A Pest Management Strategic Plan for Nectarine Production in California

The California Tree Fruit Agreement (CTFA)

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). The CMCC received additional support from the California Tree Fruit Agreement 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

Nectarines are an important commodity in California; this one state produces virtually all the commercial nectarine crop in the United States. Over one fifth of the annual crop is exported and market expansion is of great importance to sustained economic viability of this industry. Nectarine growers, like other producers of stonefruit in California, have faced several challenges in recent years due to multiple pressures put on this industry. These include: a changing pest spectrum due to changes in pest control tactics used; resistance management issues; cancellation of, or restrictions on, pesticides formerly available; environmental restrictions on farming and worker practices; declining profitability; urban encroachment; and global competition.

New safety standards set forth by the 1996 Food Quality Protection Act (FQPA) and other regulatory statutes have impacted and will continue to affect 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 nectarine producers have reduced their use of organophosphate (OP) insecticides significantly in recent years. The successful transition to reduced risk materials has been facilitated by collaborative efforts on the part of growers, pest control advisors (PCAs), industry, processors, and research, extension, and agency personnel. Even with these improvements, however, major pest management challenges continue to exist for nectarine growers, and 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 growers to move completely away from the use of chemicals to control insects, weeds, diseases, nematodes, and vertebrate pests.

Methyl parathion, azinphos methyl (Guthion®), and methyl bromide are examples of products used in nectarine production that have already been cancelled or restricted due to FQPA and other regulatory decisions. 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 nectarine production, seasonal pest occurrences, and integrated pest management techniques throughout California for fresh market and processing varieties of nectarines. The plan addresses both current and emerging pest management needs; it is a working document that will need to be updated periodically. Efficacy ratings of various pest control techniques (chemical and non-chemical) used in nectarine 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; it serves principally as a guideline to direct future pest management efforts related to California nectarine 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 Nectarines*; these documents provide a complete review of cultural and pest management practices for California nectarines.

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 nectarine production.

Stakeholder Recommendations

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

Research Priorities

Finding effective solutions to insect and disease control is the most immediate and serious concern of nectarine growers in California. Alternatives to using organophosphate insecticides and methyl bromide are extremely important to 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 nectarine production.

- Develop new control methods for pre- and post-harvest disease control
- Develop methyl bromide alternatives for quarantine treatments
- Develop methyl bromide alternatives for nectarine 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, etc.) in addition to continued support of the Land Grant University system for research and extension activities
- Develop disease-resistant nectarine rootstocks

Regulatory Priorities

The nectarine 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 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
- Identify potential trade irritants as early as possible in the research and registration process; insure there are no conflicts with provisions of NAFTA or Codex
- Develop best management practices (BMPs) and environmental mitigation measures to address air and water quality concerns and other issues related to natural resources management

Educational Priorities

The public, including regulators and consumer groups, must be educated about the use of Integrated Pest Management (IPM) in California nectarine production and how this system optimizes food production while minimizing risks to workers and the environment. Growers and PCAs 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 fresh California nectarines 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 nectarines and their high level of food safety and quality

The California nectarine 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 nectarine 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). The CMCC received additional support from the California Tree Fruit Agreement 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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A PEST MANAGEMENT STRATEGIC PLAN FOR CALIFORNIA NECTARINES

1. CALIFORNIA NECTARINE PRODUCTION OVERVIEW

Nectarines, like peaches and plums, are members of the genus *Prunus,* and the nectarine, *Prunus persica var. nectarina*, is closely related to the peach. California is the leading nectarine producing state, supplying over 95% of the U.S. production.

The nectarine has been considered a separate and distinct fruit for over 2000 years. Early varieties were small, pale-skinned, white fleshed, and somewhat dry. In 1942, Fred Anderson, a plant breeder from central California, developed a nectarine named Le Grand; this one variety is considered the father of the modern nectarine. Today, there are over 175 different varieties of nectarines produced in California. Annual production from California now exceeds 20 million boxes, or 550 million pounds, all harvested from late April through mid-September.

For 2001, CDFA data show that California had 34,500 acres of nectarine trees in production and the nectarine crop was valued at nearly $197 million.

- California growers produce about 95% of U.S. nectarines. Other nectarine producing states include New Jersey, Pennsylvania, and Washington
- Nectarine production in California totaled 222,000 tons, an average yield of over 6.4 tons/acre in 2001
- Approximately 95% of California nectarines are sold in the fresh market and 5% are used by the freezer and other processing industries
- Although most California nectarines are consumed in domestic markets, about 25% of the fresh crop is exported, mainly to Canada, Mexico, Hong Kong, and Taiwan
- Major nectarine pests are Oriental fruit moth, katydids, San Jose scale, and thrips
- California's nectarine 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 nectarine 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 nectarine production areas in California are shown below in Figure 1. Appendix 2 contains seasonal profiles of nectarine crop development, cultural practices, and pest management activities.

Nectarine Varieties in California

- Approximately 175 varieties of nectarines are produced in California for the fresh market. About 14 of these comprise over 54% of the volume shipped
- 8-10% of the nectarine acreage is replanted each year to new varieties to keep up with consumer demands and changing tastes
- Recent variety trends: better flavor, earlier and later harvest times, better sizing potential (early varieties), sub-acid varieties, full red blush characteristic, and white-flesh varieties
- Newly planted trees reach minor production in about two years and full commercial production about 5-6 years after planting
- Almost 95% of the nectarine varieties have been bred by private breeders. There have been a small number of releases from the USDA-ARS; the University of California is not involved in fresh market nectarine breeding

Stages and Approximate Length of Time for California Nectarine Development *

Crop Stage	Description	Duration	Relative Timing
Dormancy	"Resting" phase; nectarines require approximately 750-900 chilling units to set a crop	Approximately 3 months	Nov – Jan
Bloom to jacket split	After pollination, when the tiny developing fruit actually splits the calyx	3-4 weeks	Jan – Mar
Fruit development "in-season"	From fruit set to physiologically mature fruit	45-180 days	Mar – Sep
Harvest	Removal of fruit from trees	7-20 days	April – Sep
Post-Harvest and Storage	In cold storage under controlled atmosphere conditions	Usually 14 – 28 days	

*Extremely variable according to variety, location and season

Nectarine Production Regions

The major nectarine production area in California is concentrated in Madera, Fresno, Kings, Tulare and Kern counties. As a result of variety selection and climate there is a wide window of production, even given the rather localized production of this commodity. The main nectarine production region in California is shown in Figure 1. Appendix 2 contains the production specifics by county; Appendix 3 provides seasonal profiles of crop development, cultural practices, and pest management activities for nectarines.

Figure 1. Nectarine Production in California

The Nectarine Industry

The counties of Madera, Fresno, Kings, Tulare, and Kern produced 96% of the nectarines produced in the state.

California's San Joaquin Valley

The San Joaquin Valley (SJV) is part of the larger Central Valley (represented by the brown 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.

Pests in California Nectarine Production: Overview of Key Organisms

The following section lists the most important pests of nectarines that will be the main issues dealt with throughout the strategic plan. For more detailed information on these and other pests of nectarines, the reader is directed to the *Crop Profile for California Nectarines* and to UC Publication 3389, *Integrated Pest Management for Stone Fruit.*

Chemical pest management products will be mentioned throughout this portion of the strategic plan; to find information on specific chemicals, please refer to the Appendices 5-10, which include a complete listing of all products by their chemical name and trade name. A summary of pest management concerns follows. Section 2 deals with each of the major categories in detail.

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 economic losses every year to nectarine growers. Damage may be done directly to fruit (cosmetic); under high population densities, scale infestations can cause limbs and branches to die back, thus permanently injuring 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), a pest in the larval stage, directly damages the developing fruit. This pest is troublesome as it has 3-5 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 nectarines. Damage is most severe on young trees. Some biological control of PTB is available; however, the 30+ species of parasites do not significantly reduce PTB infestations in trees before damage has occurred. Microbial insecticides (Bt) 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 the organophosphates (OPs) among them 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 nectarines in recent years, damaging nectarines 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 nectarines by leaf feeding, which can ultimately lead to leaf drop and poor fruit sizing. In addition to yield loss, loss of leaves due to spider mite feeding can lead to sunburn of nectarine trees. There are several species of mites found in nectarines: 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 is the most common and devastating fungal disease of nectarines; it is caused by two airborne fungi. Development of this disease is dependent upon moisture, temperatures, and wind. Blossoms, fruit, and twigs may be impacted by this disease. Orchard sanitation, with the goal of breaking the disease cycle, must include removing or burying mummies (old, diseased fruit), and pruning out any cankered or dead twigs as they are found and removing the prunings. Removing rotten fruit from the tree will reduce initial inoculum. Removing fallen fruit from the ground is less practical, but may be an option in small blocks or for organic growers.

Fungicides are also used to reduce losses due to brown rot. Although sanitation alone is not sufficient to control brown rot in most commercial orchards, it is a good IPM control strategy. Sanitation will decrease inoculum levels, which will improve the effectiveness of fungicide sprays. Fungicidal control may not be as good as desired when disease pressure is very high.

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 prolonged period of time. Proper planting, good drainage, and short irrigations help limit losses to root diseases.

Powdery mildew is favored by cool, moist nights and warm daytime 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; this disease 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 nectarine orchards.

Nematodes

Three major species of nematodes are found in nectarines: root knot, ring, and lesion nematodes, although root knot nematodes are considered the most important species. Plant parasitic nematodes move from the soil environment onto or into root tissues and feed on nectarine roots by puncturing them and sucking their cell contents. Nematode damage interferes with nutrient and water uptake, and nematodes may vector certain diseases. 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 nectarines. 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 nectarine trees, or may interfere with irrigation and other cultural activities. Rabbits, voles, gophers, squirrels, deer, and birds are the most troublesome to 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 not to violate any endangered species restrictions in specific areas.

2. PEST MANAGEMENT FOR NEW NECTARINE ORCHARDS

Selecting the proper orchard site and ensuring that young nectarine trees are well established will impact productivity over the lifetime of the orchard. Researching 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 must be considered. Precautions must also be taken to prevent damage to young trees by vertebrate pests.

Of great importance is the selection of varieties adapted to all production areas and conditions. In addition, selection of proper rootstock and use of certified planting stock will help the grower to avoid specific disease and nematode problems. Pre-plant fumigations of methyl bromide have provided excellent control of most soil-borne pests impacting young nectarine trees; alternative products must be developed to replace this valuable pest management tool for nectarines.

Cultural Activities

- Fallowing 1-3 years (if an economic option for the grower - unlikely)
- Mechanical cultivation – ground preparation
- Fumigation – on approximately 50-60% of the newly planted ground, but this is declining
- Planting
- Trunk painting 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; no flood irrigation is done in southern SJV orchards

INSECTS

In general, there are fewer pests on young trees, and, therefore, there are fewer in-season sprays used than on producing trees. Moderate control of scales can be achieved with oil, Sevin®, Imidan®, or Trilogy®; this is a key period of time to reduce populations which may already be somewhat resistant to insecticides from treatments at the nursery. Mites can be serious problems on young trees. Miticides such as Omite®, Vendex®, Apollo®, or Nexter® may be used; predators also provide excellent control of mites if not disrupted by insecticidal treatments for other pests. Peach twig borer treatments include Bt, pyrethroids, spinosad, Sevin®, and organophosphates; diazinon applied with oil during the dormant season provides excellent control. Aphids are best controlled through the application of an insecticide in the dormant period to kill over-wintering eggs; products used in-season include Thiodan®, Sevin®, Lannate®, M-Pede®, or pyrethroids. Several species of insects are occasional, but potentially serious, pests in young orchards; these include grasshoppers, borers, June beetles, false chinch bugs, tent caterpillars, fall webworms, red-humped caterpillars, cutworms, and armyworms.

Work Group Recommendations for Insect Management in New Orchards

Research	• Evaluate efficacy and cost effectiveness of using pheromones in non-bearing orchards • Evaluate new application techniques to optimize product efficacy • Conduct June beetle research in areas with sandy soils (biology and management)
Regulatory	• No requests at this time
Education	• Provide timely June beetle updates and guidelines for management/control

WEEDS

Weeds can be highly competitive with young orchards, so 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. Treflan®, Gallery® T and V, Prowl®, and Surflan® provide good control of grasses, but do not control many key broadleaf weed species. Surflan®, which had been reported in recent years to be available only in limited supplies due to production issues, is now available under the "generic" name Oryzalin®. Goal® is a very good broadleaf material, but is expensive and does not control grasses. Gramoxone® is a good burn-down material, but lacks residual control.

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

• 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 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 nectarine orchard establishment. Care must be taken at this point in the life of the trees since disease at this point will impact their productivity over their productive life.

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 (Vapam®).

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 moisture 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.

Delaying pruning in the northern and central part of the San Joaquin Valley may help to reduce incidence of bacterial 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 nectarine trees. The best way to avoid this complex of diseases is to use certified nursery stock. 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	• Provide education on Irrigation management to reduce soil/water diseases

NEMATODES

Plant parasitic nematodes move from the soil environment onto and into root tissues and feed by puncturing the roots and sucking their cell contents. Nematode damage interferes with nutrient and water uptake, and nematodes may vector certain diseases. Soil conditions and application procedures determine 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 nectarines. Township caps on the use of Telone® are also a concern and must be incorporated into pest management decisions.

Three nematodes can be found in nectarines: root knot, ring, and root 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. Note that the registrations for Nemacur® will be terminated in 2005. Selection of nematode-resistant rootstocks is mandatory. Fallowing, although not common due to unfavorable economics, may be a practice supported by future Farm Bill conservation provisions.

Work Group Recommendations for Nematode Management in New Orchards

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

VERTEBRATE PESTS

Rodents and vertebrates can cause significant damage to young nectarine trees themselves, and 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 guns.

Work Group Recommendations for Vertebrate Management in New Orchards

Research	• Evaluate/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 vertebrate control training for growers and PCAs on an annual basis

3. PEST MANAGEMENT FOR ESTABLISHED NECTARINE ORCHARDS

FALL
(After harvest – may be from September through November)

Cultural Activities

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

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. Products used that provide good control of SJS include oils, diazinon, and Sevin®.

Various lepidopterous pests, including OFM and PTB, occasionally can 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, residue 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. 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. According to the weed spectrum present, the following herbicides are used: Roundup®, Princep®, Gramoxone®, Goal®, Solicam®, Surflan®, and napromamide. Biological control of puncturevine is accomplished with the puncturevine weevil that feeds on developing seed pods on the plant, thus preventing reproduction and spread of this weed. Orchard floor management helps to control frost damage in the winter and spring.

The following weed species are of most concern in nectarine orchards in California:

• 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 Fall

Research	• Evaluate new herbicides including Visor® and Rely® • Evaluate new chemistries for fleabane control • Find Simazine® replacement material • Evaluate Shark® 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 shelter 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 growers and PCAs on the proper timing of deep irrigation to manage weed cycles

DISEASES

Once an orchard is established, a number of diseases must be managed during the fall and winter. Cultural practices that include sanitation, such as “clean picking” or after-harvest fruit and mummy removal, are important to help reduce disease innoculum.

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; Ridomil® and Alliette® are effective and registered for this purpose. DiTera® would be helpful for bacterial canker reduction also.

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 indicate high risk for rust in the following spring.

Work Group Recommendations for Disease Management in Fall

Research	• Evaluate sulfur/liquid lime sulfur for late fall powdery mildew control • Evaluate nectarine varieties for 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 the cooler 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 (i.e., certain chilling requirement) in order to complete dormancy and achieve maximum bloom and fruit quality; this varies according to variety. Buds that formed the previous season continue to develop slowly even in the cold winter months.

Cultural Activities

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

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 pest insects and mites. Almost all orchards receive at least one application of dormant spray during the fall or winter. Oils used with organophosphate (OP) 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 Lorsban®, diazinon, Supracide®, and Imidan®. Non-OPs used during the dormant period include carbaryl, oils, and pyriproxyfen. Because of product cancellation due to 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 dormant applications in nectarine orchards. Oil provides fair to good control, and the addition of organophosphates (as listed above) provides excellent control. The addition of carbamates to oil provides fair to excellent control. Applaud® and Esteem®, both insect growth regulators (IGRs), provide excellent control, but these products are very expensive and development of pest resistance is a concern; both should be applied with oil for maximum efficacy. Seize®, a newly registered IGR as of January 2003, may be a less expensive choice for control of scale.

Peach twig borers (PTB) and omnivorous leaf rollers (OLR) are effectively controlled with Asana®, an organophosphate with oil (Imidan®, diazinon, Lorsban®), or Supracide® with oil. Success®, a reduced-risk product, provides good control of peach twig borer (PTB). 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 insure 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 the appropriate time to reduce numbers.

Citrus cutworm is an occasional pest in orchards adjacent to citrus; this pest is effectively controlled using Bt sprays.

Spider mites need to be closely monitored at this time of year to make sure that the season is not started with numbers present that can escalate to damaging levels. Insecticidal soaps and oils are effectively used for mite control at this time of the year. Predators such as the Western predatory mite, six-spotted thrips, and the spidermite destroyer, *Stethorus picipes*, are very important in moderating mite populations. These beneficial organisms should be preserved as much as possible.

Aphids can be effectively controlled by oils during the cooler months of the year. Efficacy of oils is reported to be excellent, especially 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 • 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 and 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 14 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 help with diseases such as brown rot, "clean picking" or after-harvest fruit and mummy removal needs to be effectively practiced.

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), but 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. *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.

Work Group Recommendations for Disease Management in Winter

Research	• Evaluate sulfur/liquid lime sulfur for late fall powdery mildew control • Evaluate nectarine varieties for 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

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. 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	• Orchard floor management
• Roping trees	• Some blossom thinning
• Planting replacement trees	• Irrigating
• Trap placement and monitoring	• Monitoring of all orchard pests
• Apply mating disruption dispensers	• Pruning

Pollination: bees are not required to set a nectarine crop; nevertheless care must be taken to avoid harming or 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 on some orchards 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 loss levels. The use of a selective material like Bt has a great advantage in that it is not disruptive to beneficial organisms. Monitoring nectarine orchards to determine when larvae are emerging and timing applications of Bt is critical to efficacy, since the material must be directly consumed to be lethal. In addition, applications made with 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 is expensive and resistance issues have already been noted. 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 not yet registered, reportedly 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, Supracide®, and Imidan®) 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. When insecticides are used for OFM control, good choices include Lannate®, Imidan®, Asana®, Thiodan®, and Sevin®.

Spider mites must be closely monitored now. 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® and Nexter® are effective in controlling mite motiles; Acramite® 50WS (bifenazate), Apollo®, and Savey® are effective ovicides. Pyrethroids such as Asana® should be kept as a control option; however, it is widely recognized that these products are highly disruptive to beneficials and may cause mite populations to flare up.

Thrips are occasional pests of nectarines; thrip damage is more pronounced in cool seasons when shedding of the calyx is slow. Good to excellent control of thrips is achieved with Success®. Carzol® also provides good to excellent control of thrips; however, use of this product may flare mites, and the long reentry interval prevents heavy use during bloom. Proper management of orchard floor vegetation is an effective means by which to provide some control of the movement of thrips into nectarine orchards.

True bugs (Lygus bugs) are an occasional problem; manipulation of cover crops is important in managing this pest. 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 are usually not a problem in nectarines. When needed, several products may be effectively used for codling moth control: Supracide®, Imidan®, Asana®, and Success®. The efficacy of using mating disruption in nectarines is not well understood and therefore mating disruption is 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 very expensive.

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 are causing serious damage in nectarine orchards. Imidan® and Success® work fairly well to control katydids, but must be repeated when egg hatch occurs over prolonged periods; azadirachtin is an alternative for organic growers.

Work Group Recommendations for Insect Management in Spring

Research	• 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 • Develop effective, longer-lasting product for control of katydids • 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 • Train growers and PCAs on the use of mating disruptions • Educate APHIS on systems approaches to insect pest management • Educate growers and PCAs on Acramite® use rates • Provide training to growers on resistance management

DISEASES

Brown rot, green fruit rot, rust, and powdery mildew are the most common and troublesome diseases of nectarines during bloom, petal fall, and leaf emergence in California. Thus, management programs continue at bloom through petal fall and leaf emergence. Ridomil® is beneficial for managing *Phytophthora* root rot, but would be expensive used as a drench. Aliette® (fosetyl-al) used as a foliar spray would probably be more cost-effective.

Commonly used treatments include sulfur, Rovral®, Rally®, Break®, Vanguard®, and Elevate®. Captan and Topsin-M® are also used on fresh market nectarines. 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.

Intensive monitoring of orchards and a thorough knowledge of conditions promoting disease development are critical to controlling pathogens in nectarine 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 (e.g. *Trichoderma* spp.) 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, *Alterneria*, and blight

IN-SEASON

(Fruit development through harvest – April through September)

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
- Cultivating
- Fertilizing
- Irrigating
- Thinning
- Harvesting
- Pruning

INSECTS

Oriental fruit moth (OFM) is a serious pest in California. There are usually 4 to 5 generations per year in California, although a sixth generation has been observed in years with warm weather in early spring. In early spring, pupation takes place inside the cocoon and adults begin emerging in February or early March. Eggs are deposited on newly emerged shoots and the larvae feed in terminals where they complete their development. Larvae cause damage by feeding on developing shoots and fruits. The most severe damage occurs where larvae feed on fruit. Mating disruption is effective for Oriental fruit moth (OFM) control. Pyrethroids and Imidan® are particularly effective for this lepidopterous pest; 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.

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 <u>when populations are high and/or peach orchards are located near almond orchards, mating disruption alone will not control PTB</u> and chemical applications are likely. Imidan® provides good to excellent control, but creates 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 nectarines 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 ovicide; 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) both are well controlled by Success® and pyrethroids; timing is especially critical when using pyrethroids. Bt and Imidan® also provide good control of OBLR and OLR. Success® and the pyrethroids all provide good to excellent control of these species; Confirm®, an IGR, is also an excellent material.

Katydids can cause major cosmetic damage to nectarines; 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 it must be applied prior to the adult stage because it has a short residual, and katydid 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 nectarine production. Good control of katydid adults is provided by Lannate®, and its short PHI is desirable.

Thrips may be major pests of nectarines; reports indicate that about 90% of orchards are treated for thrips pre-harvest. Good to excellent control of this pest is achieved with Success®. Carzol® also provides good to excellent control; however, its long reentry interval prevents much use. Proper management of orchard floor vegetation provides some control of the movement of thrips into nectarine orchards. Lannate® is an extremely important insecticide for control of thrips in-season.

Occasional In-season Pests: Codling moths may be an occasional problem in nectarines in-season. Several products may be effectively used for codling moth control: Supracide®, Imidan®, Thiodan®, Asana®, and Success®. Using mating disruption in nectarines is not recommended at this time of the 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® 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 the Modesto/Stockton area. 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 to growers and PCAs regarding fungicides, insecticides, and herbicides • 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 7-10 day PHIs in IPM programs

WEEDS

As methyl bromide is phased out over the next several years, weed control, especially control of perennial weed species, will become more of a concern to nectarine growers. Herbicides commonly used at this time of year include: Roundup®, Princep®, Gramoxone®, Goal®, Solicam®, and Surflan®. For in-season weed control, there is a need for contact herbicides. Biological control of puncturevine is accomplished with the puncturevine weevil that feeds on developing seed pods on the plant, thus preventing reproduction and spread of this weed.

The following weed species are of concern in nectarine 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) • Develop reduced risk contact herbicides which are safe for bees during their active period
Regulatory	• Work to make labels more realistic in terms of grower practices; need products with PHIs of less than 7 days • Shorten PHI for Roundup® through existing IR-4 project • Reduce the PHI for Gramoxone® • Check PHI status of Rely®, Visor®, and Chateau®
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 nectarines; without appropriate pre-harvest management practices, the disease can cause significant losses in storage. Brown rot may be treated pre-harvest with Break®, Rally®, and Topsin-M®; it may also be treated in-season with 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. *Phytophthora* root rot, which is active in spring and fall, becomes inactive in-season.

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

Root and trunk diseases such as crown rot, crown gall, and wood decay fungi continue to be problems year round. Proper irrigation is an important cultural method for managing these diseases. 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. Oak root fungus may be only partially managed by the *Trichoderma* fungus in established orchards.

Work Group Recommendations for Disease Management In-Season

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

NEMATODES

Nematodes are not normally managed in-season. Very few products are registered, and many of these are under intense regulatory scrutiny. Fenamiphos, also known as Nemacur®, will be phased out in 2005, and oxamyl (Vydate®), a carbamate, is also at risk. Another material, metam sodium (Vapam®), cannot be use on established orchards, and has only limited efficacy according to soil texture, depth of root systems, and soil moisture content. Newer cultural techniques, such as soil solarization and use of cover crops, do not appear to have a significant impact on in-season nematode problems.

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 blue jays and crows, can cause significant loss to crop yield and quality by feeding directly on ripening fruit. 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 nectarines include frightening, trapping, and 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
(April through October)

DISEASES

Good post-harvest disease management starts with healthy nectarines 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 critical because an increasing amount of the nectarine crop is destined for the export market and must have good shelf life to be marketable.

Several organisms can cause post-harvest losses of nectarines, 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 nectarines in California. Gray mold causes damage in fruit stored at low temperatures; most infections occur from harvesting and handling wounds. *Mucor* decays and sour rot (*Geotrichum* spp.) may cause problems in some years and are becoming more of a problem. Currently, Scholar® and dichloran (Botran® 75W, Allisan® 75W) are the only fully registered post-harvest fungicides 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.

Full registration has been obtained for Scholar® 50WP 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 nectarine 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 treated with methyl bromide fumigation for arthropod control. The pest targeted depends 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 destined for the export market. In addition, it is extremely important that U.S. registrations are 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").

Work Group Recommendations Concerning International Issues

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 concerns
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 • 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 • Harmonize EPA registration requirements with the MRL and Codex systems used in other countries. • Encourage EPA and FAS 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 nectarines in California begins before the fruit is planted and continues until it reaches the consumer's hand. California's nectarine industry, working closely with the University of California, continually studies growing practices, pest control, irrigation, fertilization, and post-harvest handling. As part of this research, the California nectarine 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 nectarines with any reported illness or outbreak, and University laboratory data support the current view of a "low-concern status" for nectarines relative to microbial food safety.

Despite this clean record, the California nectarine industry has taken measures to develop a comprehensive quality control program, which requires an audit of farming and packing house operations. In addition, 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 grown in California, nectarines 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 others, make California nectarines safe and wholesome products for consumers throughout the world.

Work Group Recommendations Concerning Food Safety Issues

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

4. CRITICAL ISSUES FOR THE CALIFORNIA NECTARINE INDUSTRY

The following areas were identified by the Nectarine Work Group as being the most critical to the sustained viability of the California nectarine 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 nectarine 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 nectarine rootstocks
Regulatory	• Harmonize the Cal/EPA and US EPA review process to hasten new 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; insure 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 nectarines and their high level of food safety and quality

REFERENCES

Crop Profile for California Nectarines website http://pestdata.ncsu.edu/cropprofiles/docs/canectarines.html, revised September 2001

UC IPM Pest Management Guidelines: Nectarine, June 2002

Integrated Pest Management for Stone Fruits - UC Publication 3389, 1999

Post-Harvest Technology of Horticultural Crops- UC Publication 3311, 3rd Edition, 2002

USDA National Agricultural Statistics Service *Agricultural Chemical Usage 2001 Fruit Summary,* August 2002

2001 Ag Commissioners Data, California Department of Agriculture website http://www.nass.usda.gov/ca/rlsetoc.htm

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

California Tree Fruit Agreement (CTFA): http://www.caltreefruit.com.htm

CDFA Resource Directory – 2002 at their website http://www.cdfa.ca.gov/publications.htm

APPENDICES

1. 2001 California Nectarine Production Statistics

COUNTY	HARVEST ACREAGE	YIELD (Tons/Ac.)	PRODUCTION (Tons)	TOTAL VALUE ($)
Contra Costa	31	2.0	64	103,000
Fresno	14,808	8.3	123,000	102,705,000
Kern	1,288	6.3	8,100	11,046,000
Kings	1,808	6.3	11,390	6,657,000
Madera	690	4.7	3,271	2,011,000
Merced	137	7.4	1,019	568,000
Stanislaus	480	9.4	4,500	3,735,000
Tulare	15,323	4.6	70,800	70,092,000
STATE TOTALS	**34,565**	**Average 6.4**	**222,144**	**196,917,000**

Source: County Agricultural Commissioners' Data

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 Nectarines

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 - Dormant												
Frost Protection												
Girdling												
Fertilizer Application												
Summer Pruning												
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 Nectarines

Insects and Mites	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
San Jose Scale - active												
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												
Weeds	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Johnsongrass												
Bermuda Grass												
Annual Grasses												
Mustards												
Diseases	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Bacterial Canker												
Oak Root Fungus												
Brown Rot												
Jacket Rot												
Green Fruit Rot												
Powdery Mildew												
Phytophthora												
Black Mold												
Shot hole												
Crown Rot												
Crown Gall												
Peach Rust												
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												
Squirrels												
Birds												

Data based on collective field observations and experiments

4. IPM Program Monitoring Periods for Nectarines

IPM TARGET	MONITORING PERIOD				
	Dormant, Delayed Dormant	Bloom	Petal Fall	Fruit Development	Pre-harvest
Peach Twig Borer			(Shoot Strikes)		
San Jose Scale					
Brown Mite					
European Red Mite					
Leaf Rollers					
Green Fruitworm					
Oriental Fruit Moth					
Thrips					
Brown Rot					
Stink Bugs					
Lygus Bugs					
Web-spinning Mites					

Data based on collective field observations and experiments

5. Efficacy of Insect Management Tools Used in California Nectarines

Chemical 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 Rollers	Oriental Fruit Moth	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	Azadirachtin®	?	P	P	P	P	P	P	P	P	P	?	P	P
Oil		P	E	P	E	P	P	P	P	P	P	F-G	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	G	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	G	P	G	F	G	G	G	E	P	G	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

5. Efficacy of Insect Management Tools Used in California Nectarines (continued)

Impact of Chemical Insecticides on Beneficial Organisms in Nectarines

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 intended 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* = hours to days; *moderate* = days to 2 weeks; and *long* = many weeks or months

[5] Kills six-spotted thrips

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

5. Efficacy of Insect Management Tools Used in California Nectarines (continued)

Unregistered or New Insecticides for Nectarines

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	Omniverous/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
Pirimicarb	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 for California Nectarines

CONTROL AIDS	INSECTS												
	Aphids	Brown Mites	Codling Moth	European Red Mites	Fruit Tree Leaf Rollers	Katydids	Lygus Bugs	Omniverous/Oblique-Banded Leaf Roller	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	F	P	P	F-G
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

6. Efficacy of Disease Management Tools Used in California Nectarines

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											
Captan		G	G-E	G				G			
Chorothanlonil	Bravo®	F	F	P	P	P	P	G	P	P	P
Ciprodinil	Vangard®	F-G	P	P	P	?	?	P			
Copper		P	P	G	P	P	P	G	P	P	P
Fenbuconazole	Indar®	G	F								
Fenhexamid	Elevate®	?									
Fosetyl-al	Aliette WDG®			G				G			
Iprodione	Rovral®	G-E				G-F		F			
Mefenoxam	Ridomil Gold®										
Myclobutanil	Rally®	G	E		F		F	F			
Propiconazole	Break® Orbit®	G	G		G			F			
Sulfur (Wettable)		E	E		G		G-E				
Tebuconazole	Elite®	E			G		G				
Thiophanate-methyl	Topsin®	E	E		G						
Vinclozolin	Ronilan®										
Ziram			F	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

7. Efficacy of Nematode Management Tools Used in California Nectarines

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			
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

8. Efficacy of Weed Management Tools Used in California Nectarines

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	F	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

9. Efficacy of Vertebrate Management Tools Used in California Nectarines

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	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	F-G	F-G	P	P	P	P
Fumigating	G	G	P	P	P	P
Predators	P	F	F	P	P	P
Cultural Barriers	P	P	P	P	P	P
Mylar Strips						P-F

Data based on collective field observations and experiments

10. Chemical Use on California Nectarine Orchards 1999-2001

Pounds of Active Ingredient Used

PRODUCTS	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
INSECTIDICES					
Azinphos-methyl	Guthion®	915	1,598	634	1,049
Bacillus thuringiensis	Dipel®	2,317	1,914	1,785	2,005
Carbaryl	Sevin®	8,718	5,807	4,935	6,487
Chlorpyrifos	Lorsban®	23,192	36,459	23,104	27,585
Clofentezine	Apollo®	786	710	702	733
Diazinon		19,861	17,596	13,842	17,100
Dicofol	Kelthane®	2,654	1,091	2,139	1,961
Esfenvalerate	Asana XL®	924	1,365	1,057	1,115
Fenamiphos	Nemacur®	1,027	409	443	626
Fenbutatin Oxide	Vendex®	3,444	3,852	3,459	3,585
Formetanate HCL	Carzol®	38,230	30,861	3,459	24,183
Hexythiazox	Savey®	0	0	192	64
Methidathion	Supracide®	6,776	3,716	2,405	4,299
Methomyl	Lannate®	9,039	7,935	3,922	6,965
Petroleum distillate	Narrow Range Oil	0	0	11,651	3,884
Phosmet	Imidan®	39,544	26,695	61,474	42,571
Propargite	Omite®	516	506	22,965	7,996
Pyridaben	Sammite®	0	0	1,219	406
Potash Soap	M-Pede®	17,335	12,489	508	10,111
Spinosad	Success®	0	0	1,471	490
Sulfur (Wettable)		147,703	227,086	108,877	161,222
HERBICIDES					
2,4-D		0	0	29	10
Glyphosate	Roundup®	32,768	37,301	37,301	35,790
Norflurazon	Solicam®	3,060	4,134	4,171	3,788
Oryzalin	Surflan®	9,971	6,805	1,295	6,024
Oxyfluorfen	Goal®	6,094	6,198	4,932	5,741
Paraquat Dichloride	Gramoxone®	15,873	14,769	11,664	14,102
Pendimethalin		0	0	2,065	688
Simazine	Princep®	9,163	8,816	9,175	9,051

Data from CDPR

10. Chemical Use on California Nectarine Orchards 1999-2001 (continued)

Pounds of Active Ingredient Used

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
FUNGICIDES					
Benomyl	Benlate®	1,453	541	953	982
Captan		11,688	1,666	2,207	5,187
Chlorothalonil	Bravo®	12,911	11,611	5,689	10,070
Copper (hydroxide & oxide)		0	0	11,611	3,870
Cyprodinil		0	0	1,135	378
Fenbuconazole		0	0	997	332
Fosetyl-al		4	0	76	27
Iprodione	Rovral®	9,633	10,033	8,280	9,315
Methyl Parathion	Penn Cap® M	12,789	32	0	4,274
Myclobutanil	Rally®	574	884	779	746
Propiconazole	Break®	2,709	2,882	1,688	2,426
Sulfur (wettable)		147,703	227,086	108,877	161,222
Tebuconazole	Elite®	1,280	1,416	1,766	1,487
Thiophanate-methyl	Topsin®	1,621	937	557	1,038
Vinclozolin	Ronilan®	185	7	0	64
Ziram		78,943	78,274	63,283	73,500
OTHERS					
Methyl Bromide		12,554	0	112	4,222
E-8-Dodecenyl acetate		0	0	22	7
E-8-Dodecen acetate		0	0	0	0
E-8-Dodencanol		0	0	11	4
Strychnine		0	0	7	2

Data from CDPR

10. Chemical Use on California Nectarine Orchard Acreage 1999-2001 (continued)

% of Orchard Acres Treated

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
INSECTICIDES					
Azinphos-methyl	Guthion®	1	3	1	1.7
Bacillus thuringiensis	Dipel®	28	27	19	24.8
Carbaryl	Sevin®	6	4	4	4.6
Chlorpyrifos	Lorsban®	30	45	33	36.0
Clofentezine	Apollo®	13	13	14	13.3
Diazinon		21	19	15	18.4
Dicofol	Kelthane®	5	2	4	3.6
Esfenvalerate	Asana XL®	51	72	61	61.3
Fenamiphos	Nemacur®	1	1	0	0.8
Fenbutatin Oxide	Vendex®	11	12	11	11.5
Formetanate HCL	Carzol®	62	53	51	55.3
Hexythiazox	Savey®	0	0	4	1.3
Methidathion	Supracide®	8	3	0	3.7
Methomyl	Lannate®	21	19	11	16.8
Petroleum distillate	Narrow Range Oil	0	0	11	3.6
Phosmet	Imidan®	33	22	47	33.9
Propargite	Omite®	0	0	29	9.8
Pyridaben	Sammite®	21	16	8	15.1
Potash Soap	M-Pede®	0	0	0	0.1
Spinosad	Success®	0	0	33	10.9
Sulfur (wettable)		39	40	37	38.6
HERBICIDES					
2,4-D		0	0	4	1.3
Glyphosate	Roundup®	59	61	65	61.8
Norflurazon	Solicam®	9	9	11	9.7
Oryzalin	Surflan®	15	14	5	11.2
Oxyfluorfen	Goal®	41	41	43	41.5
Paraquat Dichloride	Gramoxone®	34	34	28	31.9
Pendimethalin		0	0	4	1.3
Simazine	Princep®	33	32	35	33.4

Data from CDPR

10. Chemical Use on California Nectarine Orchards 1999-2001 (continued)

% of Orchard Acres Treated

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
FUNGICIDES					
Benomyl	Benlate®	3	5	2	3.5
Captan		5	19	3	8.9
Chlorothalonil	Bravo®	5	7	8	6.8
Copper (hydroxide & oxide)		55	0	0	18.4
Cyprodinil		12	0	0	4.1
Fenbuconazole		25	0	0	8.3
Fosetyl-al		0	0	0	0.0
Iprodione	Rovral®	33	32	35	33.2
Methyl Parathion	Penn Cap® M	0	38	1	13.0
Myclobutanil	Rally®	16	11	15	13.9
Propiconazole	Break®	32	45	51	42.6
Sulfur (wettable)		37	39	40	38.6
Tebuconazole	Elite®	26	16	18	19.9
Thiophanate-methyl	Topsin®	2	4	2	2.5
Vinclozolin	Ronilan®	0	1	0	0.3
Ziram		25	27	25	25.6
OTHERS					
Methyl Bromide		0	1	0	0.4
E-8-Dodecenyl acetate		20	0	0	6.5
E-8-Dodecen acetate			0	0	0.0
E-8-Dodencanol		0	0	0	0.0
Strychnine		3	0	0	1.0

Data from CDPR

11. Members of the California Nectarine Work Group

(SJV = San Joaquin Valley, UC = University of California, UCCE=University of California Cooperative Extension, KAC=Kearney Agricultural Center)
Note: Nectarine production area of interest in parentheses

Growers, Packers, and Shippers

1. Jim Krause, Grower, Reedley, CA (Southern SJV)
2. Steve Strong, Grower, Visalia, CA (Southern SJV)
3. Bill Tos, Grower, Hanford, CA (Southern SJV)

Pest Control Advisors

4. Kelley Morrow, PCA, Parlier, CA (Southern SJV)
5. Randy Radtke, PCA, Dinuba, CA (Southern SJV)

Commodity Group Representatives

6. Lori Berger, California Minor Crops Council (CMCC), Tulare, CA
7. Gary VanSickle, California Tree Fruit Agreement (CTFA), Reedley, CA

Land Grant University Research and Extension Personnel

8. Jim Adaskaveg, Plant Pathology Department, UC Riverside, Riverside, CA (SJV)
9. Walt Bentley, IPM Entomologist, UC Kearney Agricultural Center, Parlier, CA (SJV)
10. Rich Coviello, UC Cooperative Extension Service, Fresno, CA (Southern SJV)
11. Kevin Day, Farm Advisor, UC Cooperative Extension Service, Tulare County, Tulare, CA (Southern SJV)
12. Kurt Hembree, UC Cooperative Extension Service, Fresno County, Fresno, CA (Southern SJV)
13. Susan Mallek, UC Kearney Agricultural Center, Parlier, CA (SJV)
14. Anil Shreslta, IPM-KAC, UC Kearney Agricultural Center, Parlier, CA (SJV)
15. Shawn Steffan, Staff Research Associate, UC Kearney Agricultural Center, Parlier, CA (SJV)

California Pest Management Center

16. Rick Melnicoe, California & Western Region Pest Management Center, UC Davis, Davis, CA
17. Linda Herbst, California & Western Region Pest Management Center, UC Davis, Davis, CA

USDA-ARS

18. David Obenland, USDA Agricultural Research Service (ARS), Parlier, CA

12. California Nectarine Industry - Contact Information

Jim Adaskaveg
Dept. of Plant Pathology
UC Riverside
Riverside, CA 92521
Ph: (909) 787 7577
Fax: (909) 787 3880
E-mail: jim.adaskaveg@ucr.edu

Walt Bentley
UC KAC
9240 S. Riverbend Ave.
Parlier, CA 93648
Ph: (559) 646 6527
Fax: (559) 646 6553
E-mail: walt@uckac.edu

Lori Berger
Director of Technical Affairs
CA Minor Crops Council (CMCC)
4500 S. Laspina, Suite 214
Tulare, CA 93274
Ph: (559) 688 5700
Fax: (559) 688 5527
E-mail: lori@minorcrops.org

Rich Coviello
UCCE
1720 S. Maple Ave.
Fresno, CA 93702
Ph: (559) 456 7549
Fax: (559) 456 7575
E-mail: rlcoviello@ucdavis.edu

Kevin Day
UCCE
4437 S. Laspina
Tulare, CA 93274
Ph: (559) 685 3309
Fax: (559) 685 3319
E-mail: krday@ucdavis.edu

Kurt Hembree
UCCE
1720 S. Maple Ave.
Fresno, CA 93702
Ph: (559) 456 7556
Fax: (559) 456 7575
E-mail: kjhembree@ucdavis.edu

Jim Krause
9284 S. Rio Vista Ave.
Reedley, CA 93654
Ph: (559) 280 5321
Fax: (559) 643 0207
E-mail: jkrause532@aol.com

Susan Mallek
UC KAC
9240 S. Riverbend Ave.
Parlier, CA 93648
Ph: (559) 646 6523
E-mail: susanb@uckac.edu

Kelley Morrow
Crop Care Associates
8554 S. Parlier Ct.
Parlier, CA 93648
Ph: (559) 646 2628
Cell: (559) 360 1902
Fax: (559) 646 2072
E-mail: kelley.morrow@earthlink.net

David Obenland
USDA ARS
9611 S. Riverbend Ave.
Parlier, CA 93648
Ph: (559) 596 2801
Fax: (559) 596 2791
E-mail: dobenland@fresno.ars.usda.gov

Randy Radtke
Pest Control Advisor
GAR Tootleian, Inc.
41162 Rd. 70
Dinuba, CA 93618
Ph: (559) 638 6311
Fax: (559) 591 6829
E-mail: radtke@cybernntz.net

Anil Shreslta
UC KAC
9240 S. Riverbend Ave.
Parlier, CA 93648
Ph: (559) 646 6534
Fax: (559) 646 6593
E-mail: anil@uckac.edu

Shawn Steffan
UC KAC
9240 S. Riverbend Ave.
Parlier, CA 93648
Ph: (559) 646 6572
Fax: (559) 646 6593
E-mail: ssteffan@uckac.edu

Steve Strong
1308 W. Myrtle
Visalia, CA 93277
Ph: (559) 636 9330
Fax: (559) 636 9337
E-mail: rubiconss@aol.com

Bill Tos
Tos Farms, Inc.
9240 Excelsior Ave.
Hanford, CA 93230
Ph: (559) 584 5751
Fax: (559) 583 8354
E-mail: billtos@cnetech.com

Gary VanSickle
CA Tree Fruit Agreement (CTFA)
P.O. Box 968
Reedley, CA 93654
Ph: (559) 638 8260
Fax: (559) 638 8842
E-mail: gvansickle@caltreefruit.com