A Pest Management Strategic Plan for Cherry Production in California

The California Cherry Advisory Board (CCAB)

The California Minor Crops Council (CMCC)

The California Minor Crops Council received major funding for this project from the EPA Region 9 Agricultural Initiative and the USDA Cooperative States Research, Education, and Extension Service (CSREES) Pest Management Alternatives Program (PMAP).

CMCC received additional support from the California Cherry Advisory Board and the Western Regional Pest Management Center at UC Davis. Funding for this project also has been made available by the Governor's *Buy California* initiative, the California Department of Food and Agriculture, and the U.S. Department of Agriculture, through the University of California's Specialty Crops Research Program.

We gratefully acknowledge the contributions of all of these organizations
and their participation in this process.

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Introduction

The safety standards established by the 1996 Food Quality Protection Act (FQPA) potentially will impact certain crop protection tools used by cherry growers in California. 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, regulatory, 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.

For California cherry production, the important pesticides methyl bromide and organophosphate (OP) insecticides are examples of products already restricted or cancelled due to regulatory activities. The potential loss of these and other valuable crop protection tools necessitates that the entire pest management system be evaluated and that clear objectives be set for this commodity to insure that its most critical pest management needs will be addressed.

A pest management strategic plan will help the California cherry industry work more effectively with the Land Grant University research and extension systems, which are currently experiencing severe budget reductions. All resources must be utilized in the most efficient manner possible; this strategic plan will help the grower community to direct resources to the most critical issues for California cherry growers.

This strategic plan includes an overview of cherry production practices, seasonal pest occurrences, and evaluations of pest management techniques used throughout California. Efficacy ratings of various pest control techniques (chemical and non-chemical) used in cherry production have been summarized from input made by growers, pest control advisors, and other experts involved in field activities. This plan addresses both current and emerging pest management needs; it is a working document and will need to be updated periodically.

This strategic plan serves principally as a guideline to address the most important issues of the California cherry industry as identified by the growers themselves. A list of industry experts (growers, pest control advisors, industry representatives, and university research and extension personnel) is included the appendices to serve as a reference for those seeking more information regarding California cherry production.

This strategic plan will receive periodic updates; it serves principally as a guideline to direct future pest management efforts related to California cherry production. An important document which provides a basis for this strategic plan is UC ANR Publication 3389 (*Integrated Pest Management Guidelines for Stonefruit*), which is an excellent source of information concerning horticultural and pest management practices for California stonefruit, including cherries.

The mention of specific trade names in this document is not an endorsement of any particular product.

Stakeholder Recommendations

As a result of the PMSP planning meeting held in April 2002, the California Cherry Work Group identified several research, regulatory, and educational priorities for their industry. A draft document was prepared and the entire work group and additional research and scientific personnel were invited to provide comments and modifications. Finalized in November of 2003, this is a working document that will be periodically updated to reflect the evolving needs of the California cherry industry.

As a result of this process, the following critical needs were identified by members of the cherry industry in California.

Research Priorities

The cherry export market is critical to California growers; it is imperative that methyl bromide remain available until commercially acceptable alternatives are available for post-harvest quarantine treatments. Evaluating methyl bromide alternatives for this purpose, therefore, is extremely important; it is also extremely important that all new methodologies be recognized by the importing countries.

Leafhopper control techniques and insecticides are a critical issue for California growers to address in order to reduce the spread of X-disease. To minimize loss to this disease, the relationship of pest biology and host susceptibility to bacterial canker needs to be explored. Research on cultural and biological controls, including the use of the new systemically acquired resistance (SAR) type materials should be intensified.

Risk mitigation measures to reduce human and environmental exposure to pesticides should be developed, as should a systems approach using economic thresholds for all pests of cherries. Resources such as the Land Grant University system, Cooperative Extension, and funding to commodity groups should be maintained in order to serve the needs of growers and consumers through research and educational activities.

- Evaluate new fumigants to replace methyl bromide for use in post-harvest quarantine treatments
- Evaluate methyl bromide alternatives for pre-plant fumigations
- Evaluate new products and techniques for leafhopper control
- Intensify efforts to identify effective biological and cultural techniques to control pests in cherries
- Evaluate systemically acquired resistance (SAR) materials
- Develop a systems approach to pest management in cherries based on economic thresholds
- Determine the relationship between the biology of bacterial canker and host susceptibility
- Develop best management practices (BMPs) to protect water and soil quality
- Develop monitoring and threshold-based treatments for oblique-banded leaf roller
- Evaluate new and existing rootstocks for resistance to key soil-borne pests and diseases
- Provide access to research funding directly through commodity organizations (California Cherry Advisory Board, etc.) in addition to continued support of the University of California Land Grant system for research and extension activities

Regulatory Priorities

The cherry industry needs new products registered to replace methyl bromide for pre-plant and post-harvest fumigations. Appropriate and usable pre-harvest intervals for *Botrytis* products should be established. Calcium ammonium nitrate should be registered as quickly as possible for use as a plant growth regulator (PGR). Harmonization between Cal/EPA and US EPA should be encouraged to facilitate the timely registration of reduced risk products, especially methyl bromide alternatives. Trade irritants should be identified as early as possible in the research and registration process to insure there are no conflicts with provisions of NAFTA, Codex, or other regulatory agencies.

- Expedite registrations of methyl bromide alternatives
- Shorten the pre-harvest interval (PHI) for new in-season *Botrytis* materials (e.g., fenhexamid)
- Expedite the registration of calcium ammonium nitrate as a PGR
- Register organophosphate and carbamate alternatives as soon as possible; utilize the IR-4 priority system for research on reduced risk materials
- Harmonize Cal/EPA and US EPA review process to hasten new product registrations
- Identify potential trade irritants as early as possible in the research and registration process; insure there are no conflicts with provisions of NAFTA or Codex
- Register effective insecticides for controlling leafhopper vectors of X-disease

Educational Priorities

The public, including regulators and consumer groups, must be informed about the use of Integrated Pest Management (IPM) in California cherry production, and how this system optimizes food production while minimizing risks to workers and the environment. Growers and PCAs need to be better educated to more accurately recognize the various causes of cherry tree decline and death. As alternatives to methyl bromide for pre-plant and post-harvest fumigation are developed, and new insecticides, fungicides, and resistance management techniques become available, growers and PCAs will need on-going education to maintain the effectiveness of all pesticides used. Education about adopting reduced risk pest management and BMPs should be provided to improve and protect water and soil quality. Finally, the public should be reminded that eating California cherries 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 growers and PCAs on all new methyl bromide alternatives, insecticides, and fungicides
- Conduct resistance management training for all pest categories
- Provide training on reduced risk pest management practices and BMPs to improve and protect water and soil quality in agricultural areas
- Educate the public on the nutritional values of California grown cherries and their high level of food safety and quality

The California cherry industry appreciates the support of EPA, USDA, CDPR, and the University of California Agricultural Experiment Station and Cooperative Extension throughout the development of this strategic plan.

Major contributions to the development of this document were made by Joseph A. Grant, UC Cooperative Extension Farm Advisor, San Joaquin County; James Adaskaveg, plant physiologist, UC Riverside; Greg Browne, USDAS-ARS, Davis, California; Michael V. McKenry, UC Kearney Ag Center, Parlier; Michael Devencenzi, Agricultural Consultant, Woodbridge; and Stephen Flanagan, Western Region IR-4 Program, UC Davis.

We look forward to the valuable assistance provided by these agencies, institutions, and individuals as we develop solutions for the problems facing the California cherry industry.

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November 2003

A PEST MANAGEMENT STRATEGIC PLAN FOR CALIFORNIA CHERRIES

1. CALIFORNIA CHERRY PRODUCTION OVERVIEW

Cherries originated in western Asia and have been cultivated for centuries in Europe and the Orient; nevertheless, the world's biggest producer, consumer, and exporter of cherries is the United States. The Pacific states of Washington, Oregon, and California are the leading sweet cherry producing areas. Idaho, Michigan, and Montana also have significant acreage.

- All cherries produced in California are sweet cherries; tart cherries cannot be commercially produced in California due to the extremely warm growing conditions.
- All cherries produced in California are harvested by hand.
- The top three cherry producing states - Washington, California, and Oregon - produced 46%, 24%, and 17% respectively of the total 2001 U.S. sweet cherry crop.
- A total of 57,282 tons of cherries was produced in California on approximately 23,446 acres in the year 2002, worth over $152 million.
- Approximately 95% of California cherries are sold in the fresh market; 5% are used in the processing industry.
- Approximately 45% of the fresh market cherries go to the export market, with principal destinations being Japan and Taiwan.

The main cherry production areas in California are shown in Figure 1 below. Seasonal profiles for cultural activities in these areas are provided in Appendix 2.

Approximately 40 varieties of cherries are produced in California. Six of these varieties comprise over 95% of the volume shipped. California cherries may arrive as early as late April, and generally are out of season by early July, with crops from more northerly regions gradually replacing them during the summer months.

California produces the earliest sweet cherry crop in the United States. Late production often overlaps with the Oregon and Washington crops; timing is therefore critical in producing the highest profitability crop. Future international competition will be from China, particularly for Pacific Rim markets. Major varieties are described in the chart below. Other varieties include Chelan, Early Burlat, Van, Lambert, and Ruby.

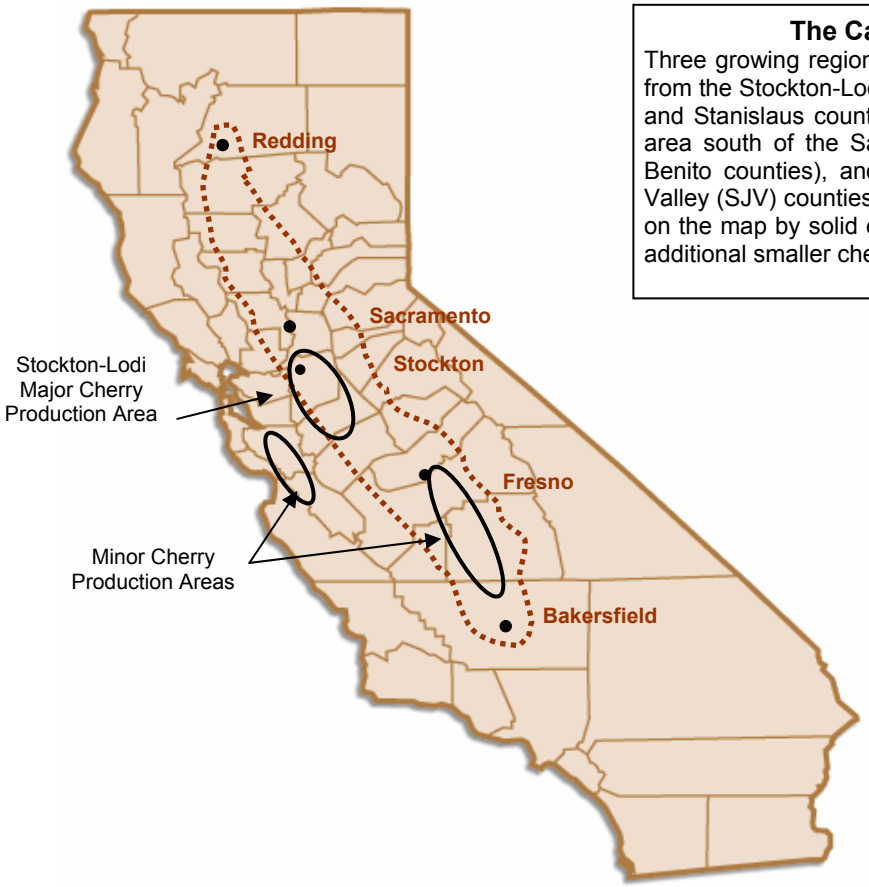
Sweet cherries are best suited to an intermediate climate, but will tolerate considerable winter cold. They have a chilling requirement of 350–1200 hours of temperatures below 45° F. Taking up to eight years to reach bearing age, the trees have a life expectancy of 30–35 years.

The time from sweet cherry bloom to harvest is 60 to100 days, with an average of 70 days. Growing seasons vary with orchard elevation. Trees grown at 500 feet elevation have an average growing season of about 200 days; trees at 1,700 feet elevation have an average growing season of about 175 days.

Cherry Varieties in California

Variety	% of CA Acres	Type of Fruit	Harvest Period
Bing	65%	Dark mahogany color, firm	5/5 - 7/4
Tulare	9%	Dark red to mahogany color, relatively rain-crack resistant	5/1 - 5/15
Brooks	8%	Large fruit, light flesh, low acid	4/20 - 5/10
Garnet	4%	Dark red	5/10 - 5/20
Rainier	3%	Yellow fruit with red blush, large and sweet	5/5 - 6/20

Figure 1. Cherry Production Regions in California



The California Cherry Industry

Three growing regions produced 95% of the cherry crop: 75% from the Stockton-Lodi area south of Sacramento (San Joaquin and Stanislaus counties), ~10% from the Morgan Hill-Hollister area south of the San Francisco Bay (Santa Clara and San Benito counties), and ~14% from the Southern San Joaquin Valley (SJV) counties of Fresno, Tulare, and Kern, represented on the map by solid ellipses. Several other counties produced additional smaller cherry harvests.

Stages and Approximate Duration for California Sweet Cherry Development *

Stage	Dormancy	Bloom	Fruit Development	Crop Harvest
Duration	~3 months	3-4 weeks	60 –100 days	15-20 days

* Extremely variable according to variety, location, and season

Characteristics of Cherry Production Areas in California*

Characteristics	Stockton/Lodi Area (Major)	Southern SJV (Minor)	Morgan Hill/Hollister Area (Minor)
Chilling Units (hours)	650 – 1200	350 –1000	400 –1100
Dormant Period	late October – mid February	mid November – early February	late October – late February
Bloom Period	March 10 – April 15	mid February – late March	mid March – late April
Harvest Period	May – June	April – May	May – July
Main Varieties	Bing, Rainier	Brooks, Tulare, Garnet	Bing
Relative Temps.	warm	hot	cooler
Soil Types	wide range, sandy to clay loams	sandy to sandy loams	generally clay loams
Key Insects	scale, leafhoppers, web-spinning mites, lepidopterous larvae	grape leaf skeletonizer, borers, web-spinning mites	earwigs, web-spinning mites, lepidopterous larvae, aphids
Key Weeds	various annual and perennial weeds	various annual and perennial weeds	various annual and perennial weeds
Key Diseases	brown rot, X-disease, *Botrytis*, *Phytophthora* root & crown rot, viruses	brown rot, *Botrytis*, *Phytophthora*, viruses	brown rot, *Botrytis*, powdery mildew, *Phytophthora* root & crown rot, viruses
Key Nematodes	ring and lesion	ring and lesion	ring and lesion

*Based on average years, typical conditions, etc.

Pests in California Cherry Production: Overview of Key Organisms

Cherries generally experience less pest pressure than other stonefruit commodities grown in California; this is largely due to the very early and compressed production season of this commodity. Lepidopterous larvae cause direct feeding damage to developing fruit. In the Northern San Joaquin Valley, leafhoppers can vector X-disease (also called cherry buckskin disease), a major cause of cherry tree mortality. The black cherry aphid can be an early season pest in coastal orchards.

Brown rot is a concern, but is much less of a problem in cherries than in other stonefruits. Powdery mildew affects cherry foliage, but generally does not infect the fruit. Weed management is accomplished through both chemical and cultural controls.

Monitoring and controlling post-harvest disease is extremely important because strict phytosanitary regulations established by the importing countries govern U.S. cherry exports. Unless effective fumigants are available for this purpose, these markets are in jeopardy. For detailed information on all pests of cherries, see *Cherry Pest Management Guidelines* at http://www.ipm.ucdavis.edu/PMG/selectnewpest.cherries.html, and UC Publication 3389, *Integrated Pest Management for Stonefruits*.

A wide variety of cultural, chemical, and biological control techniques is used to manage cherry pests. Several products will be discussed throughout this portion of the strategic plan. The Appendices list all these products by their chemical and trade names. Mention of a specific trade name does not indicate endorsement of any particular product or brand.

2. PEST MANAGEMENT FOR NEW CHERRY ORCHARDS

Selecting the proper orchard site and ensuring that the site is properly prepared and that young trees are well established will affect productivity over the lifetime of the cherry orchard. Researching site history, including previous and neighboring crops, cultural practices, pesticide use, and soil conditions, will assist the grower in deciding on optimal sites and on pre-plant preparation for new orchards. Once a site has been selected, appropriate weed, nematode, and disease control measures must be considered. Precautions must also be taken to prevent damage to young trees by vertebrate pests such as pocket gophers, ground squirrels, rabbits, and meadow mice.

Selecting cherry varieties well-adapted to the production area is critical. In addition, proper rootstock selection and use of certified virus-free planting stock help growers avoid specific disease and nematode problems.

Cultural Activities

• Leveling, sub-soiling (deep ripping), and cultivation • Fumigation • Planting • Trunk painting and wrapping • Pruning and training of young trees	• Irrigation • Grafting or budding • Fertilization (ground and foliar) • Cover crop establishment and maintenance • Herbicide treatment to ensure weed-free area around trees

WEEDS

Weeds are a major pest issue in new orchards and can be especially problematical during the first two years after planting. Fumigation reduces weed problems in the first year. In subsequent seasons, pre-emergence herbicides are used on the cherry orchard berms during the fall and winter months, and post-emergence herbicides are used during the season. Spot treatments in the middle of orchard rows may be used to control specific problem weeds.

Several cultural weed control methods are effective in young orchards. Hand weeding and hoeing are options, but they are labor intensive and costly. Mowing and disking are commonly used for weed control in the middles. Flaming is used rarely because of its high cost and restrictions due to air quality concerns.

While several herbicides are registered for non-bearing orchards, no single product controls all weed species. Prowl® and Surflan® (oryzalin) provide good pre-emergence control of many annual weeds. Goal®, a good pre- and post-emergence herbicide, is a very good broadleaf material, but is limited in terms of when it can be used. In addition, Goal® is expensive and does not effectively control other types of weeds, such as grasses. Gramoxone® Extra, is a good post-emergence material, but lacks residual control. Roundup® cannot be used in newly planted orchards because of potential damage to young trees. It also provides poor control of certain broadleaves, such as field bindweed. Solicam® has phytotoxicity issues and is not safe for very young trees. Various formulations of 2,4-D are registered on cherry. 2,4-D is an excellent post-emergence product on most broadleaf weeds, but its use is restricted to established orchards (one year or older).

Work Group Recommendations for Weed Management in New Orchards

RESEARCH	• Consider reviewing the science of methyl bromide phase-out
REGULATORY	• Obtain Dual® registration • Register methyl bromide alternatives for pre-plant fumigation

DISEASES

For some diseases, management must begin prior to orchard establishment. Site selection and preparation for planting (including sub-soiling, leveling, cultivation, and amelioration of soil salinity and acidity/alkalinity), pre-plant fumigation, selection of planting design and tree density, and selection of planting height (e.g., use of berms) may affect tree health and productivity throughout the life of the orchard.

Major diseases to consider during this stage include *Phytophthora* root and crown rot, cherry stem pitting, bacterial canker, crown gall, *Armillaria* root rot, and virus diseases.

Phytophthora root and crown rot is managed mainly by selecting proper rootstock, selecting orchard sites which do not have a history of this disease, and planting trees on raised berms, which encourages good drainage and thus limits risk of this disease. Aliette® and Ridomil® both provide some control of *Phytophthora,* but Aliette® is registered for use on non-bearing cherries only, and Ridomil® is too expensive for orchard applications. Neither fungicide has been systematically tested for *Phytophthora* control in cherries. Irrigating so as to avoid prolonged periods of soil saturation helps reduce *Phytophthora* incidence.

Cherry stem pitting (CSP) is a disease of unknown cause, thought to be spread by one or more soil-borne vectors. Though CSP is not wide-spread (it has been identified only in northern San Joaquin Valley cherry orchards), tree mortality is usually high in affected orchards. Trees on Mahaleb (*P. mahaleb*) and Mazzard (*P. avium*) rootstocks are highly susceptible, while trees on Colt rootstock show field resistance to the disease. The effects of pre-plant fumigation on CSP incidence have not been studied.

Bacterial canker, caused by *Pseudomonus syringae*, can devastate young orchards. Infections usually occur between fall and early spring, killing individual limbs and even entire trees in severe situations. Fall applications of Aliette®, or multiple applications of copper during the fall through the dormant period, are the principal chemical control measures used by growers. Cultural control methods are limited to selecting less susceptible rootstocks, pruning off infection sites, and postponing any pruning until the late delayed dormant period. Cherries grown in sandy soil types appear to be more susceptible than those grown in heavier soil.

Planting new trees in methyl bromide-treated soil helps reduce disease incidence by reducing populations of ring nematode (*Criconemella* spp.), which predisposes cherry trees to bacterial canker. Providing adequate irrigation and nutrition also helps to maintain tree vigor and reduce losses to this disease.

Crown gall management begins with obtaining clean nursery stock and avoiding injuring the crown or roots during planting. Galtrol® used as a pre-plant treatment may also reduce the incidence of crown gall.

Armillaria is only partially controlled by using methyl bromide as a pre-plant treatment. Viruses are controlled only by using planting stock developed from virus-free materials.

Work Group Recommendations for Disease Management in New Orchards

Research	• Develop economically viable methyl bromide alternatives for pre-plant fumigation • Determine what factors pre-dispose cherry trees to bacterial canker • Evaluate new technology “systemic acquired resistance” (SAR) type products for bacterial canker • Evaluate Aliette® and other phosphonates for efficacy in reducing tree losses to *Phytophthora* in bearing and non-bearing orchards • Develop effective pre-plant assays and/or treatment protocols for cherry stem pitting
Regulatory	• Register methyl bromide alternatives as soon as possible • Register phosphonate fungicides for bearing and non-bearing cherries
Education	• Educate growers and PCAs on use of phosphonate fungicides for controlling *Phytophthora* root and crown rot • Educate growers and PCAs on the use of methyl bromide alternatives

NEMATODES

Plant parasitic nematodes damage tree roots by direct feeding and by burrowing through root tissues. Nematode damage reduces tree vigor, growth, productivity, and longevity. Nematodes also vector a number of important virus diseases of cherry.

Cultural techniques to control nematodes include proper site and rootstock selection, crop rotation, and sanitation. Nematicides reduce but do not eradicate nematodes; soil conditions and application procedures determine nematicides' efficacy, which may be quite variable.

Most pre-plant fumigations are done in late summer or fall when soil is driest yet still warm. The loss of methyl bromide as a fumigant for new orchards creates significant concerns for plant health and nematode management in cherries. Cal/EPA imposes application rate and geographic restrictions on the use of Telone II® which must be considered when planning nematode control activities.

Nematode Species Found in Cherries

Root Lesion nematode (*Pratylenchus* spp.) causes damage by feeding on and entry into roots, reducing development of larger roots, tree growth, productivity, and longevity.

Ring nematode (*Mesocriconema xenoplax*) increases bacterial canker susceptibility**.**

Root knot nematode (*Meloidogyne* spp.) is not a problem if resistant rootstock is used. These nematodes have been implicated in cherry disease complexes with fungi and bacteria such as crown gall, and alone they can be very damaging to cherry roots growing in coarse-textured soils.

Dagger nematode (*Xiphenema* spp.) can reduce vigor and also vector tomato ring spot and cherry rasp leaf virus.

Methyl bromide provides excellent control of nematodes but will eventually be phased out. Nemacur® provides fair to good control of nematodes as a post-plant treatment; if properly applied, it can reduce nematode populations by about 60% for a period of six months. However, registration of Nemacur® will be phased out in spring 2005. Telone II® works extremely well if soil moisture conditions are correct and soil is coarse-textured. California limits treatment rates to 33.7 gallons per acre, but 50 to 67 gallons per acre is needed for finer-textured soils. Solarization is not effective as a nematode management tool for perennial crops.

Work Group Recommendations for Nematode Management in New Orchards

Research	• Evaluate efficacy of new nematicides DiTera® and Enzone® • Evaluate methyl bromide alternatives • Evaluate SAR (systemically acquired resistance) products • Develop economic treatment thresholds for plant parasitic nematodes that damage cherries
Regulatory	• Expedite Telone II® label modification for its application to individual tree sites; this treatment can provide nematode-free soil for the first year of tree growth, enabling early development of larger root systems • Register methyl bromide alternatives for pre-plant uses
Education	• Educate growers and PCAs on nematode diagnostic and sampling procedures, and on evaluating the need for chemical pre-plant treatments • Educate growers and PCAs on proper use of new fumigants

VERTEBRATE PESTS

Vertebrates can significantly damage cherry trees and may also interfere with irrigation and other cultural activities. Gophers and squirrels are the most troublesome vertebrate pests in new orchards. Sites adjacent to unmanaged ground or pastures will harbor more vertebrate pests, but monitoring and implementing control actions may discourage the buildup of populations within orchards. Sanitation, trapping, fumigants, and baits are used with variable levels of success.

Pocket gophers may significantly damage cherry trees because of their strong preferences for feeding on certain rootstocks. Traps are effective, but very labor-intensive given the large acreages involved. Except for flooding, there are no effective cultural techniques for controlling pocket gophers. Strychnine is an extremely effective poison, but its use is restricted. Many growers place owl boxes in the orchard in hopes that owl predation will reduce the gopher population.

Ground squirrels can be managed fairly well with bait stations and traps. Aluminum phosphide is an excellent material for ground squirrels, but is a restricted-use product.

Meadow mice are controlled very well by weed management in and around orchards. Zinc phosphide provides excellent control of voles, but is a restricted-use product. Placing owl boxes to encourage predation has been used with limited success.

Work Group Recommendations for Vertebrate Management in New Orchards

Education	• Teach growers how to recognize vertebrate damage and distinguish it from other causes of cherry tree decline and death

3. PEST MANAGEMENT FOR ESTABLISHED CHERRY ORCHARDS

The following section describes seasonal cherry orchard pest management issues during the various growing seasons, starting with winter dormancy.

WINTER
(dormancy and delayed dormancy ~ December 1 to March 1)

With the cooler weather and shorter days of fall and winter, cherry trees enter the rest period called dormancy. Developing buds must be exposed to adequate chilling (at least 850 hours of cumulative exposure to temperatures below 45° F) to ensure complete dormancy, rest, and resumption of normal growth in spring.

The terms dormancy and delayed dormancy are commonly used. Dormancy refers to the entire "resting" phase of the trees, after leaf-fall and before bud-break. Delayed dormancy refers to the period when green tissue begins to become visible at the tips of the buds, prior to the appearance of any of the immature flower parts.

Cultural Activities

- Pruning
- Applications of pesticides
- Plant growth regulator applications
- Tree replacement
- Vertebrate pest control
- Fertilization
- Field scouting

INSECTS

Various pests are managed in part by control measures undertaken during the winter dormant season. Chemical and oil applications target over-wintering populations of pest insects and mites. Most orchards receive at least one dormant spray during late fall or winter. Oils used with organophosphate insecticides have been highly effective in controlling pest populations of San Jose scale (SJS) and several other insect and mite pests.

Scales (San Jose, European fruit *leucanium,* and others) and aphids are controlled extremely well with dormant applications of an organophosphate insecticide plus oil. Typical products for this use are diazinon and Supracide®. (Lorsban® cannot be used after the dormant season.) The efficacy of pyrethroids is unknown for scale control in cherries.

Some species of leaf- and fruit-feeding lepidopterous larvae are also controlled by use of delayed dormant insecticide applications Oils alone are only marginally effective in controlling fruit-feeding larval pests at the delayed dormant stage.

Work Group Recommendations for Insect Management in Winter

Research	• Evaluate alternatives to organophosphate insecticides for dormant and delayed dormant treatments for insects and mites
Regulatory	• Register organophosphate insecticide alternatives

PLANT GROWTH REGULATORS (PGRs)

PGRs are used to help offset effects of inadequate chilling and to promote synchrony of bloom. Dormex® (hydrogen cyanide) can be used, but it causes numerous worker and environmental safety concerns. In addition, it has variable efficacy, can cause phytotoxicity, and is expensive. Mixtures of calcium ammonium nitrate (CAN-17), a fertilizer, and certain surfactants also work well as rest breaking agents without the safety and environmental issues associated with Dormex®. The registration of CAN-17, however, has been held up at the California Department of Pesticide Regulation (CDPR) due to a requirement for residue data.

Work Group Recommendations for Plant Growth Regulators in Winter

Research	• Evaluate timing, materials, and rates of fertilizer plus surfactant sprays for rest breaking in cherries
Regulatory	• Expedite registration of calcium ammonium nitrate (CAN-17) as a PGR
Education	• Educate growers and PCAs on proper use of rest breaking agents

SPRING

(bloom through fruit development and harvest ~ March 1 to mid-June)

The timing of bloom and fruit development is highly variable, depending on weather, growing region, and variety. Bud-break and bloom generally occur in March. Honey bees are placed in the orchards to ensure ample pollination, and Giberillic acid may be applied as a plant growth regulator to enhance fruit size and firmness. The fruit develops from March through May, with harvest in the major cherry production area near Stockton ending in late May or early June. Harvest occurs roughly two weeks earlier in the southern San Joaquin Valley production areas.

All Orchard Activities

- Field scouting
- Pesticide applications
- Fertilizing – foliar and ground
- Irrigation
- Harvesting
- Disking and spot treatment of weeds
- Vertebrate pest control
- Pruning
- Occasional fruit thinning, especially on pollenizer varieties

INSECTS

Spring insect pest populations are usually low in cherries due to the relative earliness and brevity of the developmental season. Nevertheless, monitoring orchards to determine when lepidopterous larvae and other insects are emerging, and timing applications of insecticides, are critical to avoid fruit injury. This is especially important when using materials such as *Bacillus thuringiensis* (Bt), which must be ingested to have a lethal effect.

Fruit-feeding lepidopterous larvae, such as green fruitworm (*Orthosia hibisci*) and fruit tree leaf roller (*Archips argyrospila*) are common pests at this time of year. Success®, a new reduced risk product, works very well, but it is expensive and its use is not accepted by some importing countries. Oblique-banded leaf roller (OBLR) is an increasing problem in cherry orchards. This pest is thought to be migrating into cherry orchards from other perennial crops, such as apples, due to increased use of pheromone mating disruption and other “soft” treatment regimes. Bt or Success® applications, when properly timed, are often effective against OBLR.

Earwigs cause problems in many orchards in the spring, feeding on leaves and developing fruit. Sevin® (carbaryl) is the only registered insecticide that provides good control; however, growers are reluctant to use it as a foliar application due to its reputation for disrupting beneficial insects. Sevin® in bait form was used for years within the industry, but is no longer available due to registration issues.

The glassy-winged sharpshooter (GWSS) has become established in southern San Joaquin Valley cherry production areas, and is frequently found in cherry orchards. GWSS is not known to cause economic damage to cherry trees or fruit, but is problematic to producers wanting to ship fruit overseas due to extremely stringent infestation quarantine standards for export markets. Thus it is extremely important to ensure that cherries are free of GWSS and that tools are available in the field to control this pest. Several new neonicotinoid products are in development; registrations are needed for their use on cherries.

Work Group Recommendations for Insect Management in Spring

Research	• Develop damage-based economic thresholds for lepidopterous larvae • Develop better understanding of OBLR biology and control in cherries, especially the influence of nearby hosts/reservoirs on OBLR abundance and damage in cherries
Regulatory	• Expedite new registrations for Actara® and Provado® to address glassy-winged sharpshooter issues • Explore re-registration of Sevin® bait for earwig control
Education	• Provide training on new products prior to registration (e.g., Actara® and Provado®) • Educate growers and PCAs on the use of economic thresholds and sampling for lepidopterous pests

DISEASES

Intensive monitoring of orchards and a thorough knowledge of conditions promoting disease development are critical to controlling pathogens in cherry orchards. Sanitation practices help to eliminate sources of inoculum for some of these diseases, but the most effective disease management tool may be carefully timed fungicide applications.

Brown rot and *Botrytis* blossom blight are the most common and troublesome decay diseases of California cherries during bloom and petal fall, and prior to harvest. Managing brown rot in the field is important because it can cause severe post-harvest losses as well. Treatment in early bloom is recommended in cherries, especially in orchards with a disease history. Brown rot can be effectively managed in season with Rally®, Elite®, Cabrio®, Flint®, or Procure®. These products, along with wettable sulfur, also provide fair to good control of powdery mildew. Resistance may be a concern with repeated use of products that have similar chemistries.

Botrytis can be a serious problem on ripening fruit. Rains occurring near harvest can cause infections within hours. Rovral® has been very effective against this disease, but it can no longer be used after bloom. Elite® and Elevate® are the only products available that provide some control of *Botrytis* infections at harvest.

During wet spring seasons *Phytophthora* root and crown rot can cause problems in established orchards. Care should be taken to promote good drainage around trees and avoid over-watering. Availability of effective and affordable fungicides could potentially reduce tree losses caused by *Phytophthora*. Research, regulatory, and educational recommendations pertaining to the use of phosphonates (e.g. Aliette®) in established orchards are the same as those presented above in Section 2.

Bacterial canker is a concern in many mature orchards. Infections usually appear on the spurs or buds of mature trees; however, infection on a mature tree is usually not as damaging as it is on young trees. A wet fall and/or a warm period followed by freezing winter temperatures often increase disease incidence. Copper fungicides applied in the fall and late dormant season appear to help reduce disease incidence.

Work Group Recommendations for Disease Management in Spring

Research	• Develop materials with a short pre-harvest interval (PHI) to alleviate post-harvest pathogens
Regulatory	• Reduce PHIs for existing registrations for *Botrytis* materials • Expedite new registrations with short PHIs for *Botrytis* control • Register a pre-harvest material with a short PHI to alleviate post-harvest pathogens • Re-instate pre-harvest uses of iprodione for fruit decay control
Education	• Educate growers and PCAs on efficacy and timing of newly registered fungicides for controlling bloom and fruit diseases

VERTEBRATES

In fruit-bearing cherry orchards, vertebrates can significantly damage cherry trees and may also interfere with irrigation and other cultural activities. Birds, gophers, and squirrels are the most troublesome species. Monitoring and implementing control actions may discourage the buildup of populations within orchards. These activities are especially important in orchards adjacent to unmanaged ground or pastures because these locations generally harbor more vertebrate pests.

Birds can significantly reduce crop yield and quality by feeding on ripening fruit. Monitoring birds when fruit starts to ripen is critical to knowing when to implement control measures. Frightening, trapping, and use of protective netting may reduce bird visitation and damage. Lethal control may sometimes be necessary, but growers must check with the Department of Fish and Game before taking this action.

There are no work group recommendations for vertebrate control.

SUMMER
(after harvest ~ mid-June to mid-September)

Even after the cherry crop has been harvested early in the summer, many pest management activities are still occurring in the orchard. The trees are now preparing to develop next year's crop, so irrigation, fertilizing, insect management, and continued monitoring for all pests are very important summer activities.

Cultural Activities

• Irrigating	• Field scouting
• Mowing/disking	• Fertilizing
• Pruning/topping	• Vertebrate control
• Pesticide applications	• Tree removal

INSECTS

Leafhoppers and mites are the primary pests of concern during the summer months. Leafhoppers feed on cherry leaves and can vector cherry buckskin disease. Asana®, a pyrethroid, provides excellent control of leafhoppers, but can cause secondary mite outbreaks. Sevin® is effective, but it, too, causes secondary mite outbreaks, and is more expensive than Asana®. Diazinon is also available for controlling leafhoppers, but has very short residual activity. Two other products, kaolin and pyrethrum, are organically approved; however, the efficacy of kaolin clay is unknown for leafhoppers, and the efficacy of pyrethrum is rated as only poor to fair.

Good water and irrigation management to limit tree stress helps to prevent mite problems during the hot summer months. Predatory mites are effective in managing pest mites; these predators can occur naturally, or can be augmented by field releases. Several products are available for mite control. Omite® is excellent, but its long re-entry interval interferes with timely performance of orchard cultural operations, including removal of X-disease infected trees. Apollo®, Savey®, and Onager® are good ovicides that are effective on mites if applied early enough. Vendex® and Kelthane® provide only poor to fair control, and mite resistance is a problem with both of these products.

Work Group Recommendations for Insect Management in Summer

Research	• Evaluate neonicotinoids for leafhopper control • Evaluate new miticides for web-spinning mites • Develop sampling protocols and treatment thresholds for mites, including consideration of predatory arthropod activity
Regulatory	• Expedite registration of neonicotinoids for leafhoppers on cherries • Expedite registration of new miticides
Education	• Educate growers and PCAs on use of mite sampling protocols and treatment thresholds

WEEDS

Grasses and certain perennial broadleaf weeds are the most troublesome weeds to manage in the summer months. Once the canopy is established, it may lower perennial weed pressure. Several cultural weed control methods are options for both organic and non-organic orchards. Hand weeding is an option, but it is labor intensive and therefore very expensive. Mowing and disking are commonly used for weed control in the middles. Flaming is sometimes used in organic orchards, but its high cost, low efficacy, and restrictions due to air quality concerns make it unfeasible in most ochards

Prowl®, Solicam®, and Surflan® (oryzalin) provide good pre-emergence control of many annual weeds. Goal®, both a pre- and post-emergence herbicide, is a very good broadleaf material, but is limited in terms of when it can be used. Goal® is expensive and does not effectively control grasses. Gramoxone® Extra, is a good post-emergence material, but lacks residual control. Roundup® is a broad spectrum, post-emergence, systemic herbicide that is effective on many annual and perennial weeds. However, Roundup® is weak against certain broadleaves, such as field bindweed. Various formulations of 2,4-D are registered for use on cherries. 2,4-D is an excellent post-emergence product on most broadleaf weeds, but it is restricted for use only on established orchards.

Work Group Recommendations for Weed Management in Summer

Regulatory	• Register Prowl® for bearing use • Obtain Dual® registration

DISEASES

Powdery mildew is the main foliar disease monitored and managed during the summer months. Although several products are registered, cherry orchards are rarely treated in summer for powdery mildew. Cultural practices to limit disease buildup and spread include removing suckers which harbor the disease organisms. Sulfur, approved for the organic market and used also in conventional orchards, provides some control of powdery mildew; however, phytotoxicity can occur if temperatures are above 85 degrees. Rally®, Cabrio®, Flint®, and Elite® provide excellent control of powdery mildew. The efficacy of Rubigan® needs to be understood. Abound® is also registered for use against powdery mildew. Growers must use materials with several modes of action to manage any resistance that might be developing; this increases the importance of obtaining registration of Quintec®.

Water management is the principal tool available for limiting losses to *Phytophthora* root and crown rot.

Work Group Recommendations for Disease Management in Summer

Research	• Evaluate efficacy of phosphite materials
Regulatory	• Expedite Quintec® registration
Education	• Provide training to growers and PCAs on resistance management for bloom and fruit disease suppression • Educate growers and PCAs on proper use of phosphite materials

VERTEBRATE PESTS

Vertebrate controls during summer are the same as for spring. No work group recommendations are proposed for these pests during these two seasons.

FALL
(~ mid-September to December 1)

Cultural Activities

• Irrigating • Mowing/disking • Pruning/topping • Applying pesticides • Scouting	• Fertilizing - ground only • Controlling rodents • Removing trees • Budding, grafting

INSECTS

Web-spinning mite populations must be monitored through early fall to avoid premature defoliation. Hard scale populations are also monitored during the late fall months, particularly after leaf drop, to determine whether treatments will need to be made in the winter dormant period. Insecticide and miticide options used during this time are the same as those available for the summer months.

Good water and irrigation management to limit tree stress continues to be important to maintain tree vigor.

Work Group Recommendations for Insect Management in Fall

Research	• Evaluate neonicotinoids for leafhopper control • Evaluate new miticides
Regulatory	• Expedite registration of neonicotinoids for leafhoppers on cherries • Expedite registration of new miticides
Education	• Educate growers and PCAs on the use of predatory mites

WEEDS

Most fall activities are intended to control weeds before winter. Orchard floor management in the fall 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.

Prowl®, Solicam®, and Surflan® (oryzalin) provide good pre-emergence control of many annual weeds. Goal®, both a pre- and post–emergence herbicide, is a very good broadleaf material, but is limited to specific times of use, is expensive, and does not effectively control grasses. Gramoxone® Extra is a good post-emergence material, but lacks residual control. Roundup® is a broad spectrum post-emergent systemic herbicide that is effective on many annual and perennial weeds, but is weak against certain broadleaves, such as bindweed. Fall applications of Roundup® can cause phytotoxicity if the chemical comes in contact with cherry tree suckers, foliage, or the bark of young trees. Various formulations of 2,4-D are registered for use on cherries. 2,4-D is an excellent post-emergence product on most to all broadleaf weeds, but its use is restricted to established orchards only.

There are no work group recommendations for weed management in fall.

DISEASES

Work Group Recommendations for Disease Management in Fall

Research	• Evaluate the effectiveness of lime-sulfur on powdery mildew • Evaluate copper and zinc for bacterial canker control

POST-HARVEST FRUIT DECAY CONTROL

Brown rot (*Monilinia* spp.) and gray mold (*Botrytis cinerea*) are the most important causes of fruit decay during post-harvest storage and handling. Brown rot infections often occur during bloom and fruit development, and the organisms may become active during the post-harvest stage when temperature and humidity are favorable. Control of both of these diseases with Elite® ranges from excellent for brown rot to fair for gray mold.

Work Group Recommendations for Post-Harvest Fruit Decay Control

Research	• Need sanitation alternatives for post-harvest disease control • Need a fumigant that is effective in decay control
Regulatory	• Expedite fenhexamid and pyraclostrobin/boscalid registrations to help with resistance management • Register a pre-harvest material with a short PHI to alleviate post-harvest pathogens
Education	• Provide training on resistance management to preserve all chemical tools (older chemistry and new) used in sweet cherries

Note: methyl bromide post-harvest fumigation was used not for decay, but rather for insect management. In general, a fumigant that is effective in decay control would also be desirable.

PROCESSOR ISSUES

Only about 5% of the annual cherry crop goes to the processing industry, but several concerns in this area should be addressed. It is very important that growers maintain good records of all pesticide applications in case of a product recall or a customer complaint. Lists of approved chemicals should be readily available to growers and PCAs so that they may know exactly what products can be used on cherries destined for the processing market; these lists might be company-specific or industry-approved (e.g., California League of Food Processors). A lot tracking system should be in place to help locate specific fruit that might be called into question.

Work Group Recommendations for Processor Issues

Research	• Develop a trace back system for California cherries to address pesticide issues or customer complaints
Regulatory	• Establish a trace back system for California cherries to address pesticide issues or customer complaints • Develop/maintain an approved list of materials that can be used on cherries, and update growers and PCAs
Education	• Commodity groups should regularly educate growers and PCAs about materials which are approved by the food processing industry

INTERNATIONAL ISSUES AND PRE-SHIPMENT QUARANTINE TREATMENT

A significant portion of the cherry crop is shipped to international markets, chiefly Japan, Taiwan, Canada, and Australia. Because export shipments can account for 50-60% of the gross crop dollar value, it is very important to prevent pest problems in the field and to comply with pre-shipment quarantine protocols. Pests that cause phytosanitary concerns in cherries include codling moths, western cherry fruit flies, oblique-banded leaf rollers, mites, and glassy-winged sharpshooters.

Strict protocols must be followed for California cherries to be allowed access to many important foreign markets. Countries like Japan, Korea, and Australia require post-harvest fruit treatment with methyl bromide to address phytosanitary concerns. Currently, methyl bromide is still available for pre-shipment quarantine use. As a specific provision of the Montreal Protocol, these uses will not be affected by the 2005 methyl bromide phase-out. However, it remains critical for the California cherry industry that pre-shipment quarantine use of methyl bromide be recognized and preserved. At the same time, it is extremely important that alternatives to methyl bromide be explored, and that alternative pre-shipment treatment protocols be established and accepted by importing countries.

Work Group Recommendations for International Issues

Research	• Evaluate new fumigants for pre-shipment quarantine treatments (methyl bromide alternatives) • Establish new quarantine protocols that are not based on use of methyl bromide • Encourage registrants to develop residue data and export tolerances for new products prior to U.S. registration
Regulatory	• Maintain the use of methyl bromide as a pre-shipment quarantine fumigant (Critical Use Exemption – CUE) • Develop and maintain an approved list of materials that can be used on cherries; request that FDA maintain a current log of international registrations • Register alternatives to methyl bromide for pre-shipment quarantine fumigation treatments • Encourage registrants to establish export tolerances for new products prior to registration • Insure that all quarantine protocols are harmonized between US EPA and importing countries
Education	• Educate growers and PCAs about materials which are approved by export countries • Educate EPA and other regulatory agencies on the critical need to maintain the use of methyl bromide as a pre-shipment quarantine fumigant to maintain export markets • 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 as they are developed • Harmonize EPA registration requirements with the MRL and Codex systems used in other countries. • Encourage EPA and FAS to work with Codex to expedite international registrations so that newer and safer products may be used in the U.S. without fear of trade irritant issues

FOOD SAFETY ISSUES

The job of producing safe, high quality California cherries begins before the fruit trees are planted and continues until the fruit reaches the consumer's hand. California's cherry industry, working closely with the University of California, continually studies growing practices, pest control, irrigation, fertilization, and post-harvest handling. As part of this research, the California cherry industry has taken an active role in studying issues pertaining to microbial safety. To date, there has been no association of fresh cherries with any reported food-borne illness.

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

Work Group Recommendations for Food Safety Issues

Regulatory	• Conduct self-audits to ensure product safety • Comply with good agricultural practices (GAP) and other food safety programs as established for the cherry industry
Education	• Provide training on the importance of clean water and personal hygiene in harvest and packing operations

4. CRITICAL ISSUES FOR THE CALIFORNIA CHERRY INDUSTRY

The following areas were identified by the Cherry Work Group as being the most critical to the sustained viability of the California cherry industry.

Work Group Recommendations for Critical Issues

Research	• Evaluate new fumigants to replace methyl bromide for use in post-harvest quarantine treatments • Evaluate methyl bromide alternatives for pre-plant fumigations • Evaluate new products and techniques for leafhopper control • Intensify efforts to identify effective biological and cultural techniques to control pests in cherries • Evaluate systemically acquired resistance (SAR) materials • Develop a systems approach to pest management in cherries based on economic thresholds • Determine the relationship between the biology of bacterial canker and host susceptibility • Develop best management practices (BMPs) to protect water and soil quality • Develop monitoring and threshold-based treatments for oblique-banded leaf roller • Evaluate new and existing rootstocks for resistance to key soil-borne pests and diseases • Provide access to research funding directly through commodity organizations (California Cherry Advisory Board, etc.) in addition to continued support of the University of California Land Grant system for research and extension activities
Regulatory	• Expedite registrations of methyl bromide alternatives • Shorten the pre-harvest interval (PHI) for new in-season *Botrytis* materials (e.g., fenhexamid) • Expedite the registration of calcium ammonium nitrate as a PGR • Register organophosphate and carbamate alternatives as soon as possible; utilize the IR-4 priority system for research on reduced risk materials • Harmonize Cal/EPA and US EPA review process to hasten new product registrations • Identify potential trade irritants as early as possible in the research and registration process; insure there are no conflicts with provisions of NAFTA or Codex • Register effective insecticides for controlling leafhopper vectors of X-disease
Education	• Educate growers and PCAs on all new methyl bromide alternatives, insecticides, and fungicides • Conduct resistance management training for all pest categories • Provide training on reduced risk pest management practices and BMPs to improve and protect water and soil quality in agricultural areas • Educate the public on the nutritional values of California grown cherries and their high level of food safety and quality

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APPENDICES

1. 2002 California Cherry Production Statistics

COUNTY	HARVEST ACREAGE	YIELD (Tons/Ac.)	PRODUCTION (Tons)	TOTAL VALUE ($)
Contra Costa	284	1.3	369	1,054,000
El Dorado	108	0.3	30	90,000
Fresno	1,825	3.1	5590	27,536,000
Kern	1,578	3.1	4830	18,327,000
Los Angeles	130	0.8	102	406,000
Riverside	27	0.7	19	77,800
Sacramento	213	1.0	213	217,000
San Benito	615	3.6	2208	3,842,000
San Joaquin	14,500	2.2	32200	69,430,000
Santa Clara	853	2.9	2474	3,206,000
Solano	84	2.1	176	223,100
Stanislaus	1,630	2.6	4240	12,516,000
Sutter	37	2.2	81	244,000
Tulare	1,562	3.0	4750	15,010,000
State Totals	**23,446**	**Average 2.4**	**57,282**	**152,178,900**

Source: County Agricultural Commissioners' Data

2. Crop Development, Cultural Practices, and Pest Management Activities for California Cherries

Stockton-Lodi Production Region

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

Data based on collective field observations and experience

3. Seasonal Pest Occurrence in California Cherries

Stockton-Lodi Production Region

Insects and Mites	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Aphids												
European Earwig												
Mites												
San Jose Scale												
Leafhoppers												
Diseases	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Brown Rot												
Powdery Mildew												
Phytophthora												
Crown Gall												
X-disease												
Weeds	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Perennial Broadleaves												
Annual Broadleaves												
Annual Grasses												
Perennial Grasses												
Nematodes	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Root Knot												
Ring												
Lesion												
Dagger												
Vertebrates	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Birds												
Gophers												
Ground Squirrels												

Data based on collective field observations and experience

4. Efficacy of Insect Management Tools Used in California Cherries

Chemical Insecticides

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

PRODUCT	TRADE NAME	Fruit Tree Leaf Roller	Orange Tortrix	Red-humped Caterpillar	European Earwig	Green Fruitworm	Eye-spotted Bud Moth	Mites	Black Cherry Aphid	Eur. Fruit Leucanium	Black Scale	San Jose Scale	Cherry Slug	Peach Twig Borer	Peachtree Borer	Am. Plum Borer	Leafhopper	Flat Borer	OBLR
B. thuringiensis	Bt	G-E	G	G		G								G					G
Carbaryl	Sevin®	G	F-G	G	E	G			F							G	G	G	
Chlorpyrifos	Lorsban®								G	G		G-E			G	G			G
Diazinon		F	F	G	P		G		G			G	G				P-F		F
Dicofol	Kelthane®							R-F											
Endosulfan	Thiodan®	G	G	G	P-F		G		G										G
Esfenvalerate	Asana® XL	F-G	F-G	F-G	P	G			G								E		F
Fenbutatin Oxide	Vendex®							R-F									R-F		
Malathion									F										
Methidathion	Supracide®	E	E			E			F	E	E	E		G					G
Phosmet	Imidan®	F				F						G		F					
Propargite	Omite®							E											
Hexythiazox	Savey®							G											

Data based on collective field observations and experiments

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

Non-Chemical Pest Management Tools

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

MANAGEMENT TOOLS	Fruit tree Leafroller	Orange Tortrix	Red-humped Caterpillar	European Earwig	Green Fruitworm	Eye-spotted Bud Moth	Mites	Black Cherry Aphid	Eur. Fruit Leucanium	Black Scale	San Jose Scale	Cherry Slug	Peach Twig Borer	Peachtree Borer	Amer. Plum Borer	Leafhoppers	Flat Borer	OBLR
Cover Crops	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Habitat Management	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Monitoring, Use Action Thresholds	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Natural Enemies	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G
Nutrition	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G	P-G
Sanitation				G														F-G
Soil, Dust Management	G	G	G	G	G	G	G											
Use of Models	G	G	G															
Resistant Varieties	G	G	G	G	G	G	G											
Water Management							G											
Weed Control				G														G
Mulching	G	G	G	G	G	G	G	G	G	G								
Trap Crops	G	G	G	G														
Netting	G	G	G	G	G	G												
Pheromones (mating disruption)	G	G	G	G	G	G												
Pheromones (population monitoring)	G	G	G	G	G	G							G					
Predatory Mites							P-G											

Data based on collective field observations and experiments

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

Impact of Insecticides on Beneficial Organisms Found in Cherry Orchards

Toxicity ratings: H = high, M = moderate, L = low

Common Name (Trade Name)	Selectivity[1] (affected groups)	Predatory Mites[2]	General Predators[3]	Parasites[3]	Honey Bees[4]	Duration of Impact to Natural Enemies[5]
Azinphos-methyl (Guthion®)	broad (insects, mites)	L-M	H	H	1	long
Bacillus thuringiensis sp. *layaway*	narrow (caterpillars)	L	L	L	4	none
Bacillus thuringiensis sp. *curtain*	narrow (caterpillars)	L	L	L	4	none
Carbaryl (Sevin® 80)	broad (insects, mites)	L-H	H	H	1	long
Carbaryl (Sevin® XLR)	broad (insects, mites)	L	H	H	2	long
Carbaryl (Sevin® XLR Plus)	broad (insects, mites)	L	H	L	3	long
Chlorpyrifos (Lorsban®)	broad (insects, mites)	M	H	H	1	moderate
Clofentezine (Apollo®)	narrow (mites)	L	L	L	4	short
Diazinon	broad (insects, mites)	L	H	H	1	moderate to long
Dicofol (Kelthane®)	narrow (pest mites and mites)	H	M	M	4	long to beneficial mites
Esfenvalerate (Asana®)	broad (insects, mites)	H	M	H	1	moderate
Fenbutatin Oxide (Vendex®)	narrow (pest mites)	L	L	L	4	short
Methidathion (Supracide®)	broad (insects, mites)	H	H	H	1	moderate to long
Petroleum oil	broad (exposed insects, mites)	L	L	L	3	short to none
Propargite (Omite®)	narrow (pest mites)	M[6]	L	L	4	short
Spinosad (Success®)	narrow (caterpillars, thrips, whiteflies, aphids, scales, leaf miners)	L	L[7]	L	3	short

Table extracted from UC Publication 3440, *UC IPM Pest Management Guidelines: Cherry*, January and May 2002, and website http://www.ipm.ucdavis.edu/PMG/selectnewpest.cherries.html

[1] Selectivity: *broad* means it affects most groups of insects and mites; *narrow* means it affects only a few specific groups

[2] Generally, toxicities are to western predatory mite, *Galendromus occidentalis*

[3] 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

[4] Ratings are: 1-Do not apply to blooming plants; 2-Apply in evening after bees have stopped foraging; 3-Apply in late evening after bees have stopped foraging until early morning before they begin to forage again; and 4-Apply at any time with reasonable safety to bees

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

[6] Use lowest rates for best management of western predatory mite/spider mite ratio

[7] Kills six-spotted thrips

5. Efficacy of Weed Management Tools Used in California Cherries

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

PRODUCT	TRADE NAME	Annual Broadleaves	Annual Grasses	Perennial Grasses	Perennial Broadleaves
Chemical					
2, 4-D	Envy®	E			F-G
Fluazifop-butyl	Fusilade®		E	E	
Glyphosate	Roundup®	G	G-E	G	F-G
Metolachlor	Dual®		F-G	P	F-G
Napropamide	Devrinol®	F	F	P	P
Norflurazon	Solicam®	G	G	F-G	F-G
Oryzalin	Surflan®	G	G	P	P
Oxyfluorfen	Goal®	E	P	P	G
Paraquat Dichloride	Gramoxone®	E	G-E	F	F
Pendimethalin	Prowl®	G	G-E	P	P
Sethoxydim	Poast®	P	E	G	P
Non-chemical					
Cultivation		G	G	G	G
Mowing		G	G	G	G
Burning		F	F	F	F

Data based on collective field observations and experiments

6. Efficacy of Disease Management Tools Used in California Cherries

Efficacy Ratings: E = Excellent, G = Good, F = Fair, P = Poor/None, R = Known Resistance, NA = Not Applicable

PRODUCT	TRADE NAME	Brown Rot	Jacket Rot	Powdery Mildew	*Phytophthora* Rot	Shothole	Crown Gall	Buckskin	Viruses
Chemical Tools									
2,4-Xylenol/Meta Cresol	Gallex®	P	P	P	P	P	G	P	P
*Agrobacterium radiobacter (*K84)	K84	P	P	P	P	P	E	P	P
Benomyl (registration cancelled)	Benlate®	R-E	R-E	R-E	P	P	P	P	P
Captan		G	G	P	P	G	P	P	P
Chlorothalonil	Bravo®	G	G	F	P	G	P	P	P
DCNA	Botran®	F	G	P	P	?	P	P	P
Fenarimol	Rubigan®	G	G	R-E	P	F	P	P	P
Fosetyl-al	Aliette®	P	P	P	E	P	P	P	P
Iprodione (registered only for bloom)	Rovral®	E	E	P	P	E	P	P	P
Calcium Polysulfide		P	P	E	P	P	P	P	P
Lime-Sulfur		P	P	E	P	P	P	P	P
Wettable Sulfur		P	P	E	P	P	P	P	P
Myclobutanil	Rally®	G	P	R-E	P	F	P	P	P
Tebuconazole	Elite®	E	F	R-E	P	F	P	P	P
Thiophanate-methyl	Topsin®	R-E	R-E	R-E	P	P	P	P	P
Vinclozolin (registration cancelled)	Ronilan®	E	E	P	P	E	P	P	P
Ziram		F	F	P	P	E	P	P	P
Non-chemical Tools									
Models (i.e., disease forecasting)		NA	NA	NA	NA	NA	NA	P	P
Irrigation Management		F	F	F	F	F	F	P	P
Weed Control		F	F	F	F	F	F	P	P
Resistant Cultivars/Rootstocks		NA	NA	NA	NA	NA	NA	P	F
Cover Crops		F	F	F	P	F	P	P	P
Adjusted Planting Date		NA	NA	NA	NA	NA	NA	P	P
Adjusted Harvest Date		P	P	P	P	P	P	P	P
Fertilizer Management		F	P	F	P	P	P	P	P
Vector Control		NA	NA	NA	NA	NA	NA	G	G
Sanitation (removal of diseased tissue)		F	P	P	F	P	F	G	G

Data based on collective field observations and experiments.

7. Efficacy of Nematode Management Tools Used in California Cherries

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

PRODUCT	TRADE NAME	Root Knot	Ring	Root Lesion	Dagger
Chemical					
1,3-D	Telone®	P-E	P-E	P-E	G-E
Metam Sodium	Vapam®	P-E	P-E	P-E	P-E
Methyl Bromide		G-E	G-E	G-E	G-E
Non-Chemical					
Clean Cultivation		F	F	F	F
Soil Sampling		G	G	G	G
Resistant Rootstock		E	P	P	P-G
Trap Crops		P	P	P	P

Data based on collective field observations and experiments

8. Efficacy of Vertebrate Management Tools Used in California Cherries

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

PRODUCT	TRADE NAME	Birds	Gophers	Ground Squirrels	Voles
Chemical					
Aluminum Phosphide	Phostoxin®			G-E	
Strychnine			E		G
Zinc Phosphide					E
Non-Chemical					
Trapping		F	G	F	P
Baits		P	G-E	G-E	G
Repellants		F	P	P	P
Frightening		F	P	P	P
Shooting/Lethal Control		F	P	P	P
Owl Boxes			F		F
Noise		F			
Mylar Strips		P-F			

Data based on collective field observations and experiments

9. Efficacy of Plant Growth Regulators (PGRs) and Post-Harvest Tools Used in California Cherries

PGRs

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

PRODUCT	TRADE NAME	EFFICACY
Gibberellins	Pro-Gibb®	E
Hydrogen Cyanamide	Dormax®	G
CAN-17+ surfactants		G

Data based on collective field observations and experiments

Post-Harvest Tools

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

PRODUCT	TRADE NAME	Brown Rot	Gray Mold	*Rhizopus* Rot	*Mucor* Decay
Sodium Hypochlorite*	Bleach	E	E	E	E
DCNA	Allisan®	F	G	E	P
Iprodione (registration cancelled)	Rovral®	E	E	G	P
Tebuconazole	Elite®	E	G	G	P
Fludioxonil	Scholar®	E	E	E	E
Fenhexamid	Elevate®	E	E	P	P

Data based on collective field observations and experiments

* Active only as a sanitizer of microbial contaminants in wash water

10. Chemical Use on California Cherries 1999 through 2001

% of Cherry Acreage Treated with Insecticides and Acaricides

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
Azinphos-methyl	Guthion®	1	0	1	1
B. thuringiensis	Bt	11	18	13	14
Carbaryl	Adios®	12	14	3	10
Chlorpyrifos	Lorsban®	4	3	3	3
Clofentezine	Apollo®	9	10	8	9
Diazinon		28	24	15	22
Dicofol	Kelthane®	2	1	2	1.7
Endosulfan	Thiodan®	0	0	0	0
Esfenvalerate	Asana® XL	42	44	39	48
Fenbutatin Oxide	Vendex®	6	4	3	4.4
Malathion		0	0	0	0
Methidathion	Supracide®	5	5	3	4.3
Narrow range oil		0	0	0	0
Permethrin	Pounce®	4	6	5	5
Petroleum distillate		0	0	1	.4
Phosmet	Imidan®	0	0	0	<1
Propargite	Omite®	32	33	35	33.3

Data from CDPR

% of Cherry Acreage Treated with Herbicides

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
2, 4-D	Envy®	0.2	0.4	0.2	0.2
Fluazifop-butyl	Fusilade®	2.2	1.6	1.3	1.7
Glyphosate	Roundup®	26.6	29.7	30.3	28.9
Methyl Bromide		7.4	4.3	1.9	4.5
Metolachlor	Dual®	0.0	0.0	0.0	0.0
Napropamide	Devrinol®	1.5	4.9	4.2	3.5
Norflurazon	Solicam®	5.8	7.2	7.1	6.7
Oryzalin	Surflan®	17.3	8.3	3.5	9.7
Oxyfluorfen	Goal®	33.6	35.1	34.1	34.3
Paraquat Dichloride	Gramoxone®	31.9	34.4	31.4	32.5
Pendimethalin	Prowl®	3.3	5.9	4.1	4.4
Sethoxydim	Poast®	0.2	0.3	0.1	0.2
Simazine	Princep®	0.8	1.9	1.0	1.3

Data from CDPR

10. Chemical Use on California Cherries 1999 through 2001 (continued)

% of Cherry Acreage Treated with Fungicides

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
Benomyl	Benlate®	3.1	2.6	0.9	2.2
Captan		3.4	3.6	2.2	3.1
Chlorothalonil	Bravo®	1.9	1.8	1.0	1.3
Copper hydroxide		0.0	0.0	24.5	8.2
DCNA (Dicloran)	Botran®	0.0	0.0	0.0	0.0
Fenarimol	Rubigan®	1.6	0.5	0.0.4	.8
Fosetyl-al	Aliette®	0.1	0.2	0.2	0.2
Iprodione	Rovral®	46.1	48.5	39.4	44.1
Lime-Sulfur		9.7	4.9	5.5	6.9
Methyl Parathion		0.2	0.0	0.0	0.1
Myclobutanil	Rally®	33.1	38.1	21.0	33
Sodium Hypochlorite	bleach	0.0	0.0	0.0	0.0
Sulfur		0.0	0.0	10.2	3.4
Tebuconazole	Elite®	19.3	16.5	16.8	17.1
Thiophanate-methyl	Topsin®	0.0	0.2	0.12	0.1
Vinclozolin	Ronilan®	3.5	0.1	0.1	1.2
Ziram		0.6	1.9	0.9	1.1

Data from CDPR

% of Cherry Acreage Treated with Nematicides and Other Chemicals

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
Nematicides					
1,3-Dichloropropene	Guthion®	1.0	0.0	0.0	0.3
Methyl Bromide		7.4	4.3	1.9	4.5
Chloropicrin		0.5	1.1	0.4	0.7
Other Chemicals					
Hydrogen Cyanamide	Dormex®	5.2	9.3	10.5	8.3

Data from CDPR

10. Chemical Use on California Cherries 1999 through 2001

Pounds of Insecticide/Acaricide Active Ingredient (AI) Applied to Cherry Acreage

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
Azinphos-methyl	Guthion®	1,774	62	285	707
B. thuringiensis	Bt	293	468	298	350
Carbaryl	Adios®	5,781	6,347	1,444	4,524
Chlorpyrifos	Lorsban®	1,807	1,072	991	1290
Clofentezine	Apollo®	205	286	223	236
Diazinon		12,697	8,921	7,680	9,766
Dicofol	Kelthane®	462	207	472	375
Endosulfan	Thiodan®	88	8	2	32
Esfenvalerate	Asana® XL	772	773	629	665
Fenamiphos	Nemacur®	2,180	843	939	1,008
Fenbutatin-oxide	Vendex®	1,011	597	387	660
Malathion		27	31	29	29
Methidathion	Supracide®	1,508	1,595	744	1,235
Permethrin	Pounce®	176	245	303	240
Petroleum distillate		0	0	5,266	1,755
Phosmet	Imidan®	36	79	112	75
Propargite	Omite®	11,615	12,259	14,216	12,700
Sulfur		22,412	15,081	18,689	18,910

Data from CDPR

Pounds of Herbicide Active Ingredient (AI) Applied to Cherry Acreage

PRODUCT	TRADE NAME	1999	2000	2001	3 YEAR AVERAGE
2, 4-D	Envy®	7	4	3	5
Fluazifop-butyl	Fusilade®	127	102	97	109
Glyphosate	Roundup®	6,872	6,145	7,566	6,850
Napropamide	Devrinol®	661	1,719	1,056	1110
Norflurazon	Solicam®	1,045	1,613	1,363	1,319
Oryzalin	Surflan®	6,444	2,857	869	3,389
Oxyfluorfen	Goal®	3,111	3,042	2,980	3,040
Paraquat Dichloride	Gramoxone®	5,937	6,351	6,665	6,350
Pendimethalin	Prowl®	804	1,735	1,434	1,322
Sethoxydim	Poast®	6	24	7	12
Simazine	Princep®	159	355	225	257

Data from CDPR

10. Chemical Use on California Cherries 1999 through 2001 (continued)

Pounds of Fungicide Active Ingredient (AI) Applied to Cherry Acreage

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
Benomyl	Benlate®	431	441	141	357
Captan		1,078	1,482	986	853
Chlorothalonil	Bravo®	1,695	1,285	801	1132
Copper Hydroxide		0	0	34,862	11,620
Fenarimol	Rubigan®	19	4	6	10
Fosetyl-al	Aliette®	44	47	0	30
Iprodione	Rovral®	9,294	10,378	7,753	9,100
Lime-Sulfur		92,213	32,458	39,210	53,000
Metalaxyl	Ridomil®				
Myclobutanil	Rally®	1,004	1,306	753	1,020
Sodium Hypochlorite	bleach	0	0	0	0
Sulfur		0	0	18,689	6,230
Tebuconazole	Elite®	1,077	764	1,132	990
Thiophanate-methyl	Topsin®	0	37	23	20
Vinclozolin	Ronilan®	573	10	0	194
Ziram		448	1,961	1,084	1,130

Data from CDPR

Pounds of Nematicide and Other Chemicals Active Ingredient (AI) Applied to Cherry Acreage

PRODUCT	TRADE NAME	1999	2000	2001	3-YEAR AVERAGE
Nematicide					
1,3-Dichloropropene	Guthion®	45,672	58,229	41,409	43,134
Methyl Bromide		58,031	16,489	20,731	29,100
Chloropicrin		8,377	3,133	3,914	5,140
Other Chemicals					
Hydrogen Cyanamide	Dormex®	13,447	29,568	35,807	26,274

Data from CDPR

11. Chemical Use on California Cherries 2002

% of Cherry Acreage Treated and Total Pounds Active Ingredient (AI) Used

PRODUCT	% BASE ACRES TREATED	TOTAL POUNDS AI
Insecticides and Acaricides		
Azinphos-methyl	0.19	35
Bacillus thuringiensis (products combined)	17.32	452
Carbaryl	9.55	7,317
Endosulfan	0.09	15
Esfenvalerate	42.68	892
Fenbutatin-oxide	3.50	479
Methidathion	7.30	3,155
Permethrin	6.66	342
Petroleum (products combined)	48.05	288,391
Phosmet	0.48	288
Propargite	31.36	14,881
Spinosad	3.45	80
Fungicides		
Azoxystrobin	1.82	108
Benomyl	0.01	1
Chlorothalonil	0.74	506
Copper Hydroxide	33.93	55,294
Fenhexamid	3.28	471
Fosetyl-al	0.11	4
Iprodione	40.47	6,945
Lime-Sulfur	9.86	68,602
Myclobutanil	29.79	1,085
Sulfur	9.53	21,364
Tebuconazole	19.68	1,144
Thiophanate-methyl	0.94	187
Ziram	0.93	1,101
Herbicides		
2,4-D (products combined)	12.87	1,270
Fluazifop-P-butyl	0.81	40
Glyphosate	36.11	10,573
Methyl Bromide	6.34	27,104
Napropamide	3.94	1,431
Norflurazon	6.39	1,538
Oryzalin	6.84	2,577
Oxyfluorfen	36.06	3,688
Paraquat Dichloride	33.96	8,054
Pendimethalin	5.06	1,837
Sethoxydim	0.76	22
Simazine	1.69	316
Nematicides and Other		
1,3-Dichloropropene	0.81	95,334
Metam-Sodium	0.00	4
Chloropicrin	4.25	11,471
Strychnine	5.41	24
PGRs		
Gibberellins	26.00	384
Hydrogen Cyanamide	9.72	35,962

Data from CDPR

12. Members of the California Cherry Work Group

(SJV = San Joaquin Valley, UC = University of California)
Note: Where provided, the area of interest is indicated in parentheses

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