

# **A Pest Management Strategic Plan for Fresh Carrot Production in California**



***June 2005***

California Fresh Carrot Advisory Board (CFCAB)

California Minor Crops Council (CMCC)

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## EXECUTIVE SUMMARY

California is the leading state in carrot production with over 70,000 acres under production. More than 1.1 million tons of fresh carrots are produced in the state with a value of nearly \$448 million. Carrots are grown in four major production regions of California; the geographical diversity of these growing locations allows for year-round production. California's year-round production, in turn, allows the carrot processing and packing plants to operate economically throughout the entire year. Nearly 90 percent of carrots produced are consumed in the fresh market and the remainder goes to the processing industry for use in prepared foods.

Integrated pest management (IPM) information is continuously being developed for weed, insect, nematode, and disease problems of California carrots. The industry, through the California Fresh Carrot Advisory Board (CFCAB), provides more than \$200,000 annually in research grants to address production problems, mostly concerning pest management issues.

California is ideally suited to growing high quality carrots; the major production regions are located in the San Joaquin Valley, low desert region, high desert region and the inland valleys of the central coast. Pest issues vary according to area of production, but across all regions, major problems in this commodity consist of diseases, weeds and nematodes. These pests have in large part been controlled by a program of crop rotation, use of resistant varieties, fertility and irrigation management and pesticides. Soil fumigants have been of particular importance to control nematodes and have also provided other benefits such as weed and soil-borne disease control. Organic carrot production in California is estimated to be between 5 and 10% of the total acreage grown.

The California carrot industry is concerned that new regulations set forth by both state and federal agencies may significantly impact the availability and/or use patterns of important crop protection chemicals used by growers. While this industry has recognized the need to evaluate, register, and implement reduced risk production practices, there are relatively few new products being evaluated. As the costs to conduct required research and register new materials increases, registrants are less willing to focus on commodities with relatively few acres (as compared to major crops, e.g., corn, soybeans, etc.), simply because their return on investment is significantly lower. Therefore, many minor crop commodities such as carrots are more likely to lose pest management tools, with less likelihood they will be replaced by new products.

In 2004, several key members of the carrot industry met to specifically discuss long-term issues associated with nematode, insect, spider mite, disease, weed and vertebrate control. The coalition consisted of growers, packers, shippers, pest control advisers (PCAs), cooperative extension personnel, farm advisors and research scientists; the work group also included representatives from the Western Region Integrated Pest Management Center at UC Davis.

The purpose of the industry meeting was to develop a Pest Management Strategic Plan (PMSP) to address the issues of greatest concern for carrot growers in California. The input gathered at this meeting provided an important perspective on the pest management products and techniques used in this commodity. The stakeholders focused on the pests that have the most significant economic impact on the California carrot industry. The "product" of the workgroup meeting was the identification of the critical research, regulatory and educational needs of California carrot growers.

This Pest Management Strategic Plan for California Carrots includes a comprehensive summary of the crop production and pest management practices used by the carrot industry in California. The foundations for this document are the "Crop Profile for California Carrots" (<http://pestdata.ncsu.edu/cropprofiles/docs/cacarrots.html>) and the UC IPM Guidelines (<http://www.ipm.ucdavis.edu>).

## Stakeholder Recommendations

As a result of the industry meeting held in Bakersfield, California, in May 2004, and with subsequent industry input in 2005, the Carrot Work Group identified the following research, regulatory, and educational priorities. These critical areas must be addressed to maintain the economic viability of the carrot industry in California.

## Research Priorities

Finding effective techniques to control nematodes and soil-borne diseases is of the most immediate concern to carrot growers in California. The availability of fumigants, especially replacement products for metam sodium (Vapam HL<sup>®</sup>, Sectagon 42<sup>®</sup>) and metam potassium (K-Pam HL<sup>®</sup>) is a critical need for the industry, and an aggressive research program should help identify new techniques and products to be registered. Economic data should be generated to demonstrate the need, use, and value of important products used in carrots. Breeding programs should identify new carrot varieties which are resistant to nematodes and diseases. Disease monitoring tools, models, and new management techniques are needed for diseases caused by *Alternaria* and *Pythium*. New products are needed for weed control as well. University research and extension programs will remain critical to identifying and adopting new technologies for pest management in California carrot production; these important systems should be supported on a continued basis by the appropriate local, state and federal agencies.

- Evaluate fumigants (alternatives for metam sodium and metam potassium)
- Develop economic data on fumigants (costs/benefits, etc.)
- Evaluate disease prediction tools, especially models for soil borne diseases.
- Evaluate techniques to manage diseases caused by *Pythium*.
- Study soil microbiology/microfauna relative to carrot production.
- Develop cultivars with an emphasis on *Alternaria*, *Pythium* and nematode resistance.
- Evaluate new herbicides to replace Lorox<sup>®</sup> (linuron) and Gowan Trifluralin 4, Trilin<sup>®</sup> 4, Clean Crop<sup>®</sup> trifluralin HF, Triap<sup>®</sup> 4HF, Tenkoz<sup>®</sup> trifluralin (trifluralin)
- Evaluate biological controls for pests of carrots
- Continue on-farm trials through UC Cooperative Extension, USDA Ag Research Service and other organizations (variety trials, production, and pest management, etc.)

## Regulatory Priorities

The carrot industry depends on the support of CDPR and EPA to register new products for California growers and an equitable regulatory system is needed to maintain availability of fumigants. Full registrations are sought for fungicides Reason<sup>®</sup> (fenamidone) and Ranman<sup>®</sup> (cyazofamid) tolerances on existing products should be maintained until suitable replacement products are commercially available. Improved harmonization between CDPR and US EPA is needed to facilitate timely registration of reduced risk products; the IR-4 program should be used efficiently to help identify good product candidates for research and registration.

- Obtain full registration for products that control cavity spot (e.g., Reason<sup>®</sup>, Ranman<sup>®</sup>)
- Maintain tolerances and commercial availability of linuron and trifluralin until replacement products are registered
- Register Prowl H<sub>2</sub>O<sup>®</sup>, Prowl<sup>®</sup> 3.3EC (pendimethalin)
- Ensure consistent regulation of all soil fumigants

## Educational Priorities

The public, including regulators and consumer groups, must be educated about the use of integrated pest management (IPM) in California carrot production, and how this system optimizes food production and ensures safety for workers and the environment. Outreach activities such as the California Carrot Research Symposium and industry updates through UC Cooperative Extension should be maintained and promoted. Growers need to be educated on pest identification, pest management, resistance management, and the most efficient and environmentally safe manner in which pesticides can be applied. The regulatory community needs to be educated on how carrots are grown and the need for effective fumigant materials for nematode, disease and weed control. Finally, consumers should be reminded that eating California carrots is an important part of a healthy lifestyle and that this commodity is grown in California under the highest standards of safety and quality in the world.

- Promote use of alternate fungicides in a resistance management program
- Provide training on the safe and effective use of soil fumigants
- Promote good communication between manufacturers, applicators, distributors, and growers on the proper use of fumigants
- Educate regulators on the critical need for fumigants in California carrot production
- Educate the industry on the importance of developing supporting data on the need and value of fumigants in carrot production
- Maintain Annual Carrot Symposium
- Continue on farm demonstration trials through the UC Cooperative Extension and other organizations
- Educate consumers on the safety and nutritional value of carrots as part of a healthy diet and lifestyle

This pest management strategic plan for California carrot production highlights the most important issues the carrot industry currently faces; this document will be periodically updated. A comprehensive list of individual growers, pest control advisors, industry representatives, and university research and extension personnel is located in the Appendix of this document for those seeking more detailed input on carrot production and pest management practices in California.

Product names listed in this document do not represent an endorsement of a particular trade brand by any member of the carrot work group. For reference, all chemical names and the accompanying trade names of each product are listed in the appendices of this document.

Pesticides are an integral part of agricultural pest management. Consequently, their usage, timing and target pests are discussed throughout this document. However, no portion of this document constitutes a literal pesticide recommendation. While every effort was made to ensure accuracy and completeness of the information contained herein, no guarantees can be provided as to its accuracy. Always READ THE LABEL before applying pesticides.

The California Minor Crops Council (CMCC) and the California Fresh Carrot Advisory Board (CFCAB) received support for this project from several sources including the Western Integrated Pest Management Center at UC Davis and the IR-4 Minor Use Program. In addition, funding was provided 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.

The California Fresh Carrot Advisory Board (CFCAB)  
The California Minor Crops Council (CMCC)  
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## A PEST MANAGEMENT STRATEGIC PLAN FOR CALIFORNIA CARROT PRODUCTION

### California Carrot Production Overview

California is the largest producer of carrots in the United States, accounting for about 65 percent of all U.S. carrot production. California produces more than 1.1 million tons of carrots annually on about 70,000 acres, with a total crop value of nearly \$448 million. Carrots are grown in four primary regions of California with the southern San Joaquin Valley being the major area of production. The San Joaquin Valley accounts for more than half the state's acreage. Other carrot production areas include the southern desert valleys (Imperial and Coachella), Antelope Valley, coastal inland valleys, Cuyama Valley, and the upper Owens Valley. The main carrot 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 Appendix 2 and 3.

With a variety of environments in California, carrot production is possible year-round. The diversity of growing locations allows carrot processing and packing plants to operate economically 12 months a year. In the San Joaquin and Cuyama Valleys, carrots are planted from December to March for harvest from May to July. Planting resumes from July to September for harvest from November to February. These gaps are filled by the southern desert, which is planted from August to February for harvest from December to June; the high desert, which is planted from February to July and harvested from July to December; and the central coast, with plantings from December to August, for an April to January harvest.

Nearly 90 percent of all carrots grown in California go to fresh market. The remainder goes to processing channels for use in baby foods, canned or frozen carrots, juices and other markets. The introduction during the 1990s of cut and peel and fresh cut carrot products led to sharp increases in fresh carrot consumption and production although that production has leveled off and somewhat declined the last few years. Cut and peel carrots are now recognized as a distinct crop from fresh whole carrot production.

Carrots are a cool-season crop that will tolerate warm temperatures early in the growing season. Consumers demand uniform roots that have a deep orange color. Roots attain optimal color when air temperatures reach 60 to 70° F, and that color deepens rapidly in this temperature range about three weeks before harvest. Temperatures below 50° F and above 86° F will impact quality and production of carrots.

Growers almost exclusively plant hybrid varieties to obtain uniform color, size and shape. Carrots are direct seeded and planted at high densities with 6 to 8 seed-lines on a 36- to 40-inch raised bed. Carrots need deep, loose, well-drained sandy loam or loam soils with an optimum pH range of 5.8 to 7.3.

Most carrots are irrigated by solid set sprinklers. A uniform water supply is critical for good color and root formation; roots will split under widely varying wet/dry cycles.

Nitrogen is typically applied to carrots during the growing season. With enough residual nitrogen, growers often do not apply preplant fertilizers before seedlings emerge. Carrot roots may fork if too much N is applied preplant. About 60 to 80 pounds N per acre is typically applied to the crop during the growing season and phosphorous is also applied at 400 to 500 pounds per acre prior to listing fields. Petiole sampling is recommended for carrots to obtain optimum nutrient status and avoid complications from over or under fertilizing.

Carrots are mechanically harvested with self-propelled multi-row harvesters that can harvest up to 1,000 tons per day. The harvester cuts off the carrot tops and delivers the roots into a truck or trailer behind the harvester. That trailer is then hauled to a packing shed where carrots are graded, sized and packed. Bunch carrots are hand-harvested.

Carrots are typically only planted once every three years in the same field to minimize pest problems. In addition, care is taken in deciding rotational crops for carrots to further reduce potential pest pressures.

## California Carrot Production Summary

- Approximately 1.1M tons of carrots are produced in California on more than 70,000 acres; the 2003 crop was valued at nearly \$448M.
- California accounts for more than 70 percent of U.S. carrot acreage.
- Carrots are California's 15th leading commodity in terms of crop value.
- California carrots averaged about 17.5 tons per acre in 2003
- There are four primary areas of carrot production in California: the San Joaquin Valley, low desert (Imperial and Coachella Valleys), high desert (Owens and Antelope Valleys) and coastal inland valleys (Salinas Valley, Cuyama Valley, Central Coast.).
- Carrot shipments are highest from December to August, although carrots are shipped from California year-round according to seasonal growing conditions and market demand.
- The major pests problems encountered in carrots include foliar and soil borne diseases, nematodes and weeds. Insects have not generally been a major issue in this commodity
- About 88% of California carrots are sold in the fresh market and 12% are used in the processing industry (juice, frozen, canned, etc.)
- About 5 to 10% of California carrots are produced using organic production methods.

### Stages of Crop Development (Days in Various Periods)

Pre-plant/Bed Preparation	Planting to Germination	Emergence to Harvest
Varies	7 - 21	110 -160

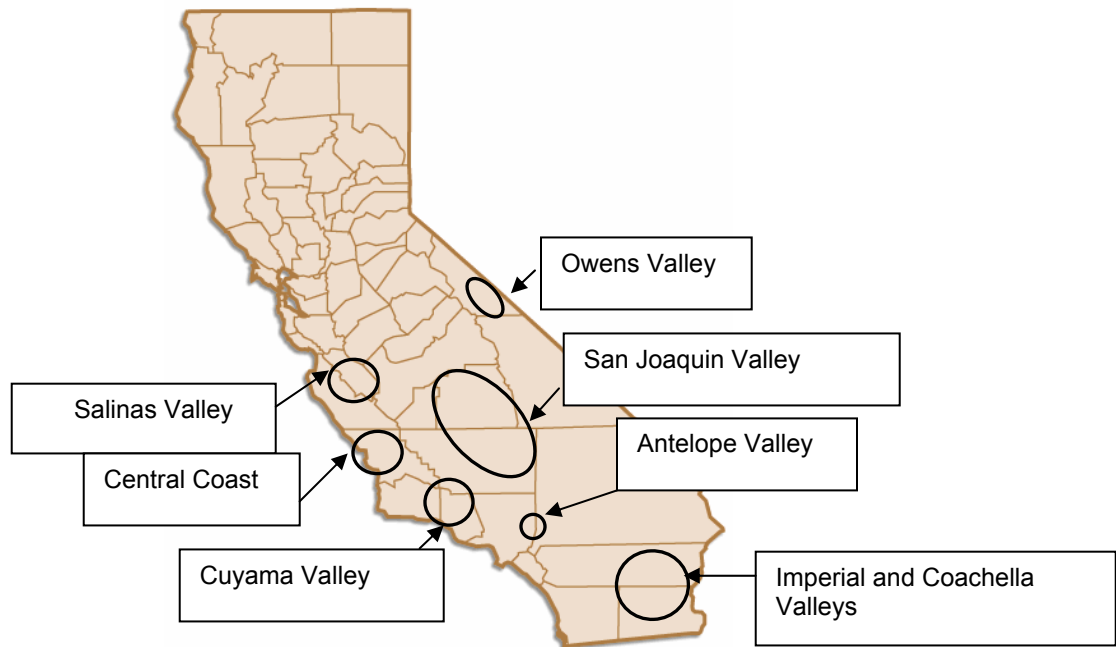
### Major Pests of Carrots in California

Diseases, nematodes and weeds are the most important pests of carrots; insect losses are not as prevalent due to the relatively rapid pace of crop development and the fact that the harvested portion of the plant grows below ground. The following are the most common pests found in California carrots.

Diseases	Alternaria leaf blight, bacterial leaf blight, bacterial soft rot, black crown, crater rot, crown rot, cavity spot, cottony soft rot, damping-off, root dieback, powdery mildew, southern blight and viruses
Weeds	Nutsedge, cheeseweed, mustards, annual and perennial grasses
Nematode	Root knot nematode
Insects	Leafhoppers, salt marsh caterpillar, cutworms, whiteflies, grasshoppers, flea beetles, aphids

## Figure 1. Carrot Production Regions in California

The main carrot production areas in California are shown below. Crop production and pest occurrence calendars for these areas are provided in Appendices 2 and 3.



Production Area	~ Acres	% of Production	Counties
San Joaquin Valley	40,000+ ac	56%	Kern, Kings, Fresno
Imperial and Coachella Valleys	15,000 ac	21%	Imperial, Riverside
Antelope Valley	7000 ac	10%	Los Angeles
Cuyama Valley	6000 ac	8%	Santa Barbara, Kern
Salinas Valley	2000 ac	3%	Monterey
Owens Valley	800 ac	1%	Mono
Central Coast	600 ac	1%	San Luis Obispo

Note: These numbers are provided as guidelines; estimates vary by year and location.

## **Historical Perspective on California Carrots: Production Trends and Integrated Pest Management**

The biggest changes in the industry within the last 20 years have been related to the increased market demand for cut and peel carrots, fresh cut carrots, and whole carrots. Production practices for these three types of fresh crop are quite different. Advances in breeding have helped to develop excellent varieties and improve disease resistance, especially for foliar diseases. There has been a huge increase in work in carrot genetics; the level and quality of disease research with industry, university and extension partners has been considerable in the last 25 years.

The California carrot industry wishes to remain economically viable and increase production returns per acre. Pest management needs must keep up with evolving consumer demand. While the industry has been successful in increasing yields for this commodity, the related costs have also risen; carrot growers have seen the cost of production increase three-fold in the last 20 years. The industry remains committed to being proactive in terms of pest management and breeding programs to develop high yielding and high quality cultivars.

**Cultural Control:** Cultural pest control is widely used in carrot production. As with all crops, a vigorous stand will help to reduce losses to several pests; this is most commonly done using the recommended varieties in combination with optimal planting, irrigation, and fertilizer management. Cultural control tactics used in California carrots include: Selection of cultivars with appropriate physical and/or disease resistance attributes; planting cover crops for soil improvement; crop rotation; fallowing; and the use of green manures. Soil sampling for nematodes, field sanitation, mowing, deep plowing and burning are also widely used to manage a variety of pests.

**Chemical Control:** The new safety standards implemented by the Food Quality Protection Act (1996) have not significantly impacted the chemical controls available to carrot growers to date. This is primarily due to the fact that organophosphates, a primary pesticide group of concern by EPA, are not widely used in carrot production. Herbicides and fungicides used in carrots have not been impacted to a great degree by these regulations up to this point.

The use of soil fumigants is the foundation of integrated pest management in carrot production. The availability of these products to manage nematode, disease, and weed pests is of paramount concern for the industry and the use of preplant fumigants has been widely used by this community of growers. There is great concern that recent regulations at the state and federal levels may limit the use or availability of these very effective pest management tools. Ongoing research projects sponsored by the industry will help provide potential mitigation strategies and new techniques to address these pest management needs.

**Biological Control:** There are few biological control options available or practical for carrot production. Due to relatively few insect pests, other areas of research on biological control have been pursued for this commodity. The focus has been on soil health, however, due to limited understanding of soil microflora interactions, that area is still limited in its use as a biological control.

**Scouting:** A key component of integrated pest management in large-scale carrot production is the use of routine scouting. Scouting is utilized throughout the growing season to monitor pest pressure. Scouting begins before planting when soil samples are taken from potential carrot fields to determine nematode levels in those fields. Costs are kept in check by also using these soil samples for soil nutritional analysis. Pest management decisions are made based on the results of the field monitoring that occurs during the growing season. Scouting usually continues up to the time of harvest to keep abreast of any late season problems that may occur.

## FOUNDATION FOR A PEST MANAGEMENT STRATEGIC PLAN

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

- Pre-Plant/Bed Preparation
- Planting to Stand Establishment
- Vegetative Development
- Harvest
- Post-harvest (Produce Handling and In-field Activities)

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

### Pre-Plant/Bed Preparation

The most common pest management practices to help manage disease, nematode, and weed pests in carrots occur during this stage of production and include rotating to appropriate crops and the use of preplant fumigants. Good bed preparation is the first step in producing a vigorous stand of high quality carrots. Selecting a site that has been managed for reduced levels of certain pests is also important in producing a vigorous crop. History of herbicide usage is another critical component in preparing the field for carrots, as certain crop protection materials have plant-back restrictions that could impact when a new crop can be planted.

Crop rotation in carrots is commonly done to control diseases and nematodes, although rotation is also commonly influenced by weed issues, soil type and water quality. Typical crops in a carrot rotation include grains, potatoes, garlic, onions, bell peppers, tomatoes and several others. Planting behind alfalfa is avoided. Generally, carrots are planted one out of three years and it is very rare that carrots are planted back to back.

### The Importance of Fumigants in Carrot Pest Management

The importance of fumigants in carrot production is widely recognized. These products, used prior to planting, provide economical and effective ways to manage nematode, disease, and weed pests. The benefits of soil fumigation are realized the entire growing season, and these products are the basis for all integrated pest management programs in all of the growing regions of the state.

Measured in pounds, fumigants represent approximately 20 percent of all agricultural pesticides used in California. Some of the most widely used fumigants include Telone II® (1,3-dichloropropene) chloropicrin, and pesticides that generate methyl isothiocyanate (MITC), such as metam sodium (Vapam®, Sectagon® 42) or K-Pam® HL (metam potassium). Before planting, farmers use fumigants to control disease, weeds, and pests in the soil. Fumigants are also used to disinfest structures and harvested commodities. Since fumigants are both toxic and gaseous, offsite movement is a concern. California Department of Pesticide Regulation has evaluated numerous studies to determine air concentrations, and assess the risks of both worker and public exposure to fumigants. Based on the analysis of data, DPR and the County Agricultural Commissioners have implemented the nation's strictest regulatory requirements on use of fumigants.

Of particular concern with the use of fumigants are the associated volatile organic compounds (VOCs) which create the biological effectiveness of these products. The VOC load is calculated annually using pesticide product emission potential (EP) data and CDPR's annual pesticide use report data.

The California carrot industry, in partnership with other commodities, is working with its local, state, and federal partners to evaluate and register alternatives to traditional fumigants. Of particular concern is the consistent enforcement of fumigant regulations at the local and state level and the timely registration of replacement products. At the present time, there is a lack of

good data on suitable replacement products. This issue will be noted several times throughout this strategic plan, as this is an ongoing issue of great concern to the California carrot industry.

### Cultural and Worker Activities

- |   |  |
|---|--|
| <ul style="list-style-type: none"><li>• Ground preparation using tractor implements: plowing, ripping, disking, land planing</li><li>• Fumigation</li><li>• Bed shaping</li><li>• Bed listing</li></ul> | <ul style="list-style-type: none"><li>• Spreading fertilizer and amendments (gypsum, compost)</li><li>• Soil sampling (nutrients, nematodes)</li><li>• Setting pipe</li><li>• Pre-irrigation</li></ul> |
|---|--|

### Nematodes

Root knot nematode (*Meloidogyne* spp.) is the primary nematode pest of carrots. It is found in all of the carrot-growing regions of California. The taproots of carrots infested with root-knot nematodes may be stubby or forked, and the feeder roots often have numerous galls. The two most prominent species include Cotton root knot nematode (*Meloidogyne Incognita*) and the Northern root knot nematode (*Meloidogyne hapla*).

Other nematode pests include the stubby root nematode (*Trichodorus* spp. and *Paratrichodorus* spp.) and the needle nematode (*Longidorus africanus*) which to date has only been found in the Imperial Valley. Although not normally considered a direct pathogen of carrots, Lesion nematode (*Pratylenchus* spp.) enter and exit roots, causing tissue damage and allowing secondary pathogens such as *Fusarium* to infect carrots.

Preplant soil testing is practiced extensively in California by growers to determine the population density of nematodes in the soil. This information allows growers to decide how to best treat each field. The fields can then be left out of rotations, planted to a non-host crop, fumigated, or left untreated if the nematode levels are low. Several alternative materials have been tested for nematode control in trials conducted in university and cooperative extension research programs, however, results have not been very favorable.

### Cultural Control

Crop rotations have not been highly effective at suppressing populations of root knot nematodes because several species of *Meloidogyne* (RKN) infect carrots and this genus has a wide host range. Additionally, it has the ability to survive under host-free conditions for prolonged periods of time.

Research is being conducted in California to help identify crop rotation patterns that may be used to reduce populations of *Meloidogyne* spp. in the soil.

Over the past few years, significant progress has been made in carrot breeding programs towards the development of nematode resistant lines. Some of this material has been incorporated into commercial breeding programs. However, no commercially acceptable carrot cultivars with nematode resistance are as yet available for use by the industry.

### Chemical Control

Metam sodium is applied to a significant amount of the carrot acreage several weeks prior to planting for the control of nematodes and soil borne pathogens, but also to control a broad spectrum of weeds. Metam sodium is applied by soil injection, rotary tiller, or chemigation. Usage is minimal in the spring carrot crop of the Southern San Joaquin Valley because of minimal pest pressures. Product performance is sometimes variable and consequently provides only fair control of nematodes.

Dichloropropene is a restricted material that requires special permits and must be applied by a certified applicator. Dichloropropene is applied by soil injection; due to restrictions on the amount of product that can be used within each township by Cal-EPA, application of

dichloropropene is limited to approximately 13% of the carrot acreage. Application is further limited to temperatures of 50° F or greater. Under high population levels of nematodes, dichloropropene is considered a better material for nematode control as compared to metam sodium, but is more expensive.

Biological Control

There are no commercially acceptable forms of biological control for nematodes.

**Work Group Recommendations for Nematode Management  
Pre-plant/Bed Preparation**

RESEARCH	<ul style="list-style-type: none"> <li>• Continue support of resistance breeding programs</li> <li>• Evaluate methyl-iodide and other soil fumigants</li> <li>• Evaluate cover crops as a nematode management tactic</li> <li>• Develop testing methodology to evaluate biological materials</li> <li>• Evaluate biologicals for nematode management</li> </ul>
REGULATORY	<ul style="list-style-type: none"> <li>• Maintain availability of fumigants until commercially acceptable alternatives are available</li> <li>• Develop industry response to CDPR and EPA risk assessments through appropriate mitigation measures</li> </ul>
EDUCATION	<ul style="list-style-type: none"> <li>• Educate CDPR on need for efficacy data, especially for biologicals</li> <li>• Educate regulatory community concerning the relationship between the cost of R &amp; D and registration (i.e., regulations are preventing the development of good efficacy data.)</li> <li>• Educate manufacturers, distributors, applicators, growers on the need to follow best management practices when applying soil fumigants</li> </ul>

**Diseases**

Cultural Control

Crop rotation of 3 to 5 years is commonly practiced to avoid many soil borne disease problems. Crop rotation is an effective management tool for Southern blight (*Sclerotium rolfsii*), cottony soft rot (*Sclerotinia sclerotiorum*), and black crown (*Alternaria radicina*). Southern blight can be reduced by burying the sclerotia by deep plowing before planting and rotating to non-host crops such as small grains or corn.

Deep plowing has also been shown to reduce the incidence of black crown in fields with a history of this disease. Preparing the soil to eliminate low spots in the field, increasing drainage, and not over-watering are measures for avoiding cottony soft rot and bacterial soft rot (*Erwinia carotovora*, *E. chrysanthemi*) later in the season.

Chemical Control

Suppression of black crown, cottony soft rot, as well as damping-off (*Fusarium spp.*, *Rhizoctonia spp.*, *Pythium spp.* and *Phytophthora spp.*) are considered to be a side benefit of using a soil fumigant.

### Biological Control

Contans® (*Coniothyrium minitans*) is used for suppression of cottony soft rot, mainly in organic production. There are no commercially acceptable forms of biological control for other soil borne pests.

### **Work Group Recommendations for Disease Management Preplant/Bed Preparation**

RESEARCH	<ul style="list-style-type: none"><li>• Continue research on disease management</li><li>• Evaluate alternatives for fumigants</li><li>• Continue research program to incorporate resistance into commercially acceptable cultivars</li><li>• Develop prediction models for disease</li><li>• Develop rapid soil immunoassay assay for the presence of soil borne diseases such as <i>Pythium</i>, <i>Rhizoctonia</i>, <i>Fusarium</i> and possibly <i>Phytophthora</i></li></ul>
REGULATORY	<ul style="list-style-type: none"><li>• Register new materials that are alternatives to fumigants</li></ul>
EDUCATION	<ul style="list-style-type: none"><li>• Educate regulators on need for soil fumigants</li></ul>

### **Weeds**

Carrot is a slow growing crop that suffers severe yield loss from weed competition. Its thin, feathery leaves do not shade out competing plants well and its long growing season creates an opportunity for successive flushes of weeds throughout the growing season. Potential carrot weed pests include a broad spectrum of weeds, both summer and winter annuals and perennials. Weed management in early season is therefore critically important to producing a high yielding, high quality crop.

Yellow nutsedge (*Cyperus esculentus*) and purple nutsedge (*Cyperus rotundus*) are the most serious weed pests in carrots. Fall planted carrots do not lose significant yield from yellow nutsedge competition because nutsedge growth slows and eventually ceases as temperatures cool. Purple nutsedge will continue to grow and be a problem in infested fall planted carrots fields. If fields are too infested, alternative production sites should be found.

Russian thistle, dodder, little mallow, and nightshade are other weeds that are also difficult to control in carrot fields.

A new weed for carrots that could be particularly troublesome in California is knotted hedge parsley (*Torilis nodosa*). Knotted hedge parsley is closely related to carrots and is difficult to distinguish from carrots in the seedling stage. This weed is also tolerant to the same herbicides as carrots.

### Cultural Control

Crop rotations help to reduce population levels of several carrot pests including some weeds. Carrots are generally rotated with other crops on a 3- to 5-year schedule. Cultivation is usually done after the plants have become established at the 3- to 4-leaf stage to remove weeds from the furrow and the center of the bed.

### Chemical Control

Metam sodium is applied prior to planting for nematode control but is also effective on a broad spectrum of weed seeds. To be most effective annual weed seeds need to have been germinated or “chitted” prior to application of metam sodium. Metam sodium will control all annual weeds but misses clover, morningglory, cheeseweed and occasionally lambsquarters. It can substantially reduce nutsedge infestations.

A long-term nutsedge control program might include Sempra® CA Herbicide (halosulfuron-methyl). Subsequent working of the fallow ground with a spring-tooth lifts any missed nutsedge plants and tubers to the soil surface where exposure to the drying heat of summer desiccates them. Control has been excellent, but the plant back interval back to carrots is exceptionally long.

Eptam® 7E (EPTC) is used for the *suppression* of nutsedges, but requires a 60-day fallow period before planting. Some deep plowing is also done in conjunction with this product and timing to destroy escaped weeds is very important to overall effectiveness of this program. Trifluralin may be preplant incorporated before listing or applied at planting through sprinkler irrigation. In instances where weed growth has advanced too quickly before planting the grower may use a contact herbicide such as Gramoxone® Max (paraquat dichloride) or Roundup® (glyphosate) to burn back the weed growth. They may be applied until emergence of the crop. Use extreme care to avoid contact with germinating seedlings or injury will undoubtedly result. Apply before germination on coarse soils to further minimize the risk of injury.

Biological Control

There are no effective biological materials for weed control in carrots.

**Work Group Recommendations Weed Management  
Preplant/Bed Preparation**

RESEARCH	<ul style="list-style-type: none"> <li>• Evaluate metam alternatives for weed control</li> <li>• Evaluate and develop management tools for nutsedge</li> <li>• Evaluate and develop management tools for Russian thistle</li> </ul>
REGULATORY	<ul style="list-style-type: none"> <li>• Obtain full registration for Prowl H<sub>2</sub>O® and Prowl 3.3EC (pendimethalin)</li> </ul>
EDUCATION	<ul style="list-style-type: none"> <li>• Educate UC on need for continuation of weed research program in carrots, i.e., there is no one in the UC/USDA system that works on weed management in carrots</li> </ul>

**Insects**

Soil pests that can be found in carrot fields include wireworms, cutworms (*Noctuidae*) and Garden Symphylan. Click beetle (various species) cause crop damage in their juvenile larva stage called wireworms. Wireworms injure seedlings by feeding on roots or chewing on the stems. Damage is most common in fields with high organic matter content in the soil or in fields that have recently been in or adjacent to alfalfa, pasture, or uncontrolled weeds.

Black Cutworm (*Agrotis ipsilon*), Granulate Cutworm (*Agrotis subterranea*), Variegated Cutworm (*Peridroma saucia*) populations are heaviest during the fall and can have a significant impact on seedling carrot stands. Their feeding is characteristic of seedlings being cut at, or slightly below the surface. Populations tend to be heavy following alfalfa or pasture crops.

Garden Symphylan (*Scutigera immaculata*) is nocturnal. Symphylans occur mainly in soil with high organic matter.

Cultural Control

Site selection is very important as a management tactic for all soil pests. Fields with a history of soil pests should be avoided or managed appropriately.

### Chemical Control

Diazinon 4E, Diazinon AG600 WBC (diazinon) provides good control of wireworms and garden symphylans, but this product is not widely used. Metam sodium and dichloropropene used for soil fumigation are reported to provide some secondary control of these pests. Cutworms are mainly managed by controlling weeds and planting in fields that are not adjacent to pastures.

### Biological Control

There are no biological control agents that are effectively and consistently used for soil pests found in carrots.

### **Work Group Recommendations for Insect Management Preplant/Bed Preparation**

RESEARCH	<ul style="list-style-type: none"><li>• No needs recorded</li></ul>
REGULATORY	<ul style="list-style-type: none"><li>• No needs recorded</li></ul>
EDUCATION	<ul style="list-style-type: none"><li>• Provide training on garden symphylan population monitoring techniques</li></ul>

### **Vertebrates**

The burrows of pocket gophers (*Thomomys bottae*), rabbits (black tailed jackrabbits, desert cottontails), and ground squirrels (*Spermophilus beecheyi*) can be a minor nuisance during bed preparation. There is not a great deal of effective management options for this group of pests.

### Cultural Control

There are no effective cultural control methods for these pests at this stage.

### Physical Control

Mechanical traps can control pocket gophers provided populations are low. Fences used for the exclusion of rabbits can be very effective if properly managed.

### Chemical Control

There are few chemicals available; many have been lost due to endangered species concerns. Phostoxin<sup>®</sup> (aluminum phosphide) provides poor to fair control of burrowing vertebrate pests; this product is more effective on squirrels. Strychnine is only registered on gophers and provides good control initially. ZP<sup>®</sup> rodent bait Ag (zinc phosphide) yields poor control. Anticoagulant baits P.C.Q. pelleted rodent bait<sup>®</sup>, Ramik<sup>®</sup> green rodenticide (diphacinone) provides excellent control of most vertebrates. Diphacinone is not registered on carrots; however it is registered for use around the perimeter of carrot fields in burrow entrances, right of ways, etc.

### Biological Control:

Owl boxes are occasionally used to encourage nesting of owls and subsequent predatory activity on vertebrate pests; this technique is considered to provide fair levels of control and results are often reported as variable. There are no effective biological control products for these pests at this stage.

**Work Group Recommendations Vertebrate Management  
Preplant/Bed Preparation**

RESEARCH	<ul style="list-style-type: none"><li>• Evaluate new materials and techniques for vertebrate (squirrel) control</li></ul>
REGULATORY	<ul style="list-style-type: none"><li>• Maintain registrations and availability of baits through county ag commissioners' offices</li></ul>
EDUCATION	<ul style="list-style-type: none"><li>• No needs recorded</li></ul>

**Planting to Stand Establishment  
(Planting to first cultivation)**

Carrot is a direct seeded crop. Jumbo-type carrots may be planted at 350,000 to 450,000 live plants per acre while cello-types are planted at higher densities of 500,000 to 600,000 live plants per acre. Cut and peel carrots require the highest planting densities at 1.1 to 1.3 million live plants per acre.

Seeds are commonly sown in 6 or 8 lines per bed with 3 or 4 placed on each shoulder. Seeds are dropped into narrow grooves approximately 1/8 to 1/4 inches in depth. Because carrots are a shallow seeded crop, wind or the splashing of irrigation water may sufficiently cover the seed with soil for germination.

**Cultural and Worker Activities**

• Planting/shaping beds	• Fungicide applications
• Fertilizer injections	• Insecticide applications
• Herbicide applications	• Hand weeding
• Setting pipe	• Scouting
• Irrigation	• Stand counts to estimate production

**Nematodes**

At this timing, fumigations have already been completed to control nematodes. A major tactic at this stage is to manage a vigorous and competitive stand. There are no real chemical control options available at this crop stage and no biologicals are commercially available for nematode control.

**Work Group Recommendations for Nematode Management  
Planting to Stand Establishment**

RESEARCH	<ul style="list-style-type: none"> <li>• Evaluate biological and chemical nematicides for use in early season</li> <li>• Work with the IR-4 program to establish research projects to address the needs of the industry</li> </ul>
REGULATORY	<ul style="list-style-type: none"> <li>• Register nematicides for use at this timing</li> </ul>
EDUCATION	<ul style="list-style-type: none"> <li>• Educate registrants on the critical need for nematicides in carrots</li> <li>• Educate IR-4 program on the need to establish research projects to address nematicide needs for the California carrot industry</li> </ul>

**Diseases**

As discussed previously, the two most damaging diseases in carrots are diseases caused by *Alternaria spp.* and *Pythium spp.* Crop rotation and irrigation management are the primary means of controlling most soil-borne diseases in carrots. Chemical control options after planting include applications of fungicides to help reduce losses to these important diseases. Use of disease indexed seed is also helpful in managing *Alternaria dauci*, *A. radicina* and *Xanthomonas campestris* problems.

Root dieback and forking (*Pythium ultimum* & *P. irregulare*) at germination – Apron® XL LS (mefenoxam) treated seed can provide some protection against root dieback and forking. Ridomil Gold® EC, Ultra Flourish® 2E (mefenoxam) applications between planting and germination works well, however, care must be taken to not overwater as this might reduce the efficacy of the fungicide. Biodegradation and fungal resistance of Ridomil is becoming an issue.

Metam sodium provides some control of this disease. Biological controls are not available. Crop rotation works fairly well as a cultural control technique.

Damping Off (*Fusarium spp.*, *Rhizoctonia solani*, *Pythium spp.* and *Phytophthora spp.*) – This condition is caused by a complex of organisms which cause forking or stubbing of the carrots. Damping off occurs when infected seedlings wilt, turn brown. It may also manifest itself by a discolored stem at ground level that eventually turns brown and topples over.

Irrigation management is the best way to manage this problem. Seed treated with Maxim 4FS (fludioxonil) provides protection against *Fusarium spp.*, *Rhizoctonia spp.*, and weakly pathogenic fungi such as *Aspergillus* and *Penicillium*. Thiram (tetramethylthiuram disulfide) and /or Rovral Brand® 4 Flowable (iprodione) seed treatments are effective; metam sodium and mefenoxam also provide fair to good control. There is no registered biological seed control for carrots. A product called Kodiak® (*Bacillus subtilis*) reportedly suppresses *Fusarium spp.*, *Rhizoctonia spp.*, *Alternaria spp.* and *Aspergillus spp.* However, it is not currently registered on carrots.

Alternaria leaf blight (*Alternaria dauci*) – Several cultural techniques help in managing this disease. Practicing good sanitation and irrigation management will help reduce disease incidence. Good weather data will help to time plantings during optimum conditions and planting on level ground to reduce standing water is very effective. Resistant varieties are also used. Biological controls are not available. Seed treatments using iprodione or hot water are also effective for control of seedborne *A. dauci* and have reduced the need for inseason fungicide applications.

Black crown (*Alternaria radicina*) – The incidence of Black crown, also known as black root rot may be reduced by the cultural control method of deep plowing. Similar to *A. dauci*, seed treatments with iprodione or hot water are relied upon for control of this disease.

Bacterial leaf blight (*Xanthomonas campestris pv. carotae*) - This seed-borne disease can be managed in part by mechanically removing volunteer carrot plants, and planting at the optimal timing and planting conditions. Field sanitation also provides fair to good control. Copper, used mainly later in the season, provides good control.

### **Work Group Recommendations for Disease Management Planting to Stand Establishment**

RESEARCH	<ul style="list-style-type: none"> <li>• Develop efficacy data for Reason® (fenamidone), for control of cavity spot</li> <li>• Develop disease resistance management strategies</li> <li>• Evaluate products and techniques for control of leaf blight (<i>Xanthomonas campestris pv. carotae</i>)</li> <li>• Evaluate how soil microflora accelerate breakdown of Ridomil Gold® (mefenoxam).</li> </ul>
REGULATORY	<ul style="list-style-type: none"> <li>• Develop flexibility in label language for use of Ridomil Gold® (mefenoxam)</li> <li>• Register additional products for alternatives to Ridomil Gold® for use in resistance management program E.g., Ranman® (cyazofamid)</li> <li>• Register a product that controls leaf blight (<i>Xanthomonas campestris pv. carotae</i>)</li> </ul>
EDUCATION	<ul style="list-style-type: none"> <li>• No needs recorded</li> </ul>

## Weeds

Trifluralin may be preplant incorporated before listing or applied at planting through sprinkler irrigation. Trifluralin is a very effective broad spectrum herbicide demonstrating excellent control on annual grasses. Annual morningglory is only suppressed. The full label rate is necessary to control Russian thistle. Trifluralin is weak on mustards and nightshades.

Growers may apply Lorox<sup>®</sup> (linuron) postplant/preemergence and/or postemergence. Best weed control is obtained when used post emergence. Linuron misses Russian thistle, maretail, clover and some grasses. It will control yellow nutsedge when applied during warmer temperatures, but can also cause some crop damage under these conditions when being used on lighter soils. Cultivation is not an option at this time of the season, but some hand weeding is done.

### Work Group Recommendations Weed Management Planting to Stand Establishment

RESEARCH	<ul style="list-style-type: none"><li>Evaluate materials for nutsedge, morningglory, bindweed, and Russian thistle control</li></ul>
REGULATORY	<ul style="list-style-type: none"><li>Register materials for nutsedge, morningglory, bindweed, and Russian thistle control</li></ul>
EDUCATION	<ul style="list-style-type: none"><li>No needs recorded</li></ul>

## Insects

Insects are generally not considered a major problem in carrot production in California. Historically, less than 25 % of the total carrot acreage receives any type of insecticide treatment.

Leafhoppers are the most serious insect pest in California carrots. They damage carrots by directly feeding on the foliage when they move into carrot fields from surrounding hills as the native vegetation begins to dry in late spring. Carrots grown in Cuyama Valley and Antelope Valley are especially prone to leafhopper infestations. The beet leafhopper is the vector of a mycoplasma that is the cause of Beet Leafhopper Transmitted Viresence Agent (BLTVA). BLTVA is therefore commonly found in those same valleys where leafhoppers are a problem.

Occasionally crickets, grasshoppers, pale-striped flea beetle larvae and adults, cutworms, and saltmarsh caterpillar can pose a serious challenge to carrot seedlings by feeding on the young plants. Saltmarsh caterpillars can be a problem in the fall when carrot fields are planted adjacent to a cotton field that has been defoliated for harvest. Aphids can be pests of carrots at all stages of development. Whiteflies usually move into carrot fields in the fall, but these insects do not appear to cause any harm to carrots.

Weeds and nearby crops affect management of several insect pests. Flea beetle populations can be kept low by removing weeds around the fields and disking in plant residue. Field sanitation also helps to reduce aphid populations around the carrot field. Occasionally a grower may pull a trench along the edge of a cotton field for the purpose of trapping saltmarsh caterpillars before they can enter newly planted carrot fields. Otherwise planting carrots near a cotton or melon field is avoided if possible to reduce the movement of aphids and white flies into carrot fields when those crops are harvested. Chemical control is usually not required for aphids because naturally occurring predators and parasites keep their populations below economic damaging levels.

Cutworms (Noctuidae), Beet Armyworm (Spodoptera exigua), Cabbage looper (Trichoplusia ni)– High infestations of larvae can take out entire stands of young carrots. While generally considered a problem in mid-season, these species can also be serious early in the season as well. Some biological control (natural control) by parasites and predators occurs, and this activity

is not rapid enough to reduce potential crop losses. Effective cultural controls include field sanitation and monitoring for pests in adjacent vegetation.

Success<sup>®</sup>, Entrust<sup>®</sup> (spinosad), Lannate<sup>®</sup> 90SP Insecticide (methomyl), the synthetic pyrethroids [Asana<sup>®</sup> XL Insecticide (esfenvalerate), Baythroid<sup>®</sup> 2 Emulsifiable Pyrethroid Insecticide or Renounce<sup>®</sup> 20WP (cyfluthrin)] all provide excellent chemical control of these pests.

Darkling ground beetle (*Blapstinus spp.*) – Darkling ground beetles tend to be active at night and hide during the day in the soil or under plant debris. No biological control is available. Weed control in areas bordering fields is an effective means of culturally managing these pests. Pulling trenches around fields works fairly well; beetles can be buried or burned when trapped in this manner. Chemical control options include methomyl, the pyrethroids or Sevin<sup>®</sup> bait (carbaryl.) All of these products provide good control.

Crickets (*Gryllus Spp.*) – Most feeding occurs at night, as they prefer to hide during the day. This is a minor insect issue. No biological controls are available. Treat with methomyl or the pyrethroids. Carbaryl bait works well; however, water “fastness” of bait is an issue.

Desert (migratory) Grasshoppers (*Melanoplus sanguinipes*) – Due to their ability to fly, it is difficult to prevent the migration of grasshoppers into a field. As fields are watered, populations of grasshoppers tend to move into an area. No biological control is available. Cultural techniques to manage these pests include treating roads and using trap crops; this latter technique is not considered very effective due to the highly migratory nature of grasshoppers. Carbaryl bait and Malathion 8EC<sup>®</sup>, Malathion Aquamul<sup>®</sup> (malathion) provide good control of this pest. Esfenvalerate only provides fair control.

Saltmarsh Caterpillar (*Estigmene acrea*) – Common in cotton, alfalfa, bean and sugarbeet fields, this species is considered an occasional problem. No biological control is available. Weed control in areas bordering fields is an effective means of culturally managing these pests. Pulling trenches around fields works fairly well; caterpillars can be buried or burned when trapped in this manner. Methomyl can be used. Carbaryl bait is a good treatment in trenches to control this pest.

Leafhoppers – These pests can be very effectively controlled using malathion, Diazinon 4E, Diazinon AG600 WBC (diazinon), Sevin<sup>®</sup> Brand 80 WSP, Sevin<sup>®</sup> XLR Plus (carbaryl) or one of the pyrethroids. No biological control is available.

Flea Beetles – Flea beetles are rarely a problem and rarely treated. When they are a problem, they typically cause damage to carrot stands during stand establishment. They can feed on the small tender leaves or the roots. A new species called the palestriped flea beetle (*Systema blada*) has been seen in some areas. These insects are mainly controlled using cultural techniques such as weed control and field sanitation. Methomyl, one of the pyrethroids, or carbaryl bait are options. Carbaryl bait provides good control. Esfenvalerate and diazinon provide fair to good control.

Whitefly (*Bemisia Spp.*) – This species can cause problems in early fields in the Imperial Valley and in the fall crop in the San Joaquin Valley. The best way to manage this pest is to promote vigorous plant growth. There are no biological controls available and there are no highly effective insecticides registered in carrots. Phaser<sup>®</sup> 3 EC, Thiodan<sup>®</sup> 3EC, Thionex<sup>®</sup> (endosulfan) provide only fair to good control of whiteflies.

Ants – These insects can cause stand loss by feeding on seeds or young plants when in the cotyledon stage. Diazinon applied as a spray provides good control of ants at this growth stage.

**Work Group Recommendations for Insect Management  
Planting to Stand Establishment**

RESEARCH	<ul style="list-style-type: none"> <li>Evaluate alternatives to diazinon for control of soil pests</li> <li>Develop mitigation techniques for runoff issues with diazinon</li> </ul>
REGULATORY	<ul style="list-style-type: none"> <li>Register Provado<sup>®</sup> 1.6 Flowable Insecticide or Admire<sup>®</sup> 2F (imidacloprid) or Platinum<sup>®</sup> (thiamethoxam) for leafhoppers.</li> </ul>
EDUCATION	<ul style="list-style-type: none"> <li>No needs recorded</li> </ul>

**Vertebrates**

Pocket gophers (*Thomomys bottae*), rabbits (black tailed jackrabbits, desert cottontails), and ground squirrels (*Spermophilus beecheyi*) can feed on plants or interfere with cultural operations at this time of the season. Birds, mainly the Horned larks (*Eremophila alpestris*), can also be problematic during the time that beds are being prepared. Birds can be discouraged by use of guns, cannons, or reflective tape. Feral pigs, sometimes a problem, can be taken if a depredation permit is obtained.

Cultural Control

There are no effective cultural control methods for these pests at this stage.

Physical Control

Mechanical traps can control pocket gophers provided they are few in numbers. Fences used for the exclusion of rabbits can be very effective, if properly managed.

Chemical Control

There are few chemicals available; many have been lost due to endangered species concerns. Phostoxin<sup>®</sup> (aluminum phosphide) provides poor to fair control of burrowing vertebrate pests; this product is more effective on squirrels. Strychnine is only registered on gophers and provides good control initially. ZP<sup>®</sup> rodent bait Ag (zinc phosphide) yield poor control. Anticoagulant baits P.C.Q.<sup>®</sup> pelleted rodent bait, and Ramik<sup>®</sup> green rodenticide (diphacinone) provide excellent control of most vertebrates.

Biological Control:

Owl boxes are occasionally used to encourage nesting of owls and subsequent predatory activity on vertebrate pests; this technique is considered to provide fair levels of control and results are often times reported as variable. There are no effective biological control products for these pests at this growth stage.

**Work Group Recommendations Vertebrate Management  
Planting to Stand Establishment**

RESEARCH	<ul style="list-style-type: none"> <li>Evaluate new materials and techniques for vertebrate (squirrel) control</li> </ul>
REGULATORY	<ul style="list-style-type: none"> <li>Maintain registrations and availability of baits through county ag commissioners' offices</li> </ul>
EDUCATION	<ul style="list-style-type: none"> <li>Promote stewardship as it relates to urban interface issues</li> </ul>

## Vegetative Development (First cultivation to harvest)

This stage of development includes the period of growth from the first cultivation until harvest. The carrot crop is well established.

### Cultural and Worker Activities

• Cultivation	• Pipe moving
• Insecticide and fungicide applications	• Irrigating (may switch from sprinklers to furrow irrigation)
• Sampling for quality	• Scouting
• Fertilizer applications	• Hand weeding

### Nematodes

At this point in the season, there is little that can be done to manage nematode problems except to promote plant vigor and to harvest the crop early.

**NOTE: There were no work group recommendations for nematode work during this phase of crop development.**

### Diseases

There are many diseases that can impact carrots in the U.S., but there are only a few that can be serious pests in California. The most important diseases during vegetative development in California are:

- Alternaria Leaf blight (*Alternaria dauci*)
- Bacterial leaf blight (*Xanthomonas campestris*)
- Bacterial soft rot (*Erwinia carotovora*, *E. chrysanthemi*)
- Black crown (*Alternaria radicina*)
- Cavity spot (*Pythium sulcatum*, *P. violae*)
- Cottony soft rot (*Sclerotinia sclerotiorum*)
- Crown Rot (*Rhizoctonia solani*)
- Early blight (*Cercospora carotae*)
- Powdery mildew (*Erysiphe polygoni*)
- Southern blight (*Sclerotium rolfsii*)
- Viruses and mycoplasma diseases

Alternaria leaf blight (*Alternaria dauci*) – *Alternaria* can cause considerable defoliation, making harvest impossible. Individual lesions appear as dark-brown to black necrotic lesions along the margins of the leaves. *Alternaria* leaf blight can reduce yields by 40% if not controlled in years that favor disease development.

*Alternaria* can sometimes be confused with Bacterial blight (*Xanthomonas campestris* pv. *carotae*) which may also be present in carrot fields. The concern here is that Bacterial blight is a completely different organism requiring a different treatment strategy. Unlike *Alternaria*, Bacterial blight produces no spores.

Resistant carrot cultivars offer the single most effective means of controlling *Alternaria* leaf blight. Genetic resistance is recognized as one the most economically efficient and environmentally preferable approaches to integrated pest management.

Newly introduced cultivars typically possess more robust tops and thicker cuticles to help resist disease development than did their predecessors. A continued emphasis in the screening of carrot cultivars for *Alternaria* resistance is a high priority for the carrot industry.

*Alternaria dauci* survives on and is spread by carrot seed. Seed companies are acutely aware of this and routinely index carrot seed before it is sold. However, this index is conducted on very small samples of seed that has been chemically treated. The results of the index serve as a rough indicator for the potential for *Alternaria* to cause problems. These results do not guarantee total freedom from *Alternaria* contaminated seed. The standard industry treatment for *Alternaria* on carrot seed is a slurry coating of iprodione. However, this treatment makes seed susceptible to cracking and chipping, which decreases its effectiveness.

Field selection and preparation should be a primary consideration for preventing *Alternaria* leaf blight. It is important to select fields with soils that are of good texture, porous and well drained. Compaction layers that could slow drainage should be broken up. Fields should be leveled to prevent standing water. Low areas that collect water should be disked out before the last cultivation to prevent *Alternaria* from gaining a foothold in the field.

Sprinkler irrigation should be carefully managed, especially when crop canopies become dense and rows close over. During this time, air circulation decreases and leaves remain wet for extended lengths of time. Finish sprinkler irrigation by early afternoon to allow foliage to dry by nightfall.

Fields with a history of *Alternaria* can be rotated out of carrots to reduce the incidence of disease in succeeding years. Rotations with beets, onions, garlic, corn, cotton or small grains can help reduce inoculum in the soil.

Slotting carrot cultivars possessing *Alternaria* resistance is always an option. Adjust stand count of fields to match anticipated disease pressure. Consider modifying the row and plant spacing to support air movement and drying of foliage. Finally, select cultivars with strong, robust tops to help fend off attacks by *Alternaria*.

Carrot fields undergoing physiological stress caused from nutrient deficiencies and excesses are at a higher risk for *Alternaria* outbreaks. Besides delaying maturity, excess nitrogen can trigger an undesirable shoot/leaf to root ratio (e.g., lots of top growth in relation to the size of the carrot). Overly vigorous top growth will prematurely close the rows. This condition extends the interval of crop canopy conditions favorable to *Alternaria* infection – high humidity without any air movement. If for no other reason, overuse of nitrogen can cause imbalances in other nutrients. Growers have a responsibility to manage nitrogen carefully to hold back excessive top growth.

Just as carrot crops can have too much fertilizer, they can also have too little. As with most crops, carrots naturally go through senescence at the end of their growth cycle. Senescence results in the foliage turning yellow and structural integrity of the petiole and leaf deteriorating. Fields deficient in nitrogen advance the onset of this condition. There is no other time when carrot foliage has a greater predisposition toward infection from *Alternaria* than during senescence.

Weeds should be kept under control. Weeds add to a dense canopy further contributing to a humid microcosm favored by *Alternaria*. Growers should bury all weed and plant debris when practicable.

Mowing of carrot tops can help maintain proper shoot/leaf to root ratio. This ratio is generally not a problem if the grower has chosen a carrot cultivar with a compact, upright top. It also helps if the crop has not been overfertilized.

When practiced, mowing allows for an increase in air movement and drying of the foliage. This results in improved disease control. As a secondary benefit, it also increases efficacy of chemical treatments by allowing spray to penetrate deeper into the canopy. On the downside, mowing may encourage the dispersal of *Alternaria* spores into the air. Carrot debris should be turned under soon after harvest to prevent further inoculum propagation and dissemination.

*Alternaria* spores overwinter in plant debris in the soil. Matted layers of crop residue from a previous carrot crop are a good indicator that insufficient disking has taken place. To minimize

carryover of the inoculum, disk or plow fields immediately after harvest to promote rapid decomposition by soil microorganisms.

Bacterial soft rot (*Erwinia carotovora*, *E. chrysanthemi*) can occur when mature carrot fields are irrigated during periods of warm weather. Overirrigation during these conditions is especially conducive to disease development. The bacterium enters the plant through wounds or expanded lenticils and under warm conditions causes a soft rot of the roots. The bacterium may also develop into a post-harvest soft rot after the carrots are harvested, washed and bagged.

Black Crown (*Alternaria radicina*) is favored by sprinkler irrigation or rainy weather and high temperatures, which may predispose tissue to infection. Secondary organisms such as white mold (*Sclerotinia spp.*) can recolonize damaged tissue. *Alternaria radicina* is seed borne and may be spread on carrot seed. It also survives in carrot debris and in the soil for several years. Black rot is important only in certain areas or regions in California. It is common in coastal mountain valleys, e.g., the Cuyama Valley.

Use *Alternaria* resistant cultivars. Plant *Alternaria*-indexed seed to reduce the potential for inoculum transfer. This is especially important in fields where black rot has not already been identified. Furrow rather than sprinkler irrigation may reduce disease development.

Crop rotation is highly recommended to prevent buildup of the fungus in the soil. Dry fallow rotations have not been especially effective in reducing inoculum. Rotations with non-host crops coupled with the irrigations they receive seem to be more effective in reducing inoculum. Moist soil tends to favor beneficial microorganisms with antagonistic properties against diseases. Keep soil moist between crops if possible and use longer crop rotations.

Practice good sanitation. Plow down crop debris. Deep tillage provides some control where high levels of infestation are known to exist by burying inoculum of the fungus away from the carrot.

Foliar ground applications with Rovral Brand® 4 Flowable (iprodione) fungicides to control black rot are marginally effective on black crown. This may be because it is difficult to get the material to the crown of the carrot (iprodione is a contact fungicide). Mowing can sometimes improve spray penetration and coverage.

Cavity Spot (*Pythium sulcaltum*, *P. violae*) – Cavity spot is aggravated by overwatering. Monitor crop irrigations. Eliminate low spots in the field. Cover crop or green manure crops, such as Seco barley, Iron clay bell beans, Sudan grass, fodder radish and white mustard grown as cover crops, have been reported to suppress *Pythium*. However, early incorporation of green manure crops is essential. Mature carrots tend to have more pronounced cavity spot lesions; therefore, harvest early.

*Pseudomonas putida*, *Trichoderma harzianum* and *T. virens* have been identified to be antagonistic to *Pythium*. However, there is insufficient evidence that these organisms could be successfully utilized by the carrot industry.

Crown Rot (*Rhizoctonia solani*) – *Rhizoctonia solani* is a common soil inhabitant that can survive many years in the absence of a crop. *Rhizoctonia solani* can survive on crop debris and in soil as black to brownish resting structures (sclerotia) or as resting fungal mycelium. Incidence is sometimes linked to crop debris (whole potatoes, onions, carrots) from the previous crop and /or short rotations. Growers should be diligent in performing proper crop sanitation.

The organism enters through wounds and natural openings. Keeping ground equipment out of the field once carrot tops close can prevent damage caused from inadvertent leaf pulling to the crown of the carrot.

Early blight (*Cerocospora carotae*) – This foliar disease tends to be more of a problem in the coastal areas and not in the inland valleys. This disease is commonly found in the Cuyama Valley but its presence seems to be increasing in other carrot growing areas as well.

Southern blight (*Sclerotium rolfsii*) – Southern blight is most prevalent in the spring crop of carrots in the Southern San Joaquin Valley. Late planted fields, especially those that encounter unseasonably high daytime temperatures, seem to have a higher incidence of southern blight.

Large areas of the field can be affected making harvesting difficult. However, losses in the field may be insignificant in relation to the potential loss caused from the spread of various post-harvest decay organisms (such as *Erwinia carotovora*) to healthy carrots via common wash water used in the packing facility. Typically, these “new” infections are not perceptible until after the unsuspecting customer discovers the problem after buying the product.

Hosts for this disease include carrots, potatoes, beans, celery, alfalfa and many weeds. Two- to three-year rotations are beneficial. Non-host crops include small grains, corn, sorghum, onions and beets.

Wet following with alternating disking can be conducive to the breakdown of sclerotia in the soil. Thorough burying of plant debris after harvest can help destroy sclerotia. Deep plowing of infested fields with a Kverneland or Wilcox plow can isolate the sclerotia inoculum from the crop by burial. However, proper soil moisture coupled with an optimum tractor speed is essential for effective burial with this type of plow.

When possible, carrot fields scheduled back to fields previously known to be infested with *Sclerotium rolfsii* should be slotted for fall planting to avoid environmental conditions conducive to southern blight development. Harvesting should be done as quickly as possible in affected fields.

Viruses – Viruses and mycoplasma cause diseases considered to be relatively minor in carrots. Carrot Mottle Dwarf is a malady caused by two viruses: carrot redleaf virus (CRLV) and carrot mottle virus (CMoV). A mycoplasma disease, beet leafhopper transmitted virescence agent (BLTVA), is spread by leafhoppers. This disease is more prevalent in the Antelope and Cuyama Valleys.

### Cultural Control

At this point in the season, it is important to manage irrigation and fertilization so that plants are vigorous. Cultivations can be done to keep weeds down and to provide for good air circulation. Trimming of tops will also help to manage later season disease issues. Irrigation should be managed to promote good drainage in fields.

Farm equipment including irrigation pipe, cultivators and spray equipment should be cleaned to remove adhering soil and crop debris that might harbor *Alternaria* spores. In many cases, equipment is steam cleaned before being transported to the next field.

### Biological Control

There are no commercially available biological control products available, although some new materials have shown promising results.

### Chemical Control

Decisions about in-season fungicide applications are predicated on the disease presenting the greatest potential risk to the crop. For example, application of strobilurin fungicides may be used in anticipation of heavy *Alternaria* leaf blight pressure. These same applications may also control crown rot and early blight. Likewise, utilizing iprodione in rotation also picks up Cottony soft rot.

For the preventive type materials, (iprodione, chlorothalonil and copper,) treatments must start early before the disease is first detected. They call for full coverage that requires sufficient quantities of water. These treatments must be made periodically to protect new foliage. In

addition, they are essential in retreating older foliage where material has been washed off by sprinklers or precipitation.

Experience has shown that fungicides applied by ground rig generally provide the best coverage. As the plant canopy fills, the quality of the coverage can be improved with electrostatic spray technology. As with any ground application, compaction of the soil is a consideration.

Fungicides applied by sprinklers are not particularly effective. However, sprinklers might be the only suitable method available, particularly when the rows close. The greatest drawback of sprinkler application is the variability in dilution rate from one site to the next. An ancillary problem is that the fungicide can be washed to the ground if too much clear water is applied behind the treatment set.

Similarly, coverage of carrot foliage by aerial application is marginal. This is especially true in dense foliage. This is why aerial application is usually reserved as a “last-ditch” effort. Slow flying helicopters applying high volumes can allow for improved coverage, but it can be costly.

Alternaria leaf blight (*Alternaria dauci*) – No biological controls exist. Typically, fungicide programs are built around the strobilurin class of fungicides. Materials include Amistar<sup>®</sup> / Quadris<sup>®</sup> Flowable (azoxystrobin), Cabrio<sup>®</sup> EG (pyraclostrobin), Pristine<sup>®</sup> (pyraclostrobin + boscalid). The later compound combines a strobilurin with the carboxamide boscalid.

The above materials are rotated with Rovral Brand<sup>®</sup> 4 Flowable / Iprodione 4L AG (iprodione) and chlorothalonil. Trade names from this group include [Bravo Ultrex<sup>®</sup> / Echo<sup>®</sup> 75WDG Agricultural Fungicide / Bravo Weather Stik<sup>®</sup> / Echo<sup>®</sup> 720 Agricultural Fungicide]. These materials are protectant fungicides requiring repeat applications after significant rain, irrigation or the formation of new growth.

Copper fungicides are sometimes used as a preventive for *Alternaria* leaf blight and *Cercospora* leaf blight, but once disease is detected then other fungicides are used.

Bacterial leaf blight (*Xanthomonas campestris pv. carotae*) – Copper is the only option and provides fair to good control. Products with various concentrations of copper hydroxide are available including: Champ<sup>®</sup> DP, Champ<sup>®</sup> formula 2 flowable, Champion WP, Bac-stop<sup>®</sup>, Kocide<sup>®</sup> 2000 DF, and Kocide<sup>®</sup> 4.5LF Fungicide/Bactericide. In addition, copper oxide formulations of Nordox<sup>®</sup> and Nordox<sup>®</sup> 75 WG are available. This disease may also be managed in part by controlling carrot volunteers around the periphery of the field originating from previous carrot crops.

Bacterial Soft rot (*Erwinia carotovora*, *E. chrysanthemi*) – There are no biological or chemical control tools available to manage this pest at this time in the season. The best method is to irrigate properly during warm periods and to avoid standing water in the fields.

Black crown (*Alternaria radicina*) – Black crown, also known as black root rot, has no chemical or biological controls for this disease. At this point in the season, furrow irrigation is recommended over sprinkler irrigation to reduce disease development.

Cavity spot (*Pythium sulcaltum*, *P. violae*) – No biological controls exist. This disease is especially problematic on cello-type carrots. Early harvest can reduce the incidence. Ridomil Gold<sup>®</sup> (mefenoxam) offers only fair control on cavity spot.

Cottony soft rot (*Sclerotinia sclerotiorum*) – Cottony soft rot, also known as white rot, is more common under cooler conditions. Trimming of tops will help to reduce disease problems by increasing air movement and promoting drying conditions. Rovral<sup>®</sup> provides good control of this disease. Three new products, Endura<sup>®</sup> (boscalid), Switch<sup>®</sup> 62.5 WG (cyprodinil + fludioxonil)

and Pristine® (pyraclostrobin + boscalid) are currently being evaluated for efficacy against this disease.

Crown Rot (*Rhizoctonia solani*) – There are no known biological controls. Metam sodium may help to indirectly reduce infections. There are no known biological controls.

Powdery mildew (*Erysiphe polygoni*) – Resistant varieties have been a good method to manage this disease. Two new biological fungicides have been registered on carrots; Serenade®, ASO / Serenade® WP (*Bacillus subtilis*) and Sonata Biofungicide (*Bacillus pumilus*) and have shown potential for powdery mildew control on carrots.

Chemical options include sulfur based products. The flowable formulations are preferred such as Suffa®, Liquid Sulfur Six®, Sulfur 6L, Sul-Preme® 52, Super Six®, THAT® flowable sulfur. Kaligreen 82%, (potassium bicarbonate) is another new addition. These materials work best in a preventative program when applied before the onset of disease symptoms. Cabrio® provides fair to good control if used prior to disease incidence.

Southern blight (*Sclerotium rolfsii*) – Rotation and fallowing are the best cultural techniques to manage this disease. Quadris® Flowable (azoxystrobin) provides good control. There are no biological controls of this pest.

Viruses and Mycoplasma Diseases – At this point in the season, it is too late to control vectors which transmit these diseases.

### **Work Group Recommendations: Disease Management Vegetative Development**

RESEARCH	<ul style="list-style-type: none"> <li>No needs recorded</li> </ul>
REGULATORY	<ul style="list-style-type: none"> <li>Pursue material for Ridomil rotation®</li> </ul>
EDUCATION	<ul style="list-style-type: none"> <li>Growers and PCAs should be trained on resistance management techniques</li> </ul>

### **Weeds**

At this later phase of production, hand weeding, hand cultivation and the use of herbicides are the major weed control options. The Occupational Safety and Health Standards Board recently approved temporary restriction on hand weeding. A permanent rule could be issued soon. The resulting rule requires growers to show that long-handled tools are not effective for use in a crop before asking farm workers to weed by hand. Workers who are asked to perform hand weeding are entitled to longer breaks and are limited in how much time they spend hand weeding. Organic farmers, who rely on hand-weeding, are exempt from the rule.

Growers may apply Lorox® DF (linuron) postplant/preemergence and/or post emergence. The best weed control is obtained through post emergence. Linuron misses Russian thistle, marestail, clover and some grasses. It will control yellow nutsedge when applied during warmer temperatures, but can also cause some crop damage under these conditions when being used on lighter soils. Fusilade DX (fluazifop-P-butyl), Prism® Herbicide (clethodim), Poast® (sethoxydim) may be used for grassy weed problems.

Cultivations are continued into the season. Carrots out-compete most annual weeds that emerge after the 4th to 5th fern leaf stage of growth. Tillage in conjunction with herbicide treatments is necessary to properly control weeds. Primary weeds of concern are the following:

Nutsedge  
Cheeseweed (Mallow)  
Lambsquarter  
Sowthistle  
Barnyardgrass

### Work Group Recommendations Weed Management Vegetative Development

RESEARCH	<ul style="list-style-type: none"> <li>• Conduct plant-back research on Lorox<sup>®</sup> DF (linuron) 12 months currently)</li> </ul>
REGULATORY	<ul style="list-style-type: none"> <li>• Adjust Lorox<sup>®</sup> DF label for more flexible plant-back restrictions</li> </ul>
EDUCATION	<ul style="list-style-type: none"> <li>• No needs recorded</li> </ul>

#### **Insects**

Treatments for insect pests at this time of the season are not routinely done. Little information is available concerning effective biological control agents that will work well at this phase.

Grasshoppers and Salt Marsh Caterpillars – Once the canopy is established, these pests are generally not a problem. Managing a vigorous stand is the best method to reduce potential losses. Chemical treatments with carbaryl are very rare, and this is only moderately effective.

Cutworms – There are no good biological or cultural techniques to manage these pests at this time of the season. Asana<sup>®</sup> XL insecticide (esfenvalerate) through the irrigation system works well especially after the rows close and prevent ground application. Air application is used as a last resort, because spray coverage is severely limited by the crop canopy.

Aphids – Ladybugs are fairly good predators and can help to limit the spread of viral diseases through these vectors. In particular, carrot Motley Dwarf is vectored by the willow carrot aphid (*Cavariella aegopodii*.) Although sporadic, this disease stunts the growth of carrots. It is important to remove volunteer plants that can serve as a reservoir of the viral diseases. General chemical control options include Malathion 8EC, Malathion Aquamul<sup>®</sup> (malathion) and Diazinon 4E, Diazinon AG600 WBC (diazinon), which both provide excellent control of aphids.

Past experience has shown that the above materials may not adequately control outbreaks of the willow carrot aphid. Fortunately, control was achieved by using the organochlorine endosulfan known as Phaser<sup>®</sup> 3EC, Thiodan<sup>®</sup> 3EC or Thinex<sup>®</sup>. These materials have restrictions, particularly in relation to water.

Leafhoppers – These are sporadic pests that can vector viral diseases. It is important to remove volunteer plants that can serve as a reservoir of the diseases. Chemical control options include malathion, diazinon, Sevin Brand 80 WSP, Sevin XLR Plus (carbaryl) or one of the synthetic pyrethroids [Asana<sup>®</sup> XL insecticide (esfenvalerate), Baythroid 2 Emulsifiable Pyrethroid Insecticide<sup>®</sup>, Renouce<sup>®</sup> 20 WP (cyfluthrin)].

Spider Mites – These pests occasionally occur following the use of a pyrethroid-type insecticide used on other pests. The only option at this time of the season is to harvest the crop.

Biological or “soft” insecticides typically have a broad range of control. These include AZA-Direct<sup>®</sup>, Ecozin<sup>®</sup> 3% EC, Neemix<sup>®</sup> 4.5 (azadirachtin) for the control of aphids, armyworms, cabbage looper, cutworms, whiteflies; Mycotrol O<sup>®</sup> (*Beauveria bassiana*) for whitefly, aphid, thrips, grasshopper, cricket; Pyganic<sup>®</sup> 1.4EC (pyrethrins) for aphids, flea beetles, leafhoppers;

and those containing *Bacillus Thuringiensis* which includes Agree® WG Biological Insecticide, Dipel® DF Biological Insecticide, Javelin® WG Biological Insecticide, Lepinox WDG Bioinsecticide, Xentari Biological Insecticide® for the control of armyworms, beet armyworm, cabbage looper, fall armyworm.

A related product to azadirachtin is Trilogy® 70 (clarified hydrophobic extract of neem oil) and is reported to control Alternaria leaf blight (*Alternaria dauci*), Powdery mildew (*Erysiphe polygoni*), Spider mites, aphid spp., and offers suppression of whiteflies and thrips. It is used primarily in organic production.

### Work Group Recommendations Insect Management Vegetative Development

RESEARCH	<ul style="list-style-type: none"> <li>No needs recorded</li> </ul>
REGULATORY	<ul style="list-style-type: none"> <li>The work group recommended that Provado 1.6 Flowable Insecticide or Admire® 2F (imidacloprid) or Platinum (thiamethoxam) be registered for leafhoppers.</li> </ul>
EDUCATION	<ul style="list-style-type: none"> <li>No needs recorded</li> </ul>

### Vertebrates

Pocket gophers (*Thomomys bottae*), rabbits (black tailed jackrabbits, desert cottontails), and ground squirrels (*Spermophilus beecheyi*) continue to feed on plants and/or interfere with cultural operations as the crop develops.

#### Cultural Control

There are no effective cultural control methods for these pests at this timing.

#### Physical Control

Mechanical traps can control pocket gophers provided they are few in numbers. Fences used for the exclusion of rabbits can be very effective if properly managed.

#### Chemical Control

There are few chemicals available; many have been lost due to endangered species concerns. Phostoxin® (aluminum phosphide) provides poor to fair control of burrowing vertebrate pests; this product is more effective on squirrels. Strychnine is only registered on gophers and provides good control initially. ZP® rodent bait Ag (zinc phosphide) yield poor control. Anticoagulant baits P.C.Q.® pelleted rodent bait, Ramik® green rodenticide (diphacinone) provide excellent control of most vertebrates.

#### Biological Control:

Owl boxes are occasionally used to encourage nesting of owls and subsequent predatory activity on vertebrate pests; this technique is considered to provide fair levels of control and results are often times reported as variable. There are no effective biological control products for these pests at this timing.

### Work Group Recommendations: Vertebrate Management Vegetative Development

RESEARCH	<ul style="list-style-type: none"> <li>Evaluate new materials and techniques for vertebrate (squirrel) control</li> </ul>
REGULATORY	<ul style="list-style-type: none"> <li>Maintain registrations and availability of baits through counties</li> <li>Register diphacinone bait</li> </ul>
EDUCATION	<ul style="list-style-type: none"> <li>Urban interface issues</li> </ul>

## Harvest

Carrots are harvested 100 to 180 days after planting, depending upon the season and region. Produce used as whole carrots stay in the ground longer than cut and peel, which is generally harvested prior to 130 days.

Carrots have a 2- to 3-week harvest interval. With the exception of bunch carrots, the crop is almost entirely harvested by machine. In order to facilitate machine harvest, some trimming of the carrot tops is done. It is critical to have a healthy carrot top for efficient harvest. Disease problems experienced earlier in the season will impact the tops later on in the season; this is a major motivation for controlling disease at earlier phases. In addition, the older the carrot, the more susceptible it is to disease.

Carrots are taken in truck loads to the shed. Once there, they are washed in chlorinated water. Chlorine gas, 99.5% calcium hypochlorate or sodium hypochlorate, is used for chlorination of the water. They are then sorted and packed according to instructions by the buyers. No post harvest fungicides are used; carrots can be stored up to 45 days under refrigerated conditions. No controlled atmosphere is required.

**NOTE: There were no work group recommendations for this phase of carrot production.**

## Post Harvest Issues

Post harvest disease problems are usually associated with carrots grown in the summer. Problems include bacterial rot, soft rot, and yeast problems. Chlorine washes are the only options to control these types of diseases. Most are culled out.

**NOTE: There were no work group recommendations for this phase of carrot production.**

## Post Harvest Field Activities

After the carrot crop is harvested, it is important to remove the top residues in the field to get rid of the disease inoculum for the next crop. This, in combination with planting non-host crops in the recommended rotation, will greatly impact the success of subsequent carrot plantings in future years.

### Work Group Recommendations: Post Harvest Field Activities

RESEARCH	<ul style="list-style-type: none"><li>Evaluate techniques to control volunteer plants and reduce soil-borne disease inoculum</li></ul>
REGULATORY	<ul style="list-style-type: none"><li>No needs recorded</li></ul>
EDUCATION	<ul style="list-style-type: none"><li>No needs recorded</li></ul>

## Food Safety Issues

Most growers practice what are known as “Good Agricultural Practices” to reduce the potential of introducing food-borne pathogens into the food chain. Proper practices will help growers, packers, shippers, and consumers avoid problems with pathogens.

### Work Group Recommendations: Food Safety Issues

RESEARCH	<ul style="list-style-type: none"><li>Evaluate ozone as an alternative to chlorine as a sanitizing agent.</li></ul>
REGULATORY	<ul style="list-style-type: none"><li>No needs recorded</li></ul>
EDUCATION	<ul style="list-style-type: none"><li>No needs recorded</li></ul>

## Food Processor Issues

Processor issues are not really applicable for California grown carrots since the majority of the crop is sold fresh. However, if product is sent to a processor, the grower must be in compliance with guidelines of the California League of Food Processors in addition to all standard regulations concerning pesticide use. Compliance is more of an issue of meeting buyer demands as compared to meeting regulatory demands.

### Work Group Recommendations: Food Processor Issues

RESEARCH	<ul style="list-style-type: none"><li>No needs recorded</li></ul>
REGULATORY	<ul style="list-style-type: none"><li>No needs recorded</li></ul>
EDUCATION	<ul style="list-style-type: none"><li>Continue efforts to educate growers, shippers, packers and processors on food safety and pesticide regulations</li></ul>

## CRITICAL ISSUES FOR THE CALIFORNIA CARROT INDUSTRY

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

RESEARCH	<ul style="list-style-type: none"> <li>• Evaluate fumigants (alternatives for metam sodium, etc)</li> <li>• Evaluate disease prediction tools, especially models for soil-borne diseases</li> <li>• Evaluate techniques to manage disease caused by <i>Pythium</i></li> <li>• Develop resistant varieties (focus on nematodes and <i>Alternaria</i>/cavity spot)</li> <li>• Evaluate new herbicides to provide alternatives to linuron and trifluralin</li> <li>• Develop economic data on fumigants (costs/benefits, etc.)</li> <li>• Evaluate biological controls for pests of carrots</li> <li>• Study soil microbiology/microfauna relative to carrot production</li> <li>• Continue on-farm trials through UC Cooperative Extension and other organizations (variety trials, production, and pest management, etc.)</li> </ul>
REGULATORY	<ul style="list-style-type: none"> <li>• Obtain full registration for products that control <i>pythium</i> (e.g., Reason<sup>®</sup> (fenamidone) and Ranman<sup>®</sup> (cyazofamid)</li> <li>• Maintain tolerances and commercial availability of linuron and trifluralin until replacement products are registered</li> <li>• Register Prowl<sup>®</sup> H20, Prowl<sup>®</sup> 3.3EC (pendimethalin)</li> <li>• Register Provado<sup>®</sup> 1.6 Flowable Insecticide or Admire<sup>®</sup> 2F (imidacloprid) or Platinum<sup>®</sup> (thiamethoxam) for leafhoppers</li> <li>• Ensure consistent regulation of all soil fumigants</li> </ul>
EDUCATION	<ul style="list-style-type: none"> <li>• Promote use of alternate fungicides in a resistance management program</li> <li>• Provide training on the safe and effective use of soil fumigants</li> <li>• Promote good communication between manufacturers, applicators, distributors, and growers on the proper use of fumigants</li> <li>• Educate regulators on the critical need for fumigants in CA carrot production</li> <li>• Educate the industry on the importance of developing supporting data on the need and value of fumigants in carrot production</li> <li>• Maintain the Annual Carrot Symposium to disseminate industry information</li> <li>• Continue on-farm demonstration trials by UC Cooperative Extension and other organizations</li> <li>• Educate consumers on the value of carrots as part of a healthy lifestyle</li> </ul>

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[http://www.cdpr.ca.gov/docs/dprdocs/methbrom/mb\\_main.htm](http://www.cdpr.ca.gov/docs/dprdocs/methbrom/mb_main.htm)

California Agricultural Statistics Service, agricultural statistics database  
<http://www.nass.usda.gov/QuickStats/>

USDA 2002 Census of Agriculture <http://www.nass.usda.gov/census/>

## APPENDICES

### Appendix 1: 2004 California Carrot Production Statistics

FRESH MARKET	HARVESTED ACREAGE	YIELD (Tons/Ac.)	PRODUCTION (Tons)	TOTAL VALUE (\$)
CALIFORNIA	66,500	15	997,500	\$433 million
UNITED STATES	83,900	15.9	1,337,600	\$543 million
<b>CA PERCENT OF TOTAL</b>	<b>80%</b>	<b>n/a</b>	<b>75%</b>	<b>80%</b>

Source: (USDA/NASS/CASS)

PROCESSING	HARVESTED ACREAGE	YIELD (Tons/Ac.)	PRODUCTION (Tons)	TOTAL VALUE (\$)
CALIFORNIA	4,300	32	137,600	\$15.3 million
UNITED STATES	15,760	27	428,080	\$34.4 million
<b>CA PERCENT OF TOTAL</b>	<b>27%</b>	<b>n/a</b>	<b>32%</b>	<b>44%</b>

Source: (USDA/NASS/CASS)

TOTAL	HARVESTED ACREAGE	PRODUCTION (Tons)	TOTAL VALUE (\$)
CALIFORNIA	70,800	1,135,100	448.3 million
UNITED STATES	99,660	1,765,680	577.4 million
<b>CA PERCENT OF TOTAL</b>	<b>71%</b>	<b>64%</b>	<b>78%</b>

Source: (USDA/NASS/CASS)

Notes: The *CDFA Resource Directory – 2003* contains additional production statistics which may be seen at their website (<http://www.cdfa.ca.gov/publications.htm>).

## Appendix 2: Cultural Practices and Pest Management Activities

### San Joaquin Valley

<b>Cultural Practices</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Bed Preparation												
Fumigation												
Irrigation												
Fertilizer Applications												
First Cultivation												
Second Cultivation												
Planting												
Harvest												
<b>IPM Activities</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Soil Sampling												
Scouting/Monitoring												
Release of Beneficials												
Insecticide Applications												
Fungicide Applications												
Herbicide Applications												
Hand Hoeing												

### Antelope Valley

<b>Cultural Practices</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Bed Preparation												
Fumigation												
Irrigation												
Fertilizer Applications												
First Cultivation												
Second Cultivation												
Planting												
Harvest												
<b>IPM Activities</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Soil Sampling												
Scouting/Monitoring												
Release of Beneficials												
Insecticide Applications												
Fungicide Applications												
Herbicide Applications												
Hand Hoeing												

### Salinas Valley

<b>Cultural Practices</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Bed Preparation												
Fumigation												
Irrigation												
Thinning												
Fertilizer Applications												
First Cultivation												
Second Cultivation												
Planting												
Harvest												
<b>IPM Activities</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Soil Sampling												
Scouting/Monitoring												
Release of Beneficials												
Insecticide Applications												
Fungicide Applications												
Herbicide Applications												
Hand Hoeing												

### Cuyama Valley

<b>Cultural Practices</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Bed Preparation												
Fumigation												
Irrigation												
Fertilizer Applications												
First Cultivation												
Second Cultivation												
Planting												
Harvest												
<b>IPM Activities</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Soil Sampling												
Scouting/Monitoring												
Release of Beneficials												
Insecticide Applications												
Fungicide Applications												
Herbicide Applications												
Hand Hoeing												

**Coachella Valley**

<b>Cultural Practices</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Bed Preparation												
Fumigation												
Irrigation												
Fertilizer Applications												
First Cultivation												
Second Cultivation												
Planting												
Harvest												
<b>IPM Activities</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Soil Sampling												
Scouting/Monitoring												
Release of Beneficials												
Insecticide Applications												
Fungicide Applications												
Herbicide Applications												
Hand Hoeing												

Appendix 3: Seasonal Pest Occurrence

San Joaquin Valley

<b>Insects &amp; Spider Mites</b>	J	F	M	A	M	J	J	A	S	O	N	D
Flea Beetles												
Cut Worms												
Fungus Gnats												
Saltmarsh Caterpillar												
Whitefly												
Aphids												
Crickets												
Grasshoppers												
Leafhoppers												
Army Worm												
Spider Mites												
<b>Diseases</b>	J	F	M	A	M	J	J	A	S	O	N	D
Damping Off												
Cavity Spot												
Alternaria												
Pythium												
Bacterial Leaf Blight												
Bacterial Soft Rot												
Powdery Mildew												
Black Rot												
Viruses												
<b>Nematodes</b>	J	F	M	A	M	J	J	A	S	O	N	D
Root knot												
Stubby Root												
Needle												
Lesion												
<b>Weeds</b>	J	F	M	A	M	J	J	A	S	O	N	D
Little Mallow												
Henbit												
Knotweed												
Lambsquarters												
Shepardspurse												
Sowthistle												
Annual Bluegrass												
Barnyardgrass												
Nutsedge												
Stinging Nettle												
Groundsel												
Purslane												
Bermuda Grass												
Russian Thistle												
<b>Vertebrate Pests</b>	J	F	M	A	M	J	J	A	S	O	N	D
Rabbits												
Gophers												
Squirrels												
Horned Lark												

## Antelope Valley

<b>Insects &amp; Spider Mites</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Flea Beetles												
Cut Worms												
Fungus Gnats												
Saltmarsh Caterpillar												
Whitefly												
Aphids												
Crickets												
Grasshoppers												
Leafhoppers												
Army Worm												
Spider Mites												
<b>Diseases</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Damping Off												
Cavity Spot												
Alternaria												
Pythium												
Bacterial Leaf Blight												
Bacterial Soft Rot												
Powdery Mildew												
Black Rot												
Viruses												
<b>Nematodes</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Root knot												
Stubby Root												
Needle												
Lesion												
<b>Weeds</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Little Mallow												
Henbit												
Knotweed												
Lambsquarters												
Shepardspurse												
Sowthistle												
Annual Bluegrass												
Barnyardgrass												
Nutsedge												
Stinging Nettle												
Groundsel												
Purslane												
Bermuda Grass												
Russian Thistle												
<b>Vertebrate Pests</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Rabbits												
Gophers												
Squirrels												
Horned Lark												

### Salinas Valley

<b>Insects &amp; Spider Mites</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Flea Beetles												
Cut Worms												
Fungus Gnats												
Saltmarsh Caterpillar												
Whitefly												
Aphids												
Crickets												
Grasshoppers												
Leafhoppers												
Army Worm												
Spider Mites												
<b>Diseases</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Damping Off												
Cavity Spot												
Alternaria												
Pythium												
Bacterial Leaf Blight												
Bacterial Soft Rot												
Powdery Mildew												
Black Rot												
Viruses												
<b>Nematodes</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Root knot												
Stubby Root												
Needle												
Lesion												
<b>Weeds</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Little Mallow												
Henbit												
Knotweed												
Lambsquarters												
Shepardspurse												
Sowthistle												
Annual Bluegrass												
Barnyardgrass												
Nutsedge												
Stinging Nettle												
Groundsel												
Purslane												
Bermuda Grass												
Russian Thistle												
<b>Vertebrate Pests</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Rabbits												
Gophers												
Squirrels												
Horned Lark												

### Cuyama Valley

<b>Insects &amp; Spider Mites</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Flea Beetles												
Cut Worms												
Fungus Gnats												
Saltmarsh Caterpillar												
Whitefly												
Aphids												
Crickets												
Grasshoppers												
Leafhoppers												
Army Worm												
Spider Mites												
<b>Diseases</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Damping Off												
Cavity Spot												
Alternaria												
Pythium												
Bacterial Leaf Blight												
Bacterial Soft Rot												
Powdery Mildew												
Black Rot												
Viruses												
<b>Nematodes</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Root knot												
Stubby Root												
Needle												
Lesion												
<b>Weeds</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Little Mallow												
Henbit												
Knotweed												
Lambsquarters												
Shepardspurse												
Sowthistle												
Annual Bluegrass												
Barnyardgrass												
Nutsedge												
Stinging Nettle												
Groundsel												
Purslane												
Bermuda Grass												
Russian Thistle												
<b>Vertebrate Pests</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Rabbits												
Gophers												
Squirrels												
Horned Lark												

## Coachella Valley

<b>Insects &amp; Spider Mites</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Flea Beetles												
Cut Worms												
Fungus Gnats												
Saltmarsh Caterpillar												
Whitefly												
Aphids												
Crickets												
Grasshoppers												
Leafhoppers												
Army Worm												
Spider Mites												
<b>Diseases</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Damping Off												
Cavity Spot												
Alternaria												
Pythium												
Bacterial Leaf Blight												
Bacterial Soft Rot												
Powdery Mildew												
Black Rot												
Viruses												
<b>Nematodes</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Root knot												
Stubby Root												
Needle												
Lesion												
<b>Weeds</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Little Mallow												
Henbit												
Knotweed												
Lambsquarters												
Shepardspurse												
Sowthistle												
Annual Bluegrass												
Barnyardgrass												
Nutsedge												
Stinging Nettle												
Groundsel												
Purslane												
Bermuda Grass												
Russian Thistle												
<b>Vertebrate Pests</b>	<b>J</b>	<b>F</b>	<b>M</b>	<b>A</b>	<b>M</b>	<b>J</b>	<b>J</b>	<b>A</b>	<b>S</b>	<b>O</b>	<b>N</b>	<b>D</b>
Rabbits												
Gophers												
Squirrels												
Horned Lark												

#### Appendix 4: Efficacy of Insecticides

PRODUCT	TRADE NAME	Flea Beetles	Salt Marsh Caterpillar	Cutworms/Armyworms	Whiteflies	Grasshoppers	Aphids	Leafhoppers	Spider Mites
ESFENVALERATE	Asana <sup>®</sup>	G	G	G	G	F	P	G	P
AZADIRACHTIN	Aza-Direct <sup>®</sup>								
CYFLUTHRIN	Baythroid <sup>®</sup>	G	G	G	G	F	P	G	P
BIFENTHRIN	Capture <sup>®</sup>	F							P
DIAZINON	Diazinon <sup>®</sup>	G	G	G	P	G	P	P	P
METHOMYL	Lannate <sup>®</sup>	G	G	G	P	G	P	G	P
MALATHION	Malathion	G	G	G	P	G	G	G	P
CARBARYL	Sevin <sup>®</sup>	G	G	G	P	G	P	G	P
SPINOSAD	Success <sup>®</sup>	F	G	G	P	P	P	P	P
SULFUR	Sulfur	P	P	P	P	P	P	P	P
ENDOSULFAN	Thiodan <sup>®</sup>	G	P	P	G	P	G	G	P
BACILLUS THURINGIENSIS	various	P	G	G	P	P	P	P	P
PYRETHRINS	various	G	G	G	P	G	P	G	P

Rating System: E = Excellent, G = Good, F = Fair, P = Poor/None  
 Data based on collective field observations and experiments

## Appendix 5: Efficacy of Insect Management Tools – Non-Chemical Tools

TECHNIQUE	Flea Beetles	Salt Marsh Caterpillar	Cutworms	Whiteflies	Grasshoppers	Aphids	Leafhoppers	Spider Mites
Cover Crops	P	P	P	P	P	P	P	F
Habitat management	G	F	G	P	G	P	F	F
Monitoring/ use of action thresholds	G	G	G	P	G	P	G	F
Natural enemies	P	P	P	P	P	P	P	E
Nutrition	P	P	P	F	P	P	P	F
Sanitation/ Weed	G	F	G	G	P	P	F	F
Soil/dust management	G	P	G	P	P	P	P	G
Use of models	P	P	P	P	P	P	P	F
Resistant varieties	P	P	P		P			
Water management	P	P	P	P	P	P	P	E
Weed control	G	F	E	F	F	F	F	G
Mulching	P	P	F	P	P	P	P	F
Trap Crops	F	F	P	P	P	P	P	F
Netting								
Pheromones (mating disrupt)	P	P	P	P	P	P	P	
Pheromones (Monitoring)	P	P	P	P	P	P	P	
Predatory Mites	P	P	P	P	P	P	P	F

Rating System: E = Excellent, G = Good, F = Fair, P = Poor/None  
 Data based on collective field observations and experiments

## Appendix 6: Efficacy of Weed Management Tools

PRODUCT	TRADE NAME	Broadleaf Weeds	Annual Grasses	Perennial Grasses	Perennial Broadleaf Weeds
<b>Chemical Tools</b>					
EPTC	Eptam <sup>®</sup>	P/F	F/G	F	P
FLUAZIFOP-P-BUTYL	Fusilade <sup>®</sup>	P	E	F	P
LINURON	Lorox <sup>®</sup>	E	F	P	P/F
PARAQUAT DICHLORIDE	Paraquat <sup>®</sup>	G/E	G/E	F	F
SETHOXYDIM	Poast <sup>®</sup>	P	G/E	F	P
GLYPHOSATE	Roundup <sup>®</sup>	G/E	G/E	F	F
HALOSULFURON	Sempre <sup>®</sup> CA	P	P	G	P
CLETHODIM	Prism <sup>®</sup>	NA	G	NA	NA
METRIBUZIN	Sencor <sup>®</sup>	G	G	P	P
TRIFLURALIN	Treflan <sup>®</sup>	F/G	G	P/F	P
<b>Non-chemical Tools</b>					
Cultivation		G/E	G	P/F	F
Soil/Water management		F	F	F	F
Cover crops		P/F	P/F	P/F	P/F
Hand weeding		G	P/F	P	P
Mowing		G	F	P	P
Burning		G/E	F/G	P/F	P/F
Crop Rotation		F/G	F/G	F/G	F/G

Rating System: E = Excellent, G = Good, F = Fair, P = Poor/None  
 Data based on collective field observations and experiments

## Appendix 7: Efficacy of Disease Management Tools

PRODUCT	TRADE NAME	Cavity Spot	Alternaria Leaf Blight	Pythium	Bacterial Leaf Blight	Bacterial Soft Rot	Powdery Mildew	Damping Off	Black Rot	Viruses
<b>Chemical Tools</b>										
AZOXYSTROBIN	Quadris®	P	G	P	P	P	G/E	P	G	P
MEFENOXAM	Apron®, Ridomil Gold®	F/G	P	F/G	P	P	P	F/G	F/G	P
BENOMYL	No longer registered	P	P	P	P	P	P	P	P	P
CHLOROTHALONIL	Bravo Weather Stik®	P	F/G	P	P	P	P	P	F	P
MANCOZEB	Ridomil Gold MZ®	P		P	P	P	P	P		P
IPRODIONE	Rovral®	P	E	P	P	P	P	P	E	P
THIRAM	Thiram®							E		
COPPER	various	P	P	P	F/G	P	P	P	P	
SULFUR	various	P	P	P	P	P	G/E	P	P	
<b>Non-chemical Tools</b>										
Prediction models (i.e. disease forecasting)		P	F	P	P	P	F	P	P	P
Irrigation management		F	G	F	F	E	P	E	F	P
Weed control		P	P	P	P	P	P	P	P	G/F
Resistant varieties		G	G	G	G	F	G	P	F	F
Cover crops		F	P	F	P	F	P	P	F	P
Fertilizer management		F	F	F	F	P	P	P	P	P
Vector control										G/E
Sanitation		F	F	F	F	F	F	F	F	G/F
Crop rotation		F	F	F	F	F	F	F	F	P/F
Hot water seed treatment		P	F	P	F	P	P	P	F	P

Rating System: E = Excellent, G = Good, F = Fair, P = Poor/None  
 Data based on collective field observations and experiments

## Appendix 8: Efficacy of Nematode Management Tools

PRODUCT	TRADE NAME	Root Knot	Stubby root	Needle
Chemical				
Chloropicrin	Chloropicrin	F	F	F
1,3-Dichloropropene	Telone <sup>®</sup>	E	E	E
Metam Sodium	Vapam <sup>®</sup> , Sectagon <sup>®</sup>	F	F	F
Non-Chemical				
Clean Cultivation		F/G	F/G	F/G
Soil Sampling		E	E	E
Resistant Rootstock		G	G	G
Trap Crops		F	P	P
Crop Rotation		G	F	P/F

Rating System: E = Excellent, G = Good, F = Fair, P = Poor/None  
 Data based on collective field observations and experiments

## Appendix 9: Efficacy of Vertebrate Management Tools

PRODUCT	TRADE NAME	Gophers	Squirrels	Voles	Birds	Rabbits	Rodents
Chemical							
Aluminum Phosphide	Phostoxin	P/F	G	P/F		P	P
Strychnine	Strychnine	F					
Zinc Phosphide	Zinc Phosphide	F	F	F		E	F
Anticoagulant Baits	Diphacinone	E	E	E			E
Non-Chemical							
Trapping		F/G	P	P/F	P/F	P	P
Baits		P	P	P	P	P/F	P
Repellants		P	P	P	P	P	P
Frightening		P	P	P	P/F	P	P
Shooting (Lethal Control)		P	G	P	G	G	P
Prevention		P	P	P	P	G	P
Exclusion (Fencing/etc.)		P	P	P	P	G/E	P
Explosive Devices		G	G	G	P/F	P	P
Owl Boxes		P/F	P/F	P/F	P	P	P
Cultural Barriers		P	P	F	P	F	G
Predators		P/F	P/F	P/F	P	P/F	P
Noise		P	P	P	P/F	P	P
Mylar Strips		P	P	P	P/F	P	P

Rating System: E = Excellent, G = Good, F = Fair, P = Poor/None  
 Data based on collective field observations and experiments

### Appendix 10: Primary Pesticides Used in California Carrots (2003 DPR)

Trade Name	Chemical Name	% Acres Treated	Total lbs AI	Num. apps
<b>FUMIGANTS</b>				
Chloropicrin	CHLOROPICRIN	3.91	70,630	44
Telone <sup>®</sup>	1,3-DICHLOROPROPENE	13.6	1,197,998	239
Vapam <sup>®</sup> , Sectagon 42 <sup>®</sup>	METAM SODIUM	36.07	5,919,588	499
<b>FUNGICIDES</b>				
Quadris <sup>®</sup>	AZOXYSTROBIN	7.58	1,626	130
Apron <sup>®</sup> , Ridomil Gold <sup>®</sup>	MEFENOXAM	35.66	15,087	1,161
Apron <sup>®</sup> , Ridomil Gold <sup>®</sup>	MEFENOXAM	33.4	430	1,096
Cabrio <sup>®</sup>	PYRACLOSTROBIN	9.22	2,594	161
Rally <sup>®</sup> (Not registered)	CHLOROTHALONIL	13.63	25,412	300
Ridomil Gold MZ <sup>®</sup>	MANCOZEB	.11	93	2
Rovral <sup>®</sup>	IPRODIONE	21.19	17,563	452
various	COPPER HYDROXIDE	11.59	20,690	328
various	COPPER OXIDE (OUS)	209	3,844	46
<b>HERBICIDES</b>				
Eptam <sup>®</sup>	EPTC	.25	951	5
Fusilade <sup>®</sup>	FLUAZIFOP-P-BUTYL	8.01	1,835	121
Lorox <sup>®</sup>	LINURON	52.31	46,505	1,403
Paraquat <sup>®</sup>	PARAQUAT DICHLORIDE	.31	320	5
Poast <sup>®</sup>	SETHOXYDIM	.67	220	24
Roundup <sup>®</sup>	GLYPHOSATE	1.15	1,457	22
Select <sup>®</sup>	CLETHODIM	1.15	129	19
Treflan <sup>®</sup>	TRIFLURALIN	41.27	32,522	627
<b>INSECTICIDES</b>				
Asana <sup>®</sup>	ESFENVALERATE	11.34	509	231
Aza-Direct <sup>®</sup>	AZADIRACHTIN	.04	1	4
Baythroid <sup>®</sup>	CYFLUTHRIN	2.01	79	29
Capture <sup>®</sup>	BIFENTHRIN	.58	85	55
Diazinon	DIAZINON	6.39	5,751	151
Lannate <sup>®</sup>	METHOMYL	3.61	2,687	100
Malathion	MALATHION	1.78	2,821	39
Sevin <sup>®</sup>	CARBARYL	.17	202	4
Success <sup>®</sup>	SPINOSAD	1.46	240	79
Sulfur	SULFUR	15.18	298,558	355
Thiodan <sup>®</sup>	ENDOSULFAN	.44	374	5
various	BACILLUS THURINGIENSIS	1.64	133	29
various	BACILLUS THURINGIENSIS	.22	35	10
various	PYRETHRINS	.27	8	10

## Appendix 11: California Carrot Industry – Contact Information

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