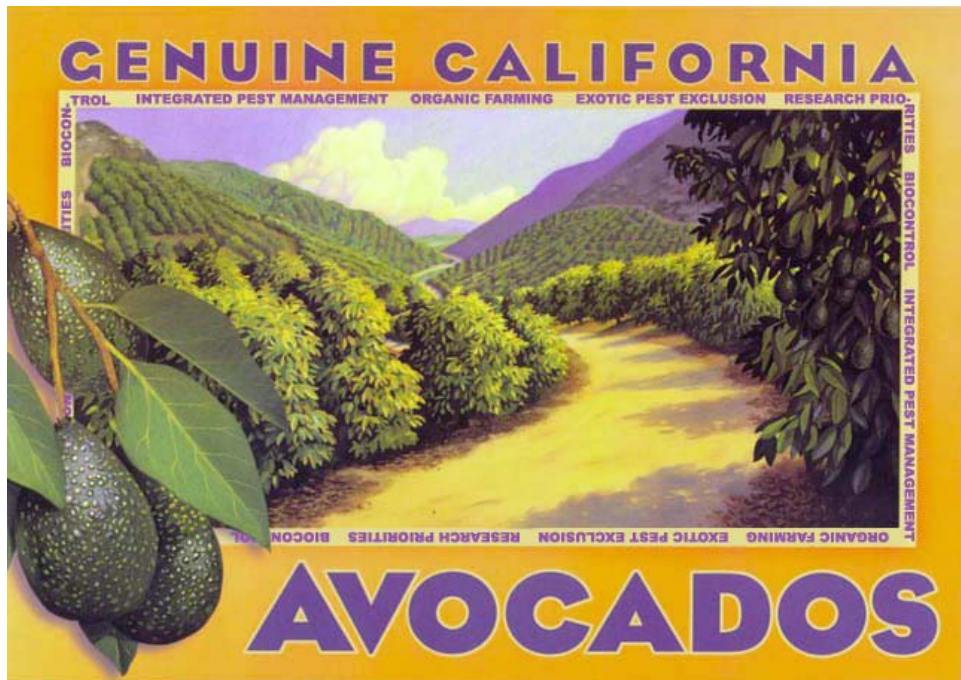


A Pest Management Strategic Plan for Avocado Production in California



The California Avocado Commission (CAC)

The California Minor Crops Council (CMCC)

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

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

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

TABLE OF CONTENTS

EXECUTIVE SUMMARY	1
1. CALIFORNIA AVOCADO PRODUCTION OVERVIEW	5
2. PEST MANAGEMENT FOR AVOCADOS.....	8
FLOWER BUD DEVELOPMENT	8
PRE-BLOOM TO OPEN FLOWER	12
POLLINATION AND FRUIT SET	15
FRUIT DEVELOPMENT TO HARVEST.....	19
HARVEST.....	24
POST-HARVEST.....	26
PLANT GROWTH REGULATORS (PGRs).....	27
GENETICALLY MODIFIED ORGANISMS (GMOs)	27
FOOD SAFETY	28
INTERNATIONAL ISSUES.....	28
3. CRITICAL ISSUES FOR THE CALIFORNIA AVOCADO INDUSTRY	29
REFERENCES	30
APPENDICES	31
1. 2002 California Avocado Production Statistics.....	31
2. Avocado Development, Cultural Practices, and Pest Management Activities.....	32
3. Seasonal Pest Occurrence in California Avocados	34
4. Efficacy of Insect Management Tools Used in California Avocados	36
5. Efficacy of Weed Management Tools Used in California Avocados.....	38
6. Efficacy of Disease Management Tools Used in California Avocados.....	39
7. Efficacy of Vertebrate Management Tools Used in California Avocados	39
8. Members of the California Avocado Work Group	40
9. California Avocado Industry – Contact Information	41

EXECUTIVE SUMMARY

California is the primary producer of avocados in the U.S., accounting for over 95% of the total U.S. crop and about 10% of the world's supply. Approximately 60,000 harvested acres of avocados in California produce from 2,000 up to 20,000 pounds of fruit per acre per year on somewhat alternate bearing trees.

California is ideally suited to growing high quality avocados; the major production regions are located in the cool, semi-arid sections of the state, mostly along the southern coast. Excellent growing conditions, in combination with a grower-supported research and education program, have enabled the industry to significantly increase average yields over the last decade. A highly productive relationship between the California avocado industry and its land grant partners (University of California and USDA-ARS) accounts for much of these gains.

Pests in avocados relative to those in other tree fruits have been historically light -- until recent years. A biologically-based system of integrated pest management (IPM) had served the growers very well until the recent introduction of new pests, including avocado thrips and persea mite. In light of this, the rush to implement NAFTA trade agreements, without adequate scientific support to ensure that phytosanitary policies are supported by credible data, has placed the California avocado industry at considerable risk of further exotic pest introductions. These factors, and the potential loss of crop protection tools, make today's industry vulnerable.

New safety standards set forth by the 1996 Food Quality Protection Act (FQPA) have significantly impacted the availability and/or use patterns of important crop protection chemicals used in agriculture, especially organophosphate and carbamate insecticides/miticides. While the avocado industry hopes to maintain very low levels of chemical input, the high value of the crop and the current threat from new pests in avocados make the availability of these tools imperative. Meanwhile, the California avocado industry continues to work diligently with its state and federal partners to evaluate, register, and implement reduced risk production practices.

"Minor" crops, such as avocados, face challenges in getting new crop protection tools registered. As the costs to conduct required research and register new materials increase, 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 like avocados are more likely to lose pest management tools, with less likelihood that these will be replaced by new products.

To help transition to "Reduced Risk" pest management in accordance with FQPA and other regulatory activities, the USDA and EPA have requested that all commodities develop Pest Management Strategic Plans (PMSPs) to identify growers' critical research, registration, and educational needs. "Reduced Risk" broadly describes pest management techniques and tools that are safe for consumers, workers, and the environment.

In 2003, several members of the avocado industry -- growers, packers, shippers, pest control advisers (PCAs), cooperative extension personnel, farm advisors and research scientists -- met specifically to discuss long-term issues associated with insect, mite, disease, weed, and vertebrate control. A work group, including representatives from the Environmental Protection Agency Region 9 and the Western Region Integrated Pest Management Center, was formed to develop a Pest Management Strategic Plan (PMSP) to address the issues of greatest concern to avocado growers in California. Focusing on the pests that have the most significant economic impact on the California avocado industry, the stakeholders identified the critical research, regulatory, and educational needs of California avocado growers.

The *Crop Profile for California Avocados* (<http://pestdata.ncsu.edu/cropprofiles/docs/caavocados.html>) is the foundation for this PMSP. The plan comprehensively summarizes the crop production and pest management practices of the California avocado industry and highlights the most important issues the industry currently faces; this document will be periodically updated. Individual growers, pest control advisers, industry representatives, and university research and extension personnel are listed in the Appendices, for those seeking more detailed information on avocado production and pest management practices in California.

The mention of any product name in this document does not represent endorsement by any member of the Avocado Work Group. Chemical names and accompanying trade names of products used in avocados are listed in the Appendices.

Stakeholder Recommendations

As a result of the industry meeting held in February 2003, and reviewers' comments since then, the Avocado Work Group identified the following research, regulatory, and educational priorities. These critical areas must be addressed to maintain the economic viability of the avocado industry in California.

Research Priorities

Finding effective techniques to detect and manage insect, mite, and disease pests is the most immediate concern of California avocado growers. The introduction of new pests in recent years makes it necessary to develop an updated system of IPM for this crop; studies of basic biology, and development of economic thresholds, including detection and sampling methods, will be required for each new pest introduction. University research and extension programs, critical to identifying and adopting new technologies for pest management in California avocado production, should be supported on a continuing basis by the appropriate local, state, and federal agencies.

- Develop a phenological model to predict physiological events in avocado production
- Evaluate and develop new pest exclusion methods
- Rebuild the biologically-based integrated pest management IPM program (addressing new pests, e.g., persea mite, avocado thrips, etc.)
- Develop sensitive pest detection tools
- Develop economic thresholds for common pests
- Locate/identify biological controls for avocado pests in their center of origin (i.e., foreign exploration)
- Identify pest species in foreign countries which could be of future concern to the California avocado industry
- Evaluate new miticides
- Validate and standardize pest sampling methods and reporting
- Evaluate new rootstocks for disease resistance
- Evaluate new rootstocks for salinity tolerance/resistance
- Evaluate the impact of recycled water on tree health
- Study the relationship between tree health/phenology and pest management
- Develop a plant growth regulator (PGR) program for avocados
- Monitor field levels of resistance to important pesticides used in avocados
- Develop a Best Management Practices (BMPs) system to address fruit quality/safety and resource management issues related to avocado production

Regulatory Priorities

The avocado industry needs the support of USDA-APHIS and all other supporting agencies in the detection and exclusion of exotic pest species. Fair policies should be established for the oversight of international phytosanitary standards. Full registrations are needed for miticides and plant growth regulators. Improved harmonization between Cal/EPA and US EPA is critical to facilitate timely registration of reduced risk products; the IR-4 program should be used efficiently to identify good product candidates for research and registration.

- Enforce pest exclusion activities and regulations
- Establish fair policies and regulations concerning international phytosanitary issues
- Establish international equity in pesticide regulations in all avocado producing countries
- Obtain a full Section 3 registration for AgriMek®
- Expedite registrations of plant growth regulators (PGRs)

Educational Priorities

The public, including regulators and consumer groups, must be educated about the use of Integrated Pest Management (IPM) in California avocado production, and how this system optimizes food production and ensures safety for workers and the environment. 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. All stakeholders need to be educated on good agricultural practices and food safety. The regulatory community needs to be educated on the unique characteristics of how this semitropical fruit is grown. Finally, consumers should be reminded that eating California avocados is an important part of a healthy lifestyle and that this produce is grown under the highest standards of safety and quality in the world.

- Educate USDA-APHIS on new techniques to exclude pests
- Educate stakeholders and the general public on the risks and economic loss associated with introductions of exotic pests
- Educate agencies on “border interception” issues and how the shift away from pest exclusion to homeland security creates situations which are detrimental to California agriculture, particularly avocados
- Continue to educate growers and PCAs on pest identification and management, and on pesticide resistance management
- Educate growers on irrigation management for disease control
- Educate growers and PCAs on the relationship between cultural management and fruit quality
- Educate regulators on avocado production and related issues through training and tours
- Provide training on Best Management Practices (BMPs) to growers, PCAs, applicators, and workers
- Provide training to all stakeholders on the use of Good Agricultural Practices (GAPs) to ensure food safety
- Educate retailers and consumers on the proper handling and preparation of avocados
- Educate retailers and consumers on the outstanding nutritional, quality, and food safety attributes of California-grown avocados

The California Minor Crops Council (CMCC) and the California Avocado Commission (CAC) received funding for this project from several sources including: the EPA Region 9 Agricultural Initiative and the USDA Cooperative States Research, Education, and Extension Service (CSREES) Pest Management Alternatives Program (PMAP); the California Avocado Commission; the Western Regional Pest Management Center at UC Davis; 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 Avocado Commission (CAC)

The California Minor Crops Council (CMCC)

November 2003

A PEST MANAGEMENT STRATEGIC PLAN FOR CALIFORNIA

1. CALIFORNIA AVOCADO PRODUCTION OVERVIEW

Avocados are subtropical, evergreen trees that produce one crop per year; mature trees can produce approximately 10 tons of fruit per acre. Suited to areas with well-drained, sandy loam soils, avocados thrive in the coastal areas of California. The trees are very sensitive to stress, especially cold temperatures and saline soil conditions. Avocados are irrigated through sprinkler and drip systems. Water, labor, and pest management account for the majority of avocado production costs.

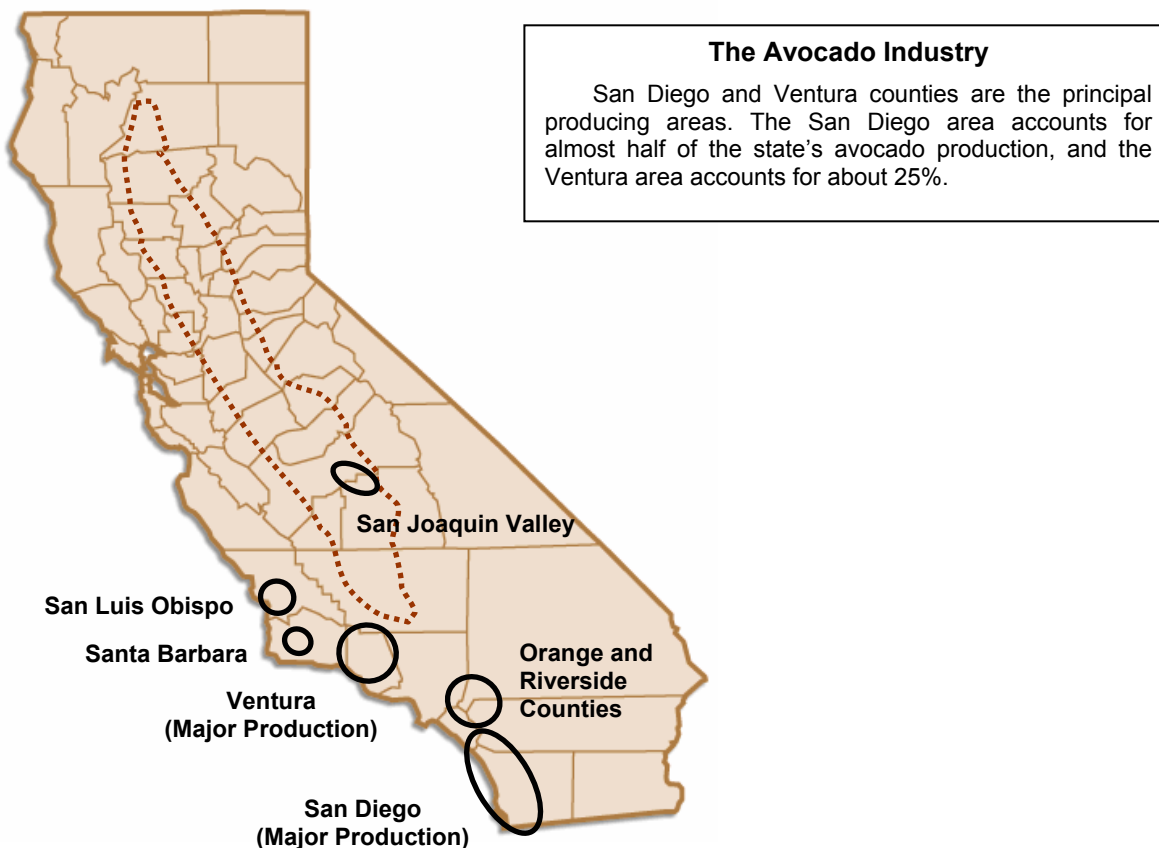
The avocado crop year extends from November through October. Avocados may exhibit two growth flushes per year and may flower for up to six months; the trees often exhibit an alternate bearing habit. Fruit can remain on the tree for several months after maturity: both “old” and “new” fruit can be found on the same tree. The harvest season may be extended over several months, so growers generally pick to meet market demands. Avocados are graded based upon the size and appearance of the fruit.

California Avocado Production Summary

- California produces approximately 95% of the avocados grown in the United States; other states, including Florida, Hawaii, and Texas, produce avocados on a smaller scale.
- California produces approximately 10% of the world production of avocados.
- Cost of production in California ranges from \$2400 to \$4800 per acre.
- There are approximately 60,000 acres of bearing avocados in California.
- It takes 3 to 6 years for an avocado tree to come into commercial production; a tree can remain productive for over 50 years.
- The California avocado industry has grown in recent years due to increased domestic consumer demand.
- California has 6 regions of avocado production: the major counties in order of importance are San Diego, Ventura, Riverside, and Santa Barbara; the San Luis Obispo area and the San Joaquin Valley are minor production areas.
- Avocados are alternate bearing and can produce from 2,000 to 20,000 pounds of fruit per acre; the average is approximately 6,500 pounds per acre for the widely grown Hass variety.
- Hass is the major variety of avocado produced in California (>90% of the acreage).
- The California avocado crop goes almost exclusively to the fresh market; little is used for processing.
- Virtually all California avocados are consumed in the U.S.; very little fruit is exported.
- Integrated pest management (IPM) has been a critical component of avocado production in California; this system has traditionally relied heavily on biological control.
- California avocado growers have historically used very few pesticides; recent problems with avocado thrips, persea mite, root rot, citricola canker, and other pest introductions have caused a significant shift in pest management practices.
- Since few new materials are registered for avocados, it is very important that replacement tools are developed before older materials are phased out due to FQPA and other regulatory actions.
- Approximately 2% of avocado acres are managed organically.
- Provisions in international trade agreements such as the North American Free Trade Agreement (NAFTA) have seriously compromised California’s ability to exclude invasive pests; this will likely force California growers to use more chemicals.

The main avocado production areas in California are shown in Figure 1. Appendix 2 contains seasonal calendars for avocado crop development, cultural practices, and pest management activities.

Figure 1: Avocado Production Regions in California



The University of California recognizes the following areas of avocado production in California.

- San Diego (major production ~47%)
- Ventura (major production ~24%)
- Riverside (~14%)
- Santa Barbara (~13%)
- Orange County (~3%)
- San Luis Obispo (very minor production)
- San Joaquin Valley (primarily Tulare and Fresno Counties – very minor production)

Generalized Timeline for Hass Avocado Development for California Conditions

Stage	Flower Bud Development	Pollination & Fruit Set	Fruit Growth & Development	Harvest	Storage
Duration	4 months	5 months	12 months	10 months	4 weeks
Timing	mid August – October	February – June	February – March	January – October	-

Avocado Varieties in California

Several avocado varieties can be grown in California, but Hass is the dominant variety, accounting for over 90% of production. Avocado varieties differ in size, oil content, flavor, skin texture, skin color, and other characteristics.

Variety	% of CA Production	Variety	% of CA Production
Hass	94	Pinkerton	<1
Bacon	2	Reed	<1
Lamb-Hass	<1	Gwen	<1
Fuerte	<1	others	<1
Zutano	<1		

Overview of Key Pests and Common Application Methods in Avocados

This section lists the most important pests of avocados that will be the main focus throughout the strategic plan. For more detailed information on avocado pests, please refer to the following:

- University of California Pest Management Guidelines for Avocados: <http://www.ipm.ucdavis.edu/PMG/selectnewpest.avocado.html>
- The California Avocado Commission website: <http://www.avocado.org>
- Extensive information on pest biology and biocontrol with excellent photos: <http://www.biocontrol.ucr.edu>
- Searchable information on avocados is available at Avocadosource: <http://www.avocadosource.com>, a privately managed website (by the Hofshi Foundation); an excellent source of information on many aspects of avocado production throughout California and the world.

Category	Important Pests
Insects and Mites	avocado thrips, perseia mite, greenhouse thrips, Western avocado leaf roller (<i>Amorbia</i>), brown mite, omnivorous looper, omnivorous leaf roller, glassy-winged sharpshooter
Snails	brown garden snail
Diseases	avocado root rot, <i>Phytophthora</i> root and collar rot, <i>Dothiorella</i> canker and fruit rot, <i>Armillaria</i> root rot, avocado black streak, <i>Verticillium</i> wilt, anthracnose, sunblotch
Weeds	annual grasses, Johnsongrass, Bermuda grass, field bindweed, mustard, nutsedge, nightshade, cocklebur, prickly pear cactus
Nematodes	not generally considered a problem in avocados
Vertebrates	gophers, meadow mice (voles), ground squirrels, coyotes, rats, deer, bears

Biological control has been the foundation of pest management in avocados for the last several decades, resulting in minimal pesticide use relative to other commodities. When pesticides are needed, the method of application varies according to pest species, severity, and orchard location. Small-scale applications often are made on a “spot spray” basis. For larger areas, most applications are aerial because 90% of the groves are on hilly ground, making access by tractor difficult and/or dangerous. Helicopters are used for all air applications. Since very few companies offer this specialized air application service, growers are sometimes forced to apply preventive pesticide sprays. This is a serious concern to the industry as it tries to manage resistance and retain the effectiveness of its limited number of registered crop protection tools.

2. PEST MANAGEMENT FOR AVOCADOS

This section tracks avocado development under California conditions and provides information on typical field activities and important pest issues during the following seasonal intervals which the work group identified as important in terms of horticultural and pest management events:

- Flower Bud Development
- Pre-bloom to Open Flower
- Pollination and Fruit Set
- Fruit Development to Harvest
- Harvest
- Post-harvest

Calendars for crop development and pest occurrence in the major avocado production regions are provided in Appendices 2 and 3.

FLOWER BUD DEVELOPMENT

(Bud Swell to “Cauliflower” Stage)

This stage of development covers the period of time in which primordia are forming (visible upon bud dissection) up through the time the tops of the flowers can be seen within the inflorescence. Prior to extension, the floral buds appear as small cauliflower-shaped protrusions, hence this name. During this period, the tree may also be starting to push some vegetative growth. This well-recognized period of development is an important event in terms of crop projection and crop insurance issues.

Cultural and Worker Activities

<ul style="list-style-type: none">• Harvesting• Pruning• Weed control• Frost control (irrigation and wind machines)• Scouting	<ul style="list-style-type: none">• Fertilization applications (chemigation and foliar sprays)• Collection of budwood for grafting• Brush cutting• Mulching
---	--

Insects and Mites

Avocado thrips - This new pest of California avocados was first found in 1996. Mulches and *Franklinothrips* are being evaluated as cultural and biological aids to manage avocado thrips. Lacewings can be used as general predators, but their efficacy is extremely variable. Success[®] with oil provides excellent control, but has a short residual. Veratran D[®] plus sugar or molasses provides poor to good control; this combination has a very short residual, and weather significantly impacts performance. A Section 18 for AgriMek[®] was approved in 1999; this widely-used product provides excellent control. However, use of Agri-Mek in certain counties has been severely limited when beehives are present.

Greenhouse thrips - This species is a problem mainly along the immediate coast. Spot treatments of malathion or Success[®] work well to manage this pest, and also may limit damage from avocado thrips.

Persea mite - Augmentative releases of predators can keep persea mites below damaging levels. Avoiding use of broad spectrum insecticides helps to reduce outbreaks during this time of the year; no miticides other than refined petroleum oils are registered for persea mite control.

Western avocado leaf roller (*Amorbia*) - A good cultural technique for controlling this leaf roller is to thin clusters of fruit to eliminate sites for nesting. Pruning will allow more light and air into the canopy, producing a less desirable environment for this pest. *Trichogramma* wasps provide excellent control of leaf rollers, if the release of adult wasps is well timed. Parasitic flies can also provide good levels of biological control. No chemicals are registered for this pest. Microbial insecticides such as Bt work well.

Omnivorous looper - *Trichogramma* wasps provide good to excellent control of loopers if the timing of adult wasps is proper. Scouts should also be aware of naturally occurring polyhedrosis viruses (granulosis virus), which provide good control of loopers, especially as the season progresses or as loopers reach peak population levels.

Work Group Recommendations for Insect and Mite Management during Flower Bud Development

RESEARCH	<ul style="list-style-type: none"> • Evaluate the effectiveness of mulching for suppression of avocado thrips • Develop a phenological model to predict physiological events in avocado production • Locate and evaluate biological control agents for avocado thrips • Evaluate the effectiveness of pre-bloom sprays of AgriMek® • Monitor AgriMek® resistance and search for alternatives to rotate • Evaluate <i>Orius</i> for efficacy on greenhouse thrips • Determine AgriMek®'s toxicity to bees and best use practices • Evaluate spot spraying for avocado thrip control • Conduct regional monitoring with GIS for avocado thrips
REGULATORY	<ul style="list-style-type: none"> • Work with beekeepers to overcome problems with spraying AgriMek® during bloom. • Obtain a full registration for AgriMek®
EDUCATION	<ul style="list-style-type: none"> • Educate EPA about the most effective timing of AgriMek® applications • Educate and involve beekeepers on AgriMek® toxicity issues • Educate growers and PCAs on the value of scouting • Educate growers and PCAs on pest/beneficial biology

Diseases

Phytophthora root rot and collar rot - Avocado root rot, caused by *Phytophthora cinnamomi*, is the most serious disease of avocados in California. Irrigation management to insure that tree roots do not stand in water is critical to managing this disease. Gypsum can be used to promote water penetration/percolation into the soil for better drainage. Mounding around new trees, using resistant root stocks, and providing proper nutrition to maintain vigorous trees will also help in managing root rot. Aliette® and Ridomil Gold® both work very well to control this disease, but these products are very expensive, especially Ridomil Gold®, to which resistance has developed. Collar rot, a disease caused by *Phytophthora citricola*, occurs at the crown of the tree; management techniques for collar rot are similar to those for root rot. Spreading coarse mulch encourages cellulose-feeding fungi that attack *Phytophthora* cells.

Dothiorella canker and leaf blast - Several cultural techniques aid in managing this disease. Applying water and nutrients so that trees are not stressed is important. Removing outer infected bark encourages regeneration of healthy tissue. Only disinfected tools should be used when pruning.

Bacterial canker - Controls for this disease are similar to the above mentioned cultural techniques; there are no chemical controls. Although this disease is rare, severely diseased trees occasionally must be removed from an orchard.

Anthracose - This disease sometimes follows wet winters. To allow for good ventilation and rapid drying after rain, the foliage on lower limbs should be pruned. Copper sprays are fairly effective in slowing the progress of the disease in affected areas of the orchard.

Armillaria – Although not common, this disease can be very serious. Care should be taken to not plant in areas where susceptible crops have been growing. In affected orchards, tree removal (including roots) may be required, followed by fumigation prior to replanting.

Avocado black streak - This disease can affect Guatemalan varieties of avocado, probably as a result of poor irrigation management.

Verticillium wilt - Care should be taken to not plant in areas where susceptible crops have been growing. In affected orchards, tree removal (including roots) may be required, followed by fumigation prior to replanting.

Sunblotch - The best way to avoid this increasingly common viroid-induced disease is to use certified disease-free plant materials, and to use only disinfected tools when pruning. Tree removal followed by killing the remaining stumps may be necessary to limit the spread of this disease in an orchard.

Work Group Recommendations for Disease Management during Flower Bud Development

RESEARCH	<ul style="list-style-type: none"> • Evaluate biological controls for <i>Phytophthora</i> collar rot and root rot • Evaluate new rootstocks for resistance to/tolerance of <i>Phytophthora</i> collar rot and root rot • Evaluate mulches for management of <i>Phytophthora</i> collar rot and root rot • Evaluate the relationship between fertilizer management and <i>Phytophthora</i> • Conduct studies on sunblotch and its transmission via pollen • Evaluate new rootstocks for salinity and disease tolerance/resistance • Monitor resistance to Ridomil®/Aliette® • Determine potential invasive species in other avocado growing countries
REGULATORY	<ul style="list-style-type: none"> • Establish international equity in pesticide regulations in all avocado producing countries
EDUCATION	<ul style="list-style-type: none"> • Educate growers and PCAs on resistance management

Weeds

Weeds are a problem mainly in avocado orchards less than 10 years old, where a variety of grass, broadleaf, and annual weeds can grow on the open ground between the trees. By 10 years after planting, the tree canopies shade the orchard floor, preventing most weed growth, so only minor weed control is required. In the young orchards, spot treatments of Roundup® work very well for isolated areas. Simazine® provides excellent pre-emergence weed control, but it needs to be incorporated and has some ground water restrictions. Proper irrigation management and mowing will limit weed build-up. Both hand hoeing and cutting with line trimmers work well to manage minor orchard weeds.

Work Group Recommendations for Weed Management during Flower Bud Development

RESEARCH	<ul style="list-style-type: none"> • Evaluate the benefits of weeds as habitat for beneficial insects • Evaluate the benefits of weeds for erosion control and biodiversity of insect fauna • Evaluate weed species for biological benefits and nutrient value to orchards • Find alternatives to Simazine® and Roundup®
EDUCATION	<ul style="list-style-type: none"> • Educate growers on weed control relative to canopy management

Vertebrates

Vertebrate pests can feed directly on the roots, bark, and inner tissues of avocado trees. They can also disrupt irrigation and other equipment used in the orchards. Groves near fields, pastures, and trashy areas are especially susceptible; therefore, sanitation in and around orchards is important. Monitoring for damage and presence of vertebrate pests is important throughout the year. Techniques used with variable success for vertebrate control include baiting, fumigating, trapping, lethal control, and habitat management.

Rats - Warfarin baits work very well if maintained properly; sanitation and habitat management to discourage nesting is effective. Dogs will also frighten rats and discourage nesting.

Gophers - Traps and baits (strychnine, zinc phosphide, and arsenic) work well for gophers. Blaster devices are not effective. Predators should be encouraged (e.g., by providing owl nesting boxes, hawk perches, etc.).

Coyotes - Trapping is the only effective non-lethal method of controlling coyotes.

Ground squirrels - Baits (zinc phosphide, aluminum phosphide, and arsenic) work well for ground squirrels.

Deer - Fencing effectively prevents deer from feeding on young trees. Bloodmeal and soap have been used as repellents. Hunting is allowed in season.

Work Group Recommendations for Vertebrate Management during Flower Bud Development

RESEARCH	<ul style="list-style-type: none">• Evaluate new squirrel management and control techniques• Evaluate new coyote management and control techniques• Evaluate new gopher management and control techniques
EDUCATION	<ul style="list-style-type: none">• UCCE should regularly update growers and PCAs on vertebrate control options• Develop and distribute updated literature on vertebrate control• Educate growers and PCAs on life cycles and proper timing of vertebrate management techniques

PRE-BLOOM TO OPEN FLOWER

Cultural and Worker Activities

<ul style="list-style-type: none"> • Bees are moved into orchards • Pre-bloom spray (nutrients and pest control) • Harvesting • Pruning • Weed control • Scouting 	<ul style="list-style-type: none"> • Fertilization applications (chemigation and foliar sprays) • Collection of budwood for grafting • Grafting • Brush cutting • Mulching • Irrigation
---	---

Insects

Avocado thrips - Agrimek[®] and oil are used on a wider scale at this time of the season with excellent results, but care must be taken to avoid bee kills. Success[®] used with oil provides excellent control of thrips, but has a shorter residual. Veratran D[®] plus sugar or molasses provides control rated from poor to good; this combination has a very short residual, and weather significantly impacts its performance.

Greenhouse thrips - Established populations of the parasitic wasp *Thripobious* spp. help to control greenhouse thrips biologically. Thinning clusters of fruit to remove the thrips' preferred nesting habitat is an effective cultural technique. Spot treatments of malathion work very well to manage this pest.

Work Group Recommendations for Insect and Mite Management during Pre-bloom to Open Flower

RESEARCH	<ul style="list-style-type: none"> • Develop economic thresholds for avocado thrips • Study the relationship between avocado thrip numbers pre-bloom and crop damage observed at harvest • Develop a sampling method for avocado thrips • Evaluate the use of spot spraying for avocado thrip control • Evaluate the impact of spraying AgriMek[®] over honeybee hives
REGULATORY	<ul style="list-style-type: none"> • Work with beekeepers to overcome problems with spraying AgriMek[®] during bloom • Obtain a full registration for AgriMek[®]
EDUCATION	<ul style="list-style-type: none"> • Provide training on the value of scouting and economic thresholds versus calendar-based spray programs • Educate growers on crop phenology (language, nomenclature for proper cultural and pest management timings) • Educate beekeepers on the importance of registering their hives with the county and clearly identifying hives so PCAs can easily contact them

Diseases

Phytophthora root rot and collar rot - Avocado root rot, caused by *Phytophthora cinnamomi*, is the most serious disease of avocados in California. Irrigation management to insure that tree roots do not stand in water is critical to managing this disease. Gypsum can be used to promote water penetration/percolation into the soil for better drainage. Mounding around new trees, using resistant root stocks, and providing proper nutrition to maintain vigorous trees will also help in managing root rot. Aliette® and Ridomil Gold® both work very well to control this disease, but these products are very expensive, especially Ridomil Gold®, to which resistance has developed. Collar rot, a disease caused by *Phytophthora citricola*, occurs at the crown of the tree; management techniques for collar rot are similar to those for root rot. Spreading coarse mulch encourages cellulose-feeding fungi that attack *Phytophthora* cells.

Dothiorella canker and leaf blast - Several cultural techniques aid in managing this disease. Applying water and nutrients so that trees are not stressed is important. Removing outer infected bark encourages regeneration of healthy tissue. Only disinfected tools should be used when pruning.

Bacterial canker - Controls for this disease are similar to the above mentioned cultural techniques; there are no chemical controls. Although this disease is rare, severely diseased trees occasionally must be removed from an orchard.

Anthracnose - This disease sometimes follows wet winters. To allow for good ventilation and rapid drying after rain, the foliage on lower limbs should be pruned. Copper sprays are fairly effective in slowing the progress of the disease in affected areas of the orchard.

Armillaria – Although not common, this disease can be very serious. Care should be taken to not plant in areas where susceptible crops have been growing. In affected orchards, tree removal (including roots) may be required, followed by fumigation prior to replanting.

Avocado black streak - This disease can affect Guatemalan varieties of avocado, probably as a result of poor irrigation management.

Verticillium wilt - Care should be taken to not plant in areas where susceptible crops have been growing. In affected orchards, tree removal (including roots) may be required, followed by fumigation prior to replanting.

Sunblotch - The best way to avoid this increasingly common viroid-induced disease is to use certified disease-free plant materials, and to use only disinfected tools when pruning. Tree removal followed by killing the remaining stumps may be necessary to limit the spread of this disease in an orchard.

Work Group Recommendations for Disease Management during Pre-bloom to Open Flower

RESEARCH	<ul style="list-style-type: none"> • Evaluate biological controls of <i>Phytophthora</i> collar rot and root rot • Evaluate new rootstocks for <i>Phytophthora</i> collar rot and root rot • Evaluate mulches for management of <i>Phytophthora</i> collar rot and root rot • Study sunblotch and its transmission via pollen • Evaluate new rootstocks for salinity and disease tolerance/resistance • Evaluate the relationship between fertilizer management and <i>Phytophthora</i> • Monitor resistance to Ridomil®/Aliette® • Determine potential invasive disease species in other avocado growing countries
REGULATORY	<ul style="list-style-type: none"> • Establish international regulatory equity
EDUCATION	<ul style="list-style-type: none"> • Educate growers and PCAs on resistance management

Weeds

Weeds are a problem mainly in avocado orchards less than 10 years old. After this point, the maturing trees cover the orchard floor with shade and leaf litter, which prevents most weed growth. Until trees are established, however, all weeds can pose problems; the most troublesome species are annual weeds, which require minor control. Spot treatments of Roundup® work very well for isolated areas. Simazine® provides excellent pre-emergence weed control, but this product needs to be incorporated and has some ground water restrictions. Proper irrigation management and mowing will limit weed buildup. Both hand hoeing and cutting with line trimmers work well in most situations.

Work Group Recommendations for Weed Management during Pre-bloom to Open Flower

RESEARCH	<ul style="list-style-type: none"> • Evaluate the benefits of weeds as habitat for beneficial insects • Evaluate the benefits of weeds for erosion control and biodiversity of insect fauna • Evaluate weed species for biological benefits and nutrient value to orchards • Find alternatives to Simazine® and Roundup®
EDUCATION	<ul style="list-style-type: none"> • Educate growers on weed control relative to canopy management

Vertebrates

Vertebrate pests can feed directly on the roots, bark, and inner tissues of avocado trees. They can also disrupt irrigation and other equipment used in the orchards. Groves near fields, pastures, and trashy areas are especially susceptible; therefore, sanitation in and around orchards is important. Monitoring for damage and presence of vertebrate pests is important throughout the year. Techniques used with variable success for vertebrate control include baiting, fumigating, trapping, lethal control, and habitat management.

Rats - Warfarin baits work very well if maintained properly; sanitation and habitat management to discourage nesting is effective. Dogs will also frighten rats and discourage nesting.

Gophers - Traps and baits (strychnine, zinc phosphide, and arsenic) work well for gophers. Blaster devices are not effective. Predators should be encouraged (e.g., by providing owl nesting boxes, hawk perches, etc.).

Coyotes - Trapping is the only effective non-lethal method of controlling coyotes.

Ground squirrels - Baits (zinc phosphide, aluminum phosphide and arsenic) work well for ground squirrels.

Deer - Fencing effectively prevents deer from feeding on young trees. Bloodmeal and soap have been used as repellents. Hunting is allowed in season.

Work Group Recommendations for Vertebrate Management during Pre-bloom to Open Flower

RESEARCH	<ul style="list-style-type: none"> • Evaluate new squirrel management and control techniques • Evaluate new coyote management and control techniques • Evaluate new gopher management and control techniques
EDUCATION	<ul style="list-style-type: none"> • UCCE should regularly update growers and PCAs on vertebrate control options • Develop and distribute updated literature on vertebrate control • Educate growers and PCAs on life cycles and proper timing of vertebrate management techniques

POLLINATION AND FRUIT SET

Avocados have a unique flowering and pollination system termed “dichogamy.” The flowers open twice on subsequent days, and depending on the time of day, will function as either female or male flowers. The benefits of bees and other insect visitors to avocado blossoms are not well understood; the actual need for honeybees, their best spatial placement in the grove, and optimal hive density are all debated. Still, most growers will place bees in their orchards to enhance yield.

During pollination and fruit set, any insecticide applications are generally made very early in the morning to avoid foraging bees. A permit to apply these materials is required, as is notification of beekeepers 24 to 48 hours before spraying begins. Beekeepers should be encouraged to register with the county and to make sure their hives are clearly identifiable in the event that PCAs and/or applicators need to contact them.

The avocado trees are exhibiting a spring growth flush at this time. The young, tender tissue is very attractive to thrips and serves as a reservoir for these insects, which will subsequently move onto the developing fruit.

Cultural and Worker Activities

- | | |
|---|---|
| <ul style="list-style-type: none">• Apply bee attractants• Pre-bloom spray (nutrients and pest control)• Harvesting• Pruning• Weed control• Scouting | <ul style="list-style-type: none">• Fertilization applications (chemigation and foliar sprays)• Grafting• Brush cutting• Mulching• Irrigation |
|---|---|

Insects and Mites

Avocado thrips - Success[®] used with oil provides excellent control of thrips, but has a short residual. Veratran D[®] plus sugar or molasses provides control rated from poor to good; this combination has a very short residual, and weather significantly impacts performance. AgriMek[®] provides excellent control of avocado thrips, but not all counties or growers have equal access to using this product due to different interpretations of the label language (related to bee foraging) by local regulatory authorities. Lacewings can be used as general predators, but their performance varies greatly from poor to very good.

Greenhouse thrips - This species is a problem mainly in San Diego County. Spot treatments of malathion work very well to manage this pest and can also reduce damage from avocado thrips. Oils are often used as a spot treatment with good results. Thinning fruit clusters limits thrip population development by removing the pest's preferred habitat.

Persea mite - Natural biological control, augmentative releases of predators, and environmental conditions usually keep mites below damaging levels. Avoiding the use of broad spectrum insecticides also helps to reduce outbreaks during this time of the year. No chemicals are registered for persea mite. Narrow-range petroleum oils are often applied as an effective spot treatment, but must be used cautiously because they can cause pest resurgence or leaf burn during warm temperatures. Sulfur is used occasionally, but should not be applied in hot weather due to phytotoxicity.

Brown mite - Oils are often used as a spot treatment with good results on brown mites; predatory mites and beetles can provide excellent biological control. Sulfur is occasionally used, but must be avoided in hot weather due to phytotoxicity.

Western avocado leaf roller (*Amorbia*) – Controls include thinning clusters of fruit to eliminate nesting sites and pruning to allow more light and air into the canopy, producing a less desirable environment for this pest. *Trichogramma* wasps provide excellent control of leaf rollers, if the timing of adult wasps is proper. No chemicals are registered for this pest.

Omnivorous looper - *Trichogramma* wasps provide good to excellent control of loopers if the timing of adult wasps is proper. Scouts should also be aware of naturally occurring polyhedrosis viruses, which provide good control of loopers, especially as the season progresses.

Glassy-winged sharpshooter - Local regulatory authorities may require treatment of this pest.

Work Group Recommendations for Insect Management during Pollination through Fruit Set

RESEARCH	<ul style="list-style-type: none"> • Study the effects of forced early vegetative growth during fruit set and early fruit development on avocado thrip management • Evaluate insecticides for control of glassy-winged sharpshooter
REGULATORY	<ul style="list-style-type: none"> • Work with beekeepers to overcome problems with spraying AgriMek[®] during bloom • Obtain a full Section 3 registration for AgriMek[®]
EDUCATION	<ul style="list-style-type: none"> • Provide training on the value of scouting and economic thresholds versus calendar-based spray programs • Educate growers on staging of crop (language, nomenclature for proper cultural and pest management timings) • Educate beekeepers on the importance of registering their hives with the county and clearly identifying hives so PCAs can easily contact them

Diseases

Phytophthora root rot and collar rot - Avocado root rot, caused by *Phytophthora cinnamomi*, is the most serious disease of avocados in California. Irrigation management to insure that tree roots do not stand in water is critical to managing this disease. Gypsum can be used to promote water penetration/percolation into the soil for better drainage. Mounding around new trees, using resistant root stocks, and providing proper nutrition to maintain vigorous trees will also help in managing root rot. Aliette[®] and Ridomil Gold[®] both work very well to control this disease, but these products are very expensive, especially Ridomil Gold[®], to which resistance has developed. Collar rot, a disease caused by *Phytophthora citricola*, occurs at the crown of the tree; management techniques for collar rot are similar to those for root rot. Spreading coarse mulch encourages cellulose-feeding fungi that attack *Phytophthora* cells.

Dothiorella canker and leaf blast - Several cultural techniques aid in managing this disease. Applying water and nutrients so that trees are not stressed is important. Removing outer infected bark encourages regeneration of healthy tissue. Only disinfected tools should be used when pruning.

Bacterial canker - Controls for this disease are similar to the above mentioned cultural techniques; there are no chemical controls. Although this disease is rare, severely diseased trees occasionally must be removed from an orchard.

Anthraco nose - This disease sometimes follows wet winters. To allow for good ventilation and rapid drying after rain, the foliage on lower limbs should be pruned. Copper sprays are fairly effective in slowing the progress of the disease in affected areas of the orchard.

Armillaria – Although not common, this disease can be very serious. Care should be taken to not plant in areas where susceptible crops have been growing. In affected orchards, tree removal (including roots) may be required, followed by fumigation prior to replanting.

Avocado black streak - This disease can affect Guatemalan varieties of avocado, probably as a result of poor irrigation management.

Verticillium wilt - Care should be taken to not plant in areas where susceptible crops have been growing. In affected orchards, tree removal (including roots) may be required, followed by fumigation prior to replanting.

Sunblotch - The best way to avoid this increasingly common viroid-induced disease is to use certified disease-free plant materials, and to use only disinfected tools when pruning. Tree removal followed by killing the remaining stumps may be necessary to limit the spread of this disease in an orchard.

Work Group Recommendations for Disease Management during Pollination through Fruit Set

RESEARCH	<ul style="list-style-type: none"> • Evaluate biological controls of <i>Phytophthora</i> collar rot and root rot • Evaluate new rootstocks for <i>Phytophthora</i> collar rot and root rot • Evaluate mulches for management of <i>Phytophthora</i> collar rot and root rot • Study sunblotch and its transmission via pollen • Evaluate new rootstocks for salinity and disease tolerance/resistance • Evaluate the relationship between fertilizer management and <i>Phytophthora</i> • Monitor resistance to Ridomil® and Aliette® • Determine potential invasive disease species in other avocado growing countries
REGULATORY	<ul style="list-style-type: none"> • Establish international regulatory equity
EDUCATION	<ul style="list-style-type: none"> • Educate growers and PCAs on resistance management

Weeds

Weed control activity becomes more intense during this part of the season due to the possibility of fires. Irrigation management and mowing will limit weed build-up. Mowing is regulated by some local fire departments. Simazine® provides excellent pre-emergence weed control, but this product needs to be incorporated and has some ground water restrictions. Spot treatments of Roundup® work very well for controlling isolated areas of weeds. Natural mulch from avocado leaves also helps control weeds. Both hand hoeing and cutting weeds with rotary line trimmers work well.

Work Group Recommendations for Weed Management during Pollination through Fruit Set

RESEARCH	<ul style="list-style-type: none"> • Evaluate the benefits of weeds as habitat for beneficial insects • Evaluate the benefits of weeds for erosion control and biodiversity of insect fauna • Evaluate weed species for biological benefits and nutrient value to orchard • Find alternatives to Simazine® and Roundup®
EDUCATION	<ul style="list-style-type: none"> • Educate growers on weed control relative to canopy management • Educate growers and PCAs on the potential benefits of weeds (habitat for beneficial insects, erosion control, nutrient value)

Vertebrates

Vertebrate pests can feed directly on the roots, bark, and inner tissues of avocado trees. They can also disrupt irrigation and other equipment used in the orchards. Groves near fields, pastures, and trashy areas are especially susceptible; therefore, sanitation in and around orchards is important. Monitoring for damage and presence of vertebrate pests is important throughout the year. Techniques used with variable success for vertebrate control include baiting, fumigating, trapping, lethal control, and habitat management.

Rats - Warfarin baits work very well if maintained properly; sanitation and habitat management to discourage nesting is effective. Dogs will also frighten rats and discourage nesting.

Gophers - Traps and baits (strychnine, zinc phosphide, and arsenic) work well for gophers. Blaster devices are not effective. Predators should be encouraged (e.g., by providing owl nesting boxes, hawk perches, etc.).

Coyotes - Trapping is the only effective non-lethal method of controlling coyotes.

Ground squirrels - Baits (zinc phosphide, aluminum phosphide and arsenic) work well for ground squirrels.

Deer - Fencing effectively prevents deer from feeding on young trees. Bloodmeal and soap have been used as repellents. Hunting is allowed in season.

Work Group Recommendations for Vertebrate Management during Pollination through Fruit Set

RESEARCH	<ul style="list-style-type: none">• Evaluate new squirrel management and control techniques• Evaluate new coyote management and control techniques• Develop hose line that coyotes are not able to chew through• Evaluate new gopher management and control techniques
EDUCATION	<ul style="list-style-type: none">• UCCE should regularly update growers and PCAs on vertebrate control options• Develop and distribute updated Information on vertebrates• Educate growers and PCAs on life cycles and proper timing of vertebrate management techniques

FRUIT DEVELOPMENT TO HARVEST

An avocado develops from an open flower into a harvestable fruit in approximately eight months. The young fruit is particularly susceptible to insect damage.

Cultural and Worker Activities

- | | |
|---|---|
| <ul style="list-style-type: none">• Moving bees into orchard as needed• Applying bee attractants• Conducting insect and weed control• Harvesting• Pruning | <ul style="list-style-type: none">• Scouting• Fertilizing• Grafting• Brush cutting• Mulching• Irrigating |
|---|---|

Insects and Mites

Fruit Flies - CDFA maintains a system of border stations, conducts inspections at international ports and airline terminals, and has developed a public information program to prevent fruit fly (*Anastrepha* spp., including Mexican fruit fly, Oriental fruit fly, and Mediterranean fruit fly) infestations. If fruit flies are detected, CDFA may initiate an emergency eradication program and quarantine that includes additional trapping, ground spraying host plants with malathion/bait, and releasing sterile fruit flies. In most quarantined avocado groves a Malathion bait mixture is applied by air; and a spinosad bait mixture has also been developed. The status of the Hass avocado variety as a fruit fly host has been under intense scientific scrutiny and is as yet unresolved.

Glassy-winged sharpshooters (GWSS) - GWSS are known to infest avocado orchards when other suitable hosts are not available for feeding or when populations of GWSS are very high. Tests for *Xylella fastidiosa* (a pathogen of great economic concern in other crops, e.g., wine grapes) have come up positive on avocado in some areas, raising concern that this disease organism may cause economic damage to the crop. So far no direct symptoms have been identified or linked to positive *Xylella* test results. Additionally, adjacent to Valencia orange groves, GWSS adults may invade avocado orchards, where they feed on fruit pedicels. GWSS excrement can cover fruit and reduce its marketability.

Avocado thrips - Success[®] used with oil provides excellent control of thrips, but has a short residual. Veratran D[®] plus sugar or molasses provides control rated from poor to good; this combination has a very short residual, and weather significantly impacts performance. AgriMek[®] provides excellent control of avocado thrips, but not all counties or growers have equal access to using this product due to different interpretations of the label language (related to bee foraging) by local regulatory authorities.

Greenhouse thrips - This species is a problem mainly in San Diego, Santa Barbara, and other coastal counties. Spot treatments of malathion manage this pest very well, and also limit damage from avocado thrips. Oil spot treatments are often used with good results.

Persea mite - Natural control generally keeps these mites at low levels. Avoiding use of broad spectrum insecticides helps to reduce outbreaks of this mite species during this period. Spot releases of predator mites are effective for persea mite control. Sulfur provides good control of this pest in inland areas, but does not work in the cooler coastal areas. Oils are often used as a spot treatment; however, re-treatment is often required. Coverage is very important; care must be taken to avoid phytotoxicity. No chemicals are registered for persea mite control.

Brown mite – These mites generally occur in summer and late fall. Spot treatments with narrow-range petroleum oils are often used with good results. Spot releases of predator mites are also effective.

Western avocado leaf roller and omnivorous looper - *Trichogramma* spp. and other parasitic wasps help to control these lepidopterous pests. In certain seasons, naturally occurring viruses can hold these populations in check. Bt works very well for these pests, but timing of applications is critical. Lannate[®] is registered, but generally not used because it causes severe mite outbreaks. Aerial applications of Malathion bait sprays for fruit fly eradication may cause populations of leaf rollers and loopers to flare up.

June beetles - These pests occasionally occur during summer on young trees near the foothills. Sevin® provides excellent control when used for border treatments only (this product is not registered for use in avocados).

Grasshoppers - Sevin® provides excellent control when used as a border treatment. Nosema® baits are most effective on the second generation.

Argentine ants - Pruning tree skirts can reduce ant problems in avocado trees. There are currently no products registered for ant control in avocados.

Snails

Snails can be problems in orchards where the skirts of the trees hang low or touch the ground and in areas where moisture/humidity is high. Snails cause only minor leaf damage, but can significantly damage fruit when their feeding penetrates the skin and damages the pulp underneath. Fruit damaged by snails is downgraded at packing. Irrigation management will help to reduce the incidence of these pests. Pruning the skirts and using copper bands will discourage snail migration and subsequent damage in trees. In some areas, decollate snails can be used to provide excellent biological control of pest snails. Metaldehyde and iron phosphate both provide good control of snails, although iron phosphate is very expensive.

Work Group Recommendations for Insect, Mite, and Snail Management during Fruit Development through Harvest

<p>RESEARCH</p>	<ul style="list-style-type: none"> • Develop feeding stations/ food sources to prevent bee movement out of the orchards • Evaluate tools to control ants around honeybee hives • Evaluate effectiveness of current inspection procedures at border and check stations • Conduct foreign exploration to locate and identify effective biological control agents for pests (e.g., avocado thrips and perseas mite) of California avocados • Survey pests in export countries for potentially invasive species which are not yet present in the U.S. • Evaluate avocado thrips' potential resistance and cross resistance to AgriMek® and Success®
<p>REGULATORY</p>	<ul style="list-style-type: none"> • Obtain a full Section 3 registration of AgriMek® • Challenge NAFTA trade agreements which seriously compromise California's ability to exclude invasive avocado pest species • Enforce current inspection procedures at border and check stations • Inspect roadside stands and vehicles for invasive pest species • Evaluate the potential for mandated chemical treatments for glassy-winged sharpshooters near nurseries, grapes, and citrus bins
<p>EDUCATION</p>	<ul style="list-style-type: none"> • Educate growers on resistance management for AgriMek® • Educate the EPA, USDA-APHIS, and the California congressional delegation in Washington on the fact that the NAFTA trade agreement has seriously compromised California's ability to exclude invasive pest species and forced the increased use of chemicals

Diseases

Phytophthora root rot and collar rot - Avocado root rot, caused by *Phytophthora cinnamomi*, is the most serious disease of avocados in California. Irrigation management to insure that tree roots do not stand in water is critical to managing this disease. Gypsum can be used to promote water penetration/percolation into the soil for better drainage. Mounding around new trees, using resistant root stocks, and providing proper nutrition to maintain vigorous trees will also help in managing root rot. Aliette® and Ridomil Gold® both work very well to control this disease, but these products are very expensive, especially Ridomil Gold®, to which resistance has developed. Collar rot, a disease caused by *Phytophthora citricola*, occurs at the crown of the tree; management techniques for collar rot are similar to those for root rot. Spreading coarse mulch encourages cellulose-feeding fungi that attack *Phytophthora* cells.

Dothiorella canker and leaf blast - Several cultural techniques aid in managing this disease. Applying water and nutrients so that trees are not stressed is important. Removing outer infected bark encourages regeneration of healthy tissue. Only disinfected tools should be used when pruning.

Bacterial canker - Controls for this disease are similar to the above mentioned cultural techniques; there are no chemical controls. Although this disease is rare, severely diseased trees occasionally must be removed from an orchard.

Anthracnose - This disease sometimes follows wet winters. To allow for good ventilation and rapid drying after rain, the foliage on lower limbs should be pruned. Copper sprays are fairly effective in slowing the progress of the disease in affected areas of the orchard.

Armillaria - Although not common, this disease can be very serious. Care should be taken to not plant in areas where susceptible crops have been growing. In affected orchards, tree removal (including roots) may be required, followed by fumigation prior to replanting.

Avocado black streak - This disease can affect Guatemalan varieties of avocado, probably as a result of poor irrigation management.

Verticillium wilt - Care should be taken to not plant in areas where susceptible crops have been growing. In affected orchards, tree removal (including roots) may be required, followed by fumigation prior to replanting.

Sunblotch - The best way to avoid this increasingly common viroid-induced disease is to use certified disease-free plant materials, and to use only disinfected tools when pruning. Tree removal followed by killing the remaining stumps may be necessary to limit the spread of this disease in an orchard.

Work Group Recommendations for Disease Management during Fruit Development through Harvest

RESEARCH	<ul style="list-style-type: none"> • Evaluate the potential for nematode strains to transmit <i>Xylella</i> disease • Study the susceptibility of avocado to the sudden oak death strain of <i>P. ramorum</i> • Evaluate topical applications of Aliette® and Ridomil® (fungicides) for control of collar rot • Evaluate hyphoderma-like disease and its potential impact on avocados • Study how sunblotch disease is transmitted • Evaluate the long-term effectiveness of mulch for control of <i>Phytophthora</i> • Develop a standard for mulch efficacy • Continue research on salinity
REGULATORY	<ul style="list-style-type: none"> • Establish equitable regulatory policies on potential imported crops • Regulate the consistency of mulch quality to minimize its potential for causing disease and weed problems. • Establish a standard for mulch efficacy
EDUCATION	<ul style="list-style-type: none"> • Provide training on the benefits of keeping equipment clean • Provide information on how disease-contaminated personnel and equipment spread disease when moving between groves, and how this cross-contamination can be managed

Weeds

Weed control activity becomes more intense during this part of the season due to the possibility of fires. Irrigation management and mowing will limit weed build-up. Mowing is regulated by some local fire departments. Simazine® provides excellent pre-emergence weed control, but this product needs to be incorporated and has some ground water restrictions. Spot treatments of Roundup® work very well for controlling isolated areas of weeds. Natural mulch from avocado leaves also helps control weeds. Both hand hoeing and cutting weeds with rotary line trimmers work well.

Work Group Recommendations for Weed Management during Fruit Development through Harvest

RESEARCH	<ul style="list-style-type: none"> • Evaluate the benefits of weeds as habitat for beneficial insects • Evaluate the benefits of weeds for erosion control and biodiversity of insect fauna • Evaluate weed species for biological benefits and nutrient value to orchards • Find alternatives to Simazine® and Roundup®
EDUCATION	<ul style="list-style-type: none"> • Educate growers on weed control relative to canopy management

Vertebrates

Vertebrate pests can feed directly on the roots, bark, and inner tissues of avocado trees. They can also disrupt irrigation and other equipment used in the orchards. Groves near fields, pastures, and trashy areas are especially susceptible; therefore, sanitation in and around orchards is important. Monitoring for damage and presence of vertebrate pests is important throughout the year. Techniques used with variable success for vertebrate control include baiting, fumigating, trapping, lethal control, and habitat management.

Rats - Warfarin baits work very well if maintained properly; sanitation and habitat management to discourage nesting is effective. Dogs will also frighten rats and discourage nesting.

Gophers - Traps and baits (strychnine, zinc phosphide, and arsenic) work well for gophers. Blaster devices are not effective. Predators should be encouraged (e.g., by providing owl nesting boxes, hawk perches, etc.).

Coyotes - Trapping is the only effective non-lethal method of controlling coyotes.

Ground squirrels - Baits (zinc phosphide, aluminum phosphide and arsenic) work well for ground squirrels.

Deer - Fencing effectively prevents deer from feeding on young trees. Bloodmeal and soap have been used as repellents. Hunting is allowed in season.

Work Group Recommendations for Vertebrate Management during Fruit Development through Harvest

RESEARCH	<ul style="list-style-type: none">• Evaluate new squirrel management and control techniques• Evaluate new coyote management and control techniques• Evaluate new gopher management and control techniques
EDUCATION	<ul style="list-style-type: none">• UCCE should regularly update growers and PCAs on vertebrate control options• Develop and distribute updated information on vertebrate control• Educate growers and PCAs on life cycles and proper timing of vertebrate management techniques

HARVEST

The avocado harvest extends over a 10-month period, usually from January through October, with July as the peak month. Avocados are generally harvested from the ground, on ladders, and, in the case of very large trees, by climbing, or by using cherry pickers. Avocado pickers use picking clippers and picking poles. Most fruit is clipped, with a small amount of fruit stem (button) remaining, but some fruit is snapped from the tree without clippers and is packed without any fruit stem remaining. All fruit pests should be under control at this point.

Fruit thinning or size picking is performed in order to allow the remaining fruit to increase in size, so that fruit of commercially desirable sizes can be harvested. Thinning also reduces physical contact between the fruits, which reduces habitat for greenhouse thrips, mealybugs, omnivorous looper, leaf rollers, and other pests. Thrips do not like the exposed habitat of solitary fruit, so by size-picking, growers achieve two goals at the same time. However, size-picking is not practiced industry-wide because it is expensive to go through a grove multiple times to pick. On the other hand, if there is a shortage of, and consequent price advantage to, a particular size category, some growers will concentrate on picking that particular size to meet market demand, leaving remaining fruit for a subsequent harvest. Some growers combine picking with pruning the trees.

Harvest should not be done right after a rain because of the increased possibility of anthracnose. At this time of the season, sanitation of equipment is extremely important. Clean bins should be used for storing picked fruit. The fruit must be protected from the sun, so the bins are often covered with leaves or branches. Bins should be kept under a watchful eye for theft.

Cultural and Worker Activities during Harvest

<ul style="list-style-type: none"> • Harvesting • Pruning • Weed control • Fertilization 	<ul style="list-style-type: none"> • Grafting • Brush cutting • Mulching • Irrigation
--	---

Work Group Recommendations for Insect and Disease Management during Harvest

RESEARCH	<ul style="list-style-type: none"> • Quantify the relationship between moisture and temperature in the orchard to development of post-harvest disease • Evaluate the amount of rain that will affect post-harvest disease development • Evaluate stress caused by salt build-up from fertilizers and poor water quality at this time of year
EDUCATION	<ul style="list-style-type: none"> • Educate contract workers on proper sanitation and harvest procedures • Provide training on “snap” versus “clip” picking techniques for avocados • Educate growers and PCAs on PHIs associated with the products they use

Weeds

Controls are generally the same as those reported earlier, with special emphasis on practices that reduce the potential for fires, as much of the Southern California avocado acreage is planted in coastal areas which are subject to brush fires annually.

Vertebrates

Controls are generally the same as discussed earlier, with special consideration given to rats, ground squirrels, and opossums because of their preference for mature fruit.

Work Group Recommendations for Vertebrate Management During Harvest

EDUCATION	<ul style="list-style-type: none">• Provide training on control of vertebrate pests and proper placement of bins• Provide education on the role of vertebrate management in food safety
------------------	--

Theft Issues

The high value of avocado fruit on the wholesale and retail markets has made avocado theft, both large-scale and petty, a major problem, costing the California avocado industry several million dollars annually. A sheriff monitoring program, anti-theft signage, fences, and a reward system are all employed to deter theft. Orchards without security fencing and gates are highly prone to theft. Growers also should be educated on the importance of monitoring the number of bins leaving their ranches to prevent theft.

POST-HARVEST

Avocado fruit is picked into bags or bins, then sorted and placed into lugs or bags. Next it is exposed to ethylene gas in a forced air chamber, to trigger, hasten, and promote uniform ripening. Generally, the more mature the fruit, the less ethylene is needed for this pre-conditioning.

Insects

Harvested fruit is very attractive to certain fly species, especially Mexican fruit fly and Oriental fruit fly. If the harvest occurs within a fruit fly quarantine area, the fruit must be stored at proper temperatures to avoid damage by these pests.

Work Group Recommendations for Insect Management during Post-Harvest

RESEARCH	<ul style="list-style-type: none"> Evaluate efficacy of new post-harvest quarantine treatments; evaluate fruit tolerance of these treatments
REGULATORY	<ul style="list-style-type: none"> Establish equitable policies with trading partners on quarantine issues
EDUCATION	<ul style="list-style-type: none"> Educate USDA-APHIS, Department of Homeland Security, BNAC, and other regulatory agencies on the problems associated with bringing contaminated fruit into the U.S. Broadcast more and better public service announcements on the role of the public in agricultural homeland security

Diseases

Anthracnose, Dothiorella fruit rot, Alternaria, and Phomopsis - No fungicides are registered for post-harvest use on avocados; all disease management is accomplished by maintaining proper temperature during storage.

Work Group Recommendations for Disease Management during Post-Harvest

RESEARCH	<ul style="list-style-type: none"> Conduct research to establish the relationship of cultural management and post-harvest disease incidence and severity Evaluate the use of pre-harvest fungicide applications to control post-harvest diseases Evaluate the role of PGRs in post-harvest disease management
REGULATORY	<ul style="list-style-type: none"> Enforce the minimum maturity standards for avocados Investigate uniform maturity standards for all avocados on the U.S. domestic market
EDUCATION	<ul style="list-style-type: none"> Educate fruit handlers on proper temperature management and fruit handling during ethylene treatments Insure that new growers have access to best management practices including fruit handling after harvest Educate retailers on how fruit should be handled to avoid bruising

Vertebrates

Fruit contact with rodents and birds should be prevented after harvest to reduce potential food safety issues. These pests must be excluded from stored avocados to prevent their feeding on the fruit and contaminating it with feces.

Work Group Recommendations for Vertebrate Pest Management during Post-Harvest

EDUCATION	<ul style="list-style-type: none">Educate growers, PCAs, and packers on the importance of rodent and bird management
------------------	--

PLANT GROWTH REGULATORS (PGRs)

Flowering, fruit set, fruit growth, fruit size, fruit shape, and vegetative growth can all be manipulated with plant growth regulators. Most PGRs have very soft chemistries and are not strictly regulated. Many other fruit crops rely on PGRs during the season to produce a high-value end product. The avocado industry needs to invest more in research to develop useful PGRs that may result in improved avocado production techniques and greater grower returns.

Work Group Recommendations for Plant Growth Regulators (PGRs)

RESEARCH	<ul style="list-style-type: none">Evaluate PGRs for avocadosDevelop a comprehensive PGR program for California avocados
REGULATORY	<ul style="list-style-type: none">Insure equity between the U.S. and other countries in regulations on the use of PGRs and all crop protection/management tools
EDUCATION	<ul style="list-style-type: none">Educate regulators and the public on inequities between the U.S. and other countries in regulations and policies concerning use of PGRs and other crop protection tools

GENETICALLY MODIFIED ORGANISMS (GMOs)

The California avocado industry has adopted the position that new advances in genetic science that accelerate the identification of genes and their modes of action, as well as rapid screening techniques for selecting new varieties from conventional breeding crosses, has made the pursuit of GMO varieties unnecessary. By adopting this position, the industry will circumvent criticism being leveled at GMOs, while still rapidly advancing the introduction of superior varieties.

FOOD SAFETY

The California avocado industry has an obligation to the U.S. consumer to deliver avocado fruit that is safe to eat, with no threat of food-borne illness arising from consumption. The industry has come to accept as “standard” some orchard practices which would probably not stand up to third-party scrutiny in a food safety audit (e.g., picking up windfall fruit from the orchard floor). Potential food pathogen contaminants of primary concern are *Salmonella* and *E. coli*.

Work Group Recommendations for Food Safety

RESEARCH	<ul style="list-style-type: none"> Evaluate production practices which may impact food safety status of the fruit
REGULATORY	<ul style="list-style-type: none"> Establish equity between the U.S. and other countries in regulations and policies on food safety issues
EDUCATION	<ul style="list-style-type: none"> Develop a Best Management Practices (BMP)/ Good Agricultural Practices (GAPs) manual for growers and workers Train workers on the importance of hygiene to food safety Educate regulators and the public on inequities between the U.S. and other countries in regulations and policies concerning food safety

INTERNATIONAL ISSUES

The USDA-APHIS has diverged from sound scientifically-based policies toward politically-based decisions stemming from free trade policies. The rush to implement NAFTA trade agreements, without adequate scientific support to ensure that phytosanitary policies are backed up with solid data, is placing the California avocado industry at considerable risk due to increased exotic pest introductions, increased pesticide use, and increased industry-crippling quarantines.

Work Group Recommendations for International Issues

RESEARCH	<ul style="list-style-type: none"> Conduct risk assessments on the introduction of exotic pests
REGULATORY	<ul style="list-style-type: none"> Establish equity between the U.S. and other countries in regulations and policies concerning chemical use Establish parity with other countries on Mexican import/export issues concerning chemical use USDA-APHIS risk assessments concerning introduction of exotic pests should be based on science rather than politics
EDUCATION	<ul style="list-style-type: none"> Educate regulators and the public on inequities between the U.S. and other countries in regulations and policies concerning chemical use

3. CRITICAL ISSUES FOR THE CALIFORNIA AVOCADO INDUSTRY

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

<p>RESEARCH</p>	<ul style="list-style-type: none"> • Develop a phenological model to predict physiological events in avocado production • Evaluate and develop new pest exclusion methods • Rebuild the biologically-based integrated pest management IPM program (addressing new pests, e.g., persea mite, avocado thrips, etc.) • Develop sensitive pest detection tools • Develop economic thresholds for common pests • Locate/identify biological controls for avocado pests in their center of origin (i.e. foreign exploration) • Identify pest species in foreign countries which could be of future concern to the California avocado industry • Evaluate new miticides • Validate and standardize pest sampling methods and reporting • Evaluate new rootstocks for disease resistance • Evaluate new rootstocks for salinity tolerance/resistance • Evaluate the impact of recycled water on tree health • Study the relationship between tree health/phenology and pest management • Develop a plant growth regulator (PGR) program for avocados • Monitor field levels of resistance to important pesticides used in avocados • Develop a Best Management Practices (BMPs) system to address fruit quality/safety and resource management issues related to avocado production
<p>REGULATORY</p>	<ul style="list-style-type: none"> • Enforce pest exclusion activities and regulations • Establish fair policies and regulations concerning international phytosanitary issues • Establish international equity in pesticide regulations in all avocado producing countries • Obtain a full Section 3 registration for AgriMek® • Expedite registrations of plant growth regulators (PGRs)
<p>EDUCATION</p>	<ul style="list-style-type: none"> • Educate USDA-APHIS on new techniques to exclude pests • Educate stakeholders and the general public on the risks and economic loss associated with introductions of exotic pests • Educate agencies on “border interception” issues and how the shift away from pest exclusion to homeland security creates situations which are detrimental to California agriculture, particularly avocados • Continue to educate growers and PCAs on pest identification and management, and on pesticide resistance management • Educate growers on irrigation management for disease control • Educate growers and PCAs on the relationship between cultural management and fruit quality • Educate regulators on avocado production and related issues through training and tours • Provide training on Best Management Practices (BMPs) to growers, PCAs, applicators, and workers • Provide training to all stakeholders on the use of Good Agricultural Practices (GAPs) to ensure food safety • Educate retailers and consumers on the proper handling and preparation of avocados • Educate retailers and consumers on the outstanding nutritional, quality, and food safety attributes of California-grown avocados

REFERENCES

Publications

UC IPM Pest Management Guidelines: Avocado (UC ANR Publication 3436).

The U.S. Avocado Industry. Bertelsoen, D., J. Harwood, G. Zepp. 1995. USDA-ERS.

Websites

UC Pest Management Guidelines: Pests of Avocado

<http://www.ipm.ucdavis.edu/PMG/selectnewpest.avocado.html>

UC Pest Management Guidelines: Avocado Anthracnose, Pathogen: *Colletotrichum gloeosporioides* (07/01)

<http://www.ipm.ucdavis.edu/PMG/r8100711.html>

Crop Profile for Avocados in California, Prepared: July 13, 1999

<http://pestdata.ncsu.edu/cropprofiles/docs/caavocados.html>

Avocadosource.com, a website managed by the Hofshi Foundation. For information and contribution of materials contact Reuben Hofshi at rhofshi@avocadosource.com.

California's Agricultural Resource Directory: 2002 Edition

http://www.cdfa.ca.gov/card/card_new02.htm

Fruit and Tree Nuts Outlook and Yearbook, United States Department of Agriculture, Economic Research Service

<http://www.ers.usda.gov/publications/fts/>

National Agricultural Statistical Service Commodity Reports, United States Department of Agriculture

<http://www.usda.gov/nass/pubs/estindx.htm>

California Department of Pesticide Regulation (CDPR) Pesticide Use Reports

<http://www.cdpr.ca.gov/dprdatabase.htm>

California Avocado Commission (CAC) website <http://www.avocado.org>

APPENDICES

1. 2002 California Avocado Production Statistics

COUNTY	HARVESTED ACREAGE	YIELD (Tons/Ac.)	PRODUCTION (Tons)	TOTAL VALUE (\$)
Los Angeles	46	3.2	146	124,000
Monterey	135	1.5	204	489,000
Orange	1,746	2.2	3,848	8,161,600
Riverside	7,199	2.6	18,717	36,426,900
San Bernardino	223	4.4	990	2,661,000
San Diego	25,729	2.9	75,515	152,277,100
San Luis Obispo	1,527	3.3	4,992	9,665,000
Santa Barbara	8,620	2.8	24,136	44,932,300
Tulare	367	3.1	1,130	2,011,000
Ventura	18,588	3.3	60,894	99,341,000
STATE TOTALS	64,180	Average 3.0	190,572	356,088,900

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

Notes: The *CDFA Resource Directory – 2002* contains additional production statistics which may be seen at their website (<http://www.cdfa.ca.gov/publications.htm>). The California Avocado Commission also has production statistics available at <http://avocado.org>. There are discrepancies in acreage reports according to various reporting sources.

2. Avocado Development, Cultural Practices, and Pest Management Activities

San Diego Production Area

Crop Development	J	F	M	A	M	J	J	A	S	O	N	D
Root Growth					■	■	■	■	■	■	■	
Flower Bud Initiation								■	■	■	■	■
Flower Bud Development	■	■	■									■
Flowering and Pollination	■	■	■	■	■	■						
Fruit Set		■	■	■	■	■	■					
Fruit Drop					■	■	■	■	■			
Fruit Growth and Development	■	■	■	■	■	■	■	■	■	■	■	■
Leaf Growth Flush		■										■
Harvest	■	■	■	■	■	■	■	■	■	■	■	■
Storage	■	■	■	■	■	■	■	■	■	■	■	■
Cultural Practices	J	F	M	A	M	J	J	A	S	O	N	D
Irrigation	■	■	■	■	■	■	■	■	■	■	■	■
Pruning				■			■	■		■		■
Thinning				■				■	■	■		■
Frost Protection	■	■	■								■	■
Fertilizer Application	■	■	■	■	■	■	■	■	■	■	■	■
Bees Placed in Orchards		■	■	■	■	■	■	■	■	■	■	■
Pest Management Activities	J	F	M	A	M	J	J	A	S	O	N	D
Soil Sampling	■	■	■	■	■	■	■	■	■	■	■	■
Scouting	■	■	■	■	■	■	■	■	■	■	■	■
Foliar Nutrient Applications		■	■	■				■	■	■		
Insecticide Applications				■	■	■	■	■	■	■		
Miticide Applications			■	■	■	■	■	■	■	■		
Release of Beneficials				■	■	■	■	■	■	■		
Fungicide Applications	■	■	■									
Use of Pheromones		■	■	■	■	■	■	■	■	■	■	■
Herbicide Applications	■	■	■	■	■	■	■	■	■	■	■	■
Vertebrate Control	■	■	■	■	■	■	■	■	■	■	■	■

Data based on collective field observations

2. Avocado Development, Cultural Practices, and Pest Management Activities (Cont'd)

Ventura Production Area

Crop Development	J	F	M	A	M	J	J	A	S	O	N	D
Root Growth							■	■	■	■	■	■
Flower Bud Initiation	■									■	■	■
Flower Bud Development	■	■	■	■							■	■
Flowering and Pollination		■	■	■	■	■						
Fruit Set			■	■	■	■	■					
Fruit Drop						■	■	■	■	■	■	■
Fruit Growth and Development	■	■	■	■	■	■	■	■	■	■	■	■
Leaf Growth Flush												
Harvest	■	■	■	■	■	■	■	■	■	■	■	■
Storage	■	■	■	■	■	■	■	■	■	■	■	■
Cultural Practices	J	F	M	A	M	J	J	A	S	O	N	D
Cultivation			■	■	■	■	■	■	■			
Irrigation	■	■	■	■	■	■	■	■	■	■	■	■
Pruning	■	■	■	■				■	■	■		
Thinning							■	■				
Frost Protection										■	■	■
Fertilizer Application	■	■	■	■	■	■	■	■	■		■	
Bees Placed in Orchards		■	■	■	■	■	■	■				
Pest Management Activities	J	F	M	A	M	J	J	A	S	O	N	D
Soil Sampling	■	■	■								■	
Scouting	■	■	■	■	■	■	■	■	■	■	■	■
Insecticide Applications		■	■	■	■	■	■	■	■	■		
Miticide Applications										■		
Release of Beneficials				■	■	■	■	■	■			
Fungicide Applications				■	■	■	■	■				
Use of Pheromones	■	■	■	■	■	■						
Herbicide Applications	■	■	■	■	■	■	■	■	■	■		■
Vertebrate Control		■	■	■	■	■	■	■	■	■	■	■

Data based on collective field observations

3. Seasonal Pest Occurrence in California Avocados

San Diego Production Region

INSECTS/MITES	J	F	M	A	M	J	J	A	S	O	N	D
Avocado Thrips												
Persea Mite												
Greenhouse Thrips												
Western Avocado Leaf Roller												
Omnivorous Leaf Roller												
Avocado Brown Mite												
Whiteflies												
Glassy-Winged Sharpshooter												
Six-Spotted Thrips												
Brown Garden Snail												
DISEASES	J	F	M	A	M	J	J	A	S	O	N	D
Avocado Root Rot												
<i>Phytophthora</i> Canker												
<i>Dothiorella</i> Canker												
<i>Phytophthora</i> Fruit Rot												
<i>Dothiorella</i> Fruit Rot												
Anthracnose												
<i>Armillaria</i> Root Rot												
Avocado Black Streak												
Sunblotch												
WEEDS	J	F	M	A	M	J	J	A	S	O	N	D
All weeds												
VERTEBRATES	J	F	M	A	M	J	J	A	S	O	N	D
Pocket Gophers												
California Ground Squirrel												
Meadow Mice												
Rats												
Coyotes												

Data based on collective field observations

3. Seasonal Pest Occurrence in California Avocados (Cont'd)

Ventura Production Region

INSECTS/MITES	J	F	M	A	M	J	J	A	S	O	N	D
Avocado Thrips												
Persea Mite												
Greenhouse Thrips												
Western Avocado Leaf Roller												
Omnivorous Leaf Roller												
Avocado Brown Mite												
Whiteflies												
Glassy-Winged Sharpshooter												
Six-Spotted Thrips												
Brown Garden Snail												
DISEASES	J	F	M	A	M	J	J	A	S	O	N	D
Avocado Root Rot												
<i>Phytophthora</i> Canker												
<i>Dothiorella</i> Canker												
<i>Phytophthora</i> Fruit Rot												
<i>Dothiorella</i> Fruit Rot												
Anthracnose												
<i>Armillaria</i> Root Rot												
Avocado Black Streak												
Sunblotch												
WEEDS	J	F	M	A	M	J	J	A	S	O	N	D
All weeds												
VERTEBRATES	J	F	M	A	M	J	J	A	S	O	N	D
Pocket Gophers												
California Ground Squirrel												
Rats												
Coyotes												

Data based on collective field observations

4. Efficacy of Insect Management Tools Used in California Avocados

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

PRODUCT	TRADE NAME	Avocado Thrips	Persea Mite	Greenhouse Thrips	Western Avocado Leafroller	Omnivorous Looper	Avocado Brown Mite	Whiteflies	Glassy-Winged Sharpshooter	Armored Scales	Soft Scales	Six-spotted Mite	Mealybugs	Brown Garden Snail	June Beetles	False Chinch Bug	Fuller Rose Beetle	Orange Tortrix	
Chemical																			
Abamectin	Agri-Mek®	E	E																
Azadirachtin	Neem Oil	P		P				P											
<i>Bacillus thuringiensis</i>	Dipel®				F-G	F-G													
Carbaryl	Sevin®														E	E	E		
Chlorpyrifos	Lorsban®																		
Copper	various																		
Dimethoate (Section 18)	Cygon®																		
Imidacloprid (Section 18)	Admire®								E										
Malathion	various			E															
Metaldehyde	various													G					
Methomyl	Lannate®	G			E	E												E	
Narrow Range Oil	various	P	G				G	P				G							
Permethrin	Pounce®	P		F															
Pyrethrin	various	P		F															
Rotenone	Rotenone																		
Sabadilla Alkaloids	Veratran-D®	G																	
Spinosad	Success®	G		E															
Sulfur (wetable)	various	P	G				G					G							
Non-Chemical																			
Augmentative Biocontrol		F	G	F	E	G		P					F	E					
Natural Biocontrol		P	F	P	G	G	E	P	F	G	E	E	G	E					
Early Harvest/Thinning																			
Copper Bands													E						
Mulches													G						
Pruning		F	G																
Good Management			G																

Data based on collective field observations

4. Efficacy of Insect Management Tools used in California Avocados (continued)

Impact of Insecticides and Miticides on Beneficial Organisms

PRODUCT	TRADE NAME	IMPACT
Abamectin	Agri-Mek [®]	Soft
Azadirachtin	Neem Oil	Soft
<i>Bacillus thuringiensis</i>	Dipel [®]	No Effect
Copper	various	No Effect
Dimethoate	Cygon [®]	Harsh
Imidacloprid	Admire [®]	Soft
Malathion	various	Harsh
Methomyl	Lannate [®]	Harsh
Narrow Range Oil	various	Moderate
Permethrin	Pounce [®]	Moderate
Pyrethrin	various	Soft
Piperonyl Butoxide	Pyrenone [®]	No Effect
Sabadilla Alkaloids	Veratran D [®]	Soft
Sulfur (wetable)	various	Moderate

5. Efficacy of Weed Management Tools Used in California Avocados

Rating System: C = Control Provided, P = Partial Control Provided, N = No Control Provided

WEEDS	Oxyfluorfen (Goal®)	Oryzalin (Surflan®)	Simazine (Princep®, etc.)	Glyphosate (Roundup®, etc.)
Annual Grasses				
Bluegrass	P	C	C	C
Barnyardgrass	P	C	P	C
Crabgrasses	P	C	N	C
Fescues	P	C	C	C
Foxtails	N	C	C	C
Lovegrasses	P	C		C
Sandburs	N	C	P	C
Spangletops	P	C	N	C
Witchgrass	P	C	C	C
Annual Broadleaves				
Common Groundsel	C	P	C	C
Mustard	C	N	C	C
Nettles	C	P	C	P
Sowthistle	C	P	C	C
Cocklebur	C	N	C	C
Nettle-leaved Goosefoot	C	C	C	C
Knotweed	C	C	C	C
Common Lambsquarters	C	C	C	C
Little Mallow (Cheeseweed)	C	P	N	P
Nightshade	C	N	C	C
Pigweed	C	C	C	C
Puncturevine	C	P	P	C
Common Purslane	C	C	C	C
Yellow Star Thistle	C	N	C	C
Russian Thistle	P	P	P	C
Velvetleaf	C	P	C	C
Perennials (seedlings)				
Bermuda Grass	N	C	P	P
Field Bindweed (Morning Glory)	C	P	C	C
Dallisgrass	C	C	C	C
Johnsongrass	C	C	C	C
Established Perennials				
Bermuda Grass	N	N	N	N
Field Bindweed	N	N	N	N

6. Efficacy of Disease Management Tools Used in California Avocados

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

PRODUCT	TRADE NAME	Avocado Root Rot	Phytophthora Canker	Dothiorella Canker	Phytophthora Fruit Rot	Dothiorella Fruit Rot	Anthraco	Armilaria Root Rot	Avocado Black Streak	Verticillium Wilt	Sunblotch	Bacterial Canker
CHEMICAL												
Copper Hydroxide	various	P	P	G	G	G	F	P	P	P	P	P
Fosetyl-al	Aliette®	G	G	P	G	P	P	P	P	P	P	P
Mefenoxam	Ridomil®	F-G	P	P	F	P	P	P	P	P	P	P
Sulfur	various	P	P	P	P	P	P	P	P	P	P	P
NON-CHEMICAL												
Irrigation Management		G	G	P	G	P	P	P	P	P	P	P
Mulching and Gypsum		G	P	P	P	P	P	P	P	P	P	P
Mounding and Fertilization		G	P	P	P	P	P	P	P	P	P	P

Data based on collective field observations

7. Efficacy of Vertebrate Management Tools Used in California Avocados

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

MANAGEMENT TOOLS	Ground Squirrels	Gophers
Chemical		
Anti-coagulants	P-G	P-G
Strychnine	G	
Aluminum Phosphide	G	G
NAA	G	G
Non-Chemical		
Blasters	P-G	P-G
Cover Crops	P	
Owls	P	P

Data based on collective field observations

8. Members of the California Avocado Work Group

Growers

1. Dick Beckstead
2. Len Francis
3. Andrew Gabryszak
4. Reuben Hofshi
5. Ed Jefferson
6. John Lindstrom
7. Tom Markle
8. Ed McFadden
9. Sam McIntryre
10. Donald Reeder
11. Paddy Taber

Pest Control Advisors

12. Joe Barcinas
13. Jim Davis
14. Jane Delahoyde
15. Charles Gribble
16. Dave Machlitt
17. Tom Roberts

Commodity Group Representatives

18. Lori Berger, California Minor Crops Council
19. Steve Pierce, California Avocado Commission
20. Guy Witney, California Avocado Commission

Land Grant University Research and Extension Personnel

21. Mary Lu Arpaia, Horticulture
22. Gary Bender, UCCE
23. Mary Bianchi, UCCE
24. Ben Faber, UCCE
25. Mark Hoddle, Entomology
26. Lawrence Marais, Nematology/Plant Pathology
27. Peggy Mauk, UCCE
28. Joe Morse, Entomology
29. Pascal "Eve" Oevering, UCCE
30. Phil Phillips, UCCE

California Pest Management Center

31. Linda Herbst, California & Western Region Pest Management Center, UC Davis
32. Rick Melnicoe, California & Western Region Pest Management Center, UC Davis

US EPA Region 9

33. Cindy Wire

9. California Avocado Industry – Contact Information

Mary Lu Arpaia
Dept. of Botany & Plant Sciences
University of California
UC-Kearny Ag Center
9240 South Riverbend Ave.
Parlier, CA 93648
Ph: (559) 646-6561
Fax: (559) 646-6593
E-mail: arpaia@uckac.edu

Joe Barcinas
ESI
550 Foothill Pkwy.
Corona, CA 92882
Ph: (909) 371-0120
Fax: (909) 279-5150
E-Mail: jbarcinas@aolcom

Dick Beckstead
A Grove Concern, Inc.
1459 La Honda Drive
Escondido, CA 92027
Ph: (760) 743-3754
Fax: (760) 743-0551
E-Mail: mutoa@pacbell.net

Gary Bender
555 Overland Ave., Bldg. 4
San Diego, CA. 92123
Ph: (858) 694-2856
Fax: (858) 694-2849

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

Mary Bianchi
University of California
2156 Sierra Way, Suite C
San Luis Obispo, CA 93401
Ph : (805) 781-5949
Fax : (805) 781-4316
E-mail: mlbianchi@ucdavis.edu

Jim Davis
American Insectaries
243 S. Escondid Blvd. # 318
Escondido, CA 92025
Ph: (760) 747-2920
Fax: (760) 489-0353
E-mail: betterbugs@cox.net

Jane Delahoyde
Oxnard Pest Control Assn.
P.O. Box 1187
Oxnard, CA 93032
Ph: (805) 483-1024
Fax: (805) 487-6867
E-mail: jane@oxnardpest.com

Ben Faber
University of California
2156 Sierra Way, Suite C
San Luis Obispo, CA 93401
Ph: (805) 645-1462
Fax: (805) 645-1474
E-mail: bafaber@ucdavis.edu

Charles Gribble
Biospectrum, Inc.
P.O. Box 4626
Ventura, CA 93007
Ph: (805) 525-7077
Fax: (805) 933-1195
Cell: (805) 625-0077

Linda Herbst
Assistant Director
Western Region Pest Management Center
University of California
One Shields Avenue
Davis, CA 95616
Ph: (530) 752-7010
Fax: (530) 754-8379
E-mail: llherbst@ucdavis.edu

Mark Hoddle
Dept. of Entomology
University of California
Riverside, CA 92521
Ph: (909) 787-4714
Fax: (909) 787-3086
E-mail: mark.hoddle@ucr.edu

Reuben Hofshi
Avocadosource.com
1260 South Main
Fallbrook, CA 92028
Ph: (760) 728-8325
E-mail: rhofshi@avocadosource.com

David Jefferson
2294 Worthing Lane
Los Angeles, CA 90077
Ph: (310) 471-2765
Fax: (310) 472-7435
E-mail: davidjefferson2003@hotmail.com

Ed Jefferson
2294 Worthing Lane
Los Angeles, CA 90077
Ph: (310) 471-2765
Fax: (310) 472-7435
E-mail: edj@belaircrest.net

John Lindstrom
30301 Calle La Reina
Bonsall, CA 92003
Ph: (760) 945-5412
E-mail: lindstromjd@aol.com

Dave Machlitt
Consulting Entomology Services
12142 River Grove St.
Moorpark, CA 93021
Ph: (805) 218-1916
Fax: (805) 523-8044
E-Mail: dwmacya@yahoo.com

Lawrence Marais
Dept. of Plant Pathology
University of California
Riverside, CA 92521
Ph: (909) 787-2959
Fax: (909) 787-2959
E-mail: lawrence@citrus.ucr.edu

Tony Markle
18326 Starvation Mountain Road
Escondido, CA 92025
Ph: (760) 746-6334
E-mail: markles@mail.com

Peggy Mauk
UCCE
21150 Box Springs Road
Moreno Valley, CA 92557
Ph: (909) 683-6491 Ext. 224
Fax: (909) 788-2615
E-Mail: pamauk@ucdavis.edu

Ed McFadden
Rancho Simpatico
P.O. Box 517
Fillmore, CA 93016
Ph: (805) 524-0107
Fax: (805) 524-4157
E-mail: emcfadden@telis.org

Sam McIntrye
Somis Pacific Ag
P.O. Box 136
Somis, CA 93066
Ph: (805) 523-7200
Fax: (805) 531-9319
E-mail: sompacag@aol.com

Rick Melnicoe
Director
Western Region Pest Management Center
University of California
One Shields Avenue
Davis, CA 95616
Ph: (530) 752-8378
Fax: (530) 754-8379
E-mail: remelnicoe@ucdavis.edu

John Menge
Dept. of Plant Pathology
University of California
Riverside, CA 92521
Ph: (909) 787-4130
Fax: (909) 787-4132
E-Mail: john.menge@ucr.edu

Joseph Morse
Entomology Dept.
University of California
Riverside, CA 92521
Ph: (909) 787-2959
Fax: (909) 787-2959
E-mail: joseph.morse@ucr.edu

Pascal "Eve" Oevering
UCCE – Ventura
669 County Square Drive #100
Ventura, CA 93003
Ph: (805) 645-1467
Fax: (805) 645-1474
E-mail: poevering@ucdavis.edu

Steve Pierce
California Avocado Commission
38 Discovery Drive, Suite 150
Irvine, CA 92618
Ph: (949) 341-1955
Fax: (949) 341-1970
E-mail: spaii@iinet.com

Phil Phillips
UCCE – Ventura
669 County Square Drive #100
Ventura, CA 93003
Ph: (805) 645-1457
Fax: (805) 645-1474
E-mail: paphillips@ucdavis.edu

Donald Reeder
Somis Pacific Ag
P.O. Box 136
Somis, CA 93066
Ph: (805) 523-7200
Fax: (805) 531-9319
E-mail: lemonpickr@aol.com

Tom Roberts
Integrated Consulting Entomology
120 Stanislaus Avenue
Ventura, CA 93004
Ph: (805) 659-4137
Fax: (805) 659-4137
E-mail: troberts@west.net

Paddy Taber
4615 Gainsborough Ave.
Los Angeles, CA 90027
Ph: (323) 662-3029
Fax: (323) 783-0625
E-mail: paddytaber@pacbell.net

Cindy Wire
Agriculture Initiative
US EPA Region 9
75 Hawthorne Street, CMD-1
San Francisco, CA
Ph: (415) 947-4242
Fax: (415) 947-3583
E-mail: wire.cindy@epa.gov

Guy Witney
California Avocado Commission
38 Discovery Drive, Suite 150
Irvine, CA 92618
Ph: (949) 341-1955
Fax: (949) 341-1970
E-mail: gwitney@avocado.org