■	■	■	■	■			

Data based on collective field observations and experiments

3. Seasonal Pest Occurrence in California Peaches (continued)

Northern San Joaquin Valley

Insects and Mites	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
San Jose Scale												
Peach Twig Borer												
Aphids												
European Red Mite												
Fruit Tree Leaf Roller												
Oblique-Banded Leaf Roller												
Thrips												
Stinkbugs												
Oriental Fruit Moth												
Codling Moth												
Prune Limb Borer												
American Plum Borer												
Mites												
Katydids												
Omnivorous Leaf Roller												
Diseases	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Bacterial Canker												
Armillaria Root Rot (Oak Root)												
Brown Rot												
Jacket Rot												
Green Fruit Rot												
Powdery Mildew												
Phytophthora Root & Crown Rots												
Black Mold												
Shot hole												
Crown Rot												
Crown Gall												
Peach Rust												
Weeds	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Johnsongrass												
Bermuda grass												
Annual grasses												
Mustards												
Nematodes	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Root Knot Nematode												
Ring Nematode												
Lesion Nematode												
Dagger Nematode												
Vertebrates	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Rabbits												
Voles												
Gophers												
Deer												
Squirrels												
Birds												

Data based on collective field observations and experiments

3. Seasonal Pest Occurrence in California Peaches (continued)

Southern San Joaquin Valley

Insects and Mites	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
San Jose Scale												
Peach Twig Borer												
Aphids												
European Red Mite												
Fruit Tree Leaf Roller												
Oblique-Banded Leaf Roller												
Thrips												
Stinkbugs												
Oriental Fruit Moth												
Codling Moth												
Prune Limb Borer												
American Plum Borer												
Mites												
Katydids												
Omnivorous Leaf Roller												
Diseases	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Bacterial Canker												
Armillaria Root Rot (Oak Root)												
Brown Rot												
Jacket Rot												
Green Fruit Rot												
Powdery Mildew												
Phytophthora												
Black Mold												
Shot hole												
Crown Rot												
Crown Gall												
Peach Rust												
Weeds	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Johnsongrass												
Bermuda grass												
Annual grasses												
Mustards												
Nematodes	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Root Knot Nematode												
Ring Nematode												
Lesion Nematode												
Dagger Nematode												
Vertebrates	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Rabbits												
Voles												
Gophers												
Deer												
Squirrels												
Birds												

Data based on collective field observations and experiments

4. Efficacy of Insect Management Tools Used in California Peaches

Chemical Insecticides

Efficacy Ratings: E = Excellent, G = Good, F = Fair, P = Poor/None, R = Known Resistance

PRODUCT	TRADE NAME	INSECTS												
		Aphids	Brown Mites	Codling Moths	European Red Mites	Fruit Tree Leaf Rollers	Katydids	Lygus Bugs	Omniv./Oblique Banded Leaf Rollers	Oriental Fruit Moths	Peach Twig Borers	San Jose Scale	Stinkbugs	Webspinning Mites
Azinphos-Methyl	Guthion®	P	P	E	P	F	E	G	F	E-R	E	P	G	R
B. thuringiensis	Bt	P	P	P	P	F-G	P	P	F	P	G-E	P	P	P
Carbaryl	Sevin®	P	P	G	P	F	?	F	G	G	G	G	G	P
Chlorpyrifos [1]	Lorsban®	E	P	E	P	E	G[2]	G	E	G	G-E	E-R	E	R
Clofentezine	Apollo®	P	G	P	E	P	P	P	P	P	P	F-G	P	G
Diazinon		E	P	G	P	G	G	G	G	G	G-E	E-R	G	P
Dicofol	Kelthane®	P	G	P	G	P	P	P	P	P	P	P	P	G
Endosulfan	Thiodan®	G-R	P	P	P	P	?	F	?	P	F-G	P	E-G	P
Esfenvalerate	Asana® XL	P	P	G	P	P	G	G	E	G	G-E	P	E	P
Fenamiphos	Nemacur®	P	P	P	P	P	P	P	P	P	P	P	P	P
Fenbutatin Oxide	Vendex®	P	E	P	E	P	P	P	P	P	P	P	P	E
Fenoxycarb	Comply®	P	P	G	P	?	P	P	?	?	?	P	P	P
Formetanate HCL	Carzol®	P	P	P	P	P	?	G	P	P	P	P	G	P
Kaolin	Surround®	?	?	?	?	?	?	?	?	?	?	?	?	?
Methidiathion	Supracide®	E	F	F	F	P	?	F	?	?	E	E-R	?	R-P
Methomyl	Lannate®	G	P	G	F	G	G	G	G	G	F-G	F	F-G	P
Methyl Bromide		E	E	E	E	E	E	E	E	E	E	E	E	E
Naled	Dibrom®	E	P	P	P	F	?	F	?	P	G-E	E	F	R-P
Neem Seed Oil	Azadirach-tin®	?	P	P	P	P	F	P	P	P	P	?	P	P
Oil		P	E	P-F	E	P	P	P	P	P	P	G-E	P	F
Permethrin	Ambush®, Pounce®	P	P	G	P	G	G	G	G	G	G	P	G	P-R
Pheromones	Isomate®, Checkmate®	P	P	P-F	P	P	P	F	E	E	F	P	P	P
Phosmet	Imidan®		P	G	P	E	E	F	G	G	G	P	F	R-P
Propargite[3]	Omite®	P	E	P	E	P	P	P	P	P	P	P	P	E
Pyrethrins		P	P	P	P	P	P	P	P	P	P	P	P	P
Pyriproxyfen	Esteem®	?	?	?	?	?	?	?	?	?	?	E	?	P
Soap	M-pede®	P	F	P	F	P	P	P	P	P	P	F	P	F
Sulfur		P	P	P	P	P	P	P	P	P	P	P	P	P

[1] Dormant season use only [2] Not in-season [3] Non-bearing trees only

Data based on collective field observations and experiments

4. Efficacy of Insect Management Tools used in California Peaches (continued)

Impact of Chemical Insecticides on Beneficial Organisms

Toxicity Ratings: L = Low toxicity, M = Medium toxicity, H = High toxicity

PRODUCT	TRADE NAME	BENEFICIALS				
		Predatory Mites[1]	General Predators[2]	Parasites[2]	Honey Bees[3]	Duration of Impact to Natural Enemies[4]
Azinphos-methyl	Guthion®	L-M	H	H	I	long
Bacillus thuringiensis	Bt	L	L	L	IV	none
Carbaryl	Sevin® 80S	L-H	H	H	I	long
Carbaryl	Sevin® XLR Plus	M	H	M	III	long
Chlorpyrifos	Lorsban®	M	H	H	I	moderate
Diazinon-foliar		L	H	H	I	moderate to long
Dicofol	Kelthane®	H	M	M	IV	long to beneficial mites
Endosulfan	Thiodan®	L	M	M	III	short
Esfenvalerate	Asana®	H	M	H	I	moderate
Fenbutatin oxide	Vendex®	L	L	L	IV	short
Hexythiazox	Savey®	L	L	L	IV	short
Methidathion	Supracide®	H	H	H	I	moderate to long
Neem oil	Trilogy®	L	L	L	III	short
Petroleum oil		L	L	L	III	short to none
Phosmet	Imidan®	H	H	H	I	moderate to long
Spinosad	Success®	L	L[5]	L	III	short
Sulfur		L-H	L	H	IV	short

[1] Generally, toxicities are to native strains of western predatory mites, *Galendromus occidentalis*. Where differences have been measured in toxicity to the pesticide-resistant strain versus the native strain, these are listed as pesticide-resistant strain/native strain

[2] Toxicities are averages of reported effects and should be used only as a general guide. Actual toxicity of a specific chemical depends on the species of predator or parasite, environmental conditions, and application rate

[3] Ratings are as follows: I = Do not apply to blooming plants; II = Apply in evening after bees have stopped foraging; III = Apply in late evening after bees have stopped foraging until early morning before they begin to forage again; and IV = Apply at any time with reasonable safety to bees

[4] Duration: *short* means hours to days; *moderate* means days to 2 weeks; and *long* means many weeks or months

[5] Kills six-spotted thrips

Data and information above from *UC IPM Pest Management Guidelines: Peaches*

4. Efficacy of Insect Management Tools used in California Peaches (continued)

Unregistered or New Insecticides

Efficacy Ratings: E = Excellent, G = Good, F = Fair, P = Poor/None, R = Known Resistance

PRODUCT	TRADE NAME	INSECTS												
		Aphids	Brown Mites	Codling Moth	European Red Mites	Fruit Tree Leaf Rollers	Katydids	Lygus Bugs	Omniv./Oblique-Banded Leaf Roller	Oriental Fruit Moth	Peach Twig Borers	San Jose Scale	Stinkbugs	Webspinning Mites
Abamectin	Agrimek®	P	G	P	G	P	P	P	P	P	P	P	P	E
Buprofrezin	Applaud®	P	?	P	?	P	P	P	?	?	?	E	?	P
Hethiazox	Savey®	P	E	P	E	P	P	P	P	P	P	P	P	E
Imidachloprid	Provado®	E	P	P	P	P	P	F-P	P	P	P	P	P	P
Milbemectin	Koromite®	P	G	P	G	P	P	P	P	P	P	P	P	G
Prirmicarb	Pirimor®	E	?	?	?	?	?	?	?	?	?	?	?	?
Pyridiben	Sanmite®	P	P	P	P	P	P	P	P	P	P	P	P	E
Tebufenozide	Confirm®	P	P	F	P	G	P	P	E	F	E	P	P	P

Non-Chemical Insect Management Aids

MANAGEMENT AIDS	INSECTS												
	Aphids	Brown Mites	Codling Moth	European Red Mites	Fruit Tree Leaf Rollers	Katydids	Lygus Bugs	Omniv./Oblique-Banded Leaf Rollers	Oriental Fruit Moth	Peach Twig Borers	San Jose Scale	Stinkbugs	Webspinning Mites
Clean Cultivation	P	P	P	P	P	G	G	P	P	P	P	G	F
Cover Crops*	P	P	P	P	P	P	P	P	P	P	P	P	P
Host Destruction	P	P	P	P	P	P	G	P	P	P	P	G	P
Monitoring	E	E	E	E	E	E	E	E	E	E	E	E	E
Models (DD)	P	P	G	P	F	P	P	G	E	E	E	P	P
Pheromones	P	P	E	P	E	P	P	E	E	E	E	P	P
Parasites	P	F	P	F	F	P	P	F	F-G	P	G	F	P
Predators	G	F	P	F	P	P	P	P	P	E	P	P	E
Pathogens	G	P	P	P	P	P	P	P	P	P	P	P	P
Scouting	E	E	E	E	E	E	E	E	E	E	E	E	E
Trapping	P	P	P	P	P	P	P	P	P	P	P	P	P
Irrigation Management	P	P	P	P	P	P	P	P	P	P	P	P	G
Nutrition Management	P	P	P	P	P	P	P	P	F	F	P	P	P
Whitewash	P	P	P	P	P	P	P	P	P	P	P	P	P

* Has effect only on Lygus and Stinkbugs

Data based on collective field observations and experiments

5. Efficacy of Disease Management Tools Used in California Peaches

Efficacy Ratings: E = Excellent, G = Good, F = Fair, P = Poor/None, R = Known Resistance

PRODUCT	TRADE NAME	DISEASES									
		Brown Rot	Jacket Rot	Peach Leaf Curl	Powdery Mildew	*Phytophthora* Rot	Peach Rust	Shot Hole	Crown Gall	Bacterial Canker	Viruses
Chemical											
Azoxystrobin	Abound®										
Bordeaux mix 10:10:100											
Captan											
Chorothanlonil	Bravo®	F	F	P	P	P	P	G	P	P	P
Ciprodinil	Vangard®										
Copper		P	P	G	P	P	P	G	P	P	P
Fenbuconazole	Indar®										
Fenhexamid	Elevate®										
Fosetyl-al	Aliette WDG®			G				G			
Iprodione	Rovral®					G-F					
Mefenoxam	Ridomil Gold®										
Myclobutanil	Rally®	E	E				F	F			
Propiconazole	Break®	G	G		G						
Sodium tetrathio-carbonate	Enzone®										
Sulfur (wettable)		E	E		G		G				
Tebuconazole	Elite®				G		G				
Thiophanate-methyl	Topsin®	E	E		G						
Vinclozolin	Ronilan®										
Ziram				E			F	G			
Non-Chemical											
Orchard Sanitation		F									
Irrigation Management						E				F	
Fertilizer Management		F				F				F	
Vector Control											
Certified Planting Stock									F		E
Rootstock Selection						F			F	F	
Resistant Varieties											
Avoiding Injury									F	F	
Remove Alternate Hosts											
Weed Management		P	P	P	F	P	F	P			

Data based on collective field observations and experiments

6. Efficacy of Nematode Management Tools Used in California Peaches

Efficacy Ratings: E = Excellent, G = Good, F = Fair, P = Poor/None, R = Known Resistance

PRODUCT	TRADE NAME	NEMATODES							
		Root Knot PRE	Root Knot POST	Ring Nematode PRE	Ring Nematode POST	Root Lesion PRE	Root Lesion POST	Dagger PRE	Dagger POST
Chemical									
Fenamiphos	Nemacur®	P	G		G	P	G		P
Metam Sodium	Vapam®	P-E		P-E		P-E		P-E	
Methyl Bromide		G-E		P-E		G-E		G-E	
1,3-D	Telone®	P-E		P-E		P-E		G-E	
Oxamyl	Vydate®	G				G-E			
Sodium Tetrathio-carbonate	Enzone®	P	P	P-G		P	P	G-E	G
Non-Chemical									
Clean Cultivation		F	F	F	F	F	F	F	F
Soil Sampling		G							
Resistant Rootstock		E		P		P		P-G	
Trap Crops		P	P	P	P	P	P	P	P

Data based on collective field observations and experiments

7. Efficacy of Weed Management Tools Used in California Peaches

Efficacy Ratings: E = Excellent, G = Good, F = Fair, P = Poor/None, R = Known Resistance

PRODUCT	TRADE NAME	WEEDS											
		Johnsongrass	Bermuda grass	Nutsedge	Curly Dock	Bindweed	Mallow	Annual Bluegrass	Mustards	Filaree	Annual Grasses	Purslane	Fleabane
Chemical													
Glyphosate	Roundup®	G-E	G	P	G	P	P	G	G	F	G	G	P
Norflurazon	Solicam®	G	F	F	F	P	F	G	F	F	G	G	P
Oryzalin	Surflan®	P	F	P	P	F	G	G	F	P	G	G	P
Oxyfluorfen	Goal®	P	P	P	P	P	E	F	G	F	F	G	P
Paraquat Dichloride	Gramoxone®	F	P	F	F	P	F	F	G	F	F	G	P-F
Simazine	Simazine®	P	F	P	P	F	F	G	G	P	G	G	P
Non-Chemical													
Cultivation		P	P	G	G-E	P	G-E	G-E	G-E	G-E	G-E	G-E	G-E
Soil Solarization (little used)		P	P	F	F	P	F	F	F	F	F	F	F
Cover Crops		P	P	P-F	P-F	P	P-F	P-F	P-F	P-F	P-F	P-F	P

Data based on collective field observations and experiments

8. Efficacy of Vertebrate Management Tools Used in California Peaches

Efficacy Ratings: E = Excellent, G = Good, F = Fair, P = Poor/None, R = Known Resistance

MANAGEMENT TOOLS	VERTEBRATES					
	Squirrels	Gophers	Voles	Rabbits	Deer	Birds
Trapping	F	F	P	G	P	F
Baits	G-E	G-E	G	P	P	P
Fences, Exclusion	P	P	P	G	F-G	P
Tree Protectors	P	P	G	G	P	P
Repellants	P	P	P	F	F	F
Frightening	P	P	P	P	F	F
Lethal Control	E	P	P	E	E	E
Noise, Explosive Devices	F-G	F-G	P	P	P	P
Fumigating	G	G	P	P	P	P
Prevention						
Predators						
Cultural Barriers						
Mylar Strips						

Data based on collective field observations and experiments

9. Chemical Use on California Peaches 1999-2001

Pounds of Active Ingredient Used

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
Insecticides					
Azinphos-methyl	Guthion®	1,376	2,095	1,637	1,855
Bacillus thuringiensis	Dipel®	2,257	1,892	2,105	2,014
Carbaryl	Sevin®	19,308	20,541	16,081	20,130
Chlorpyrifos	Lorsban®	23,752	31,873	29,038	29,166
Clofentezine	Apollo®	1,616	1,624	1,809	1,621
Diazinon		30,288	35,101	33,052	33,497
Dicofol	Kelthane®	5,324	5,207	7,278	5,246
Esfenvalerate	Asana® XL	1,968	2,779	2,647	2,509
Fenbutatin Oxide	Vendex®	15,401	14,671	13,737	14,914
Formetanate HCL		1,179	621	295	807
Methidathion		12,328	13,504	7,386	13,112
Methomyl	Lannate®	1,670	1,807	1,063	1,761
Methyl Parathion		22,857	44	4	7,648
Permethrin	Ambush® / Pounce®	6,755	8,092	7,938	7,647
Phosmet	Imidan®	55,158	45,440	79,476	48,679
Herbicides					
Glyphosate	Roundup®	42,590	46,923	49,824	45,479
Oxyfluorfen	Goal®	8,522	8,018	6,637	8,186
Paraquat Dichloride	Gramoxone®	19,783	16,634	17,084	17,684
Simazine	Princep®	11,121	11,109	13,131	11,113
Fungicides					
Azoxystrobin	Abound®	11	152	526	105
Benomyl	Benlate®	2,334	2,125	995	2,195
Captan		26,391	11,068	6,932	16,176
Chlorothalonil	Bravo®	13,766	11,634	8,755	12,345
Copper Oxide & Hydroxide		1	1	131,581	43,860
Dicloran	Allisan®	107	180	32	156
Fludioxonil (Sect. 18)	Scholar®	0	0	74	27
Fosetyl-al		36	0	1	12
Iprodione	Rovral®	21,583	20,698	16,410	20,993
Metalaxyl		0	0	0	0
Myclobutanil	Rally®	1,155	1,922	1,287	1,667
Propiconazole	Break®	4,129	3,683	2,747	3,832
Sulfur (wettable)		878,785	895,676	994,816	890,046
Tebuconazole	Elite®	3,653	3,254	2,839	3,387
Thiophanate-methyl	Topsin®	2,212	1,286	514	1,595
Vinclozolin	Ronilan®	304	3	0	104
Ziram		151,494	161,238	159,017	157,249
Nematicides					
Fenamiphos	Nemacur®	4,087	4,253	3,841	4,198
Metam Sodium		1,532	7,153	4,282	5,280
Methyl Bromide		332,346	88,204	32,318	150,956
Sodium Tetrathiocarbonate		11,993	7,791	2,890	9,192

Zero = < 100 pounds of Active Ingredient reported for that chemical for that year
Data from CDPR

9. Chemical Use on California Peaches 1999-2001 (continued)

% of Peach Crop Acres Treated

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
Insecticides					
Azinphos-methyl	Guthion®	1	2	1	1
Bacillus thuringiensis	Dipel®	16	14	11	13
Carbaryl	Sevin®	6	7	6	6
Chlorpyrifos	Lorsban®	16	20	18	18
Clofentezine	Apollo®	14	15	17	15
Diazinon		18	19	18	18
Dicofol	Kelthane®	5	4	6	5
Esfenvalerate	Asana® XL	45	59	54	53
Fenbutatin Oxide	Vendex®	27	25	22	25
Formetanate HCL		2	1	1	1
Methidathion		10	11	0	7
Methomyl	Lannate®	2	2	2	2
Methyl Parathion		35	0	0	12
Permethrin	Ambush® / Pounce®	23	25	25	25
Phosmet	Imidan®	21	17	28	22
Herbicides					
Glyphosate	Roundup®	41	41	0	28
Oxyfluorfen	Goal®	25	27	25	26
Paraquat Dichloride	Gramoxone®	25	23	17	22
Simazine	Princep®	22	20	22	22
Fungicides					
Azoxystrobin	Abound®	0	1	0	1
Benomyl	Benlate®	5	3	2	3
Captan		21	7	3	10
Chlorothalonil	Bravo®	6	4	4	5
Copper Oxide & Hydroxide		0	0	42	14
Dicloran	Allisan®	0	0	0	0
Fludioxonil (Sect. 18)	Scholar®	0	0	0	0
Fosetyl-al		0	0	0	0
Iprodione	Rovral®	37	34	30	34
Metalaxyl		0	0	0	0
Myclobutanil	Rally®	10	14	10	11
Propiconazole	Break®	38	34	27	34
Sulfur (wettable)		48	50	50	50
Tebuconazole	Elite®	22	20	19	21
Thiophanate-methyl	Topsin®	3	2	1	2
Vinclozolin	Ronilan®	1	0	0	0
Ziram		27	29	30	29
Nematicides					
Fenamiphos	Nemacur®	2	2	2	2
Metam Sodium		0	0	0	0
Methyl Bromide		5	2	2	3
Sodium Tetrathiocarbonate		0	0	0	0

Zero = < 100 pounds of Active Ingredient reported for that chemical for that year
Data from CDPR

10. Members of the California Peach Work Group

(SJV=San Joaquin Valley, UC=University of California, KAC=Kearney Agricultural Center)
Note: where provided, the area of interest is included in parentheses

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