A Pest Management Strategic Plan for Plum Production in California

2006

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.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Plums, like peaches and nectarines, are an important stonefruit commodity in California. The industry is geographically centered in only five counties, but annually produces over $200 million of revenue on about 38,000 acres. The major outlet for California plums is in the fresh market, and a significant portion of the annual crop is exported to Asia and Canada.

Many factors affect the profitability and sustainability of plum production in California. The industry continues to adapt to new pests, regulatory changes, quarantine concerns, resistance management issues, environmental and worker protection issues, declining profitability, urban encroachment, and global competition. These factors have led growers, pest control advisors (PCAs), packers, and shippers to work more closely with research, extension, and agency personnel in recent years.

The Food Quality Protection Act (FQPA) of 1996 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 plum producers have reduced their use of organophosphate insecticides significantly in recent years. The successful transition to reduced risk materials has been facilitated by collaborative efforts on the part of growers, PCAs, industry, processors, and research, extension, and agency personnel. But even with these improvements, major pest management challenges continue to exist for plum 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.

Several products important to plum production have already been cancelled or restricted due to FQPA and other regulatory decisions (e.g., methyl parathion, azinphos methyl, methyl bromide). 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 plum production, seasonal pest occurrences, and integrated pest management techniques throughout California for fresh market and processing varieties of plums. 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 plum production have been summarized from input made by growers, pest control advisors, and other experts involved in field activities. It should be noted that the mention of specific trade names in this document is not an endorsement of any particular product.

This strategic plan will receive periodic updates and serves principally as a guideline to direct future pest management efforts related to California plum production. Important documents that provide a basis for this strategic plan are UC Publication 3389 (*Integrated Pest Management for Stonefruits*) and the *Crop Profile for California Plums*; these documents provide a complete review of cultural and pest management practices for California plums.

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 plum production.

Stakeholder Recommendations

As a result of the PMSP planning meeting held in September 2002 and in revisions to this document in late 2006, the Plum Work Group identified the following research, regulatory, and educational priorities. These critical areas were presented by various segments of the plum industry in California.

Research Priorities

Finding effective solutions for insect and disease control is the most immediate and serious concern of plum 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 plum production.

- Develop new methods for pre- and post-harvest disease, insect and weed control
- Develop methyl bromide alternatives for quarantine, nursery, and pre-plant treatments
- Develop best management practices (BMPs), sustainability plans, and/or mitigation measures for environmental issues (e.g. to address water quality, air quality, volatile organic compounds (VOCs), reduced risk practices, etc.)
- Assess environmental and economic costs of pest management alternatives
- Improve application technology, especially for newer materials
- 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

Regulatory Priorities

The plum 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.

- Retain key products which complement current IPM practices and products which are a part of a resistance management program
- Register ethephon (Ethrel®) as a crop management tool
- Register abamectin (Agri-mek®) for reduced risk control of mites
- Register propiconazole (Orbit®) for post-harvest reduced risk control of sour rot
- Establish prescriptive uses for certain key pest management tools (e.g. organophosphates, carbamates, etc.) to complement IPM practices and to serve as backup products in critical pest management situations
- Develop best management practices(BMPs) to mitigate environmental concerns
- Coordinate research and registration activities to avoid potential trade barriers (NAFTA, Codex and other international standards)
- Harmonize IR-4, Cal/EPA, U.S. EPA, and international standards for pesticide residues to hasten new product registrations
- Develop labels which are realistic in terms of field practices in the field, e.g., growers need products with PHIs of less than 7 days

Educational Priorities

The public, including regulators and consumer groups, must be educated about the use of Integrated Pest Management (IPM) in California plum production and how this system optimizes food production while minimizing risks to workers and the environment. Growers need to be educated on new materials and the most efficient manner in which these can be applied. University programs in the areas of research and education, particularly agricultural engineering, should be enhanced to provide adequate technology transfer of reduced risk pest management practices. Finally, the public should be reminded that eating fresh California plums 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.

- 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 for stonefruit
- Educate the public on the nutritional value of California grown plums and their high level of food safety and quality
- Educate growers, PCAs, applicators and commodity members on the use of best management and sustainable practices to protect and improve environmental quality.
- Educate growers, PCAs, applicators and commodity members on resistance management
- Educate growers, PCAs, applicators and commodity members on safe and efficient application techniques

The California plum industry appreciates the support of US 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 plum industry.

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A PEST MANAGEMENT STRATEGIC PLAN FOR CALIFORNIA PLUMS

1. CALIFORNIA PLUM PRODUCTION OVERVIEW

Plums, like peaches and nectarines, are members of the genus *Prunus*. California is the leading plum producing state, supplying over 95% of the U.S. production. Plums come in two types: *Prunus salacina* (Japanese) and *Prunus domesticus* (European). Japanese plums make up the majority of California plum varieties and tend to be tarter tasting, juicier, and larger than European plums. They also come in the widest range of colors – red, purple, black, green, and yellow. Japanese plums were first introduced in the late 1880s when parent stock was introduced from the Satsuma province of Japan. European plums, which are produced in lesser quantities as compared to Japanese varieties, were introduced into the United States by the early colonists. European plums are generally smaller, sweeter, and blue/purple or mottled red in coloration as compared to Japanese varieties.

California's fresh plum crop ranges from 10 to 18 million boxes or up to 530 million pounds annually. Harvest begins in mid-May and continues through October. For 2001, USDA (NASS/CASS) data show that California had 38,000 acres of plum trees in production and the plum crop was valued at nearly $208 million.

- California growers produce about 95% of U.S. plums
- Plum production totaled 265,000 tons on approximately 38,000 acres, an average yield of 7 tons/acre in 2002
- Approximately 98% of California plums are sold in the fresh market and 2% are used by the freezer and other processing industries
- Although most California plums are consumed in domestic markets, about 32% of the fresh crop is exported, mainly to Canada, Hong Kong, Taiwan, Mexico, Venezuela, Malaysia, and Singapore
- California's plum 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 plum 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

Plum Varieties in California

- Approximately 250 varieties of plums are produced in California for the fresh market; about 10 of these comprise over 70% of the volume shipped
- 6-8% of the plum acreage is replanted each year to new varieties to keep up with consumer demands and changing tastes
- Newly planted trees reach minor production in about three years and full production after about seven years
- Recent variety trends: better flavor, larger sizing potential, earlier and later harvest, better/more consistent crop yield, specific skin or flesh color
- Almost 70% of the plum varieties have been bred by private breeders. There have been a small number of releases from the USDA-ARS and 3 of the top 5 varieties are USDA releases; University of California is not involved in fresh market plum breeding
- Plums, unlike other stonefruit, require bees to pollinate and set a crop. This presents additional challenges when making pest management decisions; adverse weather at bloom time can cause significant crop loss due to poor set
- Dried plums are also called prunes; pest management practices and crop statistics for the dried plum segment of the plum industry are reported separately

Stages and Approximate Length of Time for California Plum Development *

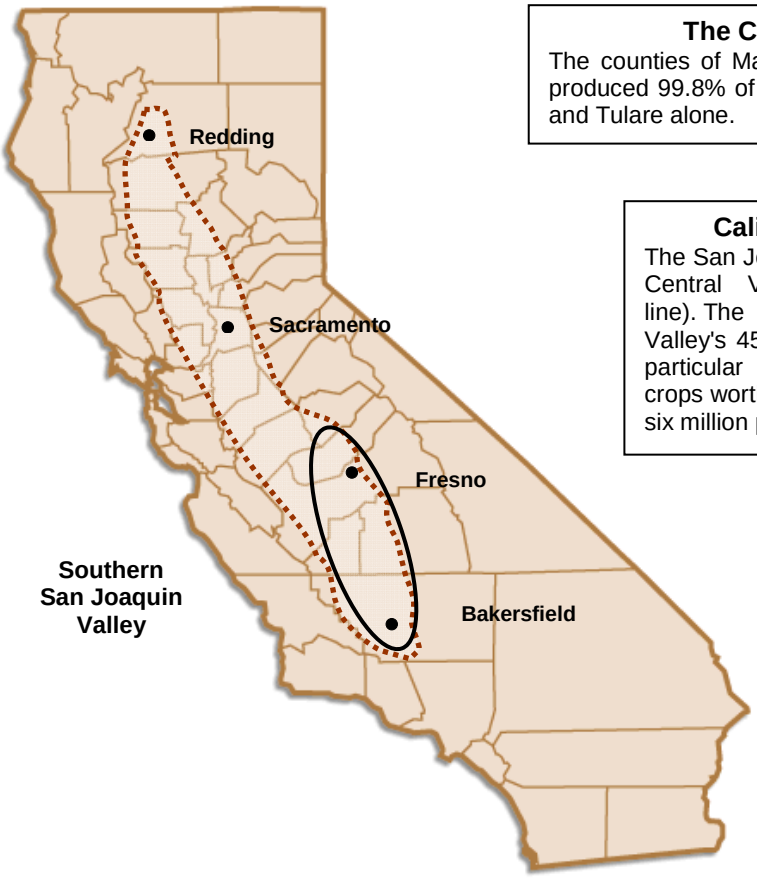
Crop Stage	Description	Duration	Relative Timing
Dormancy	"Resting" phase; plums require approximately 600-900 chilling units to set a crop	Approximately 3 months	Nov – Feb
Bloom to jacket split	After pollination, when the tiny developing fruit actually splits the calyx	3-4 weeks	Feb – Mar
Fruit development "in-season"	From fruit set to physiologically mature fruit	45-180 days	Mar – Oct
Harvest	Removal of fruit from trees	15-20 days	May – Oct
Post-Harvest and Storage	In cold storage under controlled atmosphere conditions	Usually 14 – 28 days	

*Extremely variable according to variety, location, and season

Plum Production Regions

The major plum 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 plum production region in California is shown in Figure 1. Appendix 2 contains seasonal profiles of plum crop development, cultural practices, and pest management activities for this region.

Figure 1. Plum Production in California



The California Plum Industry

The counties of Madera, Fresno, Kings, Tulare and Kern produced 99.8% of the plums, with over 90% from Fresno and Tulare alone.

California's San Joaquin Valley

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

Pests in California Plum Production: Overview of Key Organisms

The following section lists the most important pests of plums that will be the main issues dealt with throughout the strategic plan. For more detailed information on these and other pests of plums, the reader is directed to *Crop Profile for California Plums* on website http://pestdata.ncsu.edu/cropprofiles/docs/caplums.html, and 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 Appendices 4-9, which include a complete listing of all products by their chemical name and trade name. A summary of the most significant pests follows, and is discussed in detail in Section 2 below.

Insects

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

Codling moth can be a pest in plums in the San Joaquin Valley. A single treatment timed using pheromone traps and degree-days should be all that is needed at these sites.

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

Peach twig borer (PTB) can be a pest to both fruit and branches and may cause severe losses to plums. 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 (Bts) are widely used for PTB and are often part of an overall IPM program which includes dormant sprays. Several insecticides are used for PTB, although several of these are organophosphates and may not be available in the future.

Omnivorous leaf roller (OLR) has become a more important pest of plums in recent years. OLR damages plums 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 plums by leaf feeding, which can ultimately lead to leaf shed and poor fruit sizing. In addition to yield loss, loss of leaves due to spider mite feeding can lead to sunburn of plum trees. There are several species of mites found in plums: 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; i.e., they are secondary or induced pests. Insecticidal soaps are used with moderate success; oils and miticides can effectively control mite populations.

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 (e.g., katydids, oblique-banded leaf rollers and others) are now of increasing importance in integrated pest management programs. Several of these species will be mentioned throughout the strategic plan.

Diseases

Brown rot is the most common and devastating fungal disease of plums; it is caused by two airborne fungi. Development of this disease is dependent upon wind, moisture, and temperatures. Blossoms, fruit, and twigs may be impacted by this disease. Orchard sanitation to remove or bury mummies (old, diseased fruit) will help reduce

inoculum; pruning also helps to prevent the spread of this disease. Fungicides are used to reduce losses due to brown rot.

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

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

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, only occasionally a problem, is caused by a soil-borne fungus and the disease is the 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 plum orchards.

Nematodes

Three major species of nematodes are found in plums: root knot, ring, and lesion nematodes, although root knot nematodes are considered the most important species. All plant parasitic nematodes move from the soil environment onto and into the root tissues and feed on plum roots by puncturing and sucking the cell contents of the roots. Nematode damage interferes with nutrient and water uptake and certain diseases may be vectored by nematodes. Soil conditions and application procedures determine efficacy of nematicides, which may be quite variable. The loss of methyl bromide and restrictions on other fumigants present significant concerns for plant health and nematode management in plums. 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 plum trees themselves, or may interfere with irrigation and other cultural activities. Rabbits, voles, gophers, squirrels, and deer are the most troublesome species and birds are pests which impact established orchards. Sites which are adjacent to unmanaged ground or pastures will harbor more vertebrate pests, but monitoring and implementing control actions may discourage the buildup of populations within orchards. Control tactics for vertebrate pests include the use of barriers, traps, frightening tactics, and lethal control. Care must be taken not to violate any endangered species restrictions in specific areas.

2. PEST MANAGEMENT FOR NEW PLUM ORCHARDS

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

Of great importance is the selection of well-adapted varieties for all production areas and conditions. In addition, rootstock selection 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 soilborne pests impacting young plum trees; alternative products must be developed to replace this valuable pest management tool for plums.

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 rapidly declining
- Planting
- Trunk painting and wrapping
- Pruning – first year in the spring; then in the following 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 and miticides such as Omite®, Vendex®, Apollo®, or Nexter® may be used; predators provide excellent control of mites if not disrupted by insecticidal treatments for other pests. Peach twig borer treatments include Bts, 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. There are several species of insects that are occasional, but potentially serious, pests in young orchards; these include Fuller rose beetles, grasshoppers, borers, June beetles, false chinch bugs, tent caterpillar, fall webworms, red-humped caterpillar, 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 and control

WEEDS

Weeds can be highly competitive with young orchards and care should be taken to manage populations. While most orchards were fumigated in the past, increasing numbers of new plantings will need to rely on new techniques to provide control of weeds and other soilborne 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® also has been reported in recent years to be available only in limited supplies due to production issues; however, Oryzalin®, a generic version, has become available recently and may be more cost-effective. 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 plum 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 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 depending 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.

Enzone® provides only poor to fair control of oak root fungus (*Armillaria*). 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 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 training on irrigation management and planting techniques to reduce soilborne and waterborne disease on roots and crowns

NEMATODES

Plant parasitic nematodes move from the soil environment into the root tissues and feed on plum roots by puncturing and sucking the cell contents of the roots. Nematode damage interferes with nutrient and water uptake and certain diseases may be vectored by nematodes. Soil conditions and application procedures determine efficacy of nematicides, which may be quite variable. The loss of methyl bromide as a fumigant for new orchards presents significant concerns for plant health and nematode management in plums. 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 plums: root knot, ring, and root lesion nematodes. Besides maintaining good tree vigor with proper irrigation and fertilization, two nematicides are effective controls. DiTera® and Nemacur® provide good to excellent control when used in low volume irrigation systems, but Nemacur® will be phased out in 2005. Enzone® provides fair to good control and is most effective when used with drip irrigation systems. Selection of nematode-resistant rootstocks is strongly suggested. 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 efforts of all products • Educate regulators on benefits of pre-plant pest management (chemical) and the role nematicides 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 direct damage to young plum trees, and may also interfere with irrigation and other cultural activities. Rabbits, voles, gophers, squirrels, and deer are the most troublesome species and birds are pests which impact established orchards. Sites which are adjacent to unmanaged ground or pastures will harbor more vertebrate pests, but monitoring and implementing control actions may discourage the buildup of populations within orchards. Control tactics for vertebrate pests include the use of barriers, traps, frightening tactics, and lethal control. Care must be taken to not violate any endangered species restrictions in specific geographies.

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

Work Group Recommendations for Vertebrate 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 system 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 PLUM ORCHARDS

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

Cultural Activities

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

INSECTS

San Jose scale (SJS) is the major insect of interest in the fall, particularly for late harvested varieties. Oil provides fair to good control and the addition of organophosphates and carbamates increases scale control. Products used that provide good control of SJS include oils, diazinon, Sevin®, and Phosmet® less so.

Various lepidopterous pests including OFM and PTB occasionally can be found in damaging numbers; there is a lack of products labeled for pests occurring during this time.

Work Group Recommendations for Insect Management in the Fall

Research	• Establish biological parasite for OFM • Develop spur sampling techniques and economic thresholds for SJS • Extend mating disruption for OFM, TMDL (total daily maximum 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. 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 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.

The following weed species are of most concern in plum 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 the 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 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 inoculum.

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) and 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. Problems with bacterial canker are reduced if trees are kept vigorous to avoid disease; Enzone® and DiTera® also are potentially good products for managing this disease.

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

Work Group Recommendations for Disease Management in the Fall

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

Cultural Activities

• Pruning	• Tying trees	• Replanting trees
• Mummy removal	• Irrigation	• Pest monitoring & 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 dormant spray during the fall or winter. Oils used with organophosphate insecticides have been highly effective in controlling pest populations of San Jose scale and several other insect and mite pests. Currently used OP products include Lorsban®, diazinon, Supracide®, and Imidan®. Non-OPs used during the dormant period include carbaryl, oils, and pyriproxyfen. Due to 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 plum 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, provide excellent control, but these products are very expensive; both should be applied with oil for maximum efficacy.

Seize®, a new scale growth regulator, recently received registration. It controls scale and suppresses PTB. Produced by Valent, currently it is less expensive than Applaud® and Esteem®, and it has a full label.

Oriental fruit moth (OFM) is treated at this time of year with pheromones to disrupt mating. Products which are effective for this use include Iso-Mate® M-10, Checkmate®, and a longer-life dispenser M-Rosso® from Pacific BioControl. Mating disruption is the only pest management option used for OFM during late winter, but growers and PCAs are reluctant to use mating disruption due to the potential for secondary pest outbreaks.

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 PTBs. Sevin® is occasionally used, but its performance is considered weak. Ants may provide some natural control of emerging twig borers during the season.

Codling moth can be a significant problem in some areas, and it is important to monitor for this pest and ensure levels are kept down by removing abandoned host trees and removing unharvested fruit from the trees. Organic growers may also use mating disruption at this time to reduce numbers.

Spider mites need to be closely monitored at this time of year to make sure 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 spider mite 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 the Winter

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

WEEDS

Orchard floor management helps to control frost damage in the winter and spring. Winter annual weeds are generally not as troublesome as summer and perennial weeds. Cultivation, chemical mowing, and pre-emergence herbicides are the most extensively used tools for weed management at this time. According to the weed spectrum present, the following herbicides are used: Roundup®, Princep®, Gramoxone®, Goal®, Solicam®, Surflan®, and napromamide. 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 work group recommendations for management of weeds during the winter are the same as those indicated for the fall season on page 15 above.

DISEASES

Winter orchard management is similar to fall disease management; practices are often delayed due to weather. Cultural practices that include sanitation, such as “clean picking” or after-harvest fruit and mummy removal, continue to be important to help reduce disease inoculum.

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) and 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 powdery mildew to cause problems in the following spring and summer can be monitored during the winter season. Pre-bloom applications of lime sulfur are very effective in controlling powdery mildew.

The work group recommendations for management of diseases during the winter are the same as those indicated for the fall season on page 16 above.

SPRING

(Bloom through jacket split – approximately February 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
- Roping trees
- Planting replacement trees
- Trap placement and monitoring
- Apply mating disruption dispensers
- Orchard floor management
- Some blossom thinning
- Irrigating
- Pruning
- Monitoring of all orchard pests

Pollination: bees are required to set a plum crop and care must be taken to not disrupt bees 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 extensively during bloom to control lepidopterous pests. One or two applications of Bt will help to keep over-wintering peach twig borer and other caterpillar pest levels below economic levels. The use of a selective material like Bt has a great advantage in that it is not disruptive to beneficial organisms. Monitoring plum orchards to determine when larvae are emerging and timing applications of Bt is critical to efficacy, since the material must be directly consumed to have a lethal effect. In addition, ground applications will ensure coverage throughout the tree canopy.

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

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

Thrips are only occasional pests of plums during bloom, and good to excellent control of this pest is achieved with Success®. Carzol® provides good to excellent control of thrips; however, long reentry interval prevents much use. Proper management of orchard floor vegetation is an effective means by which to provide some control of the movement of thrips into plum orchards.

True bugs (Lygus bugs) are an occasional problem and manipulation of cover crops is an important consideration in management of 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 a problem in plums. The efficacy of using mating disruption in plums is not well understood and therefore not widely used. Several products may be effectively used for codling moth control: Supracide®, Imidan®, Thiodan®, Asana®, and Success®.

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

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

Work Group Recommendations for Insect Management in the Spring

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

DISEASES

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

Commonly used treatments include sulfur, Rovral®, Rally®, Break®, Vanguard®, and Elevate®. Captan and Topsin-M® are also used on fresh market plums. 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 areas prone to prolonged periods of wetness. All disease controls are rated in the Appendices; the UC IPM guidelines also have this information.

Intensive monitoring of plum orchards and a thorough knowledge of conditions promoting disease development are critical to controlling pathogens in plum 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 chemicals in order to preserve these products and avoid the buildup of resistance

Work Group Recommendations for Disease Management in the Spring

Research	• Evaluate biocontrols (e.g., *Trichoderma* spp.) for oak root fungus • Evaluate additional systemic brown rot materials • Evaluate and develop additional multi-site mode of action materials • Evaluate and develop more “reduced risk” fungicides • Improve timing for fungicide applications • Evaluate new rootstocks for improved bacterial control
Regulatory	• 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 – May to October)

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

Cultural Activities

- Cultivation
- Fertilizer applications
- Pruning
- Thinning
- Irrigation

INSECTS

Mating disruption has been an effective tool for peach twig borer (PTB), providing from good to excellent control on low to moderate populations. It is important to note that when populations are high, mating disruption alone will not control PTB and chemical applications are likely. Imidan® provides good to excellent control, but there are PHI and ERI issues for workers. Success®, a new reduced risk material, has excellent efficacy on PTB and the use of 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 to this material.

Codling moths are a problem in plums in-season. The efficacy of using mating disruption in plums is not recommended at this time of the season. Several products may be effectively used for codling moth control: Supracide®, Imidan®, Thiodan®, Asana®, and Success®.

San Jose scale (SJS) is a minor in-season pest of plums and should be treated only if populations are extremely high.

Mating disruption is a good Oriental fruit moth (OFM) control. Imidan® and pyrethroids 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.

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

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

Katydids can cause major cosmetic damage to plums; therefore, this pest should be closely monitored throughout the season. Sevin® and Imidan® provide excellent control of this species. Success® is also a very good

material but needs to be applied prior to the adult stage; Success® has too short a residual to control katydids as their 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 plum production.

Flat-headed and other borers can be a problem in plum orchards. Lorsban® or Asana® are directed at the trunk for control; Thiodan® is also used to control borers.

Occasional In-season Pests:

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

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	• Reduce PHIs to 7 to 10 days; 21-day PHIs render products useless in IPM programs • Obtain in-season registration for Esteem® • 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” program for use of “old” tools to be used in certain extreme and critical situations when reduced risk programs are not effective or severe infestations of pests occur
Education	• Provide growers with resistance management education • Continue to educate growers on reduced risk options including mating disruption, use of microbials, etc. • Provide training on the great need for monitoring throughout the year for all pests; stress the importance of this practice to coordinating the pest management activities for multiple pests • Provide training on timing and methodology of applications for maximum control of orchard pests • Educate regulators on the need for 7-10 day PHIs in IPM programs

WEEDS

As methyl bromide is phased out over the next several years, weed control will become more of a concern to plum growers, especially with perennial weed species. 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.

The following species are of concern in plum 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	• Evaluate and develop reduced risk contact herbicides which are safe for bees • Develop improved technologies for drip systems, chemigation, and subsurface irrigation • Develop guidelines for spot treatments of herbicides • Conduct needed research to shorten the PHIs for Roundup® and Gramoxone® • Evaluate Gramoxone® and Rely® for fleabane control (alone and in tank mix) • Develop weed control tactics suitable for use in organic production (e.g., mulches)
Regulatory	• 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 plums and without the appropriate pre-harvest management practices, the disease can cause significant losses in storage.

Pre-harvest fungicides commonly used include Rally®, Break®, and Topsin-M®. 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 resistance.

Good control of powdery mildew is provided by Break®, and Topsin-M®. Sulfur is also very effective for this disease. Two other products, Bravo® and copper, provide only very weak control of powdery mildew.

Root and trunk diseases such as *Phytophthora* root rot, crown rot, crown gall, and wood decay fungi continue to be problems year round. Proper irrigation is an important cultural method for managing these diseases. For *Phytophthora* root rot, the use of Ridomil® is beneficial; however, applied as a drench it becomes prohibitively expensive. Aliette® (fosetyl-al) could be used more cost-effectively. 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 is 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 biocontrols (e.g., *Trichoderma* spp.) for oak root fungus • Evaluate additional systemic brown rot materials • Evaluate and develop additional multi-site mode of action materials • Evaluate and develop more “reduced risk” fungicides • Improve timing for fungicide applications • Evaluate new rootstocks for improved bacterial control
Regulatory	• No needs currently reported
Education	• Provide resistance management training for fungicide use • Provide irrigation management for preventing soilborne disease

NEMATODES

Nematodes are not normally managed in-season. There are very few products registered and many of these are under intense regulatory scrutiny. Fenamiphos, also known as Nemacur®, will be phased out by 2005 and oxamyl (Vydate®), a carbamate, is also at risk. Other materials, such as metam sodium (Vapam®), have 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. DiTera® could provide an effective alternative for nematode control.

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 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 in knowing when to implement control measures. Tactics to reduce bird visitation and damage to plums includes frightening, trapping, or use of protective netting. Lethal control may be necessary in certain cases, but growers must first check with the Department of Fish and Game before taking this action.

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

POST-HARVEST
(May through October)

DISEASES

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

Several organisms can cause post-harvest losses of plums, 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 cause significant post-harvest decay of plums in California. Gray mold causes damage in fruit stored at low temperatures and most infections occur from harvesting and handling wounds. *Mucor* decays and sour rot (*Geotrichum* spp.) may cause problems in some years. Currently, Scholar® and dichloran (Botran® 75W, Allisan® 75W) are the only fully registered post-harvest fungicides for use on 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 for post-harvest disease control in all stonefruit, including plums. 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	• Evaluate and 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 plum crop is shipped to international markets. The major markets are Taiwan, Canada, and Mexico. Shipments to some destinations, such as Mexico and B.C. Canada, require the fruit to be treated with methyl bromide fumigation for arthropod control. The targeted pest is dependent on the market destination, but usually is OFM or codling moth. Export shipments can account for 50-60% of the gross crop dollar value. It is therefore of great importance to prevent pest problems in the field and to ensure that no organisms are present in product bound for the export market. In addition, it is extremely important that U.S. registrations are harmonized with the requirements of all importing countries to avoid situations that might limit trade opportunities for US produce (i.e., avoid "trade irritants").

Research	• Encourage registrants to develop residue data and export tolerances for new products prior to U.S. registration • Evaluate new fumigants for pre-shipment quarantine treatments (methyl bromide alternatives) • Establish new quarantine protocols that are not based on use of methyl bromide • Conduct research on population threshold issues that are an important phyto-sanitary issue
Regulatory	• Register alternatives to methyl bromide for pre-shipment quarantine fumigation treatments • Establish new quarantine protocols that are not based on use of methyl bromide • Encourage registrants to establish export tolerances for new products prior to registration • Harmonize registrations between the US EPA and importing countries • Harmonize EPA registration requirements with the MRL and Codex systems used in other countries. • Ensure that all quarantine protocols are synchronized between the US EPA and importing countries • Request that FDA maintain a current log of international registrations
Education	• Educate and encourage registrants to develop tolerances in compliance with foreign markets prior to full U.S. registration • Educate commodity groups on new quarantine methods and protocols • Encourage 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 plums in California begins before the fruit is planted and continues until it reaches the consumer's hand. Working closely with the University of California, California's plum industry continually studies growing practices, pest control, irrigation, fertilization, and post-harvest handling. As part of this research, the California stonefruit 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 plums with any reported illness or outbreak and University laboratory data support the current view of a "low-concern status" for plums relative to microbial food safety.

Despite this clean record, the California plum 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 American to the orchard in which the fruit was grown.

As with any produce item produced in California, plums 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 and other efforts make California stonefruit safe and wholesome products for consumers throughout the world.

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 stonefruit industry
Education	• Provide training on the importance of clean water and personal hygiene in packing operations

4. CRITICAL ISSUES FOR THE CALIFORNIA PLUM INDUSTRY

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

Research	• Develop new methods for pre- and post-harvest disease, insect and weed control • Develop methyl bromide alternatives for quarantine, nursery, and pre-plant treatments • Develop best management practices (BMPs), sustainability plans, and/or mitigation measures for environmental issues (e.g. to address water quality, air quality, volatile organic compounds (VOCs), reduced risk practices, etc.) • Assess environmental and economic costs of pest management alternatives • Improve application technology, especially for newer materials • 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
Regulatory	• Retain key products which complement current IPM practices and products which are a part of a resistance management program • Register ethephon (Ethrel®) as a crop management tool • Register indoxicarb (Avaunt®) for reduced risk control of katydids • Register abamectin (Agri-mek®) for reduced risk control of mites • Register propiconazole (Orbit®) for post-harvest reduced risk control of sour rot • Establish prescriptive uses for certain key pest management tools (e.g. organophosphates, carbamates, etc.) to complement IPM practices and to serve as backup products in critical pest management situations • Develop best management practices(BMPs) to mitigate environmental concerns • Coordinate research and registration activities to avoid potential trade barriers (NAFTA, Codex and other international standards) • Harmonize IR-4, Cal/EPA, U.S. EPA, and international standards for pesticide residues to hasten new product registrations • Develop labels which are realistic in terms of field practices in the field, e.g., growers need products with PHIs of less than 7 days
Education	• 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 for stonefruit • Educate the public on the nutritional value of California grown peaches and their high level of food safety and quality • Educate growers, PCAs, applicators and commodity members on the use of best management and sustainable practices to protect and improve environmental quality. • Educate growers, PCAs, applicators and commodity members on resistance management • Educate growers, PCAs, applicators and commodity members on safe and efficient application techniques

REFERENCES

Crop Profile for California Plums website http://pestdata.ncsu.edu/cropprofiles/docs/caplums.html

UC IPM Pest Management Guidelines: Plum

Integrated Pest Management for Stonefruits UC Publication 3389,

Post-Harvest Technology of Horticultural Crops UC Publication 3311

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

Crop Protection Reference. 2001. Seventeenth Edition. C and P Press. New York.

Crop Data Management System, Inc. website http://www.cdms.net/manuf/manufac.asp

California Tree Fruit Agreement website http://www.caltreefruit.com/

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

APPENDICES

1. 2001 California Plum Production Statistics

Fresh Plums

COUNTY	HARVEST ACREAGE	YIELD (Tons/Ac.)	PRODUCTION (Tons)	TOTAL VALUE ($)
Contra Costa	23	2.2	51	47,600
El Dorado	58	2.9	168	161,300
Fresno	14,774	8.0	119,000	95,438,000
Kern	2,276	7.7	17,600	11,410,000
Kings	1,660	5.2	8,615	5,302,000
Madera	1,050	5.9	6,164	3,236,000
Placer	158	1.3	205	207,900
Tulare	18,081	6.3	114,000	92,340,000
STATE TOTALS	**38,080**	**Average 7.0**	**265,803**	**208,142,800**

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 Plums

San Joaquin Valley *

Crop Development	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Dormancy												
Bud Break												
Bloom												
Pollination												
Fruit Development												
Harvest												
Post-harvest												
Storage												
Cultural Practices	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Cultivation												
Irrigation												
Pruning - 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

* For the purposes of this Appendix, the San Joaquin Valley is representative of the State

3. Seasonal Pest Occurrence in California Plums

San Joaquin Valley

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												
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												
Weeds	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Johnsongrass												
Bermuda Grass												
Annual Grasses												
Mustards												
Nematodes	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Root Knot Nematode												
Ring Nematode												
Lesion Nematode												
Dagger Nematode												
Vertebrates	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Rabbits												
Voles												
Gophers												
Squirrels												
Birds												

Data based on collective field observations and experiments

4. Efficacy of Insect Management Tools Used in California Plums

Chemical Insecticides

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

PRODUCT	TRADE NAME	INSECTS												
		Aphids	Brown Mite	Codling Moth	European Red Mite	Fruit Tree Leaf Roller	Katydids	Lygus Bugs	Omniv./Oblique Banded Leaf Roller	Oriental Fruit Moth	Peach Twig Borer	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
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
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	F	P	P	P	P	?	P	P
Oil		P	E	P-F	E	P	P	P	P	P	P	G-E	P	F
Permethrin	Ambush®, Pounce®	P	P	G	P	G	G	G	G	G	G	P	G	P-R
Pheromones	Isomate®, Checkmate®	P	P	P-F	P	P	P	F	E	E	F	P	P	P
Phosmet	Imidan®		P	G	P	E	E	F	G	G	G	P	F	R-P
Propargite[3]	Omite®	P	E	P	E	P	P	P	P	P	P	P	P	E
Pyrethrins		P	P	P	P	P	P	P	P	P	P	P	P	P
Pyriproxyfen[2]	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 plums only

Data based on collective field observations and experiments

4. Efficacy of Insect Management Tools Used in California Plums (continued)

Impact of Chemical Insecticides on Beneficial Organisms in Plum Orchards

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

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

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

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

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

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

[5] Kills six-spotted thrips

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

4. Efficacy of Insect Management Tools Used in California Plums (continued)

Unregistered or New Insecticides

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

PRODUCT	TRADE NAME	INSECTS												
		Aphids	Brown Mite	Codling Moth	European Red Mite	Fruit Tree Leaf Roller	Katydids	Lygus Bugs	Omniv./Oblique Banded Leaf Roller	Oriental Fruit Moth	Peach Twig Borer	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

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

* Has effect only on Lygus and Stinkbugs

Data based on collective field observations and experiments

5. Efficacy of Disease Management Tools Used in California Plums

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 mixture											
Captan		G	G-E					G			
Chorothanlonil	Bravo®	F	F	P	P	P	P	G	P	P	P
Ciprodinil	Vangard®	G									
Copper	Copper	F	F	G	P	P	P	G	P	P	P
Fenhexamid	Elevate®										
Fosetyl-al	Aliette WDG®			G				G			
Iprodione	Rovral®	G-E				G-F					
Mefenoxam	Ridomil Gold®										
Myclobutanil	Rally®	G	E				F	F			
Propiconazole	Break®	G	G		G						
Sodium tetrathio-carbonate	Enzone®										
Sulfur (wettable)		E	E		G		G				
Thiophanate-methyl	Topsin®	E	E		G						
Vinclozolin	Ronilan®										
Non-Chemical											
Orchard Sanitation		F									
Irrigation Management						E				F	
Fertilizer Management		F				F				G	
Vector Control											
Certified Planting Stock											E
Rootstock Selection						F			F	F	
Resistant Varieties											
Avoiding Injury									G	G	
Remove Alternate Hosts											
Weed Management		F	F	F	F	F	F	F			

Data based on collective field observations and experiments

6. Efficacy of Nematode Management Tools Used in California Plums

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		P	P	G		P
Metam Sodium	Vapam®	P-E		P-E		P-E		P-E	
Methyl Bromide	Methyl Bromide	G-E		P-E		G-E		G-E	
1,3-D	Telone®	P-E		P-E		P-E		G-E	
Oxamyl	Vydate®	G				G-E			
Sodium Tetrathio-carbonate	Enzone®	P	P	P-G		P	P	G-E	G
Non-Chemical									
Clean Cultivation		F	F	F	F	F	F	F	F
Soil Sampling		G							
Resistant Rootstock		E		P		P		P-G	
Trap Crops		P	P	P	P	P	P	P	P

Data based on collective field observations and experiments

7. Efficacy of Weed Management Tools Used in California Plums

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

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

Data based on collective field observations and experiments

8. Efficacy of Vertebrate Management Tools Used in California Plums

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	F	P	P	P
Cultural Barriers	P	P	P	P	P	P
Mylar Strips	P	P	P	P	P	F

Data based on collective field observations and experiments

9. Chemical Use in California Plums 1999-2001

Total Pounds of Active Ingredient (AI) Used

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
Insecticides					
Azinphos methyl	Guthion®	963	1,521	1,298	1,261
Bacillus thuringiensis	Bt	1,148	1,096	815	1,020
Carbaryl	Sevin®	19,347	9,232	6,727	11,769
Chlorpyrifos	Lorsban®	20,920	20,936	20,434	20,763
Diazinon		14,649	12,651	12,586	13,296
Dicofol	Kelthane®	4,902	516	2,115	2,511
Esfenvalerate	Asana® XL	484	748	698	643
Fenamiphos	Nemacur®	59	3	0	21
Formetanate HCL	Carzol®	396	537	186	373
Methidathion	Supracide®	11,831	10,568	7,981	10,127
Methomyl	Lannate®	19	29	23	24
Permethrin	Pounce®	5	3	0	3
Phosmet	Imidan®	24,418	23,677	26,622	24,905
Potash Soap	M-Pede®	744	292	211	416
Sulfur (wettable)		103,090	91,454	44,033	79,526
Herbicides					
Glyphosate	Roundup®	27,960	32,761	39,161	35,588
Norflurazon	Solicam®	6,523	5,891	6,217	6,678
Oryzalin	Surflan®	20,225	11,183	935	6,096
Oxyfluorfen	Goal®	9,540	6,707	5,488	6,493
Paraquat Dichloride	Gramoxone®	19,521	13,518	10,769	12,444
Simazine	Princep®	468	549	749	525

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

9. Chemical Use in California Plums 1999-2001

Total Pounds of Active Ingredient (AI) Used (continued)

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
Fungicides					
Benomyl	Benlate®	1,097	932	641	689
Captan		5,145	5,850	2,043	3,323
Chlorothalonil	Bravo®	8,181	7,046	2,475	4,934
Copper (hydroxide & oxide)		0	0	67,461	22,487
Fludioxonil (Section 18)	Medallion®	0	0	0	9
Fosetyl-al	Fosetyl-al	179	28	4,478	5,001
Iprodione	Rovral®	7,762	5,614	0	3,400
Myclobutanil	Rally®	1,601	826	1,022	951
Propiconazole	Break®	2,196	1,579	1,345	1,494
Sulfur (wettable)		166,753	103,090	44,033	79,526
Thiophanate-methyl (24c)	Topsin®	1,120	1,032	597	821
Nematicides					
Methyl Bromide		4,002	0	7	1,336
Sodium Tetrathiocarbonate	Enzone®	2,974	16	2,518	1,836

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

9. Chemical Use in California Plums 1999-2001

Percentage of Base Acres Treated

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
Insecticides					
Azinphos-Methyl	Guthion®	2	2	3	3
Bacillus thuringiensis	Bt	28	23	23	25
Carbaryl	Sevin®	13	11	6	10
Chlorpyrifos	Lorsban®	24	28	28	27
Diazinon		19	18	17	18
Dicofol	Kelthane®	8	10	1	5
Esfenvalerate	Asana® XL	24	30	48	34
Fenamiphos	Nemacur®	0	0	0	0
Formetanate HCL	Carzol®	1	1	1	1
Methidathion	Supracide®	17	15	13	15
Methomyl	Lannate®	0	0	0	0
Permethrin	Pounce®	0	0	0	0
Phosmet	Imidan®	20	21	19	20
Potash Soap	M-Pede®	0	0	0	0
Sulfur (wettable)		32	25	25	27
Herbicides					
Glyphosate	Roundup®	56	53	43	51
Norflurazon	Solicam®	16	17	7	13
Oryzalin	Surflan®	16	10	1	9
Oxyfluorfen	Goal®	35	37	28	33
Paraquat Dichloride	Gramoxone®	32	33	18	28
Simazine	Princep®	2	1	4	2

Zero = < 1% of Base Acreage involved for that chemical for that year
Data from CDPR

9. Chemical Use in California Plums 1999-2001

Percentage of Base Acres Treated (continued)

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
Fungicides					
Benomyl	Benlate®	3	2	0	2
Captan		11	3	1	5
Chlorothalonil	Bravo®	5	5	25	12
Copper (hydroxide & oxide)		0	0	26	9
Fludioxonil (Section 18)	Medallion®	0	0	0	0
Fosetyl-al		0	0	0	0
Iprodione	Rovral®	20	19	17	19
Myclobutanil	Rally®	16	20	10	15
Propiconazole	Break®	30	35	26	30
Sulfur (wettable)		25	25	14	22
Thiophanate-methyl (24c)	Topsin®	3	2	0	2
Nematicides					
Methyl Bromide		0	0	0	0
Sodium Tetrathiocarbonate	Enzone®	0	0	0	0

Zero = < 1% of Base Acreage involved for that chemical for that year
Data from CDPR

10. Members of the California Plum Work Group

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

Growers, Packers, and Shippers

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

Pest Control Advisors

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5. Randy Radtke, PCA, Dinuba, CA, (Southern SJV)

Commodity Group Representatives

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7. Gary VanSickle, California Tree Fruit Agreement (CTFA), Reedley, CA

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