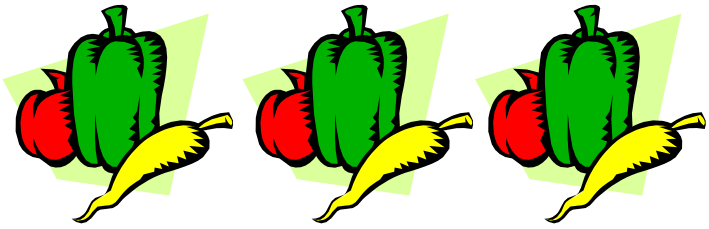
A Pest Management Strategic Plan for Pepper Production in California



December 2004

The California Pepper Commission (CPC)

The California Minor Crops Council (CMCC)

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Executive Summary

The California pepper industry representing statewide chili, pepper, and pimento production met in June of 2003 to begin the process of developing a strategic plan to address the long term pest management needs of their industry. A one day meeting was held that included growers, pest control advisors (PCAs), handlers, and university and cooperative extension personnel. The input from this meeting, along with commodity statistics on pepper production in California, has been summarized.

This document has been developed in response to several regulatory actions (e.g., Food Quality Protection Act, methyl bromide phaseout, etc.), which will potentially impact availability and/or use of pest management products used by growers. In addition, new pests are emerging and/or new technologies must be incorporated into efficient production systems which are protective of consumers, workers and the environment. The California pepper industry wishes to be proactive in its approach to crop and pest management.

This strategic plan will facilitate the transition to "Reduced Risk" pest management by the California pepper industry. "Reduced Risk" broadly describes pest management techniques and tools that have low inherent toxicities and minimal impact on the environment. This long term approach to pest issues will also help the California pepper industry work more effectively with the Land Grant University research and extension systems that are currently experiencing severe budget reductions. All resources must be utilized in the most efficient manner possible; this plan will help the grower community to direct resources to address the most critical issues of the California pepper industry.

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

This strategic plan principally serves as a guideline to address the most important issues of the California Pepper 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 in this document to serve as a reference for those needing more information regarding California pepper production.

The foundation for the strategic plan is the Crop Profile for California Peppers (http://pestdata.ncsu.edu/cropprofiles/docs/CAbellpepper.html) and the UC Pest Management guidelines for peppers (http://www.ipm.ucdavis.edu/PMG/selectnewpest.peppers.html).

Stakeholder Recommendations

As a result of the meeting held in June 2003 and industry input made in 2004, the California pepper work group identified the following research, regulatory and educational priorities for their industry.

Research Priorities

Insect and disease management are the most critical pest issues in peppers at this time, especially soil pests, pepper weevil, *Phytophthora*, powdery mildew and viruses. Research programs to establish basic studies on biology and management of these pests using new varieties, pesticides; economic loss data and pest monitoring techniques are needed.

- Encourage a publicly funded research program for peppers
- Conduct basic studies on powdery mildew and *Phytophthora* (biology and management)
- Develop a model to aid in monitoring and managing powdery mildew and other diseases
- Develop *Phytophthora* and virus resistant varieties
- Evaluate methyl bromide alternatives
- Evaluate vector control to limit virus problems
- Evaluate the use of cover crops as they impact pest management
- Conduct basic research on virology and virus management
- Develop diagnostic techniques for viruses
- Evaluate pepper weevil biology and management techniques
- Study the biology and new management techniques and products for soil insects
- Develop pest management practices for whitefly (area wide)
- Develop economic loss data for peppers

Regulatory Priorities

The pepper industry is in need of standardization of label language between pepper types; product registrations should be expanded to include all varieties. Full registrations are needed for soil pests and powdery mildew; use of reduced risk active ingredients will benefit overall pest and crop management programs. Harmonization and concurrent review of data by Cal/EPA and US EPA is greatly needed to facilitate timely registration of reduced risk products; the IR-4 program should be used efficiently by the industry to expedite research and registration of new products. Registrations for older products should be maintained until alternatives are commercially available.

- Standardize labels for all pepper types
- Obtain/maintain registration for Rally®/myclobutanil for powdery mildew control
- Register insecticides for soil pests
- Register methyl bromide alternatives
- Extend methyl bromide registration through the Critical Use Exemption (CUE) process until suitable alternatives are available

Educational Priorities

The industry needs to be educated on pest identification, pest management, resistance management, and the most efficient and environmentally safe manner in which pesticides can be applied. Registrants should be aware of the needs of the pepper industry and develop label language that is consistent between pepper types; registrants and regulatory agencies should work together to make products available to the industry. The regulatory community needs to be educated on practices that are economically feasible for California pepper growers. The industry, university and cooperative extension systems should work together to provide training on new practices and findings that will benefit growers. Consumers should be reminded that peppers are an important part of a healthy lifestyle and that California produce is grown with the highest standards of safety and quality in the world.

- Educate registrants on the need to standardize labels across all pepper types
- Educate commodity group on efficacy requirements for a registration
- The public should be educated on the food safety and nutritional aspects of California peppers
- The California Pepper Commission and universities should collaborate to educate and update the industry; these organizations should promote increased industry involvement

The California pepper industry intends that this document be used as a resource by US EPA, USDA, CDPR and other agencies as they inquire about pest management issues, needs, and practices in California; this strategic plan will be periodically updated to remain current with industry developments and issues. For follow-up inquiries, contact information for work group members is provided in the Appendices.

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

The mention of any product in this document does not represent endorsement by the California Pepper Commission or any member of the California Pepper Work Group.

Chemical and trade names for products used in peppers are listed in the efficacy tables in the Appendices.

The California Pepper Commission (CPC)

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A Pest Management Strategic Plan for California Peppers

California Pepper Production Overview

Different areas grow certain types of peppers depending on market demand. Peppers come in yellow, green, red, orange, black and purple, depending on the variety and maturity of the pepper fruit. Peppers may be sugary sweet to hot in taste; shapes range from large to small, long to short, round or flat and globed or pointed. Peppers are a warm season crop and need a long season for maximum production. Temperature has a great effect on the rate of growth of the plants; temperature also affects the development and quality of the pigments. It takes approximately 120 days to go from seed to the harvestable crop; transplants are used for the vast majority of the acreage and it takes approximately 60 – 90 days to harvest from transplants.

In California, there are four major areas of production in the Southern two thirds of the state. The main pepper production areas in California are shown in Figure 1. Seasonal profiles for cultural practices and pest management activities for major production areas are provided in the Appendix.

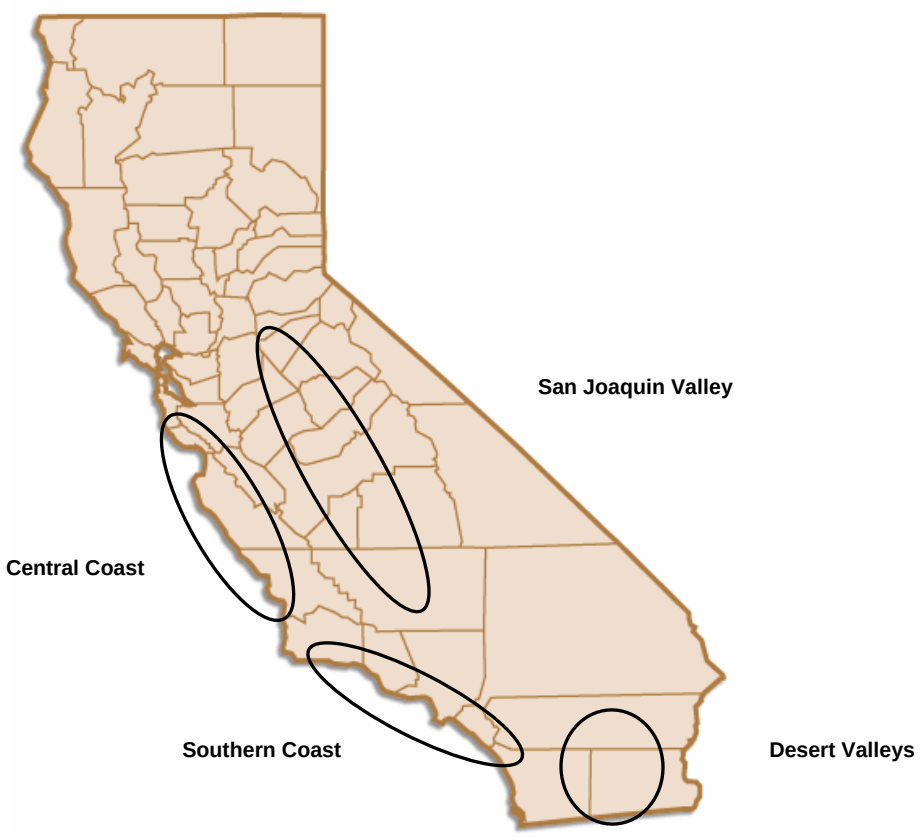
This document will deal with all pepper types grown in California: Each of these species has specific regions and growing seasons in which they have optimal production. Numbers of planted acres can vary a great from season to season; these variations can be due to fluctuations in the price of pepper themselves, or, the value of other commodities that can be grown may make pepper production more or less attractive in a given year. Areas in which peppers are produced in California are shown below.

Several soil types are suitable for pepper production but sandy soils are generally preferred since they are warmer in the spring. Heavier soils can also be quite productive; however irrigation and drainage management must be more closely monitored to prevent disease problems.

Irrigation of peppers is done through drip, furrow, or sprinkler irrigation systems. Drip systems are increasingly popular. Irrigation is critical in peppers since yield and quality are greatly impacted by stress. Fertilizers are widely used in peppers to increase vigor, reduce sunburn and promote fruit sizing.

- There are 4 major categories of peppers produced in California: fresh, processed, dehydrated, and seed.
- Approximately 350,000 tons of peppers are produced in California on 18,000 acres; the 2002 crop was valued at over $190M.
- There are four major areas of pepper production in California; these regions produce according to seasonal growing conditions and market demand.
- Peppers range in color, shape and size according to variety and maturity.
- Major pests of peppers are insects and diseases.
- Approximately 66% of California peppers are sold in the fresh market and 33% are used in the processing industry (frozen, canned, dried or pickled); this product includes chilis, peppers, and pimentos.
- Most of the California fresh pepper crop is domestically consumed.
- 100% of the processed pimento crop is domestically consumed.
- An estimated 10 -15% of the processed bell and chili peppers are exported.
- Approximately 2 -5 % of California peppers are produced using organic production methods.

California Pepper Production Regions



Counties of Production

Central Coast	San Luis Obispo, Monterey, San Benito, Santa Clara counties
Southern Coast	San Diego, Orange, Ventura counties
Central Valley	Kern, Tulare, Fresno, Merced, Stanislaus, Sacramento, San Joaquin counties
Desert Valleys	Imperial and Riverside counties

Major Pests of Peppers in California

Insects	Flea beetles, cutworms, wirewoms, aphids, beet armyworms, tomato fruitworm, pepper weevil, whitefly, psyllids, thrips
Weeds	*Malva*, nightshade, nutsedge, bindweed, dodder, annual and perennial grasses
Diseases	*Phytophthora*, powdery mildew, bacterial spot, *Rhizoctonia*, *Fusarium*, viruses
Nematodes	Rootknot nematode

Stages of Crop Development

Bed Preparation	Seeding to Germination	Germination to Transplanting	Transplanting to Harvest
Varies	~ 3 – 10 days	~ 60 days	~ 85 – 120 days

A PEST MANAGEMENT STRATEGIC PLAN FOR CALIFORNIA PEPPERS

The work group identified several distinct phases that are important to horticultural and pest management events in pepper production. These include:

- Bed Preparation
- Planting/Transplanting to Thinning
- Thinning to Flowering (also called layby)
- Fruit Development through Harvest
- Harvest
- Post-harvest (Fruit Handling and In-field activities)

The following section tracks pepper development under California conditions and provides information on typical field activities and important pest issues during these intervals.

Bed Preparation

Because of the year round growing conditions in California, peppers can follow a wide variety of fall or winter crops in the spring of the year. The old crop must be disced (or plowed under utilizing heavy field discing equipment) or chopped down mechanically followed by the preparation of the field for the new pepper plantings.

Field preparation can include multiple discings of the previous crop, plowing (or turning) of the soil, followed by more discing, land leveling, fumigation and bed preparation. Raised beds are "listed up", mulched, and shaped prior to planting. Beds are normally 40 – 60 inches from center to center with 20-inch with one or two seed lines of plants; plant populations range from 15,000 – 25,000 plants per acre. Involved in this final preparatory operation may also be the laying of drip irrigation tape and the placing of plastic mulch on the bed tops for weed control and water retention. If mulch is used then another operation to mechanically poke holes in the plastic for the later planting of the peppers must occur.

Cultural and Worker Activities

• Fumigation	• Laying of drip tape and mulches
• Herbicide applications	• Subsurface drip tape layed
• Bed mulching – with rolling cultivator	• Cover crops worked into soils
• Preplant fertilizer	• Preirrigation
• Soil testing	

Insects

Pests of concern at this time are soil dwelling and/or harbored in alternate hosts near fields. Proper cultivation, fumigation, sanitation and planting dates will help to avoid problems with these pests. It is unlikely that resistant varieties will ever be developed for these types of pests and biological control of these pests is not well understood or impractical to utilize at this time of the production cycle.

Garden symphylans (also incorrectly called centipedes) – This pest is a localized problem; the organisms become active when soil temperatures begin to warm. Success of control tactics is variable because the symphylans tend to move a lot. Delaying the planting date is a cultural method to avoid infestations, but if you wait too long, you can miss the market. Mustards used as a cover crop have been reported to reduce symphylan populations, but this has not been verified with research. Vapam®/metam sodium can provide good efficacy if placement, moisture, and temperature are optimal during applications. It is difficult to control all of these variables. Methyl bromide provides control of symphylans, but the cost of using this fumigant is very high. Diazinon used as a preplant material provides fair control of symphylans. Soil type impacts the efficacy and performance of all chemical control tactics. There are no known biological controls for symphylans.

Ground beetles - This pest is a localized problem; the organisms become active when soils begin to warm. Success of control tactics is variable because, like symphylans, the beetles tend to move a lot. Delaying the planting date is a cultural method to avoid infestations. Mustards used as a cover crop have been reported to reduce beetle populations, but this has not been verified with research. Vapam®/metam sodium provides control if placement, moisture, and temperature are optimal during applications. It is difficult to control all of these variables. Methyl bromide provides control, but the cost of using this fumigant is very high. Diazinon used as a preplant material provides fair control of beetles. Soil type impacts the efficacy and performance of all chemical control tactics. There are no commercially available biological controls for ground beetles.

Seed corn maggots – Maggots are a localized pest problem; alternate hosts and weedy patches near fields can harbor this pest. Delaying the planting date is a cultural method to avoid infestations. Diazinon used as a preplant material provides fair control of beetles. Soil type impacts the efficacy and performance of all chemical control tactics. There are no commercially available biological controls for seed corn maggots.

Springtails - Diazinon works fair to good for control of springtails.

Work Group Recommendations for Insect Management During Bed Preparation

RESEARCH	• Study the basic biology of symphylans • Evaluate techniques to manage symphylans • Evaluate new techniques and products for use during this part of the season • Evaluate methyl bromide alternatives • Develop sampling methods for soil pests
REGULATORY	• Standardize terminology for all pepper types • Register organophosphate alternatives for insect control
EDUCATION	• No recommendations

Diseases

Fungi that cause seedling diseases are very common in soil; therefore, preparing an environment that will encourage vigorous plant development later in the season is optimal. Several organisms can impact peppers: *Phytophthora, Pythium*, *Rhizoctonia*, and *Verticillium*. Crop rotation as a technique to manage seedling diseases is a fairly good method to manage some of these diseases, but some of these are mainly the result of water and temperature conditions in the seedbed. Seed treatments may help to avoid losses due to many of these diseases. The use of methyl bromide alone and in combination with chloropicrin is expensive. Vapam®/metam sodium provides variable results dependent upon soil and moisture conditions at application. Telone®/1,3 dichloropropene alone or in combination with chloropicrin provides good control of most of these organisms.

Phytophthora and Fusarium – These diseases are most common in heavy soils and getting treatments to work well can be very difficult. Crop rotation works fairly well, dependent upon the crop used. Irrigation and drainage management are key with this disease; anything that improves drainage will help reduce the incidence or severity of these diseases.

Rhizoctonia – Like *Phytophthora*, water management is critical to managing this disease; preparing fields that will be well drained is extremely important. Methyl bromide works very well but can be cost prohibitive to use. Vapam®/metam sodium, chloropicrin and Telone®/1,3 dichloropropene do not work very well as fumigant controls of this disease.

Pythium – Like *Phytophthora,* this disease is most common in heavy soils; getting treatments to work well can be very difficult. Crop rotation works fairly well, dependent upon the crop used. Irrigation and drainage management will help reduce the incidence and severity of *Pythium.*

Verticillium – It is important to avoid fields with a history of this disease. Water management is critical to managing this disease; preparing fields that will be well drained is extremely important. Methyl bromide works very well but can be cost prohibitive to use. Vapam®/metam sodium, chloropicrin and Telone®/1,3 dichloropropene do not work very well as fumigant controls for this disease.

Work Group Recommendations for Disease Management During Bed Preparation

RESEARCH	• Evaluate methyl bromide alternatives for control of soil borne diseases • Develop disease resistant varieties • Develop improved management techniques for *Phytophthora* • Conduct basic research on soil borne diseases • Study methods and products to manage soil borne diseases • Develop economic loss data to support research and registration requests
REGULATORY	• Obtain a critical use exemption (CUE) for methyl bromide until effective alternatives are available
EDUCATION	• No recommendations

Nematodes

Very little is known about the prevalence and impact of nematodes on pepper yield and quality, however, root knot nematode (*Meloidogyne incognita*) is the predominant species found in peppers. Other cultural techniques that are beneficial include crop rotation, deep plowing, practicing good sanitation, and maintaining weed free fallow periods. There are good sources of resistance in peppers, but it will be at least 7 – 10 years before any varieties will be commercially available.

Methyl bromide controls nematodes; however, the use of this product is not always cost effective in peppers. Telone®/1,3 dichloropropene is a good nematicide, but township caps on total amount applied in a year can create difficulties in management. Vapam®/metam sodium provides fair to good levels of nematode control, however, it is not as effective as Telone®/1,3 dichloropropene.

Work Group Recommendations for Nematode Management During Bed Preparation

RESEARCH	• Develop information on basic biology and management of nematodes in peppers • Develop nematode resistant pepper varieties • Evaluate alternatives to methyl bromide for nematode control • Develop economic loss data to support research and registration requests
REGULATORY	• Register methyl bromide alternatives • Obtain critical use exemption (CUE) for methyl bromide until effective alternatives are available • Relax restrictions on buffer zone issues with fumigants
EDUCATION	• Educate growers and PCAs on nematode problems and management in peppers • Educate growers and PCAs about the nematode problem in absence of methyl bromide • Educate regulators on the impact of regulations on practical aspects of production • Educate regulators on the need to register alternative products

Weeds

Several management techniques are used prior to planting for weed management. How the beds have been treated or worked in the previous season will impact how weeds are managed at this stage in terms of types of weeds likely to be present and if herbicides are needed. Fumigations will help to control some but not all weeds.

Preirrigations will help to bring about a “suicidal” emergence of weeds prior to cultivations, which should be done as close to planting as possible. Growers should be aware that canal water used for irrigation can be a source of weed seeds. Burning of weeds is generally not an option, especially with increasing restrictions concerning air quality. The use of contact herbicides such as Goal®/oxyfluorfen and paraquat is extremely important at this time. Using mulch is an effective way to control weeds, but this technique costs a great deal.

Weeds of most concern at this time of year include: malva, nightshade, lambsquarters, nutsedge, puncturevine, shepherd’s purse, bindweed, and dodder.

Work Group Recommendations Weed Management During Bed Preparation

RESEARCH	• Study application techniques for Vapam®/metam sodium to improve efficacy • Evaluate Vapam®/metam sodium alternatives • Evaluate new fallow bed materials (Shark®/carfentrazone Chateau®/flumioxazin, etc.) • Evaluate/screen products and techniques to manage bindweed
REGULATORY	• Relax restrictions on Vapam®/metam sodium • Maintain Vapam®/metam sodium registration until alternatives are available
EDUCATION	• No recommendations

Vertebrates

This category of pests is not actively dealt with during bed preparation.

Planting and Transplanting

In the past, peppers were either planted as seed into moist soil or planted, then irrigated up with overhead sprinklers. Today, due to increased land costs and the need to reuse the land for a second crop quickly, most peppers are transplanted into the beds, after having been started from seed in a nursery, to help decrease the time from planting to harvest.

Transplanting involves a crew of people (four to eight) who either ride on a tractor drawn sled with equipment that places the plants in the ground on the bed tops or are hand planted into the earlier holes that had been poked into the plastic mulch. After transplanting, the plants are generally irrigated with surface aluminum sprinkler pipe for at least a week or two. The plants will then be irrigated with the drip irrigation system for the remainder of the production period. Some growers still use surface irrigation pipe to run water down the furrows for the water requirements of the plants.

Cultural and Worker Activities

• Irrigation set up
• Planting and transplanting
• Fertilizing at planting
• Scouting for insects, weeds, and diseases

Insects

Several species of insects and mites can be found in new pepper fields. Some pests are only problematical in direct seeded crops. Good crop management and scouting for pests will help to avoid outbreaks. Chemical pesticides are used in conjunction with these tactics; there are very few biological controls used or available for this commodity.

Darkling and Other Ground Beetles – These are generally not a problem on transplants, but can be on direct seeded peppers. Good moisture and sanitation management are effective cultural controls for this pest.

Sevin®/carbaryl bait provides good to excellent control of this pest; pyrethroids and Lannate®/methomyl provide good control of ground beetles. Thiodan®/endosulfan only provides fair control and has water issues associated with its use; this product is rarely used.

Flea beetles – This is a problem in direct seeded peppers. Controlling weeds in ditch banks and surrounding areas which harbor these pests is an effective way to manage flea beetle problems. Sevin®/carbaryl bait provides good to excellent control. Diazinon efficacy ranges from poor to good on larvae; this product is poor on adults. Pyrethroids and Lannate®/methomyl provide good control of this species. There is no biological control commercially available for this pest.

Aphids – Some natural parasitism of aphids occurs, but this is generally not sufficient for the needed levels of good control of aphids that Disyston®/disulfoton provides. Admire®/imidacloprid and Platinum®/thiamethoxam, both new products, provide good to excellent systemic control of this pest.

Earwigs – Sevin®/carbaryl as a bait formulation works very well; sanitation and removing trash from around fields will help to reduce the numbers of earwigs infesting peppers.

Cutworms – Sevin®/carbaryl as a bait formulation works very well; pyrethroids provide fair to good control of cutworms.

Seed corn maggot – Diazinon provides fair to good control of this pest.

Springtails and centipedes - Diazinon works fair to good for control of springtails and centipedes; Vapam®/metam sodium works fair if timing and temperatures are optimal when the material is applied.

Corn rootworms –*Diabrotica* can be a problem for organic growers. Habitat (weed) management around field edges can help to minimize buildup of this pest.

Thrips – Success®/spinosad and Disyston®/disulfoton only provide fair control of this pest.

Work Group Recommendations for Insect Management from Planting/Transplanting through Thinning

RESEARCH	• Evaluate and monitor field populations of insects for resistance to Admire®/imidacloprid • Evaluate and develop complimentary products for Admire®/imidacloprid • Study the basic biology of symphylans • Evaluate techniques to manage symphylans • Evaluate products and techniques to control thrips
REGULATORY	• Expedite the DPR review and registration process to hasten registrations
EDUCATION	• Educate growers and PCAs on resistance management • Educate registrants on the need for good efficacy information to support new product registrations • Educate DPR on the need for an expedited review and registration process • The CPC needs to educate its members on specific efficacy issues relative to pests and pesticides

Diseases

Seed treatments can help to limit certain diseases after planting. For transplants, many diseases are brought to the field through infected plants; use of clean planting stock is critically important. Good cultural and irrigation management are the best defenses against diseases; there are relatively few fungicides available and there are few varieties that are disease resistant.

Phytophthora – This is most common in heavy soils; proper irrigation and drainage are the best ways of managing this disease. Ridomil®/metalaxyl and Ridomil Gold®/mefenoxam are used with fair results; it is difficult to get these products to work well in heavy soils. Resistance to Ridomil®/metalaxyl may be developing with this pathogen.

Rhizoctonia – Irrigation management and proper drainage will help to manage this disease.

Pythium – Irrigation management and proper drainage will help to manage this disease. Ridomil®/metalaxyl provides fair to good control.

Fusarium – This is most common in heavy soils; proper irrigation and drainage are the best ways of managing this disease.

Verticillium – Irrigation management and proper drainage will help to manage this disease.

Botrytis - This disease is brought in on transplants. Elevate®/fenhexamid is currently in the process of being registered.

Work Group Recommendations for Disease Management from Planting/Transplanting through Thinning

RESEARCH	• Develop disease resistant varieties • Develop improved methods of controlling *Phytophthora* • Conduct basic research on soil borne diseases and their management • Evaluate new products for controlling early season diseases • Develop economic loss data to support research and registration requests • Evaluate *Botrytis* materials, especially for use in nursery production for transplants
REGULATORY	• Register Elevate®/fenhexamid for *Botrytis* control
EDUCATION	• Educate growers on the critical need for using clean transplants • Educate growers and workers on how to handle transplants properly to avoid disease problems • Educate growers and PCAs on use of new products

Nematodes

If fields have not been fumigated, nematodes might be a problem. Vydate®/oxamyl is used for nematode control with poor to fair efficacy. This registration is likely to be lost.

There are no current recommendations for nematode management during this period.

Weeds

Annual grasses, perennial grasses, malva, nightshade, lambsquarters, nutsedge, puncturevine, shepherd's purse, bindweed, and dodder are the species of concern at this phase of production. In direct seeded fields, contact herbicides such as Roundup®/glyphosate and Gramoxone®/paraquat can be sprayed. In transplanted fields, cultivations should have eliminated most weeds at this time. Flaming can also be done, but this is becoming less prevalent due to air quality concerns and the general trend towards using transplants. Devrinol®/napropamide, Treflan®/trifluralin, and Prefar®/bensulide are grass and broadleaf herbicides, which provide good to excellent efficacy dependent upon the particular species.

Work Group Recommendations Weed Management from Planting/Transplanting through Thinning

RESEARCH	• Evaluate new herbicides (especially those with a reasonable plant back period)
REGULATORY	• Register Sandea®/halosulfuron for nutsedge control • Maintain use of hand hoes • Maintain availability of hand weeding • Check carfentrazone registration status
EDUCATION	• No recommendations

Vertebrates

Rodents and other vertebrate pests can feed directly on developing plants, but they are often more disruptive to cultural practices rather than directly impacting the crop. Fields adjacent to pastures and poorly maintained areas are especially susceptible to these types of pests; therefore, sanitation in and around fields is very important. Vertebrate management techniques used with variable levels of success include: baiting, fumigating, trapping, use of lethal control (e.g. guns), and habitat management

Voles – Zinc phosphide as a bait provides excellent control of voles.

Birds - On direct seeded fields, nothing works well. Lethal control is fairly effective, however, this is not legal in all counties.

Mice – These can be a problem on direct seeded fields. Ramik®/diphacinone provides only fair control of mice.

Squirrels - Zinc phosphide provides fair to good control; propane guns are also effective for this pest.

Rabbits – Natural predators can help control populations. Fencing is the only way to partially manage this pest, however, this technique is very expensive.

Gopher – Phostoxin and strychnine baits work well. Trapping is a poor way to control these pests.

Work Group Recommendations Vertebrate Management from Planting/Transplanting through Thinning

RESEARCH	• Evaluate effective methods to control birds
REGULATORY	• No recommendations
EDUCATION	• No recommendations

Snails

Snails feed on both vegetative and fruiting parts of the plant; metaldehyde bait provides fair to good control of snails. There are no work group recommendations for management of snails.

Thinning to Flowering

Following planting and/or transplanting is a period of time in which the plants get established in the new field environment. This period generally lasts for about three to four weeks. At the end of this period, the new plants are either thinned, then fertilized, if they had been planted from seed, or the newly established plants that had been transplanted are started on a nutrient management program of mixed fertilizer elements. All types of pepper plants are farmed in basically the same manner from this point to harvest.

Cultural and Worker Activities

• Irrigation	• Weeding
• Fertilization	• Scouting
• Cultivation	• Petiole Sampling
• Application of pesticides	• Thinning

Insects

Armyworms – There are no cultural controls for this pest. Bt (bacillus thuringiensis) as a biological provides fair control. Confirm®/tebufenozide and Lannate®/methomyl provide good control; Success®/spinosad and Avaunt®/indoxacarb are excellent armyworm materials.

Aphids - Lacewings, ladybugs, and some naturally occurring parasitic wasps provide moderate levels of control, but these biologicals generally do not provide commercially acceptable levels of control.

There are several products registered for aphids: Orthene®/acephate, Admire®/imidacloprid, Platinum®/thiamethoxam, Assail®/acetamiprid, Fulfill®/pymetrozine, and Actara®/thiamethoxam all provide excellent levels of control. Dimethoate and Lannate®/methomyl are only fair aphid control products. Insecticidal soap, Thiodan®/endosulfan, and Vydate®/oxamyl are not used very often, either because they are poor products or their usage is limited due to water concerns (Thiodan®/endosulfan).

Thrips - A cultural technique to avoid infestations is to avoid planting near crops which harbor thrips. The best product for thrips control is Success®/spinosad. Vydate®/oxamyl provides good control; Lannate®/methomyl and dimethoate provide only fair control. Dimethoate is a very economical product to use.

Whiteflies – Greenhouse, Silverleaf, and Sweet Potato Whitefly – Admire®/imidacloprid and Knack®/pyriproxyfen are the best products for these pests; these products provide good levels of control. Platinum®/thiamethoxam is variable from good to poor performance, dependent upon placement of the product. In addition, Platinum®/thiamethoxam can be slow acting and have a short residual. Lannate®/methomyl works well, but high rates are needed. Thiodan®/endosulfan is efficacious, but rarely used due to water issues. Insecticidal soaps and Orthene® are poor whitefly products; whitefly control can be improved if used in combination with other products.

Psyllids – There are no techniques or products that work very well on this pest. Vydate®/oxamyl and Provado®/imidacloprid do not control this pest.

Cutworms – Field selection and weed management around fields will help in managing this pest. Sevin®/carbaryl bait and pyrethroid products provide excellent control.

Leafminers – Agrimek®/abamectin and Success®/spinosad provide very good control of this pest. Trigard®/cyromazine is good on immatures, but does not work on adults. Growers should stay away from Lannate®/methomyl; this product provides fair to good control of leafminers, but is very disruptive. Diazinon and Sevin®/carbaryl do not control leafminers.

Pepper weevil This is a relatively new pest; there are relatively few products and techniques available for this pest. *Beauveria bassiana* works very well, as a biological control agent for the pepper weevil, but this product is too expensive to use. Cryolite provides good control and Lannate®/methomyl provides fair to good control. It is important to rotate materials; additional products that can be used include Vydate®/oxamyl, Sevin®/carbaryl, Asana®/esfenvalerate and malathion. These products only provide fair control, but they work well in a rotation. Pepper weevil adults are knocked down easily, but once eggs are laid, it is hard to catch up with the population.

Work Group Recommendations for Insect Management
Thinning to Flowering

RESEARCH	• Conduct basic studies on psyllid biology and management • Conduct basic studies on greenhouse whiteflies • Develop an IPM program for pepper weevils (pheromones, biologicals, insecticides) etc. • Develop sprayable formulations of fipronil
REGULATORY	• Standardize label language according to pepper type • Work with IR-4 to standardize pepper language and research requirements for registrations
EDUCATION	• No recommendations

Diseases

Phytophthora – Water management is the primary means to control problems with *Phytophthora*; providing good drainage and avoiding standing water is key to managing this disease. Ridomil®/metalaxyl and phosphoric acid fertilizers may help to limit disease.

Viruses – There are several viruses that impact peppers including tomato spotted wilt, cucumber mosaic virus, alfalfa mosaic, curly top viruses, potyviruses, and geminiviruses. There are not many resistant varieties available; vector control, including aphids, thrips, whiteflies, and leafhoppers, is a primary means to limit the spread of these diseases.

Botrytis
There are no effective materials registered for this disease although Endura®/boscalid and Elevate®/fenhexamid are waiting for registrations.

Work Group Recommendations for Disease Management
Thinning to Flowering

RESEARCH	• Conduct basic virology studies • Evaluate efficacy of Elevate®/fenhexamid for botrytis control
REGULATORY	• No recommendations
EDUCATION	• Educate growers and PCAs that early disease control minimizes problems later on in the season

Nematodes

Vydate®/oxamyl is the only nematicide available for use during this part of the season. The performance of this product is only fair.

Work Group Recommendations for Nematode Management
Thinning to Flowering

RESEARCH	• Determine/validate scope of nematode problems in peppers • Evaluate nematode resistant lines and if they will hold up against strains of nematodes present in California
REGULATORY	• No recommendations
EDUCATION	• Educate growers and PCAs on nematode problems in peppers

Weeds

Annual grasses, perennial grasses, purslane, malva, nightshade, lambsquarters, nutsedge, puncturevine, Shepherd's purse, bindweed, and dodder are the species of concern at this phase of production.

Cultural controls include hand hoeing and cultivation. Herbicides used at this time period (called layby) include Roundup®/glyphosate, Dacthal, and Gramoxone®/paraquat. The performance of each of these will depend on the application method; herbicide performance ranges from fair to good. Dual®/S-metolachlor is good for nutsedge and nightshade. Grass herbicides such as Poast®/sethoxydim and Prism®/clethodim provide fair to good control, dependent upon the species being treated. Devrinol®/napropamide gives inconsistent control of weeds.

Work Group Recommendations for Weed Management
Thinning to Flowering

RESEARCH	• Evaluate Shark®/carfentrazone timing and rates; determine if there is plantback problem • Evaluate Sandea®/halosulfuron efficacy, phytotoxicity, and plantback restrictions • Determine status of Shadeout®/rimsulfuron with DuPont • Evaluate use of Goal®/oxyfluorfen as a shielded spray at layby
REGULATORY	• Determine status of Shark®/carfentrazone registration • Maintain use of hoeing as a management tool; address regulatory issues
EDUCATION	• UC Cooperative Extension should update IPM guidelines for weeds in peppers

Vertebrates

Control tactics for these pests is the same as done earlier in the season.

Voles – Zinc phosphide as a bait provides excellent control of voles.

Birds - On direct seeded fields, nothing works well. Lethal control is fairly effective, however, this is not legal in all counties.

Mice – These can be a problem on direct seeded fields. Ramik®/diphacinone provides only fair control of mice.

Squirrels - Zinc phosphide provides fair to good control; propane guns are also effective for this pest.

Rabbits – Natural predators can help control populations. Fencing is the only way to partially manage this pest, however, this technique is very expensive.

Gopher – Phostoxin and strychnine baits work well. Trapping is a poor way to control these pests.

Work Group Recommendations Vertebrate Management
Thinning to Flowering

RESEARCH	• Evaluate effective methods to control birds
REGULATORY	• No recommendations
EDUCATION	• No recommendations

Fruit Development to Harvest

From thinning to harvest, most cultural practices are maintained in the same manner for all pepper crops. The plants will have pest management, water, and fertilizer needs met for the next two to three months. Weeds will need to be managed though cultivation or hand hoeing, various pests affect the crop at different stages of development. Powdery mildew can become a sever problem at this stage and if the disease becomes established, it can lead to defoliation of plants prior to harvest.

As the plants continue to grow, they begin to canopy (cover over the open ground). This will require any fertilizer or pesticide applications to be made by air versus ground rigs. Powdery mildew needs to be managed to maintain the leaf cover and avoid "sun burning" of the developing fruit. During this time fertilizer is added, as needed, generally through the drip irrigation system.

Water needs for the production of these crops can range from 3 to 4 acre feet (one acre foot is approximately 326,000 gallons) of water per acre of plants. If these peppers are being grown for fresh market, they may utilize a stake and string system to hold the plants up off of the ground as they size and the fruit pulls down on the plants.

Cultural and Worker Activities

• Irrigation	• Weeding
• Fertilization	• Staking and Tying
• Cultivation	• Application of Pesticides
• Scouting	• Defoliation (chili peppers)
• Applications of PGRs Ethrel®/ethephon	• Harvesting

Insects and Mites

Stinkbug – There are no biological or cultural controls for this pest. Pyrethroids and Orthene®/acephate work well; Thiodan®/endosulfan also control stinkbugs, but water issues preclude use of this material in many areas.

Heliothis – Worms can be late season pests. Several products work well including biologicals such as Bt (*Bacillus thuringiensis*). Pyrethroids are good for worm control, but at this time of the season care must be taken to avoid flaring mites. Avaunt®/indoxacarb and Success®/spinosad are good worm materials.

Lygus – Orthene®/acephate and Lannate®/methomyl are both good materials for Lygus; growers must be aware that not all pepper varieties are labeled.

Cabbage Loopers - Bts (*Bacillus thuringiensis*) work well on loopers but multiple applications may be needed. Pyrethroids are good for worm control, but at this time of the season care must be taken to avoid flaring mites. Avaunt®/indoxacarb and Success®/spinosad are good worm materials.

Mites - Dust and water management are techniques to minimize mite outbreaks. Sulfur dust works very well as a miticide, however wettable formulations only provide poor control. Agrimek®/abamectin is a good miticide, but resistance is suspected. Acramite®/bifenazate is waiting for registration.

Armyworms – There are no cultural controls for this pest. Bt (*Bacillus thuringiensis*) as a biological provides fair control. Confirm®/tebufenozide and Lannate®/methomyl provide good control; Success®/spinosad and Avaunt®/indoxacarb are excellent armyworm materials.

Aphids - Lacewings, ladybugs, and some naturally occurring parasitic wasps provide moderate levels of control, but these biologicals generally do not provide commercially acceptable levels of control.

There are several efficacious products registered for aphids: Orthene®/acephate Admire®/imidacloprid, Platinum®/thiamethoxam, Assail®/acetamiprid, Fulfill®/pymetrozine, and Actara®/thiamethoxam all provide excellent levels of control. Dimethoate and Lannate®/methomyl are only fair aphid control products. Insecticidal soap, Thiodan®/endosulfan, and Vydate®/oxamyl are not used very often, either because of efficacy concerns or their usage is limited due to water concerns (Thiodan®/endosulfan).

Thrips - A cultural technique to avoid infestations is to avoid planting near crops which harbor thrips. The best product for thrips control is Success®/spinosad. Vydate®/oxamyl provides good control; Lannate®/methomyl and Dimethoate provide only fair control. Dimethoate is a very economical product to use.

Whiteflies – Greenhouse, Silverleaf, and Sweet Potato Whitefly – Admire®/imidacloprid and Knack®/pyriproxyfen are the best products for these pests; these products provide good levels of control. Platinum®/thiamethoxam is variable from good to poor performance, dependent upon placement of the product. In addition, Platinum®/thiamethoxam can be slow acting and have a short residual. Lannate®/methomyl works well, but high rates are needed. Thiodan®/endosulfan is efficacious, but rarely used due to water issues. Insecticidal soaps and Orthene® are not efficacious; whitefly control with these products may potentially be improved if used in combination with other products or if used at higher rates.

Psyllids – There are no techniques or products that are known to work very well on this pest; more research is needed for this new pest.

Cutworms – Field selection and weed management around fields will help in managing this pest. Sevin®/carbaryl bait and pyrethroid products provide control.

Leafminers – Agrimek®/abamectin and Success®/spinosad provide very good control of this pest. Trigard®/cyromazine is good on immatures, but does not work on adults. Lannate®/methomyl provides fair to good control of leafminers, but is very disruptive to beneficials. Diazinon and Sevin®/carbaryl do not control leafminers.

Pepper weevil This is a relatively new pest; there are relatively few products and techniques available for this pest. *Beauveria bassiana* works very well, as a biological control agent for the pepper weevil, but this product is too expensive to use. Cryolite provides good control and Lannate®/methomyl provides fair to good control. It is important to rotate materials; additional products that can be used include Vydate®/oxamyl, Sevin®/carbaryl, Asana®/esfenvalerate and malathion. These products only provide fair control, but they work well in a rotation. Pepper weevil adults are knocked down easily, but once eggs are laid, it is hard to catch up with the population; repeated applications of insecticides are required.

Work Group Recommendations for Insect and Mite Management
Fruit Development to Harvest

RESEARCH	• Determine if there is mite resistance to Agrimek®/abamectin • Evaluate new products for stinkbug control, especially those with a short PHI • Evaluate products for psyllid control
REGULATORY	• No recommendations
EDUCATION	• No recommendations

Diseases

Phytophthora – Water management is the primary means to control problems with *Phytophthora*; providing good drainage and avoiding standing water is key to managing this disease. Ridomil®/metalaxyl and phosphoric acid fertilizers help to limit disease.

Viruses – There are several viruses that impact peppers including spotted wilt, cucumber mosaic virus, alfalfa mosaic, curly top viruses, potyviruses, and geminiviruses. There are not many resistant varieties available; vector control, including aphids, thrips, whiteflies, leafhoppers, and psyllids, is a primary means to limit the spread of these diseases.

Powdery mildew - Quadris®/Azoxystrobin, Cabrio®/pyraclostrobin, and Flint®/trifloxystrobin provide only poor control of this disease and there are phytotoxicity problems. Rally®/myclobutanil provides excellent control as it works as an early preventative material with curative properties. Serenade®/bacillus subtilis and Messenger®/harpin protein do not control powdery mildew. Flowable sulfur is useful as a preventative, but must be applied frequently and there are concerns about worker safety, phytotoxicity, and harvest issues with this product.

Bacterial spot – Copper provides good control of this disease.

Bacterial soft rot – Sanitation is the primary means to limit losses to this disease. Copper only provides poor control.

Botrytis – There are no effective products for control of this disease.

Alternaria – This is a weather related disease, there are no known controls.

Work Group Recommendations for Disease Management
Fruit Development to Harvest

RESEARCH	• Develop a disease forecasting model for powdery mildew • Evaluate chemical rotations for powdery mildew control • Develop supportive data to register powdery mildew materials (e.g. Rally®/myclobutanil situation) • Evaluate products which provide curative activity for powdery mildew • Evaluate and monitor field levels of resistance with all new products • Evaluate Elevate®/fenhexamid for disease control
REGULATORY	• Register Rally®/myclobutanil via Section 18 for powdery mildew
EDUCATION	• Educate the state regulatory agency on the poor efficacy of new powdery mildew products and why more efficacious products such as Rally®/myclobutanil are needed

Nematodes

Vydate®/oxamyl is the only nematicide available for use during this part of the season. The performance of this product is only fair.

Work Group Recommendations for Nematode Management
Fruit Development to Harvest

RESEARCH	• Determine/validate scope of nematode problems in peppers • Evaluate nematode resistant lines and if they will hold up against strains of nematodes present in California
REGULATORY	• No recommendations
EDUCATION	• Educate growers and PCAs on nematode problems in peppers

Weeds

Weed spectrum will vary according to the area of production and timing, but in general, annual grasses, perennial grasses, purslane, malva, nightshade, lambsquarters, nutsedge, puncturevine, Shepherd's purse, bindweed, and dodder are the most important weeds.

Cultural controls include hand hoeing and cultivation. Herbicides used at this time period (called layby) include Roundup®/glyphosate, Dacthal, and paraquat. The performance of each of these will depend on the application method; herbicide performance ranges from fair to good. Dual®/S-metolachlor is good for nutsedge and

nightshade. Grass herbicides such as Poast®/sethoxydim and Prism®/clethodim provide fair to good control, dependent upon the species being treated. Devrinol®/napropamide provides inconsistent weed control.

Work Group Recommendations for Weed Management
Fruit Development to Harvest

RESEARCH	• Evaluate Shark®/carfentrazone timing and rates; determine if there is plantback problem • Evaluate Sandea®/halosulfuron efficacy, phytotoxicity, and plantback restrictions • Determine status of Shadeout®/rimsulfuron with DuPont • Evaluate use of Goal®/oxyfluorfen as a shielded spray at layby
REGULATORY	• Determine status of Shark®/carfentrazone registration • Maintain use of hoeing as a management tool; address regulatory issues
EDUCATION	• UC Cooperative Extension should update IPM guidelines for weeds in peppers

Vertebrates

Deer, wild pigs, birds can be vertebrate problems at the later part of the growing season.

There are no work group recommendations for vertebrate control for this period of the production season.

Plant Growth Regulators and Defoliants

Plant Growth Regulators: These products are used in limited amounts in peppers at very specific time intervals.

Gibberellic acid is used as a seed treatment to promote seedling germination and growth. Since most peppers are now transplanted, this use is declining.

Defoliation: Ethrel is used for color enhancement, and to aids in defoliation. This product, however, softens fruit and can contribute to deterioration of the product in storage. Sodium chlorate is also used as a defoliant.

Work Group Recommendations for PGRS and Defoliants

RESEARCH	• Develop a PGR for maturity enhancement in peppers
REGULATORY	• No recommendations
EDUCATION	• No recommendations

Harvest

Depending on the crop, harvest can last from one to seven or more weeks with several pickings per individual pepper field. Maturity indices are based on fruit size, firmness, and color. Quality is based on shape, uniformity, and color typical for a given variety. Peppers must be free from defects such as cracks, decay and sunburn.

Peppers grown for processing are generally harvested once or twice. The crop is allowed to mature to the point were the majority of the crop can be harvested with one pass though the field. If the price is right the grower may go though a second time to pick any remaining peppers.

Harvest of peppers is done by hand. The harvested peppers may be placed on a tractor drawn conveyor belt that deposits the peppers in trailers for delivery to a processing plant or packing shed. Other peppers may be harvested into to buckets, taken to the ends of the rows to be deposited into bins for transport to the packing sheds. Most peppers are processed or packed in sheds.

Post-Harvest

When the peppers reach the packing shed they will be washed, graded and sized. Second grade peppers may go to a processor for cooking, freezing, or drying prior to packaging. Unmarketable peppers (culls) can be used for feed or soil amendments.

Once the field has been fully harvested, the crop is then turned under for the next crop preparation and the cycle begins again. In the case of pole peppers, the stakes, twine, and plastic mulch will have to be physically removed from the field prior to discing the crop under. In the same manner, if the peppers were drip irrigated, the drip tape and accompanying equipment will be physically removed and if the tape is in good shape, it will be reused for the next crop.

Post Harvest Disease Issues

Post harvest losses may be due to physiological disorders (due to storage and handling) or diseases. There are three main diseases impacting pepper quality after harvest.

Botrytis or grey mold – This is a very common post-harvest disease pathogen which is managed by practicing good field sanitation and preventing wounds on the fruit during picking and storage. Use of CO_2 and hot water baths can effectively control this disease.

Alternaria rot – This disease can be managed by storing peppers in the proper conditions.

Bacterial soft spot – This disease is a secondary pest that invades damaged tissue. This disease can also be common on peppers that have been picked or washed in unsanitary conditions. Proper handling and storage will prevent the onset of bacterial soft spot.

There are no work group recommendations pertaining to this period of the production season.

Critical Issues for the California Pepper Industry

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

RESEARCH	• Encourage a publicly funded research program for peppers • Conduct basic studies on powdery mildew and *Phytophthora* (biology and management) • Develop a model to aid in monitoring and managing powdery mildew and other diseases • Develop *Phytophthora* and virus resistant varieties • Evaluate alternatives to methyl bromide • Evaluate vector control to limit virus problems • Evaluate the use of cover crops as they impact pest management • Conduct basic research on virology and virus management • Develop diagnostic techniques for viruses • Evaluate pepper weevil biology and management techniques • Study the biology and new management techniques and products for soil insects • Develop pest management practices for whitefly (area wide) • Develop economic loss data for peppers
REGULATORY	• Standardize labels for all pepper types • Obtain/maintain registration for Rally®/myclobutanil for powdery mildew control • Register insecticides for soil pests • Register methyl bromide alternatives • Extend methyl bromide registration through the Critical Use Exemption (CUE) process until suitable alternatives are available
EDUCATION	• Educate registrants on the need to standardize labels across all pepper types • Educate commodity group on efficacy requirements for a registration • The California Pepper Commission and universities should collaborate to educate and update the industry; these organizations should promote increased industry involvement • The public should be educated on the nutritional value and food safety aspects of California peppers

References

Crop Profile for California Pepper Production
http://www.ipmcenters.org/cropprofiles/docs/CAbellpepper.html

University of California Pest Management Guidelines
http://www.ipm.ucdavis.edu/PMG/selectnewpest.peppers.html

University of California Vegetable Research and Information Center
http://vric.ucdavis.edu/usesites/ressite.htm

California Department of Pesticide Regulation - Pesticide Use Reports
http://www.cdpr.ca.gov/docs/pur/purmain.htm

National Ag Statistics
http://www.usda.gov/nass/

California Ag Statistics Service
http://www.cdfa.ca.gov/publications.htm

Appendices

Appendix 1: 2002 California Pepper Production Statistics

Fruiting Peppers

COUNTY	HARVESTED ACREAGE	YIELD (Tons/Ac.)	PRODUCTION (Tons)	TOTAL VALUE ($)
Fresno	1,500	22.67	34,000	17,170,000
Kern	1,730	20.12	34,800	37,761,000
Merced	236	13.29	3,137	1,745,000
Monterey	1,600	11.88	19,000	6,558,000
Orange	349	25.47	8,890	9,776,600
Riverside	2,402	18.92	45,434	30,198,400
Sacramento	111	12.50	1,388	413,000
San Benito	1,799	22.18	39,902	15,322,000
San Diego	250	16.01	4,003	2,321,500
San Joaquin	1,900	15.32	29,100	16,639,000
San Luis Obispo	870	13.87	12,071	5,078,000
Santa Barbara	408	7.03	2,869	2,433,100
Santa Clara	2,015	24.30	48,965	13,906,000
Solano	419	17.00	7,123	1,495,800
Ventura	2,599	23.67	61,515	32,069,000
STATE TOTALS	**18,188**	**19.36**	**352,197**	**192,886,400**

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

Chili Peppers

COUNTY	HARVESTED ACREAGE	YIELD (Tons/Ac.)	PRODUCTION (Tons)	TOTAL VALUE ($)
Riverside	95	8.40	798	359,300
San Bernardino	4	3.25	13	14,000
San Diego	8	13.63	109	59,600
Santa Clara	612	23.70	14,504	7,281,000
STATE TOTALS	**719**	**21.45**	**15,424**	**7,713,900**

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

Notes: The *CDFA Resource Directory – 2002* contains additional production statistics which may be seen at their website (http://www.cdfa.ca.gov/publications.htm). Acreage reports vary according to reporting sources.

Appendix 2: Cultural Practices and IPM Calendars for California Peppers

Central Coast Production

Includes: San Luis Obispo, Monterey, San Benito, Santa Clara and Ventura counties

Cultural Practice	J	F	M	A	M	J	J	A	S	O	N	D
Bed Prep	■	■	■	■	■							■
Fumigation		■	■									
Planting		■	■	■	■							
Transplanting			■	■	■	■	■					
Fertilization	■	■	■	■	■	■	■	■	■	■		
Cultivation				■	■	■	■	■				
Flowering/ Pollination				■	■	■	■	■	■			
Irrigation		■	■	■	■	■	■	■	■	■	■	
Hand Harvest							■	■	■	■	■	■
IPM Activity	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Soil Sampling	■	■									■	■
Irrigation Scheduling			■	■	■	■	■	■	■	■	■	
Petiole Sampling					■	■	■	■	■	■		
Insecticides			■	■	■	■	■	■	■	■	■	
Premerg. Herbicides	■	■	■	■	■	■						
Contact Herbicides			■	■	■	■	■					
Hand Weeding				■	■	■	■	■				
Fungicides				■	■	■	■	■	■	■	■	
Insect Scouting			■	■	■	■	■	■	■	■	■	
Disease Scouting		■	■	■	■	■	■	■	■	■	■	

Appendix 2, continued: Cultural Practices and IPM Calendars for California Peppers

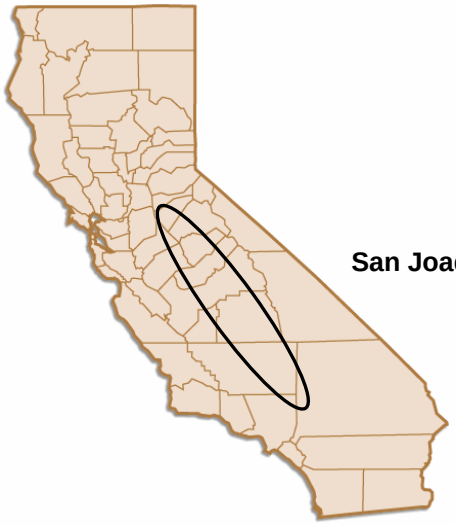
Southern Coast Production

Includes: San Diego and Orange Counties

Cultural Practice	J	F	M	A	M	J	J	A	S	O	N	D
Bed Prep												
Fumigation												
Planting												
Transplanting												
Fertilization												
Cultivation												
Flowering/Pollination												
Irrigation												
Hand Harvest												
IPM Activity	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Soil Sampling												
Irrigation Scheduling												
Petiole Sampling												
Insecticides												
Premerg. Herbicides												
Contact Herbicides												
Hand Weeding												
Fungicides												
Insect Scouting												
Disease Scouting												

Appendix 2, continued: Cultural Practices and IPM Calendars for California Peppers

San Joaquin Valley Production



Includes: Kern, Tulare, Fresno, Merced, Stanislaus, Sacramento, and San Joaquin counties

Cultural Practice	J	F	M	A	M	J	J	A	S	O	N	D
Bed Prep	■	■	■	■	■	■				■	■	■
Fumigation	■	■	■							■		■
Planting		■	■	■	■	■	■					
Transplanting		■	■	■	■							
Fertilization	■	■	■	■	■	■	■	■	■	■		
Cultivation	■		■	■	■	■	■	■	■			
Flowering/ Pollination		■	■	■	■	■	■	■	■	■		
Irrigation	■	■	■	■	■	■	■	■	■	■		■
Hand Harvest						■	■	■	■	■	■	
IPM Activity	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Soil Sampling	■										■	■
Irrigation Scheduling		■	■	■	■	■	■	■	■	■		
Petiole Sampling			■	■	■	■	■	■	■	■		
Insecticides		■	■	■	■	■	■	■	■	■		
Premergence Herbicides	■	■	■	■	■	■						
Contact Herbicides	■	■	■	■								■
Hand Weeding			■	■	■	■	■	■	■			
Fungicides		■	■	■	■	■	■	■	■	■		
Insect Scouting		■	■	■	■	■	■	■	■	■		
Disease Scouting		■	■	■	■	■	■	■	■	■		

Appendix 2, continued: Cultural Practices and IPM Calendars for California Peppers

Desert Valley Production

Includes: Imperial and Riverside counties

Cultural Practice	J	F	M	A	M	J	J	A	S	O	N	D
Bed Prep						■	■				■	■
Fumigation	■						■				■	■
Planting												
Transplanting	■	■					■	■				
Fertilization	■	■	■	■	■	■		■	■	■	■	■
Cultivation	■	■	■					■	■	■		
Flowering/ Pollination	■	■	■	■					■	■	■	
Irrigation	■	■	■	■	■	■	■	■	■	■	■	■
Hand Harvest	■			■	■	■					■	■
IPM Activity	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Soil Sampling		■				■					■	
Irrigation Scheduling	■	■	■	■	■	■	■	■	■	■	■	■
Petiole Sampling		■	■	■	■			■	■	■	■	■
Insecticides	■	■	■	■	■	■		■	■	■	■	■
Premerg, Herbicides							■					■
Contact Herbicides												
Hand Weeding	■	■	■	■	■			■	■	■	■	■
Fungicides	■	■	■	■	■	■			■	■	■	■
Insect Scouting	■	■	■	■	■	■		■	■	■	■	■
Disease Scouting	■	■	■	■	■	■		■	■	■	■	■

Appendix 3: Seasonal Pest Occurrence in California Peppers

Central Coast Production

INSECTS/MITES	J	F	M	A	M	J	J	A	S	O	N	D
Silverleaf Whitefly												
Aphid												
Cabbage Looper												
Beet Armyworm												
Western Yellowstriped Armyworm												
Leafhopper												
Leafminer												
Two Spotted Spider Mite												
Flea Beetle												
Thrip												
Omnivorous Leafroller												
Tomato Fruitworm												
Symphylan												
Centipede												
Greenhouse Whitefly												
Pepper Weevil												
Psyllid												
DISEASES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Spot												
Powdery Mildew												
Fusarium												
Verticillium Wilt												
Pepperpotivirus Mosaic												
Cucumovirus Mosaic												
Tobacco Mosaic												
Curly Top												
Tomato Spotted Wilt Virus												
Phytophthora												
Crown Rot												
WEEDS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Nightshade												
Field Bindweed												
Nutsedges												
Cheeseweed												
Bermudagrass												
Shepards Purse												
Pigweed												
NEMATODES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Root Knot Nematode												
Stubby Root Nematode												
VERTEBRATES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Rabbits												
Gophers												
Mice												
Pigs												
Deer												
Squirrels												
Birds												

Appendix 3, continued: Seasonal Pest Occurrence in California Peppers

Southern Coast Production

INSECTS/MITES	J	F	M	A	M	J	J	A	S	O	N	D
Silverleaf Whitefly												
Aphid												
Cabbage Looper												
Beet Armyworm												
Western Yellowstriped Armyworm												
Leafhopper												
Leafminer												
Two Spotted Spider Mite												
Flea Beetle												
Thrips												
Omnivorous Leafroller												
Tomato Fruitworm												
Symphylan												
Centipede												
Greenhouse Whitefly												
Pepper Weevil												
Psyllid												
DISEASES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Spot												
Powdery Mildew												
Fusarium												
Verticillium Wilt												
Pepperpotivirus Mosaic												
Cucumovirus Mosaic												
Tobacco Mosaic												
Curly Top												
Tomato Spotted Wilt Virus												
Phytophthora												
Crown Rot												
WEEDS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Nightshade												
Field Bindweed												
Nutsedges												
Cheeseweed												
Bermudagrass												
Shepherd's Purse												
Pigweed												
NEMATODES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Root Knot Nematode												
Stubby Root Nematode												
VERTEBRATES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Rabbits												
Gophers												
Mice												
Pigs												
Deer												
Squirrels												
Birds												

Appendix 3, Continued: Seasonal Pest Occurrence in California Peppers

San Joaquin Valley Production

INSECTS/MITES	J	F	M	A	M	J	J	A	S	O	N	D
Silverleaf Whitefly												
Aphid												
Cabbage Looper												
Beet Armyworm												
Western Yellowstriped Armyworm												
Leafhopper												
Leafminer												
Two Spotted Spider Mite												
Flea Beetle												
Thrips												
Omnivorous Leafroller												
Tomato Fruitworm												
Symphylan												
Centipede												
Greenhouse Whitefly												
Pepper Weevil												
Psyllid												
DISEASES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Spot												
Powdery Mildew												
Fusarium												
Verticillium Wilt												
Pepperpotivirus Mosaic												
Cucumovirus Mosaic												
Tobacco Mosaic												
Curly Top												
Tomato Spotted Wilt Virus												
Phytophthora												
Crown Rot												
WEEDS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Nightshade												
Field Bindweed												
Nutsedges												
Cheeseweed												
Bermudagrass												
Shepherd's Purse												
Pigweed												
NEMATODES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Root Knot Nematode												
Stubby Root Nematode												
VERTEBRATES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Rabbits												
Gophers												
Mice												
Pigs												
Deer												
Squirrels												
Birds												

Appendix 3, Continued: Seasonal Pest Occurrence in California Peppers

Desert Valley Production

INSECTS/MITES	J	F	M	A	M	J	J	A	S	O	N	D
Silverleaf Whitefly												
Aphid												
Cabbage Looper												
Beet Armyworm												
Western Yellowstriped Armyworm												
Leafhopper												
Leafminer												
Two Spotted Spider Mite												
Flea Beetle												
Thrips												
Omnivorous Leafroller												
Tomato Fruitworm												
Symphylan												
Centipede												
Greenhouse Whitefly												
Pepper Weevil												
Psyllid												
DISEASES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Spot												
Powdery Mildew												
Fusarium												
Verticillium Wilt												
Pepperpotivirus Mosaic												
Cucumovirus Mosaic												
Tobacco Mosaic												
Curly Top												
Tomato Spotted Wilt Virus												
Phytophthora												
Crown Rot												
WEEDS	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Nightshade												
Field Bindweed												
Nutsedges												
Cheeseweed												
Bermudagrass												
Shepherd's Purse												
Pigweed												
NEMATODES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Root Knot Nematode												
Stubby Root Nematode												
VERTEBRATES	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Rabbits												
Gophers												
Mice												
Pigs												
Deer												
Squirrels												
Birds												

Appendix 4: Efficacy of Insecticides for Insect/Mite Pests of Peppers

Product	Trade Name	Silverleaf WF	Aphids	Cabbage Looper	Beet Armyworm	WYS Armyworm	Leafhoppers	Leafminers	Spidermites	Flea Beetle	Thrips	Omn. Leafroller	Tom. Fruitworm	Symphylan	Centipede	GH Whitefly	Pepper Weevil	Psyllid
acetamiprid	Assail®	FG	GE	P						P				P	P	G		P
azadirachtin	Neemix®	P	P	P	P	P	P	P	P	P	P		P	P	P	P		PF
Bac. thuringiensis	Bt			GE	F	G				P			G	P	P	P		P
Beauveria bassiana	Various			P						P				P	P	P	E	P
carbaryl	Sevin® bait			P			F	E		P	F			P	P	P		P
carbaryl	Sevin®			P						PG					P	P	F	
cyromazine	Trigard®			P				G		PR				P	P	P		
diazinon	Diazinon		F	PF			F			FG	PF			FG	F	P		
dimethoate	Dimethoate		PF	P						F	PF			P	P	P		
endosulfan	Thiodan®	G	G	GE						FG	FG					F		
esfenvalerate	Asana®	P	G	G	PG	G	G	F		PG	PG	G	G			PF	F	
imidacloprid	Admire®	GE	GE	P				G		F	FG					GE		
malathion	Malathion		PG	P			PG	G		F	PG					P	F	
methomyl	Lannate®	G	FG	PG	G	G	G	G		FG	FG	G	G			F	FG	
orthene	Acephate®		FG	FG						P						F		
oxamyl	Vydate®		PF	P			PF	PF		PF	PF					P	F	
permethrin	Pounce®		G	G	PG	F	G	F		PG	FG		G			P		
potash soap	M-Pede®	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		
pymetrozine	Fulfill®	F	FG	P						P						F		
pyriproxyfen	Knack®	FG		P						P				P	P	GE		
Spinosad	Success®			FE	GE	PG		E		F	FE	E	GE	P	P	P		P
Sulfur	Sulfur			P					FE	P				P	P	PF		G
thiamethoxam	Actara®, Platinum®	GE	GE	P						PF						GE		F
Non-chemical Management Tools																		
Cover Crops																		
Habitat management									G	F	G							
Monitoring/use of action thresholds			G	G	G		G	G	G		G		G					
Insecticidal Soaps		P	P	P			P	P	P	P	P			P	P	P		P
Pheromones				P	P					P			P	P	P	P		P
Natural enemies		P	PG	PF	G	G	G	G	PG	P	P	G	G					
Oils		P	P	P	P	P	P	P	PF		PF	P	P	P	P	P		
Nutrition				P					F	P				P	P	P		P
Sanitation		GF	G	G	G	G	G	G	G		G	G	G					
Soil/dust management				P					GF					P	P	P		
Use of models																		
Resistant varieties																		
Water management				P					F	P						P		
Fertilizer management									F									

E = Excellent
G = Good
F = Fair
P = Poor
R = Known Resistance

Appendix 5: Relative Toxicity of Insecticides to Beneficial Organisms in Peppers

Product	Trade Name	Big-eyed bug	Damsel bug	Green Lacewings	Lady Bird Beetles	Minute Pirate Bugs	Parasites	Spiders	Syrphid Fly Larvae	All
azadirachtin	Neemix®	+		+	+	+	+		+	+
Bacillus thuringiensis	Bt	0	0	0	0	0	0	0	0	0
carbaryl	Sevin®	++		++	++	++	++			++
cyromazine	Trigard®									
diazinon	Diazinon	++		+++	+++	+++	+++		+++	+++
dimethoate	Dimethoate									++
endosulfan	Thiodan®	+++		+++	+++	+++	+++		+++	+++
esfenvalerate	Asana®	+++		+++	+++	+++	+++		+++	+++
imidacloprid	Admire®	0/+		0/+	0/+	0/+	0	0	0	0
malathion	Malathion				++	++	++			++
methamidophos	Monitor®	+++		+++	+++	+++	+++		+++	+++
methomyl	Lannate®	+++		+++	+++	+++	+++		+++	+++
oxamyl	Vydate®	++		++	++	++	++			+++
permethrin	Pounce®	+++		+++	+++	+++	+++		+++	++
potash soap	M-Pede®	0		0	0	0	0	0	0	0/+
spinosad	Success®	0/+	0	0/+	0/+	0/+	0/+	0	0/+	
sulfur	Sulfur	0/+	0	0	0	0	0/+	0	0/+	

Data Based on collective field observations and experiments (Growers, Pest Control Advisors, Farm Advisors, etc.)

Rating System:
0 = No Impact
+ = Soft
++ = Moderate
+++ = Harsh

Appendix 6: Efficacy of Weed Management Tools Used in Peppers

Product	Trade Name	Nightshade	Bindweed	Y/P Nutsedge	Johnsongrass	Bermuda grass	Dodder	Annual Grasses
bensulide	Prefar®	P	P	P	E*	E*	P	G
glyphosate	Roundup®	E	F	G	G	F	G	G
metam sodium	Vapam®	E	F	F	E*	E*	P	G
methyl bromide	Methyl bromide	E	F	G	F	F	P	G
oxyfluorfen	Goal®	E	P	P	P	P	P	P
napropamide	Devrinol®	P	P*	P	E*	E*	P	G
paraquat	Gramoxone®	G	F	F	P	P	P	P
sethoxydim	Poast®	P	P	P	G	G	P	G
trifluralin	Treflan®	P	F*	P	G*	G*	P	?*
Non-chemical Tools								
Cultivation		G	F	F	F*	F*	P	G*
Soil/water management		P	P	P	P	P	P	P
Cover crops		F	P	P	F*	F*	P	F
Crop Rotation/field selection		E/E	F/E	G/E	F/G	F/G	P/E	F/F
Pre-irrigation		G	F	P	G*	G*	P	G*

Data Based on collective field observations and experiments (Growers, Pest Control Advisors, Farm Advisors, etc.)

Rating System:
E = Excellent
G = Good
F = Fair
P = Poor / None
* = Seedling plants only (generally not effective on re-growth from perennial plants)

Appendix 7: Efficacy of Disease Management Tools Used in Peppers

Product	Trade Name	Mosaic Virus Complex	Powdery Mildew	*Monosporascus*	*Fusarium*	*Verticillium*	Damping Off	*Pythium*	*Phytophthora*	*Rhizoctonia*	*Acromonium*	Downy Mildew
chloropicrin	Chloropicrin	P			F	F	F	F	G	F		
metam sodium	Vapam®	P							F			
methyl bromide	methyl bromide	P			G	G	G		G	G		
metalaxyl	Ridomil®	P					E	E	E			
mefenoxam	Ridomil® Gold	P					E	E	E			
myclobutanil	Rally®	P	GE									
sulfur	Sulfur	P	FG									
Non-chemical Tools												
Models												
Vector management												
Irrigation management									E			
Natural enemies												
Weed control												
Resistant varieties												
Cover crops												
Post Harvest Crop Destruction		E										

Data Based on collective field observations and experiments (Growers, Pest Control Advisors, Farm Advisors, etc.)

Rating System:
E = Excellent
G = Good
F = Fair
P = Poor / None
R = Known Resistance

Appendix 8: Efficacy of Nematode Management Tools Used in California Peppers

Product	Trade Name	Root Knot Nematode
1,3-dichloropropene	Telone®	G
chloropicrin	Chloropicrin	G
metam sodium	Vapam®	FG
methyl bromide	Methyl Bromide	E
oxamyl	Vydate®	FGT
Non-chemical Tools	-	
Fallow	-	FG
Monitoring-soil samples	-	FG
Cover crops	-	FG
Soil/water management	-	F
Resistant rootstocks	-	G
Rotation	-	FG

Data Based on collective field observations and experiments (Growers, Pest Control Advisors, Farm Advisors, etc.)

Rating System:
E = Excellent
G = Good
F = Fair
P = Poor / None
R = Known Resistance

Appendix 9: Efficacy of Vertebrate Management Tools Used in Peppers

Product or Technique	Squirrels	Gophers	Pigs	Voles	Rabbits	Deer	Birds
Trapping	P	P	F	P	P	P	F
Anti-coagulants	G	F		P	F		
Strychnine		G					
Blasters	G	F	P	F	P	P	F
Aluminum Phosphide	G	G		G			
Owls	P	P	P	P	P	P	P
Avitrol®/4-aminopyridine – check regular status							G

Data based on collective field observations and experiments.

Rating System:
E = Excellent
G = Good
F = Fair
P = Poor / None
R = Known Resistance
NR = Not Registered

Appendix 10: Major Chemical Use in Chili Peppers in 2002

Chemical Name	Trade Name	Gross Pounds	Acres Treated
METAM-SODIUM	Vapam®	19,455	114
SODIUM CHLORATE	Various	6,084	774
1,3-DICHLOROPROPENE	Telone®	3,519	182
CHLOROPICRIN	Chloropicrin	1,998	182
PARAQUAT DICHLORIDE	Gramoxone®	1,275	1,040
METHOMYL	Lannate®	678	928
DIAZINON	Diazinon	674	221
ETHEPHON	Ethrel®, Prep®	553	839
DISULFOTON	Disyston®	393	207
NAPROPAMIDE	Devrinol®	356	344
SULFUR	Sulfur	347	177
COPPER HYDROXIDE	Champ®	293	279
ACEPHATE	Orthene®	262	275
CRYOLITE	Kryocide®	254	27
DIMETHOATE	Dimethoate	253	750
PHOSPHORIC ACID	Phosphoric Acid	231	987
TRIFLURALIN	Treflan®	182	317
CARBARYL	Sevin®	152	95
AZOXYSTROBIN	Quadris®	144	699
GLYPHOSATE, ISO-SALT	Roundup®	124	30
IMIDACLOPRID	Admire®	113	1,217

Note: For a complete list of all products used in this crop, please refer to http://www.cdpr.ca.gov/docs/pur/purmain.htm. The above reported chemical use data was the most recent CDPR information available at the time of publication.

Appendix 10: Major Chemical Use in Bell Peppers in 2002

	Chemical Name	Trade Name	Gross Pounds	Acres Treated
1	METAM-SODIUM	Vapam®	566,029	3,250
2	CHLOROPICRIN	Chloropicrin	147,809	3,493
3	1,3-DICHLOROPROPENE	Telone®	110,523	2,248
4	METHYL BROMIDE	Methyl Bromide	40,539	274
6	SULFUR	Sulfur	24,891	9,782
7	CRYOLITE	Kryocide®	24,816	2,894
8	ACEPHATE	Orthene®	5,615	6,663
9	METHOMYL	Lannate®	4,885	6,801
10	DIAZINON	Diazinon	4,314	2,664
11	COPPER HYDROXIDE	Champ®	3,624	5,082
12	BENSULIDE	Betasan®	3,484	1,016
13	DISULFOTON	Disyston®	3,146	1,670
14	GLYPHOSATE, ISO-SALT	Roundup®	2,794	2,029
15	CARBARYL	Sevin®	2,793	1,913
16	PARAQUAT DICHLORIDE	Gramoxone®	2,152	2,627
18	NAPROPAMIDE	Devrinol®	1,995	1,694
19	MEFENOXAM	Ridomil Gold®	1,948	8,586
20	NEEM OIL (Clarified Hydrophobic Ext)	Various	1,925	888
21	TRIFLURALIN	Treflan®	1,915	3,655
22	SPINOSAD	Success®	1,630	17,971
23	IMIDACLOPRID	Admire®	1,348	9,719

Note: For a complete list of all products used in this crop, please refer to http://www.cdpr.ca.gov/docs/pur/pumain.htm. The above reported chemical use data was the most recent CDPR information available at the time of publication.

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