UC IPM Avocado

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PEST MANAGEMENT GUIDELINES FOR AGRICULTURE

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UC PEER REVIEWED

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The UC IPM Pest Management Guidelines are available from:

- **Online: http://ipm.ucanr.edu**
- **UC Cooperative Extension County Offices**
- **University of California**
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Updates: These guidelines are updated regularly. Check with your University of California Cooperative Extension Office or the UC IPM website for information on updates.

To be used with UC ANR Publication 3503, *Integrated Pest Management for Avocados*

Avocado Year-round IPM Program *(Revision 2016)*

ANNUAL CHECKLIST

These practices are recommended for a monitoring-based IPM program that enhances the use of IPM practices to reduce the risks of pesticides on the environment and human health.

When a pesticide application is considered, review the Pesticide Application Checklist at the bottom of this page for information on how to minimize the risks of pesticide use to water and air quality. Water quality can be impaired when pesticides drift into waterways or when they move off-site. Air quality can be impaired when pesticide applications release volatile organic compounds (VOCs) into the atmosphere.

This year-round IPM program covers the major pests of avocados in California. Details on carrying out each practice, example monitoring forms, and information on additional pests can be found in the Avocado Pest Management Guidelines. Track your progress through the year with this annual checklist form. Color photo identification pages and example monitoring forms can be found at forms and photo ID pages.

✓ Done	Bloom (pre-bloom, open flower, pollination, and fruit set) **Mitigate pesticide usage to minimize air and water contamination.****
	Monitor for diseases and conditions that promote disease development. • Armillaria root rot • Bacterial canker • Branch canker and dieback • Phytophthora trunk canker and crown rot • Phytophthora root rot • Rosellinia root rot • Sunblotch Record the date and location of problem trees or sites. Manage if needed according to the Pest Management Guidelines.
	Monitor invertebrate pests, including: • Avocado thrips (February or March, then regularly from April until fruit exceed 3/4 inch). • Caterpillars (March through August). • Greenhouse thrips (late-March through July). • Persea mite and sixspotted mite (April through October). Record results (example forms available online). Manage if needed according to the Pest Management Guidelines.
	Survey weeds, especially weeds near trunks, during spring through fall. • Record results (example form PDF available online). • Manage vegetation if needed, especially weeds near trunks.
	Look for vertebrates, especially during spring and summer. Manage if needed.
	Promote pollination of flowers: • Place honey bee hives in groves during bloom. • Manage pesticides to avoid killing bees.
	Provide proper cultural care and good growing conditions to improve fruit yield and control pests.
	Apply gypsum and mulch to reduce avocado root rot and improve soil.
	Manage irrigation: • Inspect irrigation systems by late winter. • Monitor and adjust scheduling to meet trees' varying water needs.

	• Test irrigation water quality.
✓Done	**Early fruit development** (fruit are less than 2 inches long) **Mitigate pesticide usage to minimize air and water contamination.****
	Identify and manage the causes of damage to fruit.
	Monitor for diseases and conditions that promote disease development. • Armillaria root rot • Bacterial canker • Branch canker and dieback • Phytophthora trunk canker and crown rot • Phytophthora root rot • Rosellinia root rot • Sunblotch Record the date and location of problem trees or sites. Manage if needed according to the Pest Management Guidelines.
	Monitor invertebrate pests, including: • Avocado thrips (in February or March, then regularly from April until fruit exceed 3/4 inch.) • Caterpillars (March through August) • Greenhouse thrips (late-March through July) • Persea mite and sixspotted mite (April through October) • Avocado brown mite (about August through October) Record results (example forms available online). Manage if needed according to the Pest Management Guidelines.
	Look for other invertebrate pests, such as snail, ants or orange tortrix. Manage if needed according to the Pest Management Guidelines.
	Provide proper cultural care and good growing conditions to improve fruit yield, reduce insect damage, and control pests.
	Look for vertebrates, especially during spring and summer. Manage if needed.
	Survey weeds, especially during spring through fall. • Record results (example weed survey form available online). • Manage vegetation, especially weeds near trunks, as needed.
	Manage irrigation: • Monitor and adjust scheduling to meet trees' varying water needs.

✓Done	**Late fruit development** (fruit are greater than 2 inches long) **Mitigate pesticide usage to minimize air and water contamination.****
	Monitor for diseases and conditions that promote disease development, including: • Armillaria root rot • Bacterial canker • Branch canker and dieback • Phytophthora trunk canker and crown rot • Phytophthora root rot • Rosellinia root rot • Sunblotch Record the date and location of problem trees or sites. Manage if needed according to the Pest Management Guidelines.
	Monitor invertebrate pests, including: • Caterpillars (March through August) • Persea mite and sixspotted mite (April through October)

✓Done	Late fruit development (fruit are greater than 2 inches long) **Mitigate pesticide usage to minimize air and water contamination.****
	• Avocado brown mite (about August through October) • Other species (about August through October) Record results (example forms available online). Manage if needed according to the Pest Management Guidelines.
	Look for vertebrates, especially during spring and summer. Manage if needed.
	Reduce pest problems and manage tree growth by proper pruning.
	Manage nutrition: • Test foliar nutrients and fertilize if needed.
	Provide proper cultural care and good growing conditions to improve fruit yield and control pests.
	Apply frost protection when warranted through March, especially if growing on flat land. • Test frost control system by November.
	Inspect trees or sample foliage or soil during late summer or fall before winter rains to assess salinity from alkaline soils, poor quality water, and fertilizers.

✓Done	Harvest (until fruit arrives at the packing house) **Mitigate pesticide usage to minimize air and water contamination.****
	Mow or manage weeds that may interfere with harvesting. Reduce vegetation cover in cooler areas to reduce chance of frost damage to lower leaves.
	Check preharvest intervals for all products used.
	Use pruning and other cultural practices to minimize anthracnose and branch canker diseases in groves as well as postharvest fruit and stem-end rots.
	Size pick fruit. Thin clustered fruit and prune to reduce protected sites, thereby culturally controlling greenhouse thrips, leafrollers, loopers, and mealybugs: • Thin by selectively harvesting only larger fruit, which increases market price to the grower.
	Minimize fruit injury and postharvest diseases.
	Educate and supervise workers regarding fruit handling Best Management Practices (BMP), Good Agricultural Practices (GAP), and food safety.
	Inspect fruit quality before bins are moved from the picking site to identify grove areas where management practices need improvement.
	Take steps to prevent fruit contamination and theft.

✓ Done	**Pesticide application checklist When planning for possible pesticide applications in an IPM program, consult the Pest Management Guidelines, review and complete this checklist to consider practices that minimize environmental and efficacy problems.

✓Done	**Pesticide application checklist When planning for possible pesticide applications in an IPM program, consult the Pest Management Guidelines, review and complete this checklist to consider practices that minimize environmental and efficacy problems.
	✓ **Choose a pesticide from the UC IPM Avocado Pest Management Guidelines for the target pest considering these factors:** • Impact on natural enemies and honey bees. (For more information, see http://ipm.ucanr.edu/PMG/r8901111.html.) • Potential for water quality problems using the UC IPM WaterTox database. (For more information, see http://ipm.ucanr.edu/TOX/simplewatertox.html.) • Impact on aquatic invertebrates. (For more information, see *Pesticide Choice,* UC ANR Publication 8161, http://anrcatalog.ucanr.edu/pdf/8161.pdf.) • Chemical mode of action (based on efficacy, spectrum of activity, and pesticide resistance). Select an alternative chemical or nonchemical treatment, especially when resistance risk is high. • Endangered species that may be near your site. Find out using the Department of Pesticide Regulation's PRESCRIBE program. (For more information, see http://cdpr.ca.gov/docs/endspec/prescint.htm.) ✓ **Before an application:** • Ensure that spray equipment is properly calibrated to deliver the desired pesticide amount for optimal coverage. (For more information, see http://ipm.ucanr.edu/training/incorporating-calibration.html) • Use appropriate spray nozzles and pressure to minimize off-site movement of pesticides. • Choose sprayers and application procedures that keep pesticides on target. • Avoid spraying during these conditions: o Wind speed over 5 mph o Temperature inversions o Just prior to rain or irrigation (unless it is an appropriate amount, such as when incorporating a soil-applied pesticide) o At tractor speeds over 2 mph • Identify and take special care to protect sensitive areas (for example, waterways or riparian areas) surrounding your application site. • Review and follow label for pesticide handling, storage, and disposal guidelines. • Check and follow restricted entry intervals (REI) and preharvest intervals (PHI). ✓ **After an application is made:** • Record application date, product used, rate, and location of application. • Follow up to confirm that treatment was effective. ✓ **Consider water management practices that reduce pesticide movement off-site.** • Consult relevant publications: o Orchard Floor Management to Reduce Erosion, UC ANR Publication 8202, http://anrcatalog.ucanr.edu/pdf/8202.pdf o Reducing Runoff from Irrigated Lands: Causes and Management of Runoff from Surface Irrigation in Orchards, UC ANR Publication 8214, http://anrcatalog.ucanr.edu/pdf/8214.pdf o Protecting Surface Water from Sediment-Associated Pesticides in Furrow Irrigated Crops, UC ANR Publication 8403, http://anrcatalog.ucanr.edu/pdf/8403.pdf • Consult the Department of Pesticide Regulation Ground Water Protection Program (GWPA) website for pesticide information and mitigation measures. (http://cdpr.ca.gov/docs/emon/grndwtr/index.htm) • Limit irrigation to amount required using soil moisture and evapotranspiration (ET) monitoring. (http://anrcatalog.ucanr.edu/pdf/8212.pdf.) • Install an irrigation recirculation or storage and reuse system. (http://ipm.ucanr.edu/mitigation/water_reuse.html) • Use drip rather than sprinkler or flood irrigation. • Consider the use of cover crops. • Consider vegetative filter strips or ditches. (For more information, see *Vegetative Filter Strips*, UC ANR Publication 8195, http://anrcatalog.ucanr.edu/pdf/8195.pdf.) • Install sediment traps.

✓Done	**Pesticide application checklist When planning for possible pesticide applications in an IPM program, consult the Pest Management Guidelines, review and complete this checklist to consider practices that minimize environmental and efficacy problems.
	• Use polyacrylamide (PAM) tablets in furrow irrigation systems to prevent off-site movement of sediments. • Apply polyacrylamides in sprinkler irrigation systems to prevent runoff. • Redesign inlets and outlets into tailwater ditches to reduce erosion. (For more information, see UC ANR Publication 8225, *Reducing Runoff from Irrigated Lands: Tailwater Return Systems,* http://anrcatalog.ucanr.edu/pdf/8225.pdf.) ✓ **Consider orchard floor management practices that improve soil structure and reduce erosion.** • (For more information, see UC ANR Publication 8202, *Orchard Floor Management Practices to Reduce Erosion and Protect Water Quality*, http://anrcatalog.ucanr.edu/pdf/8202.pdf.) ✓ **Consider practices that reduce air quality problems.** • When possible, reduce volatile organic compound (VOC) emissions by decreasing the amount of pesticide applied, choosing low-emission management methods, and avoiding emulsifiable concentrate (EC) formulations. • Use the Department of Pesticide Regulation calculators to determine VOC emission rates from fumigant http://cdpr.ca.gov/docs/emon/vocs/vocproj/calculate.htm) and nonfumigant (http://cdpr.ca.gov/docs/emon/vocs/vocproj/calculate.htm) pesticides.

General Information

(Section reviewed 09/16)

MANIPULATING CULTURAL PRACTICES AND GROWING CONDITIONS (09/16)

Cultural practices and growing conditions can be manipulated (X) in an IPM program to help prevent and control avocado pests and disorders and improve fruit yield.

	Cultural Practices and Growing Conditions															
Pest or Problem	Ant control	Border vegetation management	Dust control	Fertilization	Irrigation amount and frequency	Irrigation water quality	Harvest methods and timing	Mulching	Pruning	Rootstock certified pathogen-free	Rootstock cultivar	Sanitation	Scion cultivar	Site selection	Soil preparation	Water placement, irrigation method
Diseases																
Armillaria root rot					X							X		X	X	X
avocado black streak					X	X							X			
bacterial canker					X	X							X			
branch canker and dieback					X	X	X		X	X	X	X				X
fruit and stem-end rots					X	X	X	X	X			X	X			X
Phytophthora canker, crown rot									X		X	X			X	X
Phytophthora root rot					X	X		X		X	X	X		X	X	X
sunblotch									X	X			X			
Verticillium wilt												X		X		
Disorders																
aeration, root asphyxiation					X									X	X	X
frost tolerance				X	X				X		X		X	X		
nutrient disorders				X	X	X		X						X	X	X
poor drainage					X	X					X			X	X	
salinity				X	X	X		X			X		X	X	X	
sunburn				X	X		X	X	X					X	X	
Invertebrates																
avocado brown mite			X	X	X								X			
avocado thrips			X	X				?								
caterpillars such as amorbia and omnivorous looper		X					X		X					X		
glassy-winged sharpshooter		X												X		
greenhouse thrips							X		X							
Homoptera	X		X	X					X							
persea mite		X		X	X								X	X		
pests of young trees only	X	X												X		
sixspotted mite			X	X									X			
Other																
vertebrates		X						X				X		X		
water contamination, soil loss		X		X	X			X						X	X	X
weeds		X			X			X				X		X	X	X

? = The effectiveness of mulching for thrips control is uncertain.

X = Cultural practices and growing conditions that can be manipulated to control pests.

TIMINGS FOR KEY CULTURAL AND MONITORING PRACTICES (09 / 16)

Outlined below in the shaded areas are approximate times of key cultural / monitoring practices for avocado trees growing in Santa Barbara and Ventura counties. Optimal times vary according to location, weather, and crop development stage. Testing foliage and soil generally are done once during the indicated period. Practices such as cultivation, frost protection, irrigation, and pest monitoring are ongoing or are repeated at appropriate intervals.

TIME OF YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CROP DEVELOPMENT STAGE	Older fruit development or presence											
			Young fruit development									
	Pollination and fruit set											
	Pre-bloom and open flower											
				Leaf flush								
CULTURAL and MONITORING PRACTICES												
Irrigate regularly based on monitoring trees' need for water	■	■	■	■	■	■	■	■	■	■	■	■
Monitor pests regularly	■	■	■	■	■	■	■	■	■	■	■	■
Prune and thin where beneficial[1]	■	■	■	■								
Protect against frost	■	■										■
Place honey bee hives in groves		■	■	■	■	■						
Test soil nutrients, pH, etc.								■	■	■		
Measure and adjust irrigation output and uniformity			■	■								
Test irrigation water quality			■	■								
Harvest		■	■	■	■	■	■	■	■	■	■	
Cultivate weeds				■	■	■	■	■	■			
Fertilize if needed			■	■	■	■	■	■	■			
Sample foliar nutrients								■	■			
Test soil salinity									■	■		

1 Major pruning period is Jan.-Apr., but minor pruning takes place year-round.

Adapted from: CAC and CMCC. 2003. *A Pest Management Strategic Plan for Avocado Production in California*. Irvine, CA: California Avocado Commission and California Minor Crops Council.

WHEN TO MONITOR PESTS, DAMAGE, AND NATURAL ENEMIES (09/16)

TIME OF YEAR			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
CROP DEVELOPMENT STAGE			Older fruit development or presence											
					Young fruit development									
			Pollination and fruit set											
			Pre-bloom and open flower											
						Leaf flush								
Grove location														
Coast	Inland	PESTS												
		DISEASES	m m	m m	m m	m m	m m	m m	m m	m m	m m	m m	m m	m m
		VERTEBRATES	o o	o o	m m	m m	m m	m m	m m	m m	m m	m m	o o	o o
		WEEDS	m	m m	o o	o o	m m	m o	o o	o o	o o	o o	o o	
		INVERTEBRATES												
+	+	avocado thrips		o o	o m	m m	m m	m o						
+	+	persea mite				m m	m m	m m	m m	m m	m m	m o	o	
–	–	caterpillars			m	m m	m m	m m	m m	m m	m o	o		
+	–	greenhouse thrips			m	m m	m m	m m	m m	o o	o o	o o	o o	
+	–	sixspotted mite			m m	m m	m m	m o	o o	o o				
+	–	avocado brown mite							o o	m m	m m	m m	m o	
+	+	avocado lace bug				m	m m	m m	m m	m m	m m	m o	o	
–	–	ants & Homoptera		o	m m	m m	o o	o o	o					
+	+	pests that migrate to young trees			o	o o	m m	m m	m o					
–	–	glassy-winged sharpshooter						o o	m m	m m	m o	o		
NATURAL ENEMIES														
predatory thrips					o m	m m	m m	m o						
predatory mites					o m	m m	m m	o						
spider mite destroyer					o m	m m	m m	o	o	m m	m m	m m		
greenhouse thrips parasites					m	m m	m o	o o	o o	o o				
caterpillar pathogens, parasites, & predators					m	m m	m m	m m	m m	m m	m			

KEY TO PESTS AND NATURAL ENEMIES

+ = Monitor routinely, commonly a pest

– = Routine monitoring probably warranted only in special circumstances, such as when a species recently was a pest there or when natural enemies have been disrupted, e.g., by broad-spectrum insecticide application

= Shading indicates period of potential for damage

= Shading indicates period damage most likely

m = major times to monitor

o = other times to monitor

MONITORING CATERPILLARS AND THEIR NATURAL ENEMIES (09 / 16)

Caterpillars are the larvae of moths and butterflies (order Lepidoptera). Omnivorous looper, western avocado leafroller (amorbia), and (least frequently) orange tortrix are sporadic pests in avocado. Healthy trees can tolerate some loss of chewed foliage and blossoms. Extensive defoliation can result in sunburn to fruit and twigs. Economic damage occurs primarily when caterpillars chew and scar fruit. Conserve natural enemies, as caterpillars are usually under effective biological control.

IDENTIFYING CATERPILLARS AND NATURAL ENEMIES

- Use the key to caterpillars and photographs of caterpillars *(Available online)*.
- Identify natural enemies of caterpillars (view photos online). The presence of natural enemies affects the decision on how to manage caterpillars.
- If parasite introductions are planned, put out pheromone traps for adults (late winter through early summer) to identify the species of egg-laying moths and to time *Trichogramma* releases.

SAMPLING CATERPILLARS AND THEIR NATURAL ENEMIES

- From March through August, monitor at least 10 trees per grove about every 7 to 10 days, concentrating efforts in areas where you see leaf chewing or found caterpillars the previous season.
- Sample caterpillars using timed counts or foliage shaking, as described below, depending on the prevalent species.
- For all samples combined from each tree, record the total number of caterpillars and the total predators of caterpillars.
- Record separately any apparently diseased and parasitized caterpillars, also record any diseased or parasitized larvae in the caterpillars per hour or caterpillars per 25 shakes column. (This "double counting" prevents the caterpillar pressure calculation from being altered by variations in the ratio of predators to diseased or parasitized caterpillars.)
- If it is not obvious whether a caterpillar is healthy versus diseased or parasitized, or if you don't know if the observed species are predators of caterpillars, collect those specimens for closer examination later. This is especially important when conducting timed counts, so time is not diverted from inspecting trees during the fixed monitoring time.

Using the Shake Method

Shake foliage to sample avocado looper:

1. Place a 1-yard square collecting surface (e.g., cloth or flattened cardboard box) beneath outer canopy foliage.
2. Vigorously shake small limbs to dislodge caterpillars onto the collecting surface. (For example, shake foliage on 2 or 3 separate sections of each tree to collect 25 shake samples.)

Using the Timed Method

Make timed counts for amorbia (western avocado leafroller), avocado looper, and orange tortrix.

1. Spend a fixed amount of time inspecting foliage for caterpillars. For example, spend 6 minutes inspecting each of 10 trees (1 hour).
2. Use a timer to ensure the entire period is spent monitoring, and that time spent moving among distant trees is not included.
3. Walk slowly around the outer canopy, looking for chewed and webbed foliage or fruit. Pull apart webbing and count any caterpillars and natural enemies.
4. Record results *(example form available online)*.

MONITORING ADULT MOTHS

Adult moths are nocturnal and consume only liquids and pollen. During the day they rest on the underside of leaves or on shady bark.

Deploy pheromone-baited sticky traps for adults to identify the species in groves and indicate peaks in flights of egg-laying adults. Each trap is baited with a separate pheromone to attract adult male amorbia, omnivorous looper, or orange tortrix. For amorbia, two different pheromones are used:

- one for northern California (including Santa Barbara and San Luis Obispo counties) and the San Joaquin Valley and
- another for southern California including Ventura County.

Unless other methods are recommended, deploy traps at a density of about one trap per ten acres when adult moths are expected to be present. Check with suppliers for recommended pheromones and the type and number of traps to use.

Trapping moths can indicate that foliage monitoring is warranted and helps to time management actions such as release of *Trichogramma* egg parasites. Adult traps generally are not useful for determining need for treatment, partly because caterpillars are the damaging stage and natural enemies kill many eggs and larvae relative to the moth population that is trapped earlier in the season.

MONITORING PERSEA AND SIXSPOTTED MITES (09/16)

Spider mites (family Tetranychidae) and predatory mites (Phytoseiidae) are tiny eight-legged arthropods (larval stage has only six legs). Persea mite is a key pest of California-grown avocados, whereas sixspotted mite is a sporadic pest. See AVOCADO BROWN MITE for details on how to manage this occasional pest.

Several beneficial mites are important predators of pest mites and certain insects. Natural enemies and certain management strategies vary among pest mites *(view photos online)*. Identify the pest and natural enemy species (*view photos online)* in your grove and learn their biology so you can manage these pests appropriately as needed.

HOW TO MONITOR

Both species feed on the underside of leaves, and the similar appearance of these mites as well as their damage can be confused. Monitor mites about every 7 to 10 days from about mid-March through October using one or more methods.

Persea Mite Quick Counting Method

1. Randomly pick current-season leaves of mixed age, one leaf from each of at least 10 trees.
2. Looking at the underside of each leaf, start at the petiole end. Locate the second major vein that goes strongly from the midrib to the left leaf edge. Ignore any partial, small, or weak veins. Examine the upper (towards the leaf tip) vein edge through a hand lens.
   - Count the persea mites adjacent to that upper edge of the second major vein.
   - Count mites in webbed nests or exposed necrotic feeding patches that touch the vein.
   - Count any other mites up against the vein.
   - Do not count mite eggs; or any visible mites located away from the vein and outside webbed or necrotic patches.
3. Total the number of persea mites counted and divide the total by the number of leaves sampled (typically 10). Multiply by 12 to derive the average mites per entire leaf.
4. Also count the predaceous mites (e.g., *Galendromus* spp.) in the persea mite feeding patches. Divide total predator mites by the number of leaves sampled. Multiply this predaceous mite average by 6.
5. Record results (*example form available online*).
6. Manage persea mite if warranted based on sampling results and past experience.

Persea and Sixspotted Mite Damage Sampling

1. Monitor for mite-damaged leaves; include locations from previous seasons that experienced premature drop of numerous green leaves with discolored spots caused by mite feeding. Pick leaves of mixed age at random from the tree, choosing 10 leaves from each of at least 10 trees per grove.
2. Visually estimate the percent of mite-damaged tissue on each leaf by comparing it to standards (*view photos online)* with known levels of damage, such as colored photographs of avocado leaves showing 1 to 50% feeding damage. Record results (*example form available online*).
3. For each tree, total the percent damage on the 10 leaves, then total the percent damage on all trees.
4. Calculate the estimated average percent damage per leaf: Total percent damage / Total number of leaves sampled (e.g., 100 leaves) = Average percent mite damage per leaf.
5. Manage persea mite or sixspotted mite if warranted based on sampling results past and experience.

Although it has not been experimentally verified, the probability of leaf drop is believed to increase greatly once 7.5 to 10% of the leaf surface is damaged by persea mite feeding. Thus, control may be warranted before reaching this damage level.

Persea Mite Density Estimation

1. In multiples of five, select a number of expanded, but not very old leaves.
2. Using a hand lens or other magnifier to examine the underside of leaves, identify whether there are any live persea mites on each leaf.
   - Consider the leaf infested only if it contains any live pest mites.
   - Be aware that mite nests (discolored spots and webbed patches) on leaves (especially older leaves) may no longer be inhabited.

- If an overall average of two or more out of five leaves have any living persea mites, some pest control advisors believe treatment may be warranted; however, there is no research-based evidence that mite density or treatment need can accurately be determined using this presence-absence sampling method.

MONITORING DISEASES AND DISEASE-PROMOTING CONDITIONS (09/16)

HOW TO MONITOR

Look for conditions that favor pathogen infection and disease development, such as inadequate cultural practices and mechanical injury to plants. Especially look for, and remedy, inappropriate irrigation.
Look for signs and symptoms of disease *(photos available online)*, and record the date and location of problem trees or sites.

- Signs (visible pathogen structures) include *Armillaria* mushrooms, *Ganoderma* fruiting bodies, white fungal mycelium growing beneath bark, and rhizomorphs (not common in CA) (i.e., *Armillaria mellea).*
- Symptoms of diseased plants include:
  - Leaves that are downward-hanging, necrotic-tipped, pale or yellow, or wilted.
  - Premature leaf drop or a sparse canopy of drooping older leaves,
  - New shoots of small pale leaves.
  - Abundant small fruit.
  - Fruit that are blotched, discolored, spotted, streaked, or rotted.
  - Cankered, cracked, discolored, or oozing bark.
  - Black, brittle, or dead roots and relatively few small roots (rootlets).
  - Variegated stems, leaves or fruit indicative of sunblotch
  - White crusty exudates on the main trunk or major branches indicative of bacterial, crown rot, Dothiorella blight or black streak

INSPECTING TREES

If a tree looks unhealthy, examine as many of plant parts as possible.

- Brush away mulch to examine the appearance of small roots for root rot and the main stem where it enters the soil for crown rot.
- Remove soil from around the root crown and cut beneath unhealthy looking bark to expose cankers or small patches of white fungal mycelium.
- Look for discolored or oozing bark on main limbs and trunks and examine beneath damaged bark to discern cankers.
- Use appropriate tools, such as a chisel or knife, to cut away bark and view deeper cankers. Keep monitoring tools, including a chisel, hatchet, hand lens, pocket-knife, and shovel, close at hand.

DIAGNOSING THE CAUSE

Inspect several nearby trees, which may show earlier, more characteristic or subtle symptoms. Patterns in symptoms among trees can provide clues to the cause. Do not rely on a single symptom. Compare your observations to photos of common root and crown diseases (*available online*). If cankers are present, distinguish among the causes of cankers *(view photos online)*, which include:

- Abiotic disorders
- Various pathogens
- Certain vertebrates

Send samples to a diagnostic laboratory or consult an expert to help diagnose the cause. Keep records of testing results.

RECORDING THE LOCATION OF DISEASED TREES

Record the date and location of problem trees or sites.

- Mark problem spots on a map of the grove or using a hand-held GPS (global positioning system).
- Use florescent spray paint and colored plastic flagging to mark trees.
- Mark maps and trees or both with symbols or color codes keyed to symptoms or the suspected or confirmed cause of disease.
- Repeat monitoring at intervals to document the progression or seasonality of symptoms and to assess whether management practices are effective.

MANAGING DISEASE

Improve growing conditions, use good sanitation, and provide appropriate cultural care as the primary means of managing:

- Anthracnose fruit rot
- Armillaria root rot
- Avocado black streak
- Bacterial canker
- Branch canker and dieback
- Phytophthora root rot
- Phytophthora trunk canker and crown rot
- Sunblotch

Fruit should be picked by clipping rather than snapping the pedicles. Clippers should be frequently sterilized using a dilution (e.g., 1:10) of household bleach.

ROOTSTOCK TOLERANCE TO DISORDERS AND PATHOGENS (09/16)

Use rootstocks that are resistant to, or tolerant of, key disorders and diseases, such as Phytophthora root rot *(Phytophthora cinnamomi).* Because rootstock cultivars resistant to one problem may be more susceptible to another, consider planting a mixture of the recommended rootstock cultivars.

	ORIGIN		PATHOGENS[1]			STRESSORS[1]	
Rootstock	Cultivar[2]	Propagation	*Phytophthora cinnamomi*	*Phytophthora mengei*	*Botryosphaeria spp*	Salinity	Frost
Barr Duke	Mex	clonal	3.5	3	5	2	4.5
Borchard	Mex	clonal	0.5	3	5	3	4.5
Duke 7	Mex	clonal	3	4	5	3	4
Duke 9	Mex	clonal	3.5	4	5	3	4.5
Dusa (Merensky 2)	Mex X G	clonal	5	—	5	4	4.5
G-6	Mex	seed	2	3	2	2	4.5
Lula	G X WI	seed	—	—	—	—	1
Latas (Merensky 1)	Mex X G	clonal	4.5	—	5	5	4.5
Martin Grande	X[3]	clonal	5	3	—	2	1
Thomas	Mex	clonal	4.5	2	2	1	4.5
Topa Topa	Mex	seed	0	3	5	2	4.5
Toro Canyon	Mex	clonal	2.5	5	5	3	4.5
Uzi (PP15)	Mex	clonal	5	4	3	4	—
Zentmyer (PP4)	Mex	clonal	5	3	4	1	5

1 Ratings for pathogen/stressor are from 0 to 5, with 0 being poor or least tolerant and 5 being the best or most tolerant. Ratings are approximate and based on observations and studies under a variety of field and greenhouse conditions. Ratings of newer rootstocks are preliminary; check with your advisor or supplier for the latest information on rootstock tolerances.

2 Cultivar or horticultural race is Mex = Mexican, G = Guatemalan, WI - West Indian, X = a hybrid of cultivars or species.

3 Martin Grande (also identified as G755 A,B,C) is a hybrid of *Persea americana* X *P. schiedeana.*

— = unknown

Adapted from: Bender, G., J. Menge, and M. L. Arpaia. 2003. *Avocado Rootstocks*. University of California Cooperative Extension. *Topics in Subtropics* 1(3): 7–8.

RELATIVE TOXICITIES OF INSECTICIDES, MITICIDES, AND MOLLUSCICIDES USED IN AVOCADOS TO NATURAL ENEMIES AND HONEY BEES (09 / 16)

Common name (Example trade name)	Mode of action[1]	Selectivity [2] (affected groups)	Predatory mites[3]	General predators[4]	Parasites[4]	Honey bees[5]	Duration of impact to natural enemies[6]
abamectin (Agri-Mek)	6	moderate (mites, thrips)	M	M[7]	M/H	I	moderate to predatory mites and long to affected insects
Bacillus thuringiensis ssp. *aizawai*	11A	narrow (caterpillars)	L	L	L	II	none
Bacillus thuringiensis ssp. *kurstaki*	11A	narrow (caterpillars)	L	L	L	III	none
Bifenthrin/zeta-cypermethrin (Hero)	3A/3A	broad (insects, mites)	H	H	H	I	long
boric acid bait (Gourmet)	8D	narrow (ants)	L	L	L	III	none
copper sulfate (Bordeaux mixture) trunk spray	—	narrow (snails)	L	L[7]	L	III	long as a barrier
etoxazole (Zeal)	10B	narrow (mites)	H[11]	L	—	II	short
fenpropathrin (Danitol)	3A	broad (insects, mites)	H	H	H	I	—
imidacloprid (Admire)	4A	narrow (sucking insects)	—	L	L	I	long
iron phosphate (Sluggo)	—	narrow (snails and slugs)	L	H[7]	L	III	short
malathion	1B	broad (insects, mites)	H	H	H	I	moderate
oil, narrow-range	—	broad (exposed insects, mites)	L	L	L	II	short
pyrethrin (PyGanic)	3A	moderate (insects)	—	M	M	I	short
pyrethrin/ piperonyl butoxide (Pyrenone)	3A/ —	moderate (insects)	—	M	M	I	short
pyriproxyfen (Esteem)	7C	broad (aphids, caterpillars, flies, leafminers, scale, whiteflies)	L	H[10]	L	II	long
sabadilla (Veratran-D)	—	narrow (feeding thrips)	L	L	L	II	short
spinetoram (Delegate)	5	narrow (caterpillars, aphids, thrips)	M	M[8]	L/M	II	moderate[9]
spinosad (Success, Entrust)	5	narrow (caterpillars, aphids, thrips)	M	M[8]	L/M	II	moderate[8]
spirodiclofen (Envidor)	23	narrow (mites)	L	—	—	II	—
spirotetramat (Movento)	23	narrow (aphids, scale, psyllids, whiteflies)	L	L	L	II	short
sulfur	un	narrow (mites)	L/H	L	H	III	moderate
thiamethoxam (Actara - foliar)	4A	narrow (sucking insects)	—[12]	M/H	M/H	I	moderate

H = high M = moderate L = low — = no information

Common name (Example trade name)	Mode of action[1]	Selectivity [2] (affected groups)	Predatory mites[3]	General predators[4]	Parasites[4]	Honey bees[5]	Duration of impact to natural enemies[6]

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

2 Selectivity: *Broad* means it affects most groups of insects and mites; *narrow* means it affects only a few specific groups.

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

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

5 Ratings are as follows:

I-Do not apply or allow to drift to plants that are flowering;

II-Do not apply or allow to drift to plants that are flowering, except when the application is made between sunset and midnight if allowed by the pesticide label and regulations;

III-No bee precaution, except when required by the pesticide label or regulations.

For more information, see *Bee precaution pesticide ratings* (http: http://ipm.ucanr.edu/beeprecaution/).

6 Duration: *Short* means hours to days; *moderate* means days to 2 weeks; and *long* means many weeks or months.

7 Toxic to predatory decollate snail.

8 Toxic against some natural enemies (predatory thrips, syrphid fly and lacewing larvae, beetles) when sprayed and up to 5-7 days after, especially for syrphid fly larvae.

9 Residual is moderate if solution is between pH of 7 to 8.

10 Kills lady beetles.

11 Does not kill adults but sterilizes females

Acknowledgments: This table was compiled based on research data and experience of University of California scientists who work on a variety of crops and contribute to the Pest Management Guideline database, and from Flint, M. L. and S. H. Dreistadt. 1998. *Natural Enemies Handbook: An Illustrated Guide to Biological Pest Control*, ANR Publication 3386.

Invertebrates: Pests of Primary Concern

(Section reviewed 09/16)

AMORBIA (WESTERN AVOCADO LEAFROLLER) (10/16)

Scientific Names: *Amorbia cuneana*

DESCRIPTION OF THE PEST

(View photos online)

Western avocado leafroller (family Tortricidae), is primarily a pest of avocado. It occurs in most California groves and occasionally increases dramatically, causing severe fruit damage. This caterpillar also damages citrus, where it is called amorbia, its official common name. Amorbia is often called just "leafroller." However, amorbia, avocado looper, and orange tortrix all roll avocado leaves and web plant parts together with silk.

Amorbia (and orange tortrix) adults are bell-shaped when their wings are folded at rest. Their variably colored forewings are typically orangish to tan with dark markings. Adult amorbia are about 1 inch (2.5 cm) long, about twice the size of orange tortrix adults.

Each amorbia female lays about 150 to 200 eggs during her 2 to 3 week life. These light green, oval-shaped eggs occur mostly on the upper side of leaves close to the midrib. Amorbia (and orange tortrix) eggs are laid overlapping or shinglelike in a flat mass. Amorbia lays about 5 to 100 eggs per mass, with an average of 25 eggs per mass. Eggs darken and larvae emerge about 2 weeks after oviposition. Hatched egg masses resemble whitish patches on leaves.

Amorbia larvae develop through five instars. At maturity they are 0.75 to 1 inch long. Caterpillars are yellowish green when young, and mostly darker green when mature. Older larvae have one short dark horizontal line on their side on their thorax just behind the head and above the first pair of legs. Other avocado caterpillars lack these distinct black marks. Amorbia feed in nests of leaves and fruit tied together with silk. When disturbed, amorbia and orange tortrix larvae often wriggle violently and drop to the ground.

Amorbia pupate for 2 to 3 weeks in rolled leaves. The 0.5 to 0.75 inch long pupae initially are pale green, gradually turn tan, and become brown when mature.

Egg to adult development time is about 1.5 months at an average temperature of 75°F. Amorbia typically has three generations per year at warmer growing areas. From inland Ventura to San Diego Counties, most adults fly and females lay eggs during January through April, May through June, and during September through October. Two generations a year occur on average in coastal groves. In Santa Barbara County most moths emerge and lay eggs during March through June, and August through November.

DAMAGE

Young amorbia larvae chew the leaf surface, leaving a thin brown membrane or skeleton of leaf veins. Mature caterpillars consume the whole leaf, starting in the center or at the leaf edge. Young larvae often web terminal leaves together and feed within them. This damage becomes apparent when terminals grow and unfold. Mature avocado trees can tolerate considerable larval chewing without severe effects on tree growth or fruit yield.

Healthy trees tolerate some loss of chewed foliage and blossoms. Extensive defoliation can result in sunburned fruit and twigs. Economic damage occurs primarily when caterpillars damage fruit. When larvae web leaves to fruit or feed among touching fruit in a cluster, in these protected sites larvae feed on fruit skin. This scarring causes downgrading or culling of fruit.

MANAGEMENT

Conserve natural enemies, which usually keep caterpillars below damaging levels. Modify cultural practices to reduce pest reproduction and survival. Avoid applying broad-spectrum or persistent insecticides for any pests. Caterpillar outbreaks often occur after spraying malathion, which kills parasites and predators. When pesticides are warranted, limit application to the most infested spots to provide refuges from which natural enemies can recolonize after treatment.

Biological Control

(View photos online)

Birds, predaceous insects, and spiders commonly prey on caterpillars. Predators include assassin bugs, damsel bugs, lacewings, and pirate bugs. A naturally occurring nuclear polyhedrosis virus often kills many amorbia when caterpillar numbers become high. The caterpillar pathogen *Bacillus thuringiensis* is commercially available as a selective insecticide.

Parasites, especially flies (family Tachinidae) are the most important natural enemies that usually keep amorbia numbers below economically damaging levels. Tachinids attacking amorbia include *Eumea* (=*Aplomya*) *caesar, Nilea* (=*Pseudoperichaeta*) *erecta,* and at least five other species. Their black to dark grayish adults are about 0.25 to 0.33 inch (6–8 mm) long and resemble a common house fly, but have more prominent stout hairs. White tachinid eggs may be observed on or near a caterpillar's head. Brown to reddish, parchmentlike tachinid pupal cases are often found near the larger pupal cases of dead caterpillars.

At least eight wasps species parasitize amorbia, including the external larval parasite *Habrobracon* (=*Bracon*) *xanthonotus* (Braconidae) and the internal pupal parasite *Brachymeria ovata* (Braconidae). *Trichogramma* spp., 0.04 inch (1 mm) long or smaller wasps, lay one to several eggs in each caterpillar egg. Black amorbia eggs are probably parasitized by *Trichogramma.*

Where naturally occurring parasitism is inadequate, amorbia has been controlled by releasing *Trichogramma platneri* during peak moth egg laying in late spring as determined by monitoring adults using commercially available pheromone-baited or black light traps. Commercial suppliers typically provide *Trichogramma* as parasitized moth eggs glued to cardboard. The adult wasps should emerge soon after the shipment arrives. Protect cards from Argentine ants and other predatory insects. Keep a small portion from any purchase in a shady location in a clear container covered with tightly woven cloth. Observe wasp emergence to assess product quality.

Cultural Control

Prune to reduce foliage touching among adjacent trees and to minimize dead twig and plant debris accumulation in canopies. Thin or selectively harvest fruit in clusters. Pruning and thinning reduce protected sites and canopy bridges that facilitate insect movement between trees, thereby reducing the abundance of caterpillars, greenhouse thrips, and mealybugs. Remove abandoned citrus to reduce the likelihood that amorbia and orange tortrix will move from citrus to nearby avocado. Control weeds near avocado that host these caterpillars. Reduce dust in groves by driving slowly and watering dirt roads. Dusty conditions reduce the effectiveness of parasites and predators that attack caterpillars and other pests including mites and scales.

Organically Acceptable Methods

Use biological and cultural controls as well as Bt-based pesticides or spinosad in an organically certified crop.

Monitoring and Treatment Decisions

Where problems may occur, monitor during spring and summer, especially after peaks in moth flights. Continue monitoring until the flight ceases. Good places to monitor include where bright lights such as security lights are used outdoors because the nocturnal moths are attracted by lights to lay eggs nearby. Be sure to correctly distinguish the cause of any damage as other insects and certain abiotic disorders cause leaf holes resembling caterpillar chewing. Correctly identify the species of caterpillars. Alternate host plants, damage potential, monitoring methods, and natural enemies vary depending on the species of caterpillar. Look for caterpillar predators and larval diseases and parasitism. Natural enemy prevalence affects treatment decision-making. See MONITORING CATERPILLARS AND THEIR NATURAL ENEMIES for details on identification and monitoring methods including inspecting foliage for caterpillars and their damage (timed counts), trapping adults, shaking foliage to dislodge larvae (primarily for avocado looper), or a combination of these methods.

There are no established amorbia thresholds for pesticide application. As a guideline, a 5% fruit infestation level can be used as a treatment threshold. Monitor parasites and other natural enemies several times to determine if their numbers are increasing. If they are, the amorbia presence will decrease. Spraying with malathion often leads to outbreaks of other pests and is not recommended. Bt sprays are the least disruptive to natural enemies.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

A. *TRICHOGRAMMA PLATNERI* PARASITES# — See comments — —
COMMENTS: Make at least 2 releases a week apart during the period of peak egg laying (as determined by pheromone traps and visual inspection). Place parasite egg cards on at least 4 trees / acre for a total minimum release of 100,000 parasites / acre per season.

B. *BACILLUS THURINGIENSIS* ssp. *AIZAWAI#*
(various products) — Label rates — 4 — 0
MODE-OF-ACTION GROUP NUMBER[1]: 11A
COMMENTS: Effective when used to control early instars of the caterpillar.

C. B*ACILLUS THURINGIENSIS* ssp. *KURSTAKI#*
(various products) — Label rates — 4 — 0
MODE-OF-ACTION GROUP NUMBER[1]: 11A
COMMENTS: Effective when used to control early instars of the caterpillar.

D. SPINOSAD
(Entrust SC)# — 4–10 fl oz — 4 — 1
MODE-OF-ACTION GROUP NUMBER[1]: 5
. . . *PLUS* . . .
NARROW RANGE OIL
(415) — 1% — see label — see label
MODE OF ACTION: Improves translaminar movement and persistence of insecticide.
COMMENTS: To delay resistance, do not apply Group 5 insecticides (spinetoram, spinosad) more than once per year. Choose a lower rate for light infestations or small trees and a higher rate for heavy infestations or large trees. When applying to organically grown produce, be sure that the oil used is also organically acceptable. Apply in a minimum of 50 gal water / acre. On larger trees, aerial applications may require larger volumes of water to achieve desired efficacy. Control may last 3 or more weeks. Only use in an alkaline or slightly acidic solution. Do not tank mix with nutrients. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

E. SPINETORAM
(Delegate WG) — 4–7 oz — 4 — 1
MODE-OF-ACTION GROUP NUMBER[1]: 5
. . . *PLUS* . . .
NARROW RANGE OIL
(415) — 1% — See label — See label
MODE OF ACTION: Oil improves translaminar movement and persistence of this insecticide.
COMMENTS: To delay resistance, do not apply Group 5 insecticides (spinetoram, spinosad) more than once per year. Choose a lower rate for light infestations or small trees and a higher rate for heavy infestations or large trees. Apply in a minimum of 50 gal water / acre. On larger trees, aerial applications may require larger volumes of water to achieve desired efficacy. Control may last 3 or more weeks. Only use in an alkaline or slightly acidic solution. Do not tank mix with nutrients. Delegate WG is toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

F. FENPROPATHRIN
(Danitol 2.4 EC)* — 16–21 1 / 3 fl oz — 24 — 1
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: Effective against high omnivorous looper and amorbia populations. Apply a minimum of 100 gallons by ground and 50 gallons by air. If oil is added to a fenpropathrin application, no more than 1% NR_415 oil may be used. Workers who enter for the purpose of harvesting within 7 days of application must wear specific harvest PPE, even though the PHI is 1 day (see label). To avoid promoting pesticide resistance, do not make more than one application of fenpropathrin product every 3 years. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In

some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on organically grown produce.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

— Not applicable.

AVOCADO BROWN MITE (09/16)

Scientific Names: *Oligonychus punicae*

MITE PESTS OF AVOCADO—GENERAL INFORMATION

Spider mites (family Tetranychidae) and predatory mites (Phytoseiidae) are tiny eight-legged arthropods, except for first stage larvae, which have six legs. Persea mite is a key pest of California-grown avocados. Avocado brown mite and sixspotted mite are sporadic pests. Several beneficial mites are important predators of pest mites and certain insects. Natural enemies and certain management strategies vary among pest mites. Identify the pest and natural enemy species in your grove and learn their biology so you can manage these pests appropriately as needed. For details about sampling techniques, see MONITORING PERSEA AND SIXSPOTTED MITES.

DESCRIPTION OF THE PEST

(View photos online)

Avocado brown mite (family Tetranychidae) is dark brown, oval, and tiny (about 0.01 inch or 0.3 mm long). Its tiny amber-colored eggs have a short projecting stalk. At low numbers most eggs are laid singly along the midrib. Eggs are increasingly found throughout the upper leaf surface as mite numbers increase. In summer there may be two complete generations per month. Temperatures of 90° to 95°F or higher, and especially if it is dry, usually kill these mites and their eggs, as does the first cold weather in fall or early winter.

DAMAGE

Avocado brown mite is a sporadic pest, mostly in coastal growing areas. Bronzing of leaves, mite cast skins, and partial defoliation of some trees by avocado brown mite is most noticeable from about July to September. Severe infestations tend to occur in border row trees along dirt roads, where road dust is detrimental to mite predators. Ash deposited on leaves from wildfires reportedly also causes brown mite outbreaks.

Avocado brown mite feeds almost entirely on upper leaf surfaces. Bronzing damage is not severe when mite numbers are low to moderate (about 10 to 20 adult females per leaf). If the spider mite destroyer lady beetle (*Stethorus picipes*) is present and reproducing well at this time, brown mite does not normally become a problem. Damage occurs if avocado brown mite averages about 80 to 100 adult females per leaf (about 200-300 motile stages, adults and nymphs combined). At these higher densities mites also colonize the lower leaf surface and sometimes fruit, and partial defoliation can occur. These higher numbers cause leaf bronzing along the midrib, then along smaller veins, and finally the entire leaf turns brown.

Persea mite damage is distinct from avocado brown mite damage, see section on PERSEA MITE

MANAGEMENT

Natural enemies and temperature (hot or cold weather) usually maintain this mite at innocuous levels. Maintain good biological control by conserving natural enemies. Control dust and avoid applying broad-spectrum pesticides for any pests. When treating any pests, including avocado brown mite during late summer or fall, spot treat individual trees where possible to allow natural enemies to persist and continue biological control.

Biological Control

(View photos online)

Naturally occurring populations of the spider mite destroyer (*Stethorus picipes*) provide the majority of brown mite biological control. Predaceous mites (especially *Euseius hibisci* and *Galendromus helveolus*) are also helpful, but predatory mites are primarily effective against sixspotted mite. Most other natural enemies listed as attacking persea mite also feed on avocado brown mite.

Cultural Control

Controlling dust, which improves predator activity, is critical for maintaining biological control.

- Oil or pave main orchard roads to reduce dust drift onto trees.
- When it is necessary to use dirt roads, drive slowly.
- Use a water truck or trailer to wet unpaved roads and prevent airborne dust, especially during summer months when heat convection currents carry dust well up into tree canopies.

Organically Acceptable Methods

Use biological and cultural controls along with sulfur and some oil sprays in an organically certified crop.

Monitoring and Treatment Decisions

Monitor for brown mite during summer through fall, together with monitoring for other pests such as caterpillars and persea mite. Look for bronzed leaves and brown mites, especially when monitoring in coastal groves. Consider monitoring specifically for brown mite in border rows along dirt roads during summer through fall where trees are dusty, were sprayed earlier in the season with a broad-spectrum insecticide, and after wildfires. To locate avocado brown mite and its webbing, use a hand lens (10X) to inspect along the midrib on the upper leaf surface.

Major outbreaks have occurred after spraying a broad-spectrum insecticide to control greenhouse thrips or omnivorous looper.

There is no suggested threshold for when treatment is warranted. Pesticide applications for avocado brown mite are rarely needed.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. NARROW RANGE OIL#	Label rates	4	0
MODE OF ACTION: Contact including smothering and barrier effects.			
COMMENTS: Requires good coverage to be effective. Check with certifier to determine which products are organically acceptable.			
B. WETTABLE SULFUR#	Label rates	24	0
MODE OF ACTION: Unknown.			
COMMENTS: Do not treat with sulfur when temperatures exceed 90°F to avoid leaf damage. Sulfur sprays are often not effective in coastal areas where temperatures do not promote fuming action.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

\# Certain products are acceptable for organically grown produce.

AVOCADO THRIPS (09 / 16)

Scientific Names: *Scirtothrips perseae*

DESCRIPTION OF THE PEST

(View photos online)

Avocado thrips (order Thysanoptera) is a key pest that scars fruit. Adults lay eggs hidden inside the underside of leaves, in young fruit, and in fruit petioles. The thrips then develop through two larval and two pupal stages. The first instar is white to pale yellow. The second instar is larger, more robust, and bright yellow. Larvae are typically found along major veins on the underside of younger leaves and anywhere on the surface of young fruit. Although some pupation occurs on the tree in cracks and in crevices, about three-fourths of avocado thrips drop from trees to pupate in the upper layer of dry, undecomposed leaf litter. Pupae are rarely seen and they do not feed. Adults are 0.03 inch (0.7 mm) long and have fringed-tipped wings. Adults are orange-yellow with distinct thin brown bands between segments of their abdomen and three small red dots (ocelli) on top of the head.

Neohydatothrips burungae, a new species of unknown importance, closely resembles avocado thrips, and may reliably be distinguished only by an expert. *Neohydatothrips burungae* often is darker brownish and has bands only on upper side of its abdomen. (See NEOHYDATOTHRIPS.)

Adult avocado thrips can closely resemble citrus thrips and to a lesser degree, western flower thrips, which occur on, but do not damage, avocado.

- Citrus thrips has no abdominal bands on its light orangish yellow to white body.
- Western flower thrips color is highly variable and some individuals have abdominal banding. Adults have thick, bristlelike hairs at the tip of the abdomen, which the other species lack. Western flower thrips are most often found in flowers.
- When at rest, avocado thrips wing tips extend beyond its abdomen, while the abdomen of western flower thrips extends beyond the tips of its wings. Avocado thrips larvae resemble those of several other species, including certain beneficial predaceous thrips.
- Predatory thrips are seldom seen at high levels as can be common with avocado thrips larvae.

Avocado thrips develops well under cool temperatures. Numbers typically begin increasing in late winter and spring, when avocado thrips feed on young leaves. Abundance peaks in late spring and early summer, when most fruit are young and after the growth flush when hardening of leaves induces thrips to move from foliage to feed on young fruit. Avocado thrips numbers are suppressed by warm, dry conditions, but this weather usually occurs later in the season, when most fruit are larger and no longer susceptible to new damage.

Avocado thrips has 6 or more generations a year. Egg to adult development occurs in about 20 to 30 days when temperatures average 65° to 75°F. Actual development time can be predicted by monitoring temperature using degree-days.

DAMAGE

Although it has little effect on tree health, avocado thrips feed directly on immature fruit. Internal fruit quality is not affected, but obvious feeding scars cause severe downgrading or culling of damaged fruit. Severe scarring when fruit are young can slow or stunt fruit growth. As fruit grows, this early feeding becomes apparent as scabby or leathery brown scars that expand across the skin. Thrips scarring is sometimes called “alligator skin." Mechanical injury or abrasion, such as from strong winds, also causes fruit scarring that can be confused with injury from avocado thrips.

Avocado thrips prefer to feed and lay eggs in succulent leaves. Feeding on young leaves causes irregular bronzing or scarring on both sides of the leaf. Discoloration is typically concentrated along the midrib and lateral leaf veins, and then appears in scattered patches between veins as numbers increase. Foliar feeding is usually unimportant, except when very high numbers cause premature leaf drop.

Thrips move to young fruit when leaves harden after the growth flush has finished. Almost all damage occurs when fruit are 0.2 to 0.6 inches (5–15 mm) long. Although Hass fruit are susceptible to feeding until they reach about 2 inches, thrips feeding rarely causes scars on fruit larger than about 0.75 inches. This scarring on young fruit may not become obvious until fruit enlarge.

MANAGEMENT

Importation of new species of natural enemies and modifications of cultural practices are being investigated for controlling avocado thrips. If insecticides are applied, choose selective materials whenever possible to minimize adverse impacts on the natural enemies that usually provide good control of other avocado pests, including caterpillars, certain mites, scales, whiteflies, and other thrips.

Biological Control

Natural enemies may suppress avocado thrips, but sometimes do not reduce numbers below damaging levels. Predatory thrips are the most important natural enemies, especially *Franklinothrips orizabensis.* At mild temperatures, about 77°F, *F. orizabensis* density can increase readily if avocado thrips numbers are increasing. This predator also eats other thrips, mites, and whiteflies, and feeds on avocado pollen and leaf juices. The adult *F. orizabensis* is mostly black with white or pale bands on its body, especially near its thin waist. Females lay eggs into plant tissue. Immatures develop through two larval and two pupal stages. First instars are yellowish with relatively long legs. Second instars have a distinctly swollen, bright orangish or red abdominal area. Pupation occurs in a silken cocoon.

Franklinothrips vespiformis, black hunter thrips (*Leptothrips mali*), and several banded-wing thrips (*Aeolothrips* spp.) also feed on avocado thrips, other pest thrips, and mites. Banded-wing thrips supplement their diet with pollen and plant juice, and can complete their life cycle and persist even when their prey are uncommon. Other general predators (especially green lacewings) and at least one parasitoid (*Ceranisus menes*) also attack avocado thrips.

Cultural Control

Avocado thrips damage is influenced by practices that increase or decrease the abundance of succulent foliage during set and growth of young fruit. Modifying fertilization (amount, application method, formulation, and timing) and pruning (the extent and time of branch removal) alters the extent to which trees continue to produce tender foliage during about May and June. Research indicates that in comparison with pruning during February through April, pruning during January does not affect yield. January pruning may also induce additional growth flush during fruit set, which may reduce thrips tendency to move from hardening leaves to young fruit.

Adding coarse organic mulch beneath trees and maintaining a mulch layer 6 inches thick may reduce survival of avocado thrips that drop from trees to pupate. The effectiveness of mulching to control thrips is uncertain and labor costs of adding mulch may not be justified solely for thrips control. However, applying coarse organic material such as composted yard waste beneath trees helps control *Phytophthora* root rot and weeds, and thrips reduction might be an additional benefit.

Organically Acceptable Methods

Use biological and cultural controls along with sprays of the Entrust formulation of spinosad for organically certified crop.

Monitoring and Treatment Decisions

Adults and second instars can be found anywhere on fruit or leaves, including on the upper leaf surface. Avocado thrips most often occur on the underside of tender, reddish foliage before or soon after leaves reach full expansion.

- Examine newly flushed leaves during February and March to get an indication of whether thrips are abundant enough to be a likely problem later when young fruit occur.
- Begin regular thrips monitoring before young fruit are present and continue monitoring until most fruit exceed 0.75 inch in diameter. Monitor regularly every 7 to 10 days beginning as early as April, looking for both mites and thrips.
- Look for thrips on 10 young leaves on at least 10 trees per grove. Use a magnifying lens to inspect the underside of these leaves and count the number seen. (Avoid leaves that are fully hardened and dark green, that touch fruit or other leaves, or are very close to flowers and fruit. Thrips on hardened leaves, touching leaves and fruit, and in flowers are often other species.)
- Calculate the average number of thrips per leaf: divide the total number of thrips counted by the number of leaves sampled (100).
- Young fruit can be monitored by clipping or pinching stems and examining the entire fruit surface for thrips, especially under the calyx. Be sure to correctly identify the thrips present, and record the results on a monitoring form (*available online*).

Depending on thrips densities, treatment decisions are sometimes made based on thrips abundance on succulent leaves. A treatment decision generally should be made before most new fruit are set or before most thrips move from leaves to young fruit. Before making a treatment decision, consider factors that influence the likelihood of thrips damage. These include thrips damage history, natural enemy abundance, weather, fruit load, and age or size of fruit.

- If extensive leaf flush continues through fruit set, the need for treatment may be reduced because more of the thrips population will remain on tender foliage.
- Conversely, little or no succulent foliage during fruit set increases the extent to which thrips will feed on and damage young fruit.

Treatment decision-making is also influenced by grower tolerance for scarring, treatment feasibility and equipment availability, and the possibility that treatments will disrupt natural enemies or promote the development of pesticide resistance. A general guideline is that an average of three to five thrips per leaf at fruit set warrants treatment.

Coordinate treatment decision-making with any persea mite management. Certain materials applied to control avocado thrips (usually earlier in the season) can reduce the need for persea mite treatment (which usually is applied later in the season). Only one application every 2 to 3 years may be permitted or recommended for certain materials (e.g., abamectin) to reduce the development of pesticide resistance. Rotate among chemical classes when making multiple applications to reduce the development of pesticide resistance.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. ABAMECTIN			
(Agri-Mek SC)*	Label rates	12	14
MODE-OF-ACTION GROUP NUMBER: 6			
. . . *PLUS* . . .			
NARROW RANGE OIL			
(415)	1%	See label	See label
MODE OF ACTION: Oil improves translaminar movement and persistence of this insecticide			
COMMENTS: Use with 1 to 2% narrow range (415) oil in a minimum of 50 gal water / acre for aerial applications and 100 gal water / acre for ground applications. On large trees aerial applications may require larger volumes of water to achieve desired efficacy. Control may last 4 or more weeks. Only use in an alkaline or slightly acidic solution. Do not tank mix with nutrients. To avoid promoting pesticide resistance, and because of heavy past use, do not make more than one application of any abamectin product every 3 years. Agri-Mek SC is highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
B. SPINETORAM			
(Delegate WG)	4–7 oz	4	1
MODE-OF-ACTION GROUP NUMBER: 5			
. . . *PLUS* . . .			
NARROW RANGE OIL			
(415)	1%	See label	See label
MODE OF ACTION: Oil improves translaminar movement and persistence of this insecticide.			
COMMENTS: To delay resistance, do not apply Group 5 insecticides (spinetoram, spinosad) more than once per year. Trials against avocado thrips have shown that spinetoram provides more persistent control than spinosad. Choose a lower rate for light infestations or small trees and a higher rate for heavy infestations or large trees. Apply in a minimum of 50 gal water / acre. On larger trees, aerial applications may require larger volumes of water to achieve desired efficacy. Control may last 3 or more weeks. Only use in an alkaline or slightly acidic solution. Do not tank mix with nutrients. Delegate WG is toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
C. SPIROTETRAMAT			
(Movento)	8–10 fl oz	24	1
MODE-OF-ACTION GROUP NUMBER: 23			
. . . *PLUS* . . .			
NARROW RANGE OIL			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
(415)	1%	See label	See label

MODE OF ACTION: Oil dramatically improves systemic movement and efficacy of this insecticide.

COMMENTS: Highly systemic material. Add 1% NR-415 oil to improve leaf penetration. Surface residues are not active and the material must be converted to spirotetramat enol inside the plant to affect thrips or mites feeding on the plant. Research is continuing on when to best apply this material but it appears flowers and young leaves take up the material best. Apply in a minimum of 10 gallons/acre by air or 15 gpa by ground.

D. FENPROPATHRIN

(Danitol 2.4 EC)*	16–21 1/3 fl oz	24	1

MODE-OF-ACTION GROUP NUMBER[1]: 3A

COMMENTS: Apply a minimum of 100 gallons by ground and 50 gallons by air. If oil is added to a fenpropathrin application, no more than 1% NR-415 oil may be used. Workers who enter for the purpose of harvesting within 7 days of application must wear specific harvest PPE, even though the PHI is 1 day (see label). To avoid promoting pesticide resistance, do not make more than one application of fenpropathrin product every 3 years. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

E. SPINOSAD

(Entrust SC)#	4–10 fl oz	4	1

MODE-OF-ACTION GROUP NUMBER[1]: 5

. . . *PLUS* . . .

NARROW RANGE OIL			
(415)	1%	see label	see label

MODE OF ACTION: Improves translaminar movement and persistence of insecticide.

COMMENTS: To delay resistance, do not apply Group 5 insecticides (spinetoram, spinosad) more than once per year. Trials against avocado thrips have shown that spinetoram provides more persistent control than spinosad. Choose a lower rate for light infestations or small trees and a higher rate for heavy infestations or large trees. When applying to organically grown produce, be sure that the oil used is also organically acceptable. Apply in a minimum of 50 gal water/acre. On larger trees, aerial applications may require larger volumes of water to achieve desired efficacy. Control may last 3 or more weeks. Only use in an alkaline or slightly acidic solution. Do not tank mix with nutrients. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

F. SABADILLA

(Veratran-D)#	10–15 lb PLUS up to 10 lb sugar-based spray adjuvant	12	NA

MODE OF ACTION: Stomach poison

COMMENTS: Must be ingested to be effective. Thrips feed more actively and are killed to a greater degree in warm weather. Acidify water in the spray tank to a pH of 4.5 before adding sabadilla; use a registered citric acid adjuvant or other approved acidifying agents. Screen must be mesh size 20 or larger to prevent plugging. Re-treat when thrips reappear, usually every 2 to 3 weeks or so. Do not tank mix with nutrients.

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‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on organically grown produce.

NA Not applicable.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

GREENHOUSE THRIPS (09/16)

Scientific Names: *Heliothrips haemorrhoidalis*

DESCRIPTION OF THE PEST

(View photos online)

Greenhouse thrips (order Thysanoptera) occurs primarily on broadleaved evergreen plants including avocado, citrus, and many ornamentals. Adult greenhouse thrips are black with white legs and white wings. Adults seldom fly, and all stages of this tiny insect are sluggish. Males are not found in California, where each parthenogenic female can lay up to 60 eggs during her life. Eggs are inserted singly into fruit or the upper or lower leaf surface. Eggs hatch in about 4 to 5 weeks during summer, longer during the winter. Unhatched eggs gradually increase in size, causing a swelling (egg blister) in the leaf cuticle that can be seen with a hand lens.

Greenhouse thrips larvae and pupae are pale yellow to whitish with red eyes. Larvae carry a greenish red to black globule of liquid feces on the tip of their abdomen. They periodically drop this excrement, leaving dark specks on fruit and foliage that help to locate infestations during monitoring. Most greenhouse thrips occur in fruit clusters and where leaves and fruit touch.

Greenhouse thrips has about five to six generations a year. All life stages are usually present throughout the year. In some colder areas, overwintering is primarily as eggs, with newly hatched larvae appearing about mid-February. Greenhouse thrips numbers are lowest during winter and spring, but can become abundant enough to damage fruit during early summer or fall. On Hass, where most greenhouse thrips reside on fruit, much of the population is removed annually at harvest.

DAMAGE

Greenhouse thrips occasionally is a serious pest in coastal avocado groves. Feeding on fruit skin causes scarring and the downgrading and culling of fruit at the packing house. Damage to leaves, although unsightly, is of no significance to tree health. Thrips injury on foliage begins to show in June as small, white-gray patches on upper leaf surfaces where thrips are found in the greatest numbers. The pale discoloration of foliage and fruit caused by early infestations turns brownish later in the season. The epidermis of injured leaves and fruit become thick, hard, and cracked. Black specks of thrips excrement may be noticeable.

Most economic damage occurs when fruit are 2 to 7 months old. Economic damage occurs when thrips cause scars or blemishes larger than 0.75 inches in diameter on fruit. Damage usually is most severe on fruit in clusters or where fruit touch leaves, as thrips are protected where fruit touch. Mexican seedling avocados and Hass are extremely susceptible. Least susceptible varieties include Anaheim, Dickinson, Fuerte, and Nabal, which are not widely planted. On green fruit avocado varieties like Bacon and Zutano, greenhouse thrips are not a pest as they feed primarily on foliage.

MANAGEMENT

Biological control, cultural practices, grove microclimate, and weather influence whether greenhouse thrips will be a problem on susceptible (Hass and Mexican seedling) avocado. Conserve natural enemies of thrips and other pests. Consider modifying harvest and pruning practices to control greenhouse thrips. If pesticide application is warranted, spot treat infested areas and avoid spraying the entire grove. Use selective materials for thrips and other pests whenever possible. Application of broad-spectrum pesticides often leads to outbreaks of pests such as caterpillars and mites.

Biological Control

An important egg parasite, *Megaphragma mymaripenne* (family Trichogrammatidae), often kills about 25 to 50% of greenhouse thrips eggs in coastal avocado. Parasitized eggs develop a relatively large round hole, usually in the middle of the egg blister, where the adult parasite emerges. When a greenhouse thrips emerges, part of the egg shell is often visible at the side of the egg blister.

Thripobius semiluteus (family Eulophidae) attacks second-instar larvae. The normally yellow to whitish thrips larvae turn black and swell around the head when a larva of this parasitic wasp matures inside. *Thripobius* egg to adult development time is about 3 weeks when temperatures average 70°F. Thrips numbers decline when about 60% of larvae are parasitized. Natural control due to *Thripobius semiluteus* is inconsistent. Release of

several thousand *Thripobius* per acre per week has controlled greenhouse thrips in coastal avocado, but *Thripobius* may not currently be commercially available.

Predaceous thrips including black hunter thrips and vespiform thrips (*Franklinothrips* spp., family Aeolothripidae), prey on greenhouse thrips. However, many predators apparently avoid greenhouse thrips because of their fecal excrement. Beneficial thrips and thrips-feeding general predators are discussed in AVOCADO THRIPS.

Cultural Control

The earlier the harvest, the less thrips damage on harvested fruit. Early harvest (about June or July) of all mature fruit on infested trees also reduces damage to next season's crop. Especially on Hass, where a large proportion of the greenhouse thrips feed and breed on fruit, early harvest minimizes the crop-to-crop overlap period, reducing the number of thrips that can move from old to new fruit.

When fruit prices are low, making early harvest less economical, selectively size-pick the larger fruit in clusters and where fruit and leaves touch. Size-picking reduces greenhouse thrips numbers by removing some thrips. Thinning clustered fruit and pruning dense canopies eliminates harborage, which reduces the density of greenhouse thrips, as well as caterpillars and mealybugs.

Organically Acceptable Methods

Use biological and cultural controls and sprays of pyrethrin (PyGanic) in an organically certified crop.

Monitoring and Treatment Decisions

Map or record the locations of infestations and check these areas each year. Greenhouse thrips problems tend to reoccur at the same sites within groves, typically where the microclimate is moderate.

1. In coastal groves, monitor for greenhouse thrips about every 10 to 14 days from late March through July. In inland groves where greenhouse thrips have been problematic, start monitoring at bloom through July. Concentrate in less exposed and interior grove areas where temperature and humidity are moderate and where your records document greenhouse thrips were most common during previous seasons. If greenhouse thrips are present, also monitor trees where mature fruit was held the longest before harvest.
2. Monitor on the inside and the north side of trees, away from direct sun exposure. Examine where older fruit touch in clusters and the upper surface of older leaves. Look for colonies of greenhouse thrips, bleached tissue, and black excrement specks. Be sure to correctly distinguish the species of any thrips you find.
3. Record on a monitoring form the number of greenhouse thrips (adults and larvae combined) per fruit on 10 fruit from each of at least 10 trees per grove.
4. Calculate the average number of thrips per fruit: divide the total number of greenhouse thrips by the total number of fruit sampled (100).

One study indicates greenhouse thrips damage can be predicted based on "thrips-weeks" (the number of thrips present × number of weeks they feed). When a colony of thrips are feeding in a group on a fruit, about 25 thrips-weeks (e.g., one thrips feeding for 25 weeks, or five thrips feeding for 5 weeks) may produce a 0.75 inch (19 mm) diameter, economically important scar. There are no more specific guidelines for when treatment is warranted.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

A. SPINOSAD
(Entrust SC)# — 4–10 fl oz — 4 — 1
MODE-OF-ACTION GROUP NUMBER¹: 5
. . . *PLUS* . . .
NARROW RANGE OIL — 1% — See label — See label
(415)
MODE OF ACTION: Improves translaminar movement and persistence of insecticide.
COMMENTS: To delay resistance, do not apply Group 5 insecticides (spinetoram, spinosad) more than once per year. Trials against avocado thrips have shown that spinetoram provides more persistent control than spinosad. Choose a lower rate for light infestations or small trees and a higher rate for heavy infestations or large trees. When applying to organically grown produce, be sure that the oil used is also organically acceptable. Apply in a minimum of 50 gal water / acre. On larger trees, aerial applications may require larger volumes of water to achieve desired efficacy. Control may last 3 or more weeks. Only use in an alkaline or slightly acidic solution. Do not tank mix with nutrients. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

B. SPINETORAM
(Delegate WG) — 4–7 oz — 4 — 1
MODE-OF-ACTION GROUP NUMBER¹: 5
. . . *PLUS* . . .
NARROW RANGE OIL — 1% — See label — See label
(415)
MODE OF ACTION: Oil improves translaminar movement and persistence of this insecticide.
COMMENTS: To delay resistance, do not apply Group 5 insecticides (spinetoram, spinosad) more than once per year. Trials against avocado thrips have shown that spinetoram provides more persistent control than spinosad. Choose a lower rate for light infestations or small trees and a higher rate for heavy infestations or large trees. Apply in a minimum of 50 gal water / acre. On larger trees, aerial applications may require larger volumes of water to achieve desired efficacy. Control may last 3 or more weeks. Only use in an alkaline or slightly acidic solution. Do not tank mix with nutrients. Delegate WG is toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

C. ABAMECTIN
(Agri-Mek SC)* — Label rates — 12 — 14
MODE-OF-ACTION GROUP NUMBER¹: 6
. . . *PLUS* . . .
NARROW RANGE OIL
(415) — 1% — See label — See label
MODE OF ACTION: Oil improves translaminar movement and persistence of this insecticide
COMMENTS: Use with 1 to 2% narrow range (415) oil in a minimum of 50 gal water / acre for aerial applications and 100 gal water / acre for ground applications. On large trees aerial applications may require larger volumes of water to achieve desired efficacy. Control may last 4 or more weeks. Only use in an alkaline or slightly acidic solution. Do not tank mix with nutrients. To avoid promoting pesticide resistance, and because of heavy past use, do not make more than one application of any abamectin product every 3 years. Agri-Mek SC is highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

D. SABADILLA
(Veratran-D)# — 10–15 lb — 12 — NA
MODE OF ACTION: unknown
COMMENTS: Acidify water in the spray tank to a pH of 4.5 before adding sabadilla; use a registered citric acid adjuvant or other approved acidifying agents. Screen must be mesh size 20 or larger to prevent plugging. Less effective than pyrethrin. Wet, cool weather conditions limit the use of this material because thrips feeding is reduced under these conditions. Do not tank mix with nutrients.

E. PYRETHRIN + PIPERONYL BUTOXIDE
(Pyrenone Crop Spray) — Label rates — 12 — 0
MODE-OF-ACTION GROUP NUMBER¹: 3A+unknown
COMMENTS: Because there is little residual activity, repeat application may be needed in 2 to 3 weeks and control may be only partial.

F.	PYRETHRINS# (PyGanic Crop Protection)	Label rates	12	0
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: Because there is little residual activity, repeat application may be needed in 2 to 3 weeks and control may be only partial.			
G.	MALATHION (Malathion 8)	4.7 pts	48	7
	MODE-OF-ACTION GROUP NUMBER[1]: 1B COMMENTS: Least IPM friendly of the listed treatments; watch for mite upsets. Treat only infested trees to avoid destroying natural enemies of mites, loopers, scales, and other potential secondary pests. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on organically grown produce.

NA Not applicable.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

OMNIVOROUS LOOPER (09/16)

Scientific Names: *Sabulodes aegrotata*

DESCRIPTION OF THE PEST

(View photos online)

The omnivorous looper (family Geometridae), also called looper or avocado looper, feeds on several dozen plant species. Omnivorous looper occurs in most avocado groves, generally in low numbers, unless natural enemies are disrupted by application of broad-spectrum insecticides.

Adults are mostly tan to orangish on top, with a narrow black band across the middle of the wings. They are white on the underside and have a wingspan of about 1.75 to 2 inches. Females live 2 to 3 weeks, laying eggs in clusters of 3 to 80 on the underside of leaves. Each barrel-shaped egg has a ring of tiny projections around one end. Eggs initially are pale green, then turn shiny reddish to brown. Eggs hatch about 8 or 9 days after oviposition, leaving transparent shells.

Young larvae are pale yellow and about 0.06 inch (1.5 mm) long. Mature larvae are 2 to 2.5 inches long and mostly yellow to pale green or pink, with a gold-colored head. Older larvae have variable dark brown, black, green, or orangish lines along their sides. In addition to three pairs of true legs behind the head, avocado looper has two pairs of appendages (prolegs) near its rear on abdominal segments 6 and 10. Larvae travel in a characteristic looping manner, where they extend their body forward, then draw their rear forward to meet their forelegs. This arches their body up into a loop. When disturbed, omnivorous loopers often drop and hang from leaves on a silken thread.

Larvae feed about 6 weeks, then pupate within rolled or webbed leaves. Pupae are 1 to 1.25 inches long and white when first formed. The case darkens as a moth with brownish wings develops and can be seen through the pupal case. Pupation lasts 1 to 4 weeks.

Numbers increase with increasing temperatures in spring. Omnivorous looper typically has four (and perhaps five) generations per year at warmer growing areas. From inland Ventura to San Diego Counties, most adults fly and lay eggs during January through March, May through June, August through September, and October through November. Three generations a year are typical in coastal Santa Barbara County, where moths typically emerge and lay eggs during March through April, June through July, and August through September. Depending on temperature, egg to adult development takes 2 to 5 months.

DAMAGE

Damage is often associated with dense foliage, lots of new leaves, and overcast/cool conditions. Leaf damage is especially evident on terminal shoots. Very young larvae feed only on the leaf surface, leaving a characteristic brown membrane. Older larvae chew all the way through the leaf, often leaving only the midrib and large veins. Full-grown larvae can consume an entire leaf in 1 day. Healthy avocado trees tolerate considerable leaf damage without severe effects on growth or yield. Extensive feeding can result in sunburn and may reduce yield the following year.

Economic damage occurs primarily when caterpillars damage fruit. Both young and old larvae can chew fruit. If young fruit is fed on, it sometimes becomes misshapen. Chewing typically scars the fruit surface, which may cause fruit to be culled or downgraded.

MANAGEMENT

Conserve natural enemies, which usually keep caterpillars below damaging levels. Modify cultural practices to reduce pest reproduction and survival–pruning to open up the tree canopy usually results in noneconomic looper populations. Avoid applying broad-spectrum or persistent insecticides for any pests. Caterpillar outbreaks commonly occur after spraying malathion, which poison parasites and predators. When pesticides are warranted, limit application to the most infested spots to provide refuges from which natural enemies can recolonize after treatment.

Biological Control

(View photos online)

Spiders are important looper predators, especially in orchards that have not been sprayed with pesticide or recently subjected to a freeze. Assassin bugs, birds, damsel bugs, lacewings, and pirate bugs and predatory insects also prey on caterpillars.

Granulosis virus frequently infects and kills larvae when they become common. A virus epidemic can cause the looper numbers to rapidly decline within 1 to 2 weeks. Virus-killed caterpillars are immobile and range in appearance from white and swollen to brownish and shriveled. Diseased larvae cease feeding, become lethargic, and eventually liquefy and then dry up.

Wasps, especially *Trichogramma* egg parasites and three larval parasites (family Braconidae), are the most important natural enemies. *Apanteles caberatae* and *Meteorus tersus* are solitary internal parasites of larvae. The *Apanteles caberatae* larva pupates in a 0.1 inch, whitish silken cocoon near its dead host. The *Meteorus tersus* larva pupates in a brown or yellowish parchmentlike cocoon, which often hangs suspended beneath leaves or twigs on a 1 to 2 inch long thread. One to several pale *Habrobracon* (=*Bracon*) *xanthonotus* larvae feed externally on each looper, then each pupates in a 0.12 inch (3 mm) long white silken cocoon near the shriveled dead caterpillar.

At least five fly species (family Tachinidae) attack omnivorous looper, including *Eumea caesar*, *Hyphantrophaga* (=*Eusisyropa*) *virilis*, and *Nilea erecta*. Their black to dark grayish adults are about 0.25 to 0.33 inch long and resemble a common house fly, but have more prominent stout hairs. White tachinid eggs may be observed on or near a caterpillars' head. Brown to reddish, parchmentlike tachinid pupal cases are often found near the larger pupal cases of dead caterpillars.

Trichogramma platneri naturally parasitizes looper eggs, which turn black when parasitized. Where natural biological control is inadequate, omnivorous looper has been controlled by releasing *T. platneri* in late spring or early summer during peak moth egg laying, as determined by monitoring using commercially available pheromone-baited or black light traps. Until all *T. platneri* have emerged, protect cards from Argentine ants and other predatory insects. Keep a small portion from any purchase in a shady location in a clear container covered with tightly woven cloth. Observe wasp emergence to assess product quality.

Organically Acceptable Methods

Use biological and cultural controls and sprays of *Bacillus thuringiensis* on an organically certified crop.

Monitoring and Treatment Decisions

Where caterpillar problems may occur, monitor during the spring and summer, especially after peaks in moth flights. Omnivorous looper is a nocturnal moth. Nocturnal moths are attracted to lights and lay eggs nearby, therefore, monitor areas where bright lights such as security lights are used. Be sure to correctly distinguish the cause of any damage since other insects and certain abiotic disorders cause leaf holes resembling caterpillar chewing. Correctly identify the species of caterpillars. Alternate host plants, damage potential, monitoring methods, and natural enemies vary depending on the species of caterpillar. Look for caterpillar predators and larval diseases and parasitism. Natural enemy prevalence affects treatment decision making.

MONITORING CATERPILLARS AND THEIR NATURAL ENEMIES methods include shaking foliage to dislodge larvae, inspecting foliage for caterpillars and their damage (timed counts), trapping adults, or a combination of these methods.

When inspecting foliage, if 15 healthy omnivorous looper larvae are found per hour of search, treatment may be warranted. Modify this guideline based on orchard history and the extent of biological control. If caterpillar damage has previously been a problem or broad-spectrum pesticides have been applied, it is more likely that treatment will be needed. If natural enemies are increasing, this may indicate treatment can be delayed or avoided. If looper numbers are near the threshold, monitor parasites and other natural enemies several times. With higher levels of larvae, watch for evidence of viral disease. When a nuclear polyhedrosis virus is present, looper numbers will often crash within 2 weeks. Diseased larvae cease feeding, become lethargic, and eventually liquefy and then dry up in their nests. Spraying with malathion often leads to outbreaks of other pests and is not recommended. Bt sprays are the least disruptive to natural enemies.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. *TRICHOGRAMMA PLATNERI* PARASITES#	See comments	NA	NA
COMMENTS: Make at least two releases a week apart during the period of peak egg laying (as determined by pheromone traps and visual inspection). Place parasite egg cards on at least four trees / acre for a total minimum release of 100,000 parasites / acre per season.			
B. *BACILLUS THURINGIENSIS* ssp. *AIZAWAI*#			
(various products)	Label rates	4	0
MODE-OF-ACTION GROUP NUMBER¹: 11A			
COMMENTS: Effective when used to control early instars of the caterpillar.			
C. *BACILLUS THURINGIENSIS* ssp. *KURSTAKI*#			
(various products)	Label rates	4	0
MODE-OF-ACTION GROUP NUMBER¹: 11A			
COMMENTS: Effective when used to control early instars of the caterpillar.			
D. SPINOSAD			
(Entrust SC)#	4–10 fl oz	4	1
MODE-OF-ACTION GROUP NUMBER¹: 5			
. . . *PLUS* . . .			
NARROW RANGE OIL			
(415)	1%	See label	See label
MODE OF ACTION: Improves translaminar movement and persistence of insecticide.			
COMMENTS: To delay resistance, do not apply Group 5 insecticides (spinetoram, spinosad) more than once per year. Choose a lower rate for light infestations or small trees and a higher rate for heavy infestations or large trees. When applying to organically grown produce, be sure that the oil used is also organically acceptable. Apply in a minimum of 50 gal water / acre. On larger trees, aerial applications may require larger volumes of water to achieve desired efficacy. Control may last 3 or more weeks. Only use in an alkaline or slightly acidic solution. Do not tank mix with nutrients. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
E. SPINETORAM			
(Delegate WG)	4–7 oz	4	1
MODE-OF-ACTION GROUP NUMBER¹: 5			
. . . *PLUS* . . .			
NARROW RANGE OIL			
(415)	1%	See label	See label
MODE OF ACTION: Oil improves translaminar movement and persistence of this insecticide.			
COMMENTS: To delay resistance, do not apply Group 5 insecticides (spinetoram, spinosad) more than once per year. Choose a lower rate for light infestations or small trees and a higher rate for heavy infestations or large trees. Apply in a minimum of 50 gal water / acre. On larger trees, aerial applications may require larger volumes of water to achieve desired efficacy. Control may last 3 or more weeks. Only use in an alkaline or slightly acidic solution. Do not tank mix with nutrients. Delegate WG is toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
F. FENPROPATHRIN			
(Danitol 2.4 EC)*	16–21 1 / 3 fl oz	24	1
MODE-OF-ACTION GROUP NUMBER¹: 3A			
COMMENTS: Effective against high omnivorous looper and amorbia populations. Apply a minimum of 100 gallons by ground and 50 gallons by air. If oil is added to a fenpropathrin application, no more than 1% NR_415 oil may be used. Workers who enter for the purpose of harvesting within 7 days of application must wear specific harvest PPE, even though the PHI is 1 day (see label). To avoid promoting pesticide resistance, do not make more than one application of fenpropathrin product every 3 years. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment until harvest. In

some cases the REI exceeds the PHI. The longer of these two intervals is the minimum time that must elapse before harvest.

Acceptable for use on organically grown produce.

' Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

NA Not applicable.

PERSEA MITE (09/16)

Scientific Names: *Oligonychus perseae*

MITE PESTS OF AVOCADO: GENERAL INFORMATION

Spider mites (family Tetranychidae) and predatory mites (Phytoseiidae) are tiny eight-legged arthropods (larval stages have only six legs). Persea mite is a key pest of California-grown avocados. Avocado brown mite and sixspotted mite are sporadic pests. Several beneficial mites are important predators of pest mites and certain insects. Natural enemies and certain management strategies vary among pest mites. Identify the pest and natural enemy species in your grove and learn their biology so you can manage these pests appropriately as needed. For details about sampling techniques, see MONITORING PERSEA AND SIXSPOTTED MITES.

DESCRIPTION OF THE PEST

(View photos online)

Persea mite (family Tetranychidae) is a key pest that occurs in most avocado-growing areas of California except the Central Valley. Many ornamentals and weeds also host persea mite. When persea mites were first intro-duced into California in the early 1990s, individual mites from large populations on avocado trees were seen drifting onto leaves of adjacent stone fruit trees, although they did not feed. Since that time, however, numbers have been reduced and persea mites have not been observed on stone fruit trees or fruit, and *Prunus* species are not known to be a host of this mite.

Persea mite develops from an egg through a six-legged larval stage and two eight-legged nymphal stages before becoming an eight-legged adult. Adult females have an oval-shaped body that is slightly flattened and elongated. Females and immatures are yellowish or greenish with two or more small dark blotches on their abdomen. Old females that have ceased laying eggs turn darker green and become somewhat smaller and inactive. Males are smaller than reproductive females. Males are somewhat pear-shaped, slightly flattened, and yellowish with or without small dark spots. Persea mites feed and reproduce mostly beneath webbed patches or silk-covered "nests."

Each female lays about 2 to 4 dozen eggs during her life. Eggs are round, pale yellow, and develop red eye spots as they mature. Egg to adult female development time is about 2 to 3 weeks when temperatures average 77° to 63°F. Generation time can be accurately estimated by monitoring degree-days.

Cool winter temperatures slow growth of persea mite numbers. Mite densities are lowest around March and gradually increase through spring feeding on new leaf flush. Numbers generally peak in July and August. Persea mite populations are suppressed, and their numbers may decline rapidly, when the daily high temperature is 100°F or more on several consecutive days and humidity is low.

DAMAGE

Persea mite is most damaging to Hass, Gwen, and a few other varieties. Esther, Pinkerton, and Reed are of intermediate susceptibility. The Bacon, Fuerte, Lamb Hass, and Zutano varieties are much less affected.

High persea mite numbers cause premature leaf drop and defoliation. Defoliation leads to sunburned bark and fruit, aborted or dropped fruit, and severely stressed trees, which later reduces yields.

Persea mite feeding on the underside of leaves causes discrete circular chlorotic to brown spots on the lower leaf surface. These spots become visible on the upper leaf surface. Persea mite colonies are small and can become very numerous. Each colony can produce dense webbing, which resembles a silvery spot on the underside of the leaf. High persea mite numbers can often be recognized by numerous brown-spotted, green leaves hanging from trees and on the ground beneath infested trees. Heavily infested canopies can appear lighter colored overall when viewed from a distance.

Persea mite damage early in the season can be confused with sixspotted mite damage.

Damage	Persea mite	Sixspotted mite
Webbing	• Dense webbing resembles a silvery spot on the underside of the leaf.	• Less dense

Feeding	• Results in roundish, mostly scattered spots.	• Results in brown to purplish irregularly shaped blotches
Damage area	• Distributed throughout the lower leaf surface. Occasionally occurs on upper leaf surface.	• Generally confined to areas immediately adjacent to veins only on lower leaf surface.

Mite feeding on the upper leaf surface is usually caused by avocado brown mite and results in the upper leaf surface to appear bronzed or scorched. Damage does not occur in discrete circular spots.

MANAGEMENT

Minimize tree stress to reduce the effect of persea mite feeding on trees. Appropriate irrigation frequency and amounts, good management of avocado root rot and other key pathogens, and harvesting fruit early will reduce the adverse impact of mite feeding. If treating, whenever possible choose pesticides that have low residual toxicity or are non-toxic to natural enemies.

In the early stages of a significant infestation, highly refined or narrow-range petroleum oils or certain other materials can be applied. Treat only where necessary and leave unsprayed areas to conserve beneficials and provide refuges from which natural enemies and pesticide-susceptible pests can recolonize treated trees. Maximize the interval between treatments and alternate applications among pesticides with a different mode of action to reduce the rate at which pesticide resistance develops.

Biological Control

(View photos of predaceous mites and other predators online)

Numerous predators feed on persea mite. Predaceous mites include *Amblyseius* (=*Neoseiulus*) *californicus*, *Euseius hibisci*, *Galendromus annectens*, and *G. helveolus*. Black hunter thrips (*Leptothrips mali*), sixspotted thrips (*Scolothrips sexmaculatus*), brown lacewings (*Hemerobius* spp.) and green lacewings (*Chrysopa* and *Chrysoperla* spp.), dustywings (family Coniopterygidae), a predatory midge (*Feltiella* sp., Cecidomyiidae), a rove beetle (*Oligota oviformis*, Staphylinidae), and the spider mite destroyer lady beetle (*Stethorus picipes*) are other common predators. Most predators are not highly effective because of persea mites' protective webbed nests. However, conserve natural enemies because they can reduce persea mite numbers, and predators often provide good biological control of avocado brown mite and sixspotted mite.

Commercially available predators include predatory mites from family Phytoseiidae (*Amblyseius californicus*, *Galendromus annectens*, and *G. helveolus*) and green lacewing larvae (*Chrysoperla* spp.). Often relatively few predaceous mites are present through the winter because presence of their persea mite prey have been suppressed by hot summer weather. Introducing *Galendromus helveolus* helps to control persea mite if sufficient numbers of predators are introduced and releases are well-timed. If predator releases are planned, monitor persea mites regularly in late February through summer and release predaceous mites when about 50% of leaves have one or more active-stage pest mites. To check the viability of purchased predaceous mites, gently pour some mites and any shipping substrate into a clear jar and look for an abundance of fast-moving mites, which indicates predators arrived in good condition.

Cultural Control

Eliminate or reduce persea mite alternate host plants growing near avocado, including mite-susceptible ornamentals, non-commercial fruit trees, and weeds. Provide trees with appropriate irrigation and other good cultural care to maintain the flush of new growth and compensate for mite-induced leaf drop. However, be careful not to overfertilize. Excess fertilization, especially with quick-release formulations, may increase persea mite numbers and damage during late spring and summer due to increased foliar nitrogen. Spraying the underside of leaves with a forceful stream of water can reduce mite presence on a few small trees where this is feasible. Whitewash trunks and major limbs to protect bark and wood from sunburn after premature leaf drop.

Organically Acceptable Methods

Use biological and cultural controls and sprays of certain oils in an organically certified crop.

Monitoring and Treatment Decisions

1. Inspect leaves for mites, mite damage, and natural enemies about every 7 to 10 days from mid-March through at least August, and perhaps through October.

2. Coordinate monitoring and treatment decision-making for persea mite and avocado thrips, which are usually the key invertebrate pests feeding on leaves. Mite monitoring frequency, and the need for treatment and choice of material, can be affected by thrips management decisions.
3. Consider the effect of weather on treatment decision-making. Heavy winter rains and high winds can substantially reduce subsequent mite presence and damage. Persea mite numbers are suppressed or may crash when the daily high temperature is 100°F or more on several consecutive days and humidity is low.

Remember:

- Certain materials applied (usually earlier in the season) to control avocado thrips can also control or suppress mite numbers (which are usually treated later in the season if needed).
- Some materials can adversely impact natural enemies, so applying a less selective material early for thrips may increase the need to later treat mites.
- Only one application per season may be permitted or recommended for certain materials (e.g., abamectin) to reduce the development of pesticide resistance.
- Rotate among chemical classes when making multiple applications to reduce the development of pesticide resistance.

There are no research-based thresholds for when persea mite treatment is warranted. Develop treatment guidelines satisfactory for your situation by keeping good records and adapting your monitoring and management methods as appropriate. Regularly monitor and record mite densities and compare these numbers from year-to-year with records of your control actions and their effectiveness. See MONITORING PERSEA AND SIXSPOTTED MITES for additional information.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. GALENDROMUS MITES#	2,000 / tree	NA	NA
. . . *or* . . .			
NEOSEIULUS CALIFORNICUS#	2,000 / tree	NA	NA
COMMENTS: Make a single release of 2,000 mites per tree, or two releases each of 1,000 mites / tree, when regular monitoring of leaves for mite presence-absence shows that about 50% of leaves have one or more active-stage pest mites, typically in spring or early summer. The most effective release strategy is to dispense predator mites and carrier (e.g., corn grits) in small paper cups attached to branches. Attach four cups per tree evenly distributed around the canopy on avocado branches that are shaded from the sun. Add about 250 to 500 predators per cup depending on the release rate. The predators will disperse from the cups.			
B. ABAMECTIN			
(Agri-Mek SC)*	Label rates	12	14
MODE-OF-ACTION GROUP NUMBER¹: 6			
…*PLUS*…			
NARROW RANGE OIL			
(415)	1%	See label	See label
MODE-OF-ACTION GROUP NUMBER¹: Improves translaminar movement and persistence of insecticide. COMMENTS: Use with 1 to 2% narrow range (415) oil in a minimum of 50 gal water / acre for aerial applications (higher water volumes are more effective in controlling high numbers of mites) and 100 gal water / acre for ground applications. On large trees aerial applications may require larger volumes of water to achieve desired efficacy. Control may last 3 or more weeks. Only use in an alkaline or slightly acidic solution. Do not tank mix with nutrients. To avoid promoting pesticide resistance, and because of past heavy use, do not make more than one application of any abamectin product every 2 to 3 years in each grove. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			
C. SPIRODICLOFEN			
(Envidor 2 SC)	18–20 fl oz	12	2
MODE-OF-ACTION GROUP NUMBER¹: 23 COMMENTS: Only one application is allowable per crop season. Apply in a minimum of 50 gal / acre by air; higher water volumes are more effective in controlling high numbers of mites. Contact material (no translaminar or systemic activity).			
D. ETOXAZOLE			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
(Zeal)	2–3 oz	12	1

MODE-OF-ACTION GROUP NUMBER¹: 10B

COMMENTS: Maximum of one application per year. Material shows some translaminar activity and addition of a surfactant or oil (more research is needed) may improve efficacy (stickers appear to limit translaminar activity and should be avoided). Apply in a minimum of 20 gallons / acre by air (higher water volumes are more effective) or 50 gpa by ground. This material works mainly as an ovicide (i.e. against mite eggs).

E.	FENPROPATHRIN (Danitol 2.4 EC)*	16–21 1 / 3 fl oz	24	1

MODE-OF-ACTION GROUP NUMBER¹: 3A

COMMENTS: Apply a minimum of 100 gallons by ground and 50 gallons by air. If oil is added to a fenpropathrin application, no more than 1% NR-415 oil may be used. Workers who enter for the purpose of harvesting within 7 days of application must wear specific harvest PPE, even though the PHI is 1 day (see label). To avoid promoting pesticide resistance, do not make more than one application of fenpropathrin every 3 years in each grove. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

	Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
F.	FENPYROXIMATE (Miteus)	2 pints	12	1
	MODE-OF-ACTION GROUP NUMBER[1]: 21A COMMENTS: Contact material (not translaminar or systemic). Apply in a minimum of 95 gal/acre by ground and 50 gal/acre by air.			
G.	NARROW RANGE OIL#	Label rates	See label	See label
	MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: Requires good coverage to be effective. Check with certifier to determine which products are organically acceptable.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on organically grown produce.

* Permit required from county agricultural commissioner for purchase or use.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

NA Not applicable.

POLYPHAGOUS SHOT HOLE BORER (09/16)
KUROSHIO SHOT HOLE BORER (09/16)

Scientific name: *Euwallacea spp.*

DESCRIPTION OF THE PEST

Polyphagous shot hole borer (PSHB) and Kuroshio shot hole borer (KSHB) are genetically different invasive species, but morphologically they are indistinguishable. Females are black and 0.07 to 1.0 inch (1.8–2.5 mm) long. Males are brown and smaller than females at 0.06 inch (1.5 mm) long. The female tunnels into a wide variety of host trees forming galleries, where it lays its eggs. More females are produced than males. Mature siblings mate with each other so that females leaving to start their own galleries are already pregnant. Males do not fly, but stay in the host tree.

Both beetle species have a special structure in their mouth called a mycangium with its own novel symbiotic fungal species. Polyphagous shot hole borer carries three fungi: *Fusarium euwallaceae, Graphium euwallaceae* and *Paracremonium pembeum*. Kuroshio shot hole borer carries two different species for fungi: *Fusarium* sp. and *Graphium* sp. The beetle grows these fungi in their galleries. The fungi cause FUSARIUM DIEBACK disease, which interrupts the transportation of water and nutrients in the host tree.

DAMAGE

A host tree's visible response to a beetle's attack varies among host species. Staining, sugary exudate (also called a sugar volcano), gumming, and frass may be noticeable before the tiny beetles are found. The beetle's entry and exit holes, which are about 0.03 inch (0.85 mm) in diameter, can be located beneath or near the symptoms. The abdomen of the female beetle can sometimes be seen sticking out of the hole, guarding the developing larvae. Advanced fungal infections will eventually lead to branch dieback.

Rapid spread of the beetle and fungi throughout various land-use areas is attributed to the diverse range and quantity of suitable hosts in Southern California.

MANAGEMENT

Currently there is Section 18 emergence exception in place for the use of Hero EW insecticide against the polyphagous shot hole borer (PSHB).

Early detection of infestations and removal of the infested branches will help reduce beetle numbers and therefore, also reduce the spread of the fungus.

- Chip infested wood onsite to a size of one inch or smaller. If the branch is too large to chip, solarize them under a clear tarp for several months
- Avoid movement of infested firewood and chipping material out of infested area
- For more information visit the UC Riverside Eskalen Lab website (http: / / eskalenlab.ucr.edu).

KNOWN REPRODUCTIVE HOSTS OF POLYPHAGOUS SHOT HOLE BORER AND KUROSHIO SHOT HOLE BORER

Polyphagous shot hole borer attacks hundreds of tree species, but it can only successfully lay its eggs and grow the fungi in certain hosts.

Known suitable reproductive host trees of polyphagous shot hole borer:
(* species known to be susceptible to Fusarium dieback)

- acacia (*Acacia* spp.)
- American sweetgum (*Liquidambar styraciflua*)*
- avocado (*Persea americana*)*
- bigleaf maple (*Acer macrophyllum*)*

- black cottonwood (*Populus trichocarpa*)
- Black Mission fig (*Ficus carica)*
- blue palo verde (*Cercidium floridum*)*
- box elder (*Acer negundo*)*
- brea (*Cercidium x sonorae*)*
- California sycamore (*Platanus racemosa*)*
- camellia (*Camellia semiserrata*)*
- castor bean (*Ricinus communis*)*
- Chinese holly (*Ilex cornuta*)*
- coast live oak (*Quercus agrifolia*)*
- coral tree (*Erythrina corallodendron)**
- cork oak (*Quercus suber*)*
- Engelmann oak (*Quercus engelmannii*)
- English oak (*Quercus robur*)*
- evergreen maple (*Acer paxii*)*
- Fremont's cottonwood (*Populus fremontii*)
- Goodding's black willow (*Salix gooddingii*)
- Japanese beech (*Fagus crenata*)
- Japanese maple *(Acer palmatum*)*
- Japanese wisteria (*Wisteria floribunda*)*
- Kurrajong (*Brachychiton populneus*)
- London plane (*Platanus x acerifolia*)
- mesquite amargo (*Prosopis articulata*)
- Mexican sycamore *(Platanus mexicana)*
- Moreton Bay chestnut (*Castanospermum australe*)*
- palo verde (*Parkinsonia aculeata*)*
- Persian silk tree (*Albizia julibrissin*)*
- red flowering gum (*Corymbia ficifolia*)
- red willow *(Salix laevigata)*
- titoki (*Alectryon excelsus*)*
- tree of heaven (*Ailanthus altissima*)
- trident maple (*Acer buergerianum*)*
- valley oak (*Quercus lobata*)*
- weeping willow (*Salix babylonica*)
- white Alder (*Alnus rhombifolia*)

Known suitable reproductive host trees of Kuroshio shot hole borer:
(* species known to be susceptible to Fusarium dieback)

- arroyo willow (*Salix lasiolepis*)
- avocado (*Persea americana*)*
- black poplar (*Populus nigra*)
- black locust (*Robinia pseudoacacia*)
- black willow (*Salix nigra*)
- California sycamore (*Platanus racemosa*)*
- castor bean (*Ricinus communis*)*
- coast live oak (*Quercus agrifolia*)*
- cork oak (*Quercus suber*)*
- dwarf coral tree (*Erythrina humeana*)*
- Fremont's cottonwood (*Populus fremontii*)
- Persian silk tree (*Albizia julibrissin*)*
- red willow (*Salix laevigata*)
- strawberry snowball tree (*Dombeya cacuminum*)*

Common name (Example trade name)	**Amount per acre****	**REI‡ (hours)**	**PHI‡ (days)**

The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

A. BIFENTHRIN / ZETA-CYPERMETHRIN*
(Hero EW) — 11.2 fl oz — 12 — 7
MODE OF ACTION: 3A/3A
COMMENTS: Use allowed under Section 18 label which expires on April 8, 2017. Registration only applies to the following counties: San Diego, Riverside, Orange, San Bernardino, Los Angeles, Ventura, Santa Barbara, San Luis Obispo, Monterey, and Tulare.
Apply up to five times per year at no less than 15-day intervals. Polyphagous shot hole borer infests the wood of avocados, not the leaves or fruit, often from the top of the tree down and appear to prefer branch crotches of primary and secondary branches rather than the main trunk. Sprays should target these areas. Apply using a hand-held sprayer targeting the trunk and major scaffold limbs. Do not allow to run off the target tree onto the ground or soil.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be

safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use

** Apply in 50 to 300 gallons of water.

SIXSPOTTED MITE (09 / 16)

Scientific Names: *Eotetranychus sexmaculatus*

MITE PESTS OF AVOCADO—GENERAL INFORMATION

Spider mites (family Tetranychidae) and predatory mites (Phytoseiidae) are tiny eight-legged arthropods, except for first stage larvae, which have six legs. Persea mite is a key pest of California-grown avocados. Avocado brown mite and sixspotted mite are sporadic pests. Several beneficial mites are important predators of pest mites and certain insects. Natural enemies and certain management strategies vary among pest mites. Identify the pest and natural enemy species in your grove and learn their biology so you can manage these pests appropriately. For details about sampling techniques, see MONITORING PERSEA AND SIXSPOTTED MITES.

DESCRIPTION OF THE PEST

(View photos online)

The oval adults are about 0.01 inch (0.3 mm) long. Their body is lemon yellow, often with about six dark blotches on the abdomen, although some individuals have no distinct spots. Females lay tiny, globular, pale greenish yellow to translucent or pearly white eggs, which have a slender projecting stalk. About 25 to 40 eggs are laid over 10 to 20 days. Eggs hatch in 5 days to 3 weeks, depending on temperature. In summer, mites reach maturity in 8 to 12 days. Numbers are highest in spring and early summer.

DAMAGE

Sixspotted mite is an occasional pest, mostly near the coast in foggy areas of San Luis Obispo and Santa Barbara counties. It generally is under good biological control in the interior growing areas (Riverside and San Diego counties) because of predators and warm weather. Sixspotted mite can become a problem anywhere trees are drought-stressed or where pesticide usage has disrupted mite biological control.

Sixspotted mite feeds only on the lower avocado leaf surface. It causes irregular brown to purplish discoloring, mostly along the midrib and larger veins. Sixspotted mite produces webbing, but not the dense roundish silk patches formed by persea mite. Densities of 25 to 30 mites per leaf may lead to defoliation.

MANAGEMENT

Enhance biological control by conserving natural enemies.

- Minimize dust.
- Avoid applying non-selective pesticides that are toxic to predaceous insects and beneficial mites that control plant-feeding mites and other pest insects.
- Limit any needed applications to spots where pests are most common.

Biological Control

(View photos online)

Sixspotted mite is controlled primarily by predatory mites (family Phytoseiidae). These phytoseiids include *Amblyseius* (=*Typhlodromalus*) *limonicus* and *Galendromus helveolus*. *Euseius hibisci*, a shiny pear-shaped predator, is important in part because it can maintain and increase its numbers on avocado pollen when pest mites are scarce. *Typhlodromus rickeri* also preys on sixspotted mite around Santa Barbara County. The spider mite destroyer lady beetle (*Stethorus picipes*) and sixspotted thrips (*Scolothrips sexmaculatus*) are other important natural enemies.

Cultural Control

Encourage predators by watering or paving main orchard roads to control road dust. Drive slowly when it is necessary to use dirt roads. Consider using a water truck or trailer to wet dirt roads, especially before travel during summer months when heat convection currents carry dust well up into the tree canopies. Individual backyard trees can be hosed down in early to midsummer to remove dust and enhance biological controls.

Organically Acceptable Methods

Use biological and cultural controls, sulfur and certain oil sprays in an organically certified crop.

Monitoring and Treatment Decisions

- Look for sixspotted mite when monitoring persea mite, see MONITORING PERSEA AND SIXSPOTTED MITES. Be sure to distinguish the mite species present.
- When specifically monitoring for sixspotted mite, select trees in dusty and more humid locations of groves.
- Use a hand lens to examine along the midrib and lateral veins on the underside of interior canopy leaves.
- Look for brown to purplish discoloring, mite webbing, and mites.

Sixspotted spider mite can severely stress trees at relatively low densities by causing premature leaf drop. However, numbers rarely exceed an average of 2 to 3 mites per leaf. At this low level, sixspotted mite is not damaging, does not warrant treatment, and is easily overlooked.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. NARROW RANGE OIL# MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: Requires good coverage to be effective. Check with certifier to determine which products are organically acceptable.	Label rates	4	0
B. WETTABLE SULFUR# MODE OF ACTION: Unknown. COMMENTS: Do not treat with sulfur when temperatures exceed 90°F to avoid leaf damage. Sulfur sprays are often not effective in coastal areas where temperatures do not promote fuming action.	Label rates	24	0

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Certain products are acceptable for organically grown produce.

Invertebrates: Young-Tree Pests

(Section reviewed 09/16)

BRANCH AND TWIG BORER (09/16)

Scientific Names: *Melalgus (=Polycaon) confertus*

DESCRIPTION OF THE PEST

The adult branch and twig borer (family Cerambycidae) is a slender brown beetle about 0.5 to 0.75 inches long. Its body is cylindrical, and the head and prothorax are narrower than the body. Females lay eggs in the dead wood of many different species of native and cultivated trees and shrubs. Larvae bore into heartwood and feed there for a year or more. Pupation occurs within the tree and adults emerge in early summer. There is one generation per year.

DAMAGE

When present, borers cause a recognizable hole in branches. This entrance to a larval feeding tunnel often exudes sugary sap that turns white and flaky. Infested branches with tunnels can be easily broken by wind. Branch and twig borer is not common in avocado and seldom causes economic injury.

MANAGEMENT

Borers prefer injured, dying wood and stressed, slow-growing trees.

- Protect trees from sunburn and injuries, such as by whitewashing exposed bark.
- Provide appropriate irrigation to keep trees healthy.
- Remove badly diseased or borer-infested trees and branches from the orchard. Promptly destroy brush piles. Branch and twig borers can emerge from cut limbs and attack nearby trees.
- Spraying insecticides does not kill borer larvae because they are protected inside the branch. Consequently, pesticides are not recommended for this insect.

BROWN GARDEN SNAIL (09/16)

Scientific Names: *Cantareus aspersus (=Helix aspersa)*

DESCRIPTION OF THE PEST

The brown garden snail (phylum Mollusca, family Helicidae) has a soft, slime-covered brown body. Its body and a pair of antennalike sensory appendages can be withdrawn into its shell. The hard spiraling shell grows up to about 1.25 inches in diameter. The shell is brown, tan, and yellow patterned in bands, flecks, and swirls.

Snails are hermaphroditic; they contain both male and female organs. After mating, snails drop eggs in a scattered group in a sheltered spot on topsoil. Mature snails lay eggs up to six times during a year, depending on climate and moisture.

Snails are most active during the night and early morning when surfaces are damp, such as after irrigation or rain. In southern California, particularly along the coast, young snails are active throughout the year. Mature snails hibernate in topsoil during cold weather.

DAMAGE

Extensive damage due to rasping of blossoms, leaves, and shoots stunts the growth of young trees and trees that have been topworked. Damage is similar to that of a chewing insect. The brown garden snail can especially be a problem following wet winters and springs. Brown garden snail feeding is not a problem in mature groves. Thick, dry leaf mulch suppresses snail numbers and large trees tolerate any modest damage.

MANAGEMENT

- Inspect young and topworked trees regularly for damage, especially during and after wet conditions. Be sure to distinguish the cause of damage. Caterpillars, earwigs, Fuller rose beetle, grasshoppers, and June beetles also chew tree foliage.
- Inspect surfaces for slimy or dry silvery trails characteristic of snails and slugs. Look for snails hidden under trunk wraps or other shelters near trunks.
- Modify cultural practices, encourage biological control, and exclude snails from canopies to provide good control.
- Control weeds in young groves and groves where tree canopies are sparse as low vegetation favors snails.
- Retain dropped leaves and apply coarse organic mulch near trunks to retard snail numbers and to suppress root rot and weeds. Frequent microsprinkler irrigation encourages snail problems.
- Increase the interval between irrigations to the extent compatible with good tree growth. Trim branches that touch soil to restrict snail access to canopies and expose the soil surface to drying.

Birds and other small vertebrates, parasitic flies, and several types of predatory beetles commonly prey on snails. The predatory decollate snail (*Rumina decollata*, family Subulinidae) is widely distributed in southern California. Decollate snail is commercially available and legal for introduction only in certain San Joaquin Valley and southern California counties (Fresno, Imperial, Kern, Los Angeles, Madera, Orange, Riverside, Santa Barbara, San Bernardino, San Diego, Ventura, and Tulare counties). Decollate introductions are not recommended in avocado. Establishment of significant decollate numbers usually requires several years after introduction, and brown garden snail primarily is a pest when avocado trees are young.

Snails and slugs are repelled by copper. Commercially available bands of copper foil wrapped around trunks exclude snails. Another alternative is to add Bordeaux mixture to whitewash and paint 1 to 2 inch strip around the trunks of trees. Certain snail baits are available for spot applications. Molluscicides also kill predatory decollate snails. Pesticides are rarely warranted for mollusk control in avocado.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. COPPER BANDS#	Label rates	NA	NA
COMMENTS: Place copper foil band around the tree trunk at a height of 1 to 2 feet above the ground. Overlap the copper foil on the tree trunk about 8 inches so it will slip and allow for trunk growth.			
B. BORDEAUX MIXTURE# (10:10:100)	Label rates	See label	See label
MODE OF ACTION: unknown			
COMMENTS: A slurry containing tribasic copper sulfate can be sprayed on trunks to act as a barrier. Not all copper compounds are approved for use in organic production; be sure to check individual products. Be sure to follow label directions for products used. For information on making a Bordeaux mixture, see UC IPM Pest Note: Bordeaux Mixture, ANR Publication 7451 (*available online*).			
C. IRON PHOSPHATE (Sluggo)#	Label rates	0	0
COMMENTS: Apply using standard fertilizer spreader. If ground is dry, wet it before applying bait. Reapply as bait is consumed or at least every 2 weeks. Check with your organic certifier to determine if this product is acceptable for use on organically certified produce.			
D. SODIUM FERRIC EDTA (Ferroxx Agriculture)	5–20 lbs	0	0

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on organically grown produce.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

NA Not applicable.

EUROPEAN EARWIG (09 / 16)

Scientific Names: *Forficula auricularia*

DESCRIPTION OF THE PEST

The introduced European earwig (family Forficulidae) is the most common of several earwig species that can occur in avocado. Adults are about 0.75 inch long, reddish brown, and have a pair of prominent tail appendages that resemble forceps. Most species have wings under short, hard wing covers, but earwigs seldom fly. Immature earwigs resemble small, wingless adults.

Earwigs feed mostly at night and hide during the day. Common hiding places include bark crevices, mulch, topsoil, protected (touching) plant parts, and under trunk wraps. Females lay masses of 30 or more eggs in soil. Nymphs are whitish and remain in soil until their first molt, after which they darken and begin searching for food. Earwigs generally have one or two generations a year. They can be active year round.

DAMAGE

Earwigs feed on dead and living insects and insect eggs, other organisms, and on succulent plant parts. Earwigs occasionally damage buds and leaves on young or newly grafted trees. They can be especially problematic on trees with trunk wraps or cardboard guards. The cause of damage can be difficult to distinguish from that of other chewing pests that hide during day and feed at night, including brown garden snail, Fuller rose beetle, and June beetles.

MANAGEMENT

If you suspect that earwigs are causing damage, lift and shake or sharply tap any trunk wraps and look for earwigs dropping to the ground, where they quickly scurry for cover. Alternatively, place a folded newspaper or burlap bag near the base of several trees with chewed foliage. Check these traps or earwig hiding places the next morning.

To manage earwigs use baited traps or remove hiding places. Cans with sardine or tuna fish oil are highly attractive to earwigs, which will climb into containers and drown. It may be necessary to cover liquid traps with heavy screening to exclude feeding by domestic and wild animals drawn to the fish odor. Remove trunk wraps where pests hide when wraps are no longer needed, thereby reducing earwig numbers. Earwigs rarely are abundant enough to warrant chemical treatment, except on young trees bordering uncultivated areas. Check with your cooperative extension advisor or county agricultural commissioner about the registration status of baits for treating earwigs.

FALSE CHINCH BUG (09/16)

Scientific Names: *Nysius raphanus*

DESCRIPTION OF THE PEST

The false chinch bug (family Lygaeidae) adult is mostly light to dark gray, elongate, and about 0.12 inch (3 mm) long. Females lay eggs on host plants or in cracks in soil. The mostly pale gray nymphs have inconspicuous reddish to brown abdominal markings. There are from four to seven generations per year. All stages can be present throughout the year.

During winter and early spring, false chinch bug primarily feeds on foliage, stems, and seeds of wild grasses and cruciferous weeds. When vegetation dries or is cut, or weeds are treated with a herbicide, bugs move in large numbers to feed on virtually any nearby green plants, including irrigated fruit and nut trees, grains, and vegetable crops. These feeding aggregations can be very large.

DAMAGE

False chinch bug occasionally causes severe injury on young trees by sucking sap from shoots and young stems. Infested shoots wither and die suddenly after attack, which typically occurs in May and June. Economic damage normally occurs in groves away from the coast only on young trees in border rows adjacent to uncultivated areas or grasslands. Otherwise healthy mature trees tolerate bug feeding.

MANAGEMENT

Monitor during late winter and early spring if young avocado trees are growing inland near unmanaged areas most susceptible to false chinch bug migrations. Before winter weeds dry or are cut, look for bugs on fences and weedy areas adjacent to young trees.

If false chinch bugs are common, consider treating weedy borders to kill bugs before they migrate. Only border trees may need treatment.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED XX/15			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. MALATHION (Malathion 8)	4.7 pt	48	7
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: Apply as a foliar spray. Use of this material will disrupt biological control of other pests such as scales, thrips, mites, and whiteflies. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

FULLER ROSE BEETLE (09/16)

Scientific Names: *Naupactus (Asynonychus) godmani (syn. Pantomorus cervinus)*

DESCRIPTION OF THE PEST

Adult Fuller rose beetles are brown to grayish snout beetles (weevils, family Curculionidae), about 0.36 inch (9 mm) long. Adults are all females, which lay eggs in clusters of several dozen in crevices on the tree or under loose bark. Larvae drop to the ground and feed on weed or tree roots, but larval feeding does not damage trees. Overwintering is as grubs that pupate beginning about June to July. Most adults emerge from June through October, but a few will emerge each month throughout the year. They feed for about 2 weeks before laying their first eggs. Feeding and egg-laying can continue into winter. There is one generation each year.

DAMAGE

Fuller rose beetle is an occasional problem in young avocado plantings. It can also damage top-worked, recently grafted, or severely pruned trees that have relatively little mature foliage and an abundance of developing immature leaves. Fuller rose beetle usually is common only on avocado growing near citrus or other preferred hosts.

Fuller rose beetle adults chew leaf margins, causing a ragged, notched, or serrated appearance that is quite different from damage caused by other pests such as snails. Most chewed leaves are on lower branches because adults cannot fly and must climb trunks and branches to reach foliage. Leaf chewing on older trees with a well-developed canopy is not economically important. There is no evidence that root feeding reduces yield and research has not been done to determine if root feeding predisposes trees to infection by *Phytophthora*.

MANAGEMENT

During late winter or early spring, apply a sticky barrier to trunks to exclude weevils if they may be a problem. Encircle a smooth section of trunk with a flexible wrap or tape and apply the sticky material on top to prevent direct contact with, and injury to, bark. A parasitic wasp (*Fidiobia citri*, family Platygastridae) parasitizes up to 50% of Fuller rose beetle eggs in citrus. Parasitized eggs darken and may persist long after unparasitized eggs have hatched. This parasite's importance in avocado is unknown.

Starting in June, inspect susceptible young or top-worked trees for leaf notching made by newly emerged adults. Be aware that caterpillars, earwigs, June beetles, grasshoppers, and snails also chew avocado leaves. Larvae and pupae of the exotic Diaprepes root weevil (*Diaprepes abbreviatus*) resemble Fuller rose beetle and adults of both species chew leaves. Be certain to identify the cause of problems before taking action. If suspected Diaprepes root weevils are found, notify agricultural officials as prompt management action may be warranted.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. STICKY POLYBUTENE MATERIALS#			
(Tanglefoot)	Label rates	NA	NA
COMMENTS: For use on all varieties. Use polybutene-based products only. Do not apply sticky materials directly on the trunk; use a 6- to 18-inch wrap under the sticky material to protect the tree from sunburn. Exercise caution in applying multiple applications (more than 3 or 4); watch for symptoms of bark cracking. Apply the sticky band high enough to avoid sprinklers, dust, and direct sunlight. Reactivate periodically by rubbing with a stick to remove dust. Check to ensure that low hanging branches, sticks, weeds, etc., are not allowing ants access to trees.			
B. THIAMETHOXAM			
(Actara)	4 oz	12	0
MODE-OF-ACTION GROUP NUMBER¹: 4A			
COMMENTS: For use on all varieties.			
C. MALATHION			
(Malathion 8)	4.7 pt	48	7
MODE-OF-ACTION GROUP NUMBER¹: 1B			

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
COMMENTS: Apply as a foliar spray. Use of this material will disrupt biological control of other pests such as scales, thrips, mites, and whiteflies and is not very effective against Fuller rose beetle. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on organically grown produce.

' Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

NA Not applicable.

GRASSHOPPERS (09/16)

Scientific Names: Devastating grasshopper: *Melanoplus devastator*
Valley grasshopper: *Oedaleonotus enigma*

DESCRIPTION OF THE PESTS

Grasshoppers (order Orthoptera) are robust, elongate insects where the winged adults that are good flyers. Commonly they are brown, gray, green, or yellowish insects with greatly enlarged hind legs adapted for jumping. Grasshoppers have relatively short antennae, which distinguishes them from crickets, katydids, and other Orthoptera, which have long antennae.

Most species of grasshopper overwinter as eggs and have only one generation a year. Adults live and feed for 2 to 3 months, during which females typically deposit elongate pods of about 20 to 100 eggs in the topsoil of undisturbed areas. Eggs hatch when soil warms in spring. The nymphs feed on most any species of nearby green plant, molting five or six times before becoming adults.

Nymphs and adults readily move. Each individual typically feeds on several different plants. As vegetation is consumed or dries when the rainy season ends, grasshoppers migrate to succulent plants. Adults, sometimes in a large swarm, can fly several miles a day. Nymphs readily jump, walk, or are carried by wind.

Grasshopper numbers vary from year to year. Grasshoppers become more numerous after warm, moist springs produce abundant vegetation in uncultivated areas, favoring grasshopper survival. Conversely, parasites and bacterial, fungal, and protozoan diseases can cause grasshopper numbers to crash. Many grasshoppers are eaten by arboreal predators such as birds and robber flies (family Asilidae) and soil-dwelling egg predators such as blister beetles (Meloidae).

DAMAGE

Grasshoppers become economic pests when young tree foliage is extensively chewed by large numbers of insects migrating from unmanaged vegetation. Mature trees are not harmed by grasshopper feeding.

MANAGEMENT

Do not take control action based solely on damage. Caterpillars, earwigs, Fuller rose beetle, June beetles, and snails also chew leaves. Some management methods vary depending on the cause. Where common, grasshoppers can be observed during the day feeding openly and flying or jumping among plants.

Grasshoppers can be difficult to manage once large numbers move onto young trees. If you believe grasshoppers may become a problem, monitor for them in uncultivated areas near young trees. Before adjacent vegetation dries or is cut, consider applying insecticide combined with bait or spraying border areas to kill grasshoppers before they migrate and start to damage crops.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. MALATHION (Malathion 8) MODE-OF-ACTION GROUP NUMBER[1]: 1B COMMENTS: Only treat infested trees to avoid destroying natural enemies of mites, loopers, scales, and other potential secondary pests. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.	4.7 pt	48	7

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

JUNE BEETLES (09/16)

Scientific Names: *Coenonycha testacea, Serica fimbriata,* and *Serica alternata*.

DESCRIPTION OF THE PESTS

June beetles (sometimes called Junebugs) and May beetles include various species in the family Scarabaeidae. Adult beetles fly into avocado from untilled fields and brush land during late spring or early summer. Adults chew tree foliage at night and when present night-after-night can completely defoliate a large number of young trees in a single grove. During the day, adults hide under litter or burrow into the upper 2 inches of soil, reappearing the following night to resume feeding.

Serica spp. are the most common and widely distributed beetles in avocado.

- The adult *Serica fimbriata* is 0.6 inch long and velvety brown with faintly striated wing covers.
- *Serica alternata* and *Coenonycha testacea* adults are 0.4 inch long and uniformly shiny brown. Adult scarabs are robust beetles, although *C. testacea* is almost rectangular and is distinctly narrower than the *Serica* spp.

Scarab larvae are C-shaped, cream colored, soil-dwelling grubs. June beetles have one generation per year.

DAMAGE

During spring they sometimes injure young, newly planted trees, typically near uncultivated land away from the coast. Chewing on mature trees with a well-developed canopy is generally of no economic importance.

MANAGEMENT

Determine whether chewing is actually caused by June beetles and not other nocturnal pests, including earwigs, Fuller rose beetles, and snails. Caterpillars and grasshoppers also cause similar damage. June beetles can be detected, and perhaps controlled somewhat in small plantings, by deploying blacklight traps at night during late winter and spring. It may be best to deploy any blacklight traps somewhat away from the young or topworked trees. Placing traps in mature trees near new plantings and along grove edges bordering unmanaged vegetation reduces the risk that traps placed among susceptible hosts might attract adult beetles to those plants.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
UPDATED 5/15			
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. MALATHION (Malathion 8)	4.7 pt	48	7
MODE-OF-ACTION GROUP NUMBER[1]: 1B			
COMMENTS: Apply as a foliar spray at night when beetles are feeding in trees. Use of this material will disrupt biological control of other pests such as scales, thrips, mites, and whiteflies. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

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Invertebrates: *Uncommon or Rarely Managed Pests*

(Section reviewed 09/16)

ANTS (09/16)

Scientific Names: Argentine ant: *Linepithema humile*
Native gray ant: *Formica aerata*
Southern fire ant: *Solenopsis xyloni*

DESCRIPTION OF THE PESTS

Most ants (family Formicidae) are wingless workers (sterile females). Workers search for food outside the nest, dig tunnels, and care for the tiny, pale, grublike ant larvae in the nest. Adult ants can also be winged males that die soon after mating or reproductive females (queens) that lay tiny elliptical eggs in underground nests. Queens and males are usually observed only during their brief mating season when they develop wings and swarm outside of the nest.

Ants have a narrow constriction between the thorax and abdomen. Their antennae are distinctly elbowed. Winged ants have hind wings that are much shorter than the forewings. It can be very helpful to identify the species present as ant biology and management often differ among species. An illustrated key is available online .

The most prevalent species is the Argentine ant, which travels in characteristic trails with numerous individuals. Workers are about 0.13 inch (3 mm) long, uniformly deep brown to light black and do not sting and rarely bite. The Argentine ant has one petiole node (hump) between the thorax and the abdomen.

Native gray ants, also called field ants, are larger than the other ants. Native gray ants are up to 0.3 inch (7.5 mm) long and have one petiole node. Gray ants nest in topsoil or under rocks and debris. Individuals move in an irregular jerky manner and generally do not travel in trails or sting.

The southern fire ant, also called the California or native fire ant, is light reddish brown with a black abdomen. The entire body is covered with golden hairs. It has two nodes (humps) between the thorax and the abdomen. Workers size is variable range from 0.1 to 0.018 inch (2.5–4.5 mm) long. Southern fire ants nest beneath loose mounds or craters and do not aggregate in colonies as large as those of the Argentine ant. Southern fire ants may swarm over the ground and may sting when disturbed. They forage mostly in the morning and early evening and usually do not travel in conspicuous trails.

Be especially alert for the highly aggressive red imported fire ant (*Solenopsis invicta =S. wagneri*). Red imported fire ants run up any objects they encounter and have a venomous sting, which can seriously injure people. Red imported fire ants can be recognized in part by their size, which varies greatly among workers. Large and small ants, 0.08 to 0.25 inches (2–6 mm) long occur together in the same clump or trail. Except for southern fire ants, which also range in size, workers outside the nest are about the same size for all other ants likely to be found in California groves. Report suspected red imported fire ant infestations to agricultural officials. Contacts include telephoning 1-888-4FIREANT toll free and the CDFA website
[https://www.cdfa.ca.gov/plant/pdep/target_pest_disease_profiles/rifa_profile.html].

DAMAGE

Ants are important natural enemies of many insect pests and provide benefits such as improving soil. However, ants sometimes chew crop twigs and tender bark, damage irrigation tubing, or annoy workers. In avocado, ants are pests primarily because they disrupt biological control of other pests. Ants are primarily a problem in young avocado trees where mealybugs and other honeydew-producers are occasional pests. Ants protect these food sources from natural enemies, causing phloem-sucking insects to become more common. When honeydew-producers are present, ants also increase numbers of armored scales and some other pests that do not excrete honeydew. Ants are general predators that attack most any other predator or parasite they encounter, regardless of what host that natural enemy is seeking.

MANAGEMENT

Periodically inspect for ants and bark damage under trunk wraps of young trees. Check for ants on trees of any age if honeydew-producing insects are a problem. If ants have swollen, almost translucent abdomens, this can indicate they are honeydew-collecting species.

Ants do not have effective natural enemies, except for competition with other ants. Cultivation controls ants, but creates dust and disturbing soil near trees damages roots. Insecticide mixed with bait is the preferred chemical control. Baits are slow acting, but effective over the long-term because they take advantage of ants' food-sharing behavior. Ants spread insecticide bait throughout the colony, including to nest-bound immatures and queens underground.

The best time to bait is late winter to early spring when ant numbers are relatively low. Bait effectiveness varies with ant species, availability of alternative food, active ingredient, type of bait, and the time of year. To determine which bait to use, offer a small quantity of each of several baits and observe which is preferred by the ants.

Solid baits are applied for fire ants. Argentine ant and other honeydew-feeding species are reduced by liquid baits, which must be applied in registered bait stations. Check for the registration and availability of new liquid baits and baits stations to control honeydew-feeding ants.

- Apply an effective bait in spots near nests or on trails.
- Spot treating takes advantage of ants' trailing behavior, which leads nest mates to locations where food is concentrated. Spot treatment minimizes toxicity to non-pest ant species, which compete with pest ants and help to limit their numbers.
- Broadcasting baits or widespread spraying with insecticide is expensive, and may not reach many ants within nests underground.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. STICKY POLYBUTENE MATERIALS#			
(Tanglefoot)	Label rates	NA	NA
COMMENTS: For use on all varieties. Use polybutene-based products only. Do not apply sticky materials directly on the trunk; use a 6- to 18-inch wrap under the sticky material to protect the tree from sunburn. Exercise caution in applying multiple applications (more than three or four); watch for symptoms of bark cracking. Apply the sticky band high enough to avoid sprinklers, dust, and direct sunlight. Reactivate periodically by rubbing with a stick to remove dust. Skirt- and canopy-prune trees so that ants have access only via the trunk. Check to ensure that low hanging branches, sticks, weeds, etc., are not allowing ants access to trees.			
B. BORIC ACID#			
(Gourmet)	Label rates	NA	0
MODE-OF-ACTION GROUP NUMBER: —			
COMMENTS: Available only for organically grown fruit under a Special Local Need (SLN) registration. Liquid boric acid formulation with sweet bait for use only in approved bait stations that meet EPA ChemSAC criteria. For use against honeydew-feeding ant species, including Argentine ant and native gray ant.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Acceptable for use on organically grown produce.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

NA Not applicable.

ARMORED SCALES (09/16)

Scientific Names: Latania scale: *Hemiberlesia lataniae*
California red scale: *Aonidiella aurantii*
Dictyospermum scale: *Chrysomphalus dictyospermi*
Greedy scale: *Hemiberlesia rapax*

DESCRIPTION OF THE PESTS

Armored scales are rarely a problem on avocados in California. If you see high numbers of armored scales on avocados, contact your local agricultural commissioner, as it is quite possibly an exotic species introduced into the state.

Armored scales (family Diaspididae) have a flattened, slightly convex cover that at maturity is about 0.06 inch (3 mm) in diameter. This platelike cover usually can be removed to reveal the actual scale body underneath. Armored scale covers typically have a different colored, slight protuberance (exuviae or "nipple") and concentric rings, which form as each nymphal stage enlarges its cover. Females develop roundish covers. For species with males, their covers are elongate in late instars.

Latania and greedy scale can reliably be distinguished only by an expert. Their covers are gray, tan, or white. Dictyospermum scale has a yellowish brown cover that is somewhat darker than the similar-looking, orange to reddish California red scale cover. California red scale and latania scale occur throughout the plant, with relatively even distribution among fruit, leaves, and wood Dictyospermum scale infests mostly fruit and leaves. Greedy scale is usually limited to twigs and branches.

Latania scale and greedy scale females lay eggs beneath their cover, from which crawlers hatch. California red scale and dictyospermum scale give live birth to young crawlers. Greedy scale and latania scale reproduce without males, at least in California. Both California red scale and dictyospermum scale produce males, which as immatures develop under elongate covers.

DAMAGE

Scales in avocado are usually under good biological control. Latania scale occasionally damages avocado. Large numbers of latania scale on bark can kill twigs, especially on young trees. Unlike many plant-sucking insects, armored scales do not secrete any noticeable liquid. Economic damage is from scale covers on the fruit skin, which appear as tiny dimples or light-colored spots. Feeding may also cause small discolored spots in the skin. Internal fruit quality is not impaired, but infested or spotted fruit may be culled. California red scale is a rare problem, and only on avocado near citrus. Dictyospermum scale and greedy scale occur in avocado only at very low numbers.

MANAGEMENT

Biological control is the primary scale control method in avocados. Conserve natural enemies by minimizing dust and avoiding application of broad-spectrum, persistent insecticides that promote pest flare-ups because they kill natural enemies. If certain areas of a grove have high armored scale numbers, determine whether encrusted fruit can be selectively harvested and sent to a packing house that uses brushes or pressure-washing equipment that can remove scale covers from fruit. In the infrequent event that direct control may be justified, oil spray has little long-term adverse impact on natural enemies. Time any scale treatments to occur soon after most scale crawlers have emerged.

Biological Control

Predatory insects and parasitic wasps control most scales. Armored scale parasites include species of tiny *Aphytis* and *Aspidiotiphagus* (family Aphelinidae), and *Plagiomerus*, *Comperiella* and *Signiphora* (family Encyrtidae). Most scale predators feed on both armored and soft scales and often on other pests. Predators include brown and green lacewings, pirate bugs, predaceous mites such as *Cheletomimus berlesei* and *Hemisarcoptes malus*, and *Karnyothrips* species.

Predaceous Coccinellidae include the spotless lady beetle (*Cycloneda sanguinea*), steelblue lady beetle (*Halmus chalybeus*), and twicestabbed lady beetle (*Chilocorus orbus =C. stigma*). As adults, these lady beetles are about 0.16 to 0.2 inch (4–5 mm) long.

- Spotless lady beetle has a black and white head and thorax and orangish wing covers without markings.
- Steelblue lady beetle is metallic bluish.
- Twicestabbed lady beetle is shiny black with two large orangish spots on its wing covers. Its larvae are black to brownish with a yellowish transverse band and are covered with branched spines.

Organically Acceptable Methods

Use biological and cultural controls and some oil sprays on an organically certified crop.

Monitoring and Treatment Decisions

In the rare situation where treatment is warranted, spray oil after the end of maximum crawler emergence. To time an application, monitor scale crawlers by trapping them with transparent tape that is sticky on both sides. Wrap tape traps tightly to encircle each of several twigs near female scales. Replace traps weekly when crawlers are expected. Preserve traps sandwiched between clear plastic and light blue paper, and label papers with the trap date and location. Visually compare crawler abundance in traps among monitoring dates. Treat when it is obvious that more crawlers per trap were caught during previous weeks and catches have definitely declined. If persistent populations of California red scale are present, consider releasing a small number (perhaps 10,000) of *Aphytis melinus* near the scale infested trees after purchasing them from an insectary.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. NARROW RANGE OIL#	Label rates	4	0
MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: Requires good coverage to be effective. Oil does kill some beneficial wasps and suppresses beneficial mite populations, however the residue does not persist and parasitic wasps can emerge from parasitized scale or be commercially released soon after treatment. Check with certifier to determine which products are organically acceptable.			
B. *APHYTIS MELINUS*#	See comments	NA	NA
COMMENTS: For release against California red scale only. Make a single release, or several smaller release at about 2 week intervals, totaling approximately 10,000 parasites per infested site. Time release so that the parasites can attack unmated female scales. Visually monitor scales and release parasites when a significant proportion of the scale population is at or approaching the virgin female stage. Alternatively, monitor using pheromone-baited sticky traps and release parasites at or just before a male flight, which is approximately 800 degree-days after the peak of the previous generation male scales.			
C. PYRIPROXIFEN (Esteem 0.86 EC)	16 fl oz	12	14
MODE-OF-ACTION GROUP NUMBER: 7C			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

Certain products are acceptable for organically grown produce.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee).

NA Not applicable.

AVOCADO LACE BUG (09/16)

Scientific Names: *Pseudacysta perseae*

DESCRIPTION OF THE PEST

(View photos online)

Avocado lace bug (family Tingidae) occurs in parts of the Caribbean, Mexico, and southeastern United States. As of 2006, in California it occurs only in San Diego County. Also known as the camphor lace bug, its only known hosts are various *Persea* species and the camphor tree (*Cinnamomum camphora*), which is grown as a landscape ornamental and commercially for its aromatic extracts.

Lace bugs do not feed on fruit. Adults and nymphs feed in groups on the underside of leaves. This sucking pest causes chlorotic blotches on foliage, which become necrotic. Severely damaged leaves may drop prematurely. Defoliation can result in sunburned fruit and wood and stressed trees, reducing subsequent yield.

Adults are about 0.08 inch (2 mm) long oval shaped insects with a dark (black or brownish) head and thorax. Their abdomen, antennae, legs, and wing covers have both dark and light (orangish, yellowish, or white) areas. Nymphs are mostly dark and orangish, resembling the adults without wings. Eggs are laid on leaves within shiny black globs of excrement. Insects develop from egg to adult in about 1 month during warm weather and have several generations a year. All stages can be present throughout the year.

DAMAGE

Relatively little is known about this insect in California. Numbers increase during summer. High numbers and severe foliage damage occur in California on some untreated avocado trees. Avocado lace bug is an intermittent pest in Florida on avocado.

MANAGEMENT

An important component of managing avocado lace bug is preventing its spread into uninfested areas.

- Do not move uncertified host material or dirty bins from infested areas.
- Clean bins and other potentially infested equipment and materials before bringing them into groves, as lace bugs may survive and spread on leaf debris.
- Conserve resident natural enemies that prey on lace bugs, including lacewing larvae and predatory thrips. The introduction of natural enemy species is being researched in an effort to provide classical biological control. At least two species of parasitic wasps kill avocado lace bug eggs in Florida, an unidentified species in the family Mymaridae and an *Oligosita* sp. (Trichogrammatidae).

Do not treat low numbers of lace bugs. If numbers are increasing and are anticipated to cause extensive foliage damage or premature leaf drop, where feasible make a foliar spray of short-persistence contact materials such as oil or pyrethrin. Avoid persistent, broad-spectrum insecticides, which can disrupt biological control of other pests in avocado. Certain systemic insecticides can be very effective and may be available for application through irrigation systems.

Organically Acceptable Methods

Spray pyrethrin (PyGanic) and certain oils in an organically certified crop.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. NARROW RANGE OIL#	Label rates	4	0
MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: Requires good coverage to be effective. Check with certifier to determine which products are organically acceptable.			
B. IMIDACLOPRID (Admire Pro)-soil	10.5–14 fl oz	12	6
MODE-OF-ACTION GROUP NUMBER1: 4A COMMENTS: Do not exceed 14 fl oz / acre per season. Apply by chemigation through low-pressure drip, trickle, microsprinkler or equivalent equipment. Application may only occur pre-bloom or during bloom period. Post bloom applications are not allowed. Bees shall not be used in avocado treated while avocado is in bloom. Remove bee hives from avocado orchards prior to application. Hives may be returned only after the avocado bloom period has ended.			
C. PYRETHRIN# (PyGanic)	Label rates	12	0
MODE-OF-ACTION GROUP NUMBER1: 3A COMMENTS: Because there is little residual activity, repeat application may be needed in 2 to 3 weeks and control may be only partial.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

\# Acceptable for use on organically grown produce.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a Group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

GLASSY-WINGED SHARPSHOOTER (09 / 16)

Scientific Names: *Homalodisca vitripennis (=H. coagulata)*

DESCRIPTION OF THE PEST

Glassy-winged sharpshooter (family Cicadellidae) sucks leaf and stem xylem tissue, and vectors *Xylella fastidiosa* bacteria lethal to certain crops. While feeding, adults and nymphs excrete large amounts of liquid. When sharpshooters are numerous the excretions accumulate on fruit and foliage giving the appearance of whitewash. Glassy-winged sharpshooter adults feed on over 300 plant species and can reproduce (lay eggs) on about 100 plant hosts.

Sharpshooter nymphs and adults are active insects. When disturbed, they hide by walking rapidly sideways, jumping or flying. The glassy-winged sharpshooter is a larger than most other leafhoppers. Adults are about 0.5 inch (13 mm) long and dark brownish with white and yellowish patches and spots. Pale head spots help to distinguish glassy-winged sharpshooter from the native smoke-tree sharpshooter (*Homalodisca lacerta*), which has light-colored wavy lines on the head.

Females lay eggs in an egg mass, a cluster of about one dozen eggs, under the epidermis of the lower leaf surface. Eggs initially resemble a greenish blister on the leaf, which females cover with a white chalky secretion to protect them from natural enemies. Eggs turn brown as they mature and leave a permanent brown to gray scar in leaf tissue after nymphs emerge.

Immature glassy-winged sharpshooters develop through five stages (instars) and resemble small adults, except the immatures are wingless, uniformly olive gray, and have prominent bulging red eyes. Smoke-tree sharpshooter nymphs appear very similar but have blue eyes.

The glassy-winged sharpshooter has two generations per year in southern California. However, in recent years the spring generation has become almost undetectable in some areas. Although all life stages can be found year-round, reproduction and immature stages occur mostly from early summer to late fall. Overwintering adults lay eggs from mid-spring through mid-summer. Adults first appear in very low numbers in April and numbers peak in July / August. These late-season adults overwinter until the following season.

DAMAGE

Glassy-winged sharpshooter is not considered a damaging pest in avocado. Quarantines may require treatment of nursery stock before young avocado trees can be shipped into uninfested areas of northern California.

Glassy-winged sharpshooter is a serious pest of other crops because it vectors *Xylella fastidiosa*, a bacterium that causes diseases such as almond leaf scorch, oleander leaf scorch, and Pierce's disease of grapes. No leafhopper-vectored avocado diseases have been observed in the United States. However, strains of *Xylella* in other parts of the world, such as one reportedly damaging avocado in Costa Rica, could be damaging if introduced into California.

MANAGEMENT

In established avocado groves, glassy-winged sharpshooter generally requires no management because avocados are not a preferred host plant and natural enemies, in particular egg parasites in the family Mymaridae, provide very good levels of control.

However, monitoring may be warranted if avocado are grown near untreated citrus or other favored hosts. Yellow sticky traps are useful for monitoring adults of glassy-winged sharpshooter and their primary parasites (Gonatocerus spp.) Mid-summer through fall are the best times to deploy and inspect traps. Glassy-winged sharpshooters are most common in the second generation (July through Sept, depending on location), when they move into avocado from nearby citrus.

If common in avocado, consider removing or replacing nearby alternate hosts such as favored ornamentals and abandoned citrus. Because glassy-winged sharpshooters reproduce in great numbers on citrus, consult with nearby citrus growers regarding any plans to promote biological control (e.g., conserve egg parasites) or treat sharpshooters in citrus.

Biological Control

Several *Gonatocerus* spp. wasps parasitize glassy-winged sharpshooter eggs. Parasitized eggs are easily recognized by a tiny, round hole at one end of the glassy-winged sharpshooter egg through which the adult parasite emerged. *Gonatocerus ashmeadi* is commonly found wherever glassy-winged sharpshooter occurs in California. In southern and coastal areas of California, *Gonatocerus walkerionesi*, can be very effective in the late summer, when the second generation of eggs are deposited. *Gonatocerus novifasciatus, G. morrilli*, and *G. triguttatus* also occur at low levels in California.

Organically Acceptable Methods

Biological control is the only effective, organically acceptable method of contol. Egg parasitoids can provide excellent control of glassy-winged sharpshooters.

LONGTAILED MEALYBUG (09/16)

Scientific Names: *Pseudococcus longispinus*

DESCRIPTION OF THE PEST

Nymphs and adult female mealybugs (order Pseudococcidae) are soft, oval, white powder- or wax-covered insects. Adult males are tiny, two-winged insects with two long tail filaments, but are rarely seen. In many mealybug species the female lays tiny yellow eggs in an ovisac, a mass of eggs intermixed with white wax. Longtailed mealybug produces no external egg sacs; it gives live birth to nymphs. Longtailed mealybug has two to four overlapping generations a year. All stages can occur throughout the year.

Longtailed mealybug is the only species common in California avocado. Other species to look out for because they can potentially infest avocado include citrus mealybug (*Planococcus citri*), pink hibiscus mealybug (*Maconellicoccus hirsutus*), and vine mealybug (*Planococcus ficus*), none of which are reported pests of avocado in California.

The citrus, longtailed, and vine mealybugs have distinct, well-developed wax filaments around their body margin. Female longtailed mealybugs have tail filaments almost as long as the body length. Citrus and vine mealybug filaments are relatively short. Pink hibiscus mealybug lacks distinct waxy filaments.

Correct identification of mealybugs is important to control. Ask an expert for help if you encounter an unfamiliar mealybug species. For example, the introduced vine mealybug has not been found in California groves, but it infests avocado elsewhere in the world. Pink hibiscus mealybug in California has been limited to Imperial and Eastern Riverside Counties, an area with few avocado groves. Introduced parasites, especially *Anagyrus kamali* (Encyrtidae), are providing good biological control of pink hibiscus mealybug. If pink hibiscus mealybug is discovered in California outside of Imperial and Eastern Riverside Counties, notify agricultural officials as prompt management action may be warranted.

DAMAGE

Mealybugs suck phloem sap. When common, they can reduce tree vigor, foul plants with sticky honeydew, and promote growth of blackish sooty mold that fouls fruit. Mealybug numbers are usually very low in avocado. They occasionally are pests of young trees. New scion grafts on old (top-worked) trees have sometimes been damaged by longtailed mealybugs, which can become common during late winter to early spring.

MANAGEMENT

Pesticide application is not recommended for mealybugs in avocado. Conserve natural enemies that control most mealybug populations.

- Selectively controlling sugar-feeding ants causes longtailed mealybug numbers to decline and can prevent outbreaks. Ants protect mealybugs from natural enemies (honeydew is an ant food source) so eliminating ants allows natural enemies to attack.
- Reduce dust, which also interferes with natural enemies.
- Whenever possible, apply only selective or short-residual pesticides when treating other pests.

Biological Control

Mealybug predators include green lacewing (*Chrysoperla* spp.) larvae, pirate bugs, predaceous fly larvae, and lady beetles, such as the mealybug destroyer (*Cryptolaemus montrouzieri*). Parasitic wasps are especially important in controlling outbreaks because the wasps specialize on mealybugs and reproduce rapidly. *Acerophagus notativentris, Arhopoideus peregrinus,* and *Anarhopus sydneyensis* (family Encyrtidae) parasitize longtailed mealybug.

Organically Acceptable Methods

Use biological control on an organically certified crop.

NEOHYDRATOTHRIPS (09 / 16)

Scientific Names: *Neohydatothrips burungae*

DESCRIPTION OF THE PEST

Neohydatothrips burungae was discovered in San Diego County in 2004. It has previously been reported throughout Central America. In Mexico it is relatively common on avocado and mango. Little is known about its biology.

Neohydatothrips burungae closely resembles avocado thrips. In comparison with avocado thrips, *N. burungae* often has darker brown shading on the thorax, darker abdominal stripes (brownish rings around the top front of each abdominal segment), and brown bands occur only on top of its abdomen, not underneath. However, coloration is variable and may not reliably distinguish these species. These thrips can be separated by differences in the position and size of setae (stout hairs) on their thorax and wings. For example, *Neohydatothrips burungae* has a continuous or complete row of short stout hairs on both midveins within its forewings. Avocado thrips has relatively few hairs along these midveins on its front wings; there are sizable gaps in both these rows of hairs on avocado thrips. Careful preparation of several specimens and a good microscope are needed to recognize these characters.

DAMAGE

The importance of *N. burungae* in California is unknown.

MANAGEMENT

No specific monitoring or management methods are recommended for *N. burungae*. Whether any management is warranted is unknown.

ORANGE TORTRIX (09/16)

Scientific Names: *Argyrotaenia citrana*

DESCRIPTION OF THE PEST

(View photos online)

Orange tortrix (family Tortricidae) is an uncommon problem on avocados grown in coastal areas. It rarely is injurious at inland growing areas. Orange tortrix feeds on various weeds and crops including citrus, grape, and strawberry.

Orange tortrix and amorbia adults resemble each other. They are orangish to tan moths with dark shading across their folded wings. At rest, their folded wings flare out at the tip so their overall shape resembles a bell. Orange tortrix adults are about 0.4 inch long, about one half the size of amorbia adults.

Orange tortrix and amorbia females lay eggs overlapping in a mass. Orange tortrix lays eggs on the surface of young leaves, green twigs, or green fruit. Each egg is pale green, flat, oval, and has a finely reticulated surface. Females lay several clusters that range from a few eggs to over 150 eggs per mass. Eggs hatch in about 9 days.

Larvae usually feed singly on shoot tips or on succulent leaves in nests they web together with silk. Larvae develop through 5 to 7 instars over about 40 days. They are about 0.08 inch (2 mm) long at hatching and about 0.5 inch long when mature. Larvae have a brownish or straw-colored head and prothoracic plate (the top of first segment behind the head). The variable body color is dark gray, greenish, straw-colored, or tan. Orange tortrix and amorbia larvae typically wriggle vigorously backwards or sideways when disturbed. Orange tortrix may drop to the ground or remain suspended from the leaf on a silken thread.

Larvae form a dense silken cocoon where they pupate within webbed foliage. Adults emerge in about 1 to 3 weeks, depending on temperature. Orange tortrix has two to four generations per year, with all stages present throughout the year.

DAMAGE

Most larval chewing occurs within silken webs on outer-canopy shoots. During bloom, tiny larvae sometimes feed among flowers. Larvae also feed on green bark, girdling some twigs. White exudate may cover wounds on larger twigs. Least common is fruit feeding, but this is the economic damage. Fruit injury closely resembles damage from other avocado caterpillars, except that orange tortrix tends to chew deeper holes. Feeding near the stem end of fruit and on the stem may cause fruit to drop.

MANAGEMENT

Conserve natural enemies, which usually keep caterpillars below damaging levels. Modify cultural practices to reduce pest reproduction and survival. Avoid applying broad-spectrum or persistent insecticides for any pests. Caterpillar outbreaks commonly occur after spraying carbamate or organophosphate insecticides, which poison parasites and predators. When pesticides are warranted, limit application to the most infested spots to provide refuges from which natural enemies can recolonize after treatment.

Biological Control

(View photos online)

More than one dozen parasite species and various predators attack orange tortrix, including assassin bugs, birds, damsel bugs, lacewings, and pirate bugs. These usually provide excellent biological control. Parasites include *Trichogramma platneri* and several tachinid flies as described in the section AMORBIA. Common internal larval parasitic wasps are *Apanteles aristoteliae* (family Braconidae) and *Exochus* spp. (family Ichneumonidae).

Organically Acceptable Methods

Use biological control and sprays of *Bacillus thuringiensis* on an organically certified crop.

Monitoring and Treatment Decisions

Where caterpillar problems may occur, monitor during at least spring and summer. Orange tortrix is a nocturnal moth. Monitor areas where bright lights such as security lights are used because nocturnal moths are attracted to lights and lay eggs nearby.

- Be sure to correctly distinguish the cause of any damage as other insects and certain abiotic disorders cause leaf holes resembling caterpillar chewing.
- Correctly identify the species of caterpillars. Alternate host plants, damage potential, monitoring methods, and natural enemies vary depending on the species of caterpillar.
- Look for caterpillar predators and larval diseases and parasitism. Natural enemy prevalence affects treatment decision making.

See MONITORING CATERPILLARS AND THEIR NATURAL ENEMIES for details on identification and monitoring methods including inspecting foliage for caterpillars and their damage (timed counts), trapping adults, shaking foliage to dislodge larvae (primarily for avocado looper), or a combination of these methods.

There are no established thresholds, and treatment for orange tortrix is rarely warranted. If sprays are needed, use *Bacillus thuringiensis* when larvae are small. Spraying with malathion often leads to outbreaks of other pests and is not recommended.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table. When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Not all registered pesticides are listed. Always read the label of the product being used.			
A. BACILLUS THURINGIENSIS ssp. AIZAWAI#			
(various products)	Label rates	4	0
MODE-OF-ACTION GROUP NUMBER[1]: 11A			
COMMENTS: Effective when used to control early instars of the caterpillar.			
B. BACILLUS THURINGIENSIS ssp. KURSTAKI#			
(various products)	Label rates	4	0
MODE-OF-ACTION GROUP NUMBER[1]: 11A			
COMMENTS: Effective when used to control early instars of the caterpillar.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment until harvest. In some cases the REI exceeds the PHI. The longer of these two intervals is the minimum time that must elapse before harvest.

\# Acceptable for use on organically grown produce.

1 Rotate chemicals with a different mode-of-action group number, and do not use products with the same mode-of-action group number more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; chemicals with a 1B group number should be alternated with chemicals that have a group number other than 1B. Mode-of-action group numbers are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://irac-online.org/.

SOFT SCALES (09/16)

Scientific Names: Black scale: *Saissetia oleae*
Brown soft scale: *Coccus hesperidum*
European fruit lecanium: *Parthenolecanium corni*
Hemispherical scale: *Saissetia coffeae*

DESCRIPTION OF THE PESTS

Black scale is the most common soft scale (family Coccidae) in California avocado. Other species occasionally present include brown soft scale, European fruit lecanium, and hemispherical scale. Pyriform scale occurs on avocado in landscapes, but is absent or rare in commercial groves.

Soft scales at maturity are 0.08 to 0.2 inch (2–5 mm) in diameter. The soft scale's surface is the actual body wall of the insect and, unlike armored scales, cannot be removed. Adults are black, brown, or orangish with a hemispherical, humped, or round shape. The exception is pyriform scale, which is flattened and somewhat deltoid (pointed at one end and rounded at the other). White wax projects from beneath the margin of female pyriform scales.

Mobile first instars (crawlers) emerge from eggs laid under the female's body. First instars settle to feed within a day or two of emergence. These nymphs are oval and yellow, pale orange, or reddish. Soft scales retain barely visible legs and are able to move slowly, as they molt through three instars. On evergreen hosts such as avocado, after the crawler stage scales usually spend the rest of their life in one spot.

DAMAGE

Soft scales rarely are pests in avocado. They suck phloem sap from foliage and twigs. Rarely do they feed on fruit. Where soft scales are common, the large quantities of sticky honeydew they excrete promotes growth of blackish sooty mold, which can foul fruit.

MANAGEMENT

Treating scales is rarely warranted. Soft scales usually are controlled by predators and parasites. Conserve natural enemies by reducing dust and selectively controlling sugar-feeding ants. Whenever possible, apply only selective or short-residual pesticides to control other pests.

Parasitic wasps are especially important in controlling scales. Parasites include *Coccophagus* spp. (family Aphelinidae) and *Metaphycus* and *Microterys* spp. (Encyrtidae). Scale-feeding lady beetles include *Chilocorus*, *Hyperaspis*, and *Rhyzobius* species and along the south coast, the steelblue lady beetle (*Halmus chalybeus*). Lady beetles can easily be overlooked because many are tiny, colored and shaped like scales, or (as small larvae) feed hidden beneath scales' bodies. Lacewings, predaceous bugs, and predatory mites are among the other invertebrates that at least occasionally feed on scales.

WHITEFLIES (09/16)

Scientific Names: Giant whitefly: *Aleurodicus dugesii*
Greenhouse whitefly: *Trialeurodes vaporariorum*
Mulberry whitefly: *Tetraleurodes mori*
Nesting whitefly: *Paraleyrodes minei*
Redbanded whitefly: *Tetraleurodes perseae*

DESCRIPTION OF THE PESTS

(View illustration online)

Whiteflies (family Aleyrodidae) are named for the appearance of the small (0.12 inch, 3 mm or less), pale, powdery adults. Females lay tiny oblong eggs on foliage. The first-instars nymphs that hatch from eggs are initially mobile and called crawlers. Crawlers soon settle to feed and lose their legs. The subsequent three nymphal stages and pupal stage are inactive. Nymphs are generally flattened and oval and may resemble certain soft scales. Whiteflies are identified to species primarily by the color, shape, and waxiness of the fourth-instar nymph or pupa. In approximate order of their abundance, the species in California avocado are redbanded whitefly, nesting whitefly, greenhouse whitefly, mulberry whitefly, and giant whitefly.

For most whiteflies all life stages can be present at any time, with several generations each year. For example, one greenhouse whitefly generation from egg to adult takes about 4 to 6 weeks depending on temperature. However, in California, redbanded whitefly has just one generation per year.

DAMAGE

Whiteflies suck phloem sap. They excrete honeydew, which collects dust and supports growth of blackish sooty mold fungi that can foul fruit. Honeydew attracts ants, which interfere with the biological control of whiteflies and many other pests. Giant whitefly, greenhouse whitefly, and mulberry whitefly each have hosts in over a dozen plant families. Nesting whitefly prefers citrus, but also infests avocado and some ornamental broadleaf evergreens. Redbanded whitefly has been found only on avocado in California. Whiteflies have many natural enemies, of which parasitic wasps are especially important, and consequently usually are under very good biological control.

MANAGEMENT

- Conserve natural enemies, especially parasitic wasps, which provide partial to complete biological control of most whitefly species unless disturbed by ants, dust, or insecticides.
- Control dust by watering or paving main orchard roads. Use a water truck or trailer to wet unpaved roads, especially during summer months when dust moving up into the tree canopies can especially disrupt natural enemies.
- Where ants are common on trees, consider applying barriers or insecticide baits to control them. Apply selective pesticides for other pests, such as *Bacillus thuringiensis* (Bt) for caterpillars, to conserve natural enemies.

No pesticide applications are recommended for whiteflies in avocado. Chemical treatment of whiteflies often is not effective; temporary suppression may be achieved only to be followed by a resurgence of the pest, especially after applying certain broad-spectrum insecticides. Have any unfamiliar whiteflies identified by an expert. New species periodically are introduced into California.

Biological Control

Parasitic wasps are the most important natural enemies. These include many *Cales*, *Encarsia*, and *Eretmocerus* spp. (family Aphelinidae). Parasitized immature whiteflies often change color and have round exit holes through which the adult parasite emerged.

Predators of whitefly nymphs include bigeyed bugs (*Geocoris* spp.), green lacewings (*Chrysoperla* spp.), lady beetles (*Delphastus* spp.), and pirate bugs (*Orius* spp.). Spiders feed on adult whiteflies.

Cultural Control

- Avoid moving uncertified or infested plant material from one orchard to another to minimize pest spread.

- Make sure bins are clean when transporting bins from giant whitefly infested areas to clean groves.
- Do not bring plant materials into California from other states or out of the country because they may be infested.
- Control dust.

Organically Acceptable Methods

Use biological and cultural controls in an organically certified crop.

Diseases

(Section reviewed 09/16)

ANTHRACNOSE (09/16)

Pathogen: *Colletotrichum gloeosporioides*

SYMPTOMS AND SIGNS

(View photos online)

Anthracnose symptoms can develop on flowers, fruit, leaves, or twigs. Infected fruit is the most serious concern, but most fruit damage does not develop until after harvest. External symptoms are difficult to see on ripe 'Haas' fruit because of its dark skin color. Unhealthy or dead leaves are the most obvious symptom in groves. Spots form on leaves, beginning as yellow, then brown discolorations that coalesce into large dead areas. Necrosis occurs across or between leaf veins, on leaf margins, and most often at leaf tips. If disease is severe, trees drop many leaves prematurely. New shoots can develop brown or purplish lesions, and shoots may dieback. Infected flower heads can turn dark and die without producing fruit, or young fruit may form and then drop.

Before harvest, brown to black lesions less than 0.2 inch (5 mm) in diameter develop around lenticels on infected fruit. These small discolorations can be overlooked while fruit are still on the tree, and lesions usually do not enlarge until fruit ripens after harvest. Large lesions sometimes occur on avocados on the tree, usually after infected fruit is injured by insects or mechanical wind rubbing.

After harvest, lesions become blacker, larger, and increasingly sunken. Lesions eventually spread over the entire fruit surface and throughout pulp. When the fruit is cut in half through one of the lesions, rot extending into the flesh often exhibits a hemispherical pattern. Decayed pulp initially is firm, but becomes soft and putrid as decay advances. Pink spore masses may form on the fruit surface and, under wet conditions, a slimy mass of pink spores erupts through the fruit skin.

COMMENTS ON THE DISEASE

Colletotrichum gloeosporioides is widespread in avocado and citrus groves. It normally is of little importance because unusually large numbers of spores are required to produce damaging infections. Low humidity and no rain during much of the growing season limit disease development in California. With extended foggy or rainy conditions and mild winter temperatures, and where many dead leaves and twigs and mummified fruit accumulate in trees, the fungus can produce enough spores to cause a disease problem. Spores spread in splashing water and can cause infection anytime from fruit set to harvest. Once infected fruit starts to ripen, temperatures of 75°F and above will accelerate anthracnose development, while temperatures below 59°F retard disease development.

Fuerte, Rincon, and Wurtz scion cultivars are more susceptible to anthracnose than Hass. Healthy trees often recover from foliar infections and defoliation once conditions become dry. Anthracnose becomes a postharvest problem after the grove has been excessively wet for extended periods. Poor growing practices and mishandling of fruit during or after harvest greatly increase the potential for significant fruit loss.

MANAGEMENT

Control anthracnose primarily with good cultural practices in the grove and proper preharvest and postharvest fruit handling.

- Prune out dead limbs and twigs where fungi sporulate. If many dead leaves are entwined in the canopy, knock them out of the tree.
- Prune low limbs to at least 2 feet off the ground to reduce humidity within canopies by improving air circulation.
- Prune and harvest only during dry conditions and minimize fruit contamination and injury.
- Dispose of dead wood and old fruit away from avocado trees before bloom.

Postharvest treatments should not be needed if fruit is properly handled. Keep fruit dry and cool until sold. Postharvest temperature is especially critical to anthracnose development. Cool fruit to 41°F as soon as possible after harvest. Delays of longer than 6 hours before cooling and higher pulp (air) temperatures during these delays will result in increased postharvest fruit decay. Cooling fruit promptly is of increasing importance as the season progresses because fruit ripens faster as it increases in maturity. Avoid storage temperatures below 41°F because chilling injury may occur. Market fruit rapidly.

Chemical Control

Anthracnose is rarely significant enough in California avocado groves to warrant fungicide application. Copper or other fungicides thoroughly sprayed on healthy tissue can prevent infection.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide's properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.			
A. AZOXYSTROBIN (Abound)	Label rates (6–15.5 fl oz)	4	0
MODE OF ACTION GROUP NAME (NUMBER[1]): Single-site, locally systemic QoI (strobilurin) (11) COMMENTS: Applications should begin prior rot diseases development and continue throughout the season on 10- to 14-day schedule. Do not apply more than 92.3 fl oz of product / acre per season.			
B. COPPER HYDROXIDE (Champ WG, Kocide 3000)	Label rates	48	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M1) COMMENTS: Apply as a trunk spray. Make the first application at the start of the growing season and repeat every 60 days. Repeat applications at 60 days are important; a single trunk spray is not sufficient to arrest the disease. Do not exceed 20 lb / acre per year.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment until harvest. In some cases the REI exceeds the PHI. The longer of these two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http: / / frac.info /). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

ARMILLARIA ROOT ROT (OAK ROOT FUNGUS) (09/16)

Pathogen: *Armillaria mellea*

SYMPTOMS AND SIGNS

(View photos online)

Armillaria is a soil-borne fungus that causes a root and trunk rot of avocado. The fungus can become well established in roots and the root crown before any symptoms become visible above ground. Infected trees usually die prematurely, and young trees often die quickly after infection. Mature trees may die quickly or slowly, or may recover at least temporarily if conditions become good for tree growth and poor for disease development.

Wilted, downward-hanging foliage is often the first obvious symptom of Armillaria root rot. Other symptoms include foliage yellowing, leaf drop, and dieback of upper limbs. During the rainy fall and winter, groups of short-lived mushrooms often grow around the base of *Armillaria*-infected trees.

The most reliable sign of Armillaria root rot is fungal growth in cambial tissue. If trees exhibit aboveground symptoms of infection, cut off bark at the base of the tree and crown to diagnose the presence of *Armillaria* mycelium. Fungal mycelia are whitish and have a strong mushroom odor. Growth typically occurs in patches in the cambium and inner bark. Large roots can be infected throughout their diameter.

COMMENTS ON THE DISEASE

Armillaria root rot infects many crops and native and ornamental plants. Common hosts include avocado, cherimoya, citrus, and oaks. The fungus persists in infested roots, stumps, and wood in soil, infecting new plantings and spreading to infect nearby plants.

Armillaria mycelia persist for years under the bark of diseased roots or the root crown. *Armillaria* spreads by any activity that moves soil containing infested wood fragments, such as during cultivation. Most infections are thought to occur when a healthy root grows into or near an infested dead root piece and the fungus moves over. In some situations, the fungus can also spread from tree to tree by cordlike rhizomorphs, which resemble small dark roots. In contrast, healthy avocado roots are lighter-colored, usually light brown to whitish. When pulled apart, rhizomorphs have a cottony interior, while the center of a healthy root is solid and woody. Rhizomorphs grow on buried wood, the surface of diseased roots and root crowns, and short distances on or through soil. Infection occurs when rhizomorphs contact and directly penetrate the healthy roots of adjacent trees which is rare in CA.

Long after the aerial parts of a tree are gone, *Armillaria* can remain alive in roots and stumps. When avocado trees are planted, new roots grow into contact with *Armillaria*-infected roots or infested wood pieces, and the new tree becomes infected. *Armillaria* can also be introduced on infected nursery stock.

MANAGEMENT

Look for diseases and disease-promoting conditions regularly throughout the grove, see MONITORING DISEASES AND DISEASE-PROMOTING CONDITIONS. Provide a good growing environment and proper cultural practices and use good sanitation to manage Armillaria root rot. Providing good drainage and avoiding excess irrigation are important. *Armillaria* fungus is very susceptible to drying. Excavating soil around the trunk to temporarily air-dry the root crown can prolong the life of citrus trees and may also be effective on avocado, but apparently has not been tested on avocado. Shade any exposed root crowns from sunburn. Once trees die, remove them and any immediately adjacent trees that may also be infected. Remove the stumps and as many root pieces from the soil as possible. Thoroughly clean all soil from equipment and leave soil on-site before removing equipment. Consider replanting only with crops not susceptible to *Armillaria*.

AVOCADO BLACK STREAK (09 / 16)

Pathogen: unknown

SYMPTOMS AND SIGNS

(View photos online)

Black streak appears as an elongated dark discoloration on bark. Small cankers can develop in a direction that parallels the direction of limb or trunk growth but sometimes cankers encircle limbs or the trunk. On green shoots and young trees, lesions look like black blotches with distinct margins. Cankered bark develops shallow cracks that ooze sap, which dries as a brownish or white powder on the bark surface. This exudate is readily washed off by rain or sprinklers, and in the absence of the powder the canker can be difficult to see externally on bark. Black streak lesions can be very small or encompass the greater part of the trunk. Cankers often first appear on the lower trunk and the underside of lower limbs and then later appear higher in the tree. Scraping off bark over the canker reveals shallow reddish brown to black areas. This discoloring forms mottled areas of dead and live tissue or merges into one large necrotic area. It rarely extends into the wood and can be removed easily by inserting a knife blade under the canker and prying upwards. Because trees can die with very few lesions, the lesions appear to be a symptom of the disease and not the cause of tree death.

COMMENTS ON THE DISEASE

Black streak develops under adverse growing conditions and is a serious disease that can kill avocado trees. The specific cause of the disease is unknown and apparently is not a viroid as was previously believed.

Many symptoms of avocado black streak are similar to those from other causes; the appearance of the cankers is the most diagnostic characteristic of this disease. Avocado black streak appears after prolonged periods of environmental or cultural stress, especially conditions of high salinity and insufficient water. An affected tree can decline gradually and may eventually die, or it may collapse and die rapidly. Conversely, with improved cultural practices trees can recover and symptoms can virtually disappear.

Avocado black streak may occur wherever Guatemalan cultivars are grown in California. All ages of trees are affected, and symptoms have been observed on trees ranging from 1 year to over 35 years old. Many groves are apparently free of the disease, and disease incidence varies considerably within affected groves. Avocado black streak symptoms typically are most severe on trees that appear to be the most stressed.

MANAGEMENT

Current management of avocado black streak consists of maintaining plant health with good fertilizer and irrigation practices, and preventing stress. Adequate irrigation with high quality water is believed to be especially important since this pathogen affects drought stressed trees.

BACTERIAL CANKER (09 / 16)

Pathogen: *Xanthomonas campestris*

SYMPTOMS AND SIGNS

(*view photos online*)

Bacterial cankers appear as slightly sunken, dark areas on the bark and vary in size from about 1 to 4 inches in diameter. Bark around cankers may crack. Fluid often oozes and dries, leaving a white powder around or over the lesion. Usually cankers appear and spread upward in a line on one side of the trunk or branch. Cutting under the bark surface reveals a decayed, reddish brown necrotic pocket, which may contain liquid. Dark streaks in the wood radiate out both above and below from the lesions. These necrotic streaks are usually in the bark cortex or xylem, but sometimes extend deeper into the center of branches or trunks. Often the disease will become inactive and canker wounds will close, except that a bark flap over the wound will remain.

Severely affected trees may have pale, sparse foliage and low yields on one branch or on the entire tree, but this is rare. Sometimes newly planted trees become stunted with many lesions; new branches may grow from buds below the affected part.

COMMENTS ON THE DISEASE

Bacterial canker is widespread but is a relatively unimportant disease. In some groves the bacterium infects over 60% of the trees, but most of these trees will perform well if otherwise cared for appropriately. The pathogen can also be introduced through nursery practices.

Xanthomonas campestris is a common bacterium on avocado leaves and green twigs, where it apparently is harmless. Its reproduction and spread is favored by wet plants and humid conditions. It can infect through wounds and branch stubs and spread within the plant's vascular system. Drought stress and boron deficiency may promote development of disease symptoms. The disease most typically shows up in drought years, at the end of irrigation lines, or at points where irrigation system water pressure is lowest.

MANAGEMENT

Normally the disease is a minor problem. Usually no control is necessary on established trees. If the disease is severe and yield is affected, remove the tree. Keep trees healthy and provide good cultural care. Provide appropriate amounts and frequency of irrigation and good uniformity of water distribution among trees. Use certified, disease-free nursery stock if available. Regularly inspect young trees and remove and dispose of young trees if they are infected. Nurseries should use stringent sanitation, regularly screen stock for disease, and dispose of affected trees so they are not planted.

BRANCH CANKER AND DIEBACK (formerly Dothiorella Canker) (09/16)

Pathogens: Fungal species in the *Botryosphaeriaceae* and *Phomopsis/Diaporthe* spp.

SYMPTOMS AND SIGNS

(View photos online)

Symptoms of branch canker and dieback include exuding reddish sap that dries to a brown and white powder. Bark may be cracked, darkly discolored, or slightly sunken. With older cankers, the bark may be friable (crumbly) and easily removed from the damaged area. Under the canker, the inner bark and wood is reddish brown to brown instead of the normal pale color. When the branch is cut transversely, a characteristic wedge-shaped canker extending deep into the xylem may be visible. If much of the xylem becomes infected, limbs may collapse and leaves quickly turn brown, but remain attached.

Symptoms observed on avocado trees with branch canker and dieback include

- shoot blight and dieback
- leaf scorch
- branch cankers
- stem end rot of fruit

Branch cankers closely resemble Phytophthora trunk canker. Branch cankers usually occur higher above the ground, beginning around the first main branch crotch or higher. Branch canker can affect twigs and smaller branches, as well as the upper trunk and large limbs. Branch cankers sometimes extend deep into wood, whereas Phytophthora cankers only discolor a shallow layer of outer wood. Except when trees are young, branch canker is usually not as serious as diseases caused by *Phytophthora* spp.

Branch canker and dieback can be a serious problem in new plantings; stock sometimes arrives from the nursery with latent infections at the graft union. When the infection kills the graft union, the dead scion retains a dry brown canopy, and shoots and green leaves sprout from the rootstock. The graft union may be unusually swollen and rough before the young tree dies. Inside the graft union, dark, discolored wood extends through the entire width of the small trunk.

This disease is less important on established, older trees. Some of the smaller branches and sometimes large limbs can die back. Usually, not the entire tree is affected and the tree remains productive. In severe cases, the main trunk may be girdled, killing the tree.

COMMENTS ON THE DISEASE

Members of the fungal family Botryosphaeriaceae are known to cause branch cankers on a variety of woody hosts, including avocado. The disease was previously known as Dothiorella canker because the pathogen most often isolated at the time was known as *Dothiorella gregaria* (teleomorph *B. ribis*).

Botryosphaeriaceae spores enter and initiate infection primarily through pruning wounds on the trunk or branches. More frequent pruning, such as would occur in a high-density grove, can increase dissemination of this pathogen among trees, leading to an increase in canker development and a possible decrease in yield as branches with cankers are pruned out.

Heavy rainfall causes increased spore production and infection. Spores spread by air and rain or irrigation splash that are hitting infected tissues. Trees that are stressed are much more susceptible to this disease. Common stresses include poor irrigation, low-quality irrigation water, nutritional deficiencies, or severe insect and mite feeding. Drought stress especially promotes symptom development and triggers latent infections to develop into disease.

MANAGEMENT

Look for diseases and disease-promoting conditions regularly throughout the grove using recommended monitoring methods. Where branch canker and dieback is a problem, rely primarily on sanitation and good cultural practices to control it.

- Prune out dead limbs and twigs, where pycnidia (spore-forming structures) and spores of the pathogen persist.
- Dispose of dead wood and old fruit well away from avocado trees.
- Prune and harvest only during dry conditions.
- Correct environmental and nutritional stresses, and minimize other pest problems.
- Appropriate amount and frequency of irrigation is especially important. Leach soil periodically and use low salinity water if salt toxicity is a problem.

Nurseries should use stringent sanitation measures, disinfest propagation material, and consider treating graft unions with an efficacious fungicide (e.g., FRAC Group 1 - MBC).

FRUIT AND STEM-END ROTS (09/16)

Pathogen: Fungal species in the *Botryosphaeriaceae* and *Colletotrichum spp.*

SYMPTOMS AND SIGNS

(View photos online)

Avocado fruit and stem-end rots are usually not obvious while fruit is on the tree. Small, superficial lesions can develop on fruit in the grove, but the disease usually is apparent only on fruit that is very overmature, hanging on dead limbs or dropped on the ground.

Infections usually become active after the fruit is picked and starts to soften. Initially lesions are small, irregular brown to reddish discolorations on the peel. Under the peel, brown streaks running lengthwise in the flesh may be observed because decay initially spreads along vascular bundles in the fruit. Small, purplish brown spots may appear on any part of the fruit, most often at the stem end. As fruit ages, the surface lesions gradually enlarge and become sunken and black. Fruit shrivels, and the black surface can become covered with grayish brown fungal mycelium and spores. Decay then spreads throughout the entire fruit, causing the flesh to turn brown and watery, with an offensive odor.

COMMENTS ON THE DISEASE

Postharvest rots are a relatively minor problem of avocados in California. Avocado fruit rot is caused by several Botryosphaeriaceae genera and species. The same group of fungi can cause avocado branch canker and dieback.

These pathogens spread by wind-blown or water-splashed spores produced in or on cankers, dead twigs and branches, and dying fruit and leaves. Spores infect through wounds and lenticels (tiny natural openings) on fruit. Infection occurs in the grove, but disease usually is not obvious until after fruit is picked and starts to ripen.

Damage from avocado fruit rot closely resembles that from ANTHRACNOSE and fruit damaged by these pathogens are usually culled and lumped together in the packing house. Anthracnose produces pink sporulation on the fruit surface, in contrast with the grayish mycelium from avocado fruit rot.

MANAGEMENT

Use good sanitation and optimal cultural practices to minimize avocado fruit rot.

- Prune out dead limbs and twigs. Dispose of dead wood and old fruit away from trees. Prune and harvest only during dry conditions.
- Correct environmental and nutritional stresses and minimize other diseases and disorders that injure bark, fruit, or leaves.
- Provide sufficient irrigation with appropriate placement of high quality water. Maintain a thick layer of mulch under canopies to hasten decomposition of pathogen propagules. Do not harvest during or soon after rain; allow trees and fruit to dry before harvesting. Minimize the interval from harvest until fruit is placed into cold storage at the packing house; prompt cold storage reduces disease incidence.
- Follow the same postharvest handling instructions discussed in ANTHRACNOSE.
- Fruit should be picked by clipping rather than snapping the pedicles. Clippers should be frequently sterilized using a dilution (e.g., 1:10) of household bleach.

FUSARIUM DIEBACK (09/16)

Pathogen: *Fusarium euwallaceae, Graphium euwallaceae* and *Paracremonium pembeum*

SYMPTOMS AND SIGNS

Fusarium dieback is caused by a complex of fungal species colonizing galleries made by the polyphagous shot hole borer or the Kuroshio shot hole borer.

External Symptoms: A host tree's visible response to disease varies among host species. Sugary exudate (also called a sugar volcano), staining, gumming, and frass may be noticeable before the tiny beetles are found. The beetle's entry and exit holes, which are about 0.03 inch (0.85 mm) in diameter, can be located beneath or near the symptoms. Advanced fungal infections will eventually lead to branch dieback.

Internal Symptoms: The fungi interrupt the transport of water and nutrients in branches of affected trees. Infected wood is discolored brown to black. Scrape away bark around beetle entry and exit holes to easily see discolored wood. Cross-sections of cut branches show the extent of infection.

COMMENTS ON THE DISEASE

Fusarium dieback is a recent, invasive, beetle-vectored disease that causes damage on avocado and more than 39 other tree species. The disease has spread in urban forests and wild lands in the Los Angeles basin since early 2012, and in Orange and San Diego counties since early 2013 and Ventura County in 2015.

Rapid spread of the beetle and fungi throughout various land-use areas is attributed to the diverse range and quantity of suitable hosts in Southern California

MANAGEMENT

Currently there are no control measures for this disease. Early detection of infestations and removal of infested branches will help reduce vector beetle numbers and the extend of disease spread.

- Chip infested wood onsite to a size of one inch (2.5 cm) or smaller. If the branches are too large to chip,
- Sterilize tools with either 5% bleach, Lysol cleaning solution, or 70% ethyl alcohol to prevent the spread of the disease through pruning tools
- Avoid movement of infested firewood and chipping material out of infested area
- For more information visit the UC Riverside Eskalen Lab website (http://eskalenlab.ucr.edu).

PHYTOPHTHORA TRUNK CANKER AND CROWN ROT
(formerly Citricola Canker) (09 / 16)

Pathogen: *Phytophthora mengei (P. citricola)*

SYMPTOMS AND SIGNS
(View photos online)

Phytophthora trunk canker and crown rot usually originates at or below ground level but can occur higher above ground, especially where trunks or lower limbs are wounded. The canker is a region of dark bark that often exudes red resin, which becomes brownish to white and powdery as it dries. Cutting away the superficial canker reveals an orange-tan to brown lesion instead of the normal white or cream-colored tissues. The lesion may have a fruity odor when exposed. The pathogen infects the inner bark and outer layer of wood, killing cambium and phloem. Discoloration rarely extends deeper than the outer woody layer. Depending on the local conditions and rootstock, the tree may overcome the disease and the lesions may heal.

Affected trees show a gradual loss of vigor and decline of the top canopy. As progress of the disease advances, foliar symptoms of Phytophthora trunk canker differ from symptoms caused by phytophthora root rot (*Phytophthora cinnamomi*). With Phytophthora trunk canker, leaves retain their normal size and there is a gradual loss of leaves causing canopy thinning, whereas branch dieback (staghorning) is less typical. Unlike root rot, canker and collar rot affects the major tree roots, and the smaller feeder roots are usually still present. Occasionally, in advanced stages, trees will die suddenly, with leaves turning brown within a short period of time. Confirmation of *P. mengei* is achieved by laboratory tissue isolations onto *Phytophthora* selective media.

COMMENTS ON THE DISEASE

Phytophthora canker is the most important of several canker diseases infecting avocado and is second only to root rot in severity among diseases of avocado. *Phytophthora mengei* infects the root crown and lower trunk and limbs of older trees, causing diseases called Phytophthora trunk canker and crown rot (formerly citricola canker). *Phytophthora mengei* also causes Phytophthora fruit rot.

Phytophthora mengei damages trunks, limbs and larger roots (although it is sometimes found on the feeder roots of diseased trees as well), while *P. cinnamomi*, damages smaller roots causing Phytophthora root rot. Disease develops after crowns, limbs, or trunks become infected through wounds, such as injuries from equipment, pruning, vertebrate injury, and wind damage. Spore spread and disease development are favored by wet soil conditions. Cankers often occur on the side of trunks wetted by irrigation sprinklers. *Phytophthora mengei* produces oospores and sporangia on the wounds that are spread by splashing water. Contaminated equipment and tools that injure healthy trees can cause a new infections.

MANAGEMENT

Look for disease symptoms and use the guidelines for MONITORING DISEASES AND DISEASE-PROMOTING CONDITIONS. In California, the diseases caused by *Phytophthora* spp. (root rot and canker) are increasingly found together. Hence, integrated approaches to the control of both need to be followed including sanitation, selection of tolerant rootstocks, good water management, and wound prevention.

Phytophthora mengei can easily spread in contaminated nursery stock and on equipment, vehicles, and people. Follow the same sanitation procedures as described in the section PHYTOPHTHORA ROOT ROT.

Certain rootstock cultivars are more resistant to or tolerant of Phytophthora trunk canker or Phytophthora root rot. Consider planting more than one rootstock in a grove with a history of Phytophthora diseases. Seedling rootstocks are much more sensitive to trunk cankers than most of the clonal cultivars. In University of California field trials, Toro Canyon, Duke 7, Duke 9, and Barr Duke have shown moderate tolerance as compared to other more susceptible rootstocks such as G1033, G6, and G755B. Thomas rootstock has tolerance to root rot, but is quite susceptible to canker and collar rot and other problems such as excess salinity.

Cultural control methods to prevent disease include irrigation management and wound prevention.

- Do not keep the lower trunks wet as this increases the chance of infection. Place sprinklers away from trunks, aim sprinklers to avoid wetting trunks, or switch from sprinkler to drip irrigation where feasible.

- Avoid wounding major roots and trunks; especially avoid pulling suckers to prevent the bark below-ground from injury.

Do not stack cut wood against trunks. When adding mulch to orchards, keep it several inches back from the trunk.

Chemical Control

Consider promptly treating fresh ground-level wounds such as pruning wounds with a fungicide. Remove suckers only by cutting them above ground, then treat the wound. Periodically disinfect pruning tools, such as after finishing work on each tree. If cankers are detected at an early stage before much of the trunk is invaded, they can sometimes be controlled by cutting out the infected tissue and spraying the wound with an effective fungicide. Where cankers extend below ground, a combination of aboveground application and soil drench with a fungicide may be warranted. There is little documentation of fungicide efficacy for managing Phytophthora trunk canker and crown rot in avocado. See Phytophthora root rot for discussion of Phytophthora fungicide application.

Common name (Example trade name)	Amount per acre	**REI‡ (hours)**	**PHI‡ (days)**

When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide's properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

A. ALUMINUM TRIS PHOSPHONATE
(Aliette WDG) — 5 lb — 12 — 0.5 (12 hours)
COMMENTS: Apply as a trunk spray. Make the first application at the start of the growing season and repeat every 60 days. Repeat applications at 60 days are important (up to 4 applications / year); a single trunk spray is not sufficient to arrest the disease. Do not exceed 20 lb / acre per year.

B. PHOSPHOROUS ACID
(Agri-fos, Fosphite) — Label rates — 4 — 0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Phosphonate (33)
COMMENTS: Do not apply with copper-based fungicides or fertilizers; allow 10 days before applying copper-based compound after phosphorous acid treatment or 20 days before applying phosphorous acid after copper treatment. Do not apply to dormant or heat- or moisture-stressed trees.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http: / / frac.info /). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

PHYTPHTHORA FRUIT ROT (09 / 16)

Pathogen: *Phytophthora mengei (P. citricola)*

SYMPTOMS AND SIGNS

(View photos online)

Diseased fruit have a distinct circular black area that usually occurs near the bottom portion or lowest spot on the fruit. Internally, the rot extends into the flesh, darkening it in the same pattern as on the affected surface. Affected fruit are often touching the soil or are hanging on low branches. Most damage occurs within 3 feet of the ground.

COMMENTS ON THE DISEASE

Phytophthora fruit rot is caused by *Phytophthora* spp., usually *P. mengei,* the same fungus that causes Phytophthora trunk canker and crown rot. Phytophthora fruit rot is usually of minor importance in California. Most damage occurs after prolonged wet conditions, the same situation that favors anthracnose. In contrast to anthracnose, which is primarily a postharvest problem, Phytophthora fruit rot infections often become obvious while fruit is still hanging on the tree, as well as causing decay after harvest.

MANAGEMENT

The most common cause of infection is likely the splashing of *Phytophthora* propagules from the soil surface to the fruit during heavy rain or sprinkler irrigation.

- Prune lower limbs so they are 2 to 3 feet from the ground.
- Maintain a thick layer of mulch to hasten decomposition of the pathogen in soil.
- Consider removing and disposing of old fruit or fruit lying on the ground because the fungus sporulates on dropped fruit.

Prune out dead limbs and twigs, and dispose chip large pieces of dead wood. Move and old fruitwood away from avocado trees.

PHYTOPHTHORA ROOT ROT (09/16)

Pathogen: *Phytophthora cinnamomi*

SYMPTOMS AND SIGNS

(View photos online)

Foliar symptoms of Phytophthora root rot include small, pale green or yellowish leaves. Leaves often wilt and have brown, necrotic tips. Foliage is sparse and new growth is rare. There may be little leaf litter under infected trees. Small branches die back in the tree top, exposing other branches and fruit to sunburn because of the lack of shading foliage. Fruit production declines, but diseased trees frequently set a heavy crop of small fruit.

Small, fibrous feeder roots are scarce at advanced stages of this disease. Where present, small roots are black, brittle, and dead from infection. Foliage is wilted even when soil under diseased trees is wet. Affected trees will decline and often die either rapidly or slowly.

COMMENTS ON THE DISEASE

Phytophthora root rot is the most serious and important disease of avocado worldwide. The causal agent, *Phytophthora cinnamomi,* has over 1,000 hosts, including many species of annual flower crops, berries, deciduous fruit trees, ornamentals, and vegetables.

Root rot thrives in areas of excess soil moisture and poor drainage. Trees of any size and age may be affected. The pathogen is easily spread through movement of contaminated nursery stock of avocado and other plants, on equipment and shoes, in seed from fruit lying on infested soil, or by any activity by people or animals that moves moist soil from one place to another. *Phytophthora* produces four different spore stages that are involved in disease development and survival: sporangia, zoospores, chlamydospores, and oospores. They spread easily and rapidly in water moving over or through the soil. Entire areas can readily become infested. *Phytophthora* species are not true fungi but have many fungal-like attributes.

MANAGEMENT

Look for diseases and disease-promoting conditions regularly throughout the grove by MONITORING DISEASES AND DISEASE-PROMOTING CONDITIONS. Use an integrated approach that emphasizes prevention.

- Purchase certified disease-free nursery stock and root rot-resistant cultivars.
- Inspect roots before planting and if their health appears questionable seek advice from a farm advisor or private consultant before planting trees.
- Employ stringent sanitation measures, good cultural practices, and appropriate chemical controls. The most important control of this disease is good irrigation management. For example, where new trees are interplanted among older trees, separate irrigation lines are needed to insure appropriate irrigation timing and amounts for the different aged trees.

Cultural Controls

Use cultural practices that promote healthy growth of the tree while discouraging growth of the pathogen.

Provide favorable soil conditions

In new plantings, avoid soils and soil conditions favorable to root rot development, including poorly drained, saline, or pathogen-infested soils. Plant on well-drained soil, or improve drainage by planting on a soil berm, deep-ripping impervious subsoils, or installing subsurface drains. In established plantings, manage soils carefully so that excess moisture does not accumulate.

Use certified disease-free nursery stock

Request certified, disease-free plants, especially when planting new areas, because disease is especially damaging to young trees. Nurseries should disinfest propagation material, such as by immersing seed in water at 120 to 122°F for 30 minutes and then quickly cooling it. Nurseries should also use pasteurized soil mix, clean irrigation water from deep wells or disinfested surface water, and stringent sanitation to prevent pathogen introduction and spread. Nurseries that rely only on fungicides for disease prevention can promote fungicide resistance and produce symptomless plants with infections that develop after planting.

Plant resistant rootstocks

Certain rootstock cultivars are more tolerant of root rot, including Dusa, Latas, and others. Newer recommended cultivars such as Uzi and Zentmyer may also be available. Barr Duke, Duke 7, and Duke 9 can also be good rootstocks but have less *Phytophthora*-resistance than some newer cultivars. To obtain rootstocks with maximum resistance to Phytophthora root rot, choose rootstocks produced by a nursery using the clonal method because clones of recommended cultivars are more resistant than seedlings. Be aware that resistant rootstocks are not immune to root rot; if they are planted or maintained under adverse conditions, they may be killed by the combination of adverse conditions and the pathogen.

Prevent soil or water movement from infested areas

Excluding *P. cinnamomi* from an uninfested grove is the most economical control method.

- Install water-tight drains to divert surface runoff if a diseased area lies above a healthy grove.
- Control gophers, as their burrows can provide means of moving the pathogen in water.
- Do not work in infested groves when the soil surface is wet; *Phytophthora* is readily spread by activities such as walking or driving on infested wet soil.
- Bring only clean bins and equipment into groves.
- Begin harvesting and other activities in healthy areas of the grove; work in diseased areas last to minimize pathogen movement.

Soil solarization

Soil solarization can be effective for treating infested soil following tree removal in warm inland areas of California through a process in which radiant heat from the sun is trapped under clear polythene sheets laid on the surface of the soil. Solarization is effective when soil temperatures in the top 2 inches of soil reach between 108° to 131°F.

Establish a barrier

If Phytophthora root rot occurs in only one area of the grove and cannot spread downhill in surface runoff or drainage water, erect a physical barrier and post warning signs to prevent people and activities from spreading the fungus into protected areas. Establish the barrier around healthy sections of the grove, at least two tree rows beyond where tests indicate the fungus is present.

Irrigate carefully

Appropriate irrigation is the single most critical practice for improving tree health and managing root rot. Schedule irrigation frequency and amount using sophisticated methods, such as based on local evapotranspiration or by installing soil moisture monitoring devices, such as tensiometers. Good irrigation management is especially important where trees are diseased, near the margins of diseased areas of groves, and beneath thick mulch. It may be necessary to replace irrigation emitters around unhealthy trees by installing lower output sprinklers to avoid saturating the soil. Install valves for irrigation lines for infected portions of the grove because infected trees do not use water at the same rate as the healthy portion of the grove. Do not water soil that is already wet because it will become waterlogged and accelerate disease.

Use high-quality irrigation water

Irrigation water with high overall salinity or an excess of boron, chloride, or sodium promotes infection of roots by *Phytophthora*. *Phytophthora* can contaminate irrigation water, such as surface water that is runoff from infested soil. The extra cost of purchasing high quality water can often be justified by reduced disease and increased crop quality and yield.

Apply gypsum and mulch

Create soil conditions that suppress development of Phytophthora root rot.

- Apply, wood chip mulch and gypsum when the orchard is being established. Consider periodically applying additional mulch. Reapply gypsum as the old material dissolves from view.
- Apply gypsum under the canopy of each tree, perhaps 25 lb beneath a medium-size tree. Gypsum supplies calcium, which suppresses the formation of *Phytophthora* spores.
- Apply at least 4 to 6 inches of coarse wood chip mulch onto soil beneath canopies, but keep mulch several inches away from the trunk. Use coarse organic mulch such as avocado trimmings, composted greenwaste (yard trimmings), or hardwood chips which provides better *Phytophthora* control than naturally dropped leaves. Mulching promotes root growth into the mulch, enhances the development of beneficial microorganisms antagonistic to *P. cinnamomi*, and reduces the adverse effects of saline soil and water.

Provide appropriate nutrition

Moderate amounts of nitrogen promote good growth that helps avocado better tolerate root rot. Avoid excess amounts of fertilizer, especially avoid large amounts of animal manures or other products high in ammonia or salts. Avocado roots are sensitive to ammonia and salts.

Rotate crops

Replanting infested soil to resistant crops for at least several years reduces Phytophthora root rot propagules in soil. The fungus has a wide host range, but plants such as cherimoya, citrus, and persimmon are highly resistant to the *Phytophthora* sp. causing Phytophthora root rot in avocado.

Chemical Control

Certain phosphonate fungistats (phosphorous acid and phosphonate compounds) can markedly improve trees' ability to tolerate, resist, or recover from infection by *Phytophthora cinnamomi*. Good control requires using materials in combination with other recommended practices, such as careful irrigation practices and applying wood chip mulch. Phosphonates cannot eradicate *Phytophthora* from the grove and Phytophthora root rot requires ongoing management throughout the life of the trees.

Fumigation is not recommended even if the the maximum rate of fumigant is applied. Often *P. cinnamomi* re-invades fumigated soil and the Phytophthora root rot becomes worse than before because the soil microbial community and competing microorganisms have been reduced by the fumigation.

Application methods

Varying with the product label, phosphonate (phosphite; FRAC Group 33) may be sprayed onto bark or foliage, injected into soil with irrigation water (chemigation), or injected into trunk vascular tissue. If permitted on the product label, proper trunk injection is generally the most effective application method when treating severely diseased trees. Proper application timing is critical. Phosphites can move both up and down within plants. To induce phosphites to move to roots, apply phosphites prior to initiation of new root growth. This effective application time is when about three-fourths of leaf flush is complete or just as new leaves harden, usually in late spring (May) and summer (August). Optimal application dates vary according to local conditions. If applied during early flush or when many new leaves are flushing, most of the phosphite will move to leaves and provide little *Phytophthora* control. If injected when new leaves are hardening, phosphites will move upward in the xylem stream, then move downward in the phloem where they can encourage healthy new root growth.

Inject trunks using proper equipment, such as spring powered or gas powered (CO_2) injectors. Drill relatively small diameter holes to the depth of the drill bit, at a slightly downward and sidewise angle so that more of the phosphonate material is deposited in the outer wood. Larger holes do not heal properly and continuous weeping and bacterial infection in the holes often occurs. Drill holes into smooth sections of the trunk or main limbs, avoiding knots and side branches. Where feasible, locate holes above any trunk area that is wetted by mini-sprinklers to facilitate injection wound closure.

Application (spraying) directly onto bark is usually not effective for managing Phytophthora root rot. Bark application may be more effective in managing the trunk canker fungus *Phytophthora mengei*. Application through the irrigation system is more effective in slowing down the spread of Phytophthora root rot disease than it is in controlling disease in already infected trees.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

When choosing a pesticide, consider its usefulness in an IPM program by reviewing the pesticide's properties, efficacy, application timing, and information relating to resistance management, honey bees, and environmental impact. Not all registered pesticides are listed. Always read the label of the product being used.

NONBEARING TREES

A.	ALUMINUM TRIS PHOSPHONATE			
	(Aliette WDG)	Drench: 5 oz / 10 gal	12	NA
	(Aliette WDG)	Foliar: 5 oz / 100 gal	12	NA

COMMENTS: For drench application: apply 1 qt per pot or sleeve of each tree 2 to 3 days before transplanting. For foliar application: begin application at transplanting or the start of the growing season and continue for up to 4 applications per year at 60-day intervals.

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
BEARING TREES			
A. PHOSPHOROUS ACID (Agri-fos, Fosphite)	Label rates	4	0
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Phosphonate (33) COMMENTS: Do not apply with copper-based fungicides or fertilizers; allow 10 days before applying copper-based compound after phosphorous acid treatment or 20 days before applying phosphorous acid after copper treatment. Do not apply to dormant or heat- or moisture-stressed trees.			
B. ALUMINUM TRIS PHOSPHONATE (Aliette WDG)	5 lb	12	0.5 (12 hours)
COMMENTS: Begin application at the start of the growing season and repeat every 60 days. Do not exceed 20 lb / acre per year.			
C. MEFENOXAM (Ridomil Gold SL)	Label rates	48	NA – drench; 28 – chemigation
MODE-OF-ACTION GROUP NAME (NUMBER[1]): Phenylamide (4) COMMENTS: Apply as a drench or by chemigation. Trials indicate this material is less effective on older trees, but is effective for a few years on young trees that have been replanted into *Phytophthora*-infested soil.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

NA Not applicable.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode-of-action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode-of-action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.

ROSELLINIA ROOT ROT (09/16)

Pathogen: *Rosellinia bunodes*

SYMPTOMS AND SIGNS

Yellow foliage, shriveled fruit, and little or no new growth are symptoms of Rosellinia root rot. Cottony, white mycelia cover small feeder roots, and roots decay. Mycelia grow into soil and upward in the tree, forming small, pale patches under or in bark of major roots, the root crown, and lower trunk, which eventually decay. Older mycelium become gray or black. The fungus can also cause a purple canker in wood at the root crown of young trees. Diseased trees will defoliate and always die prematurely, usually within 1 to 3 years of initial infection.

COMMENTS ON THE DISEASE

Rosellinia root rot is not common in avocado in the United States. Although uncommon, when present, it is a very serious disease and requires prompt action to prevent its spread to other trees.

Rosellinia root rot is also called white root rot in reference to its pale mycelium. The fungus persists for years in buried wood and organic matter in soil. It spreads to nearby trees through root grafts and can also be moved longer distances in infected soil or wood. Spores apparently are not important in causing disease.

The whitish mycelial patches of *Rosellinia* resemble those of *Armillaria*, but *Rosellinia* mycelia lack the characteristic mushroomlike odor produced by *Armillaria*. One method to diagnose *Rosellinia* is to seal infected wood, roots, or soil in a moist container. Extensive white mycelium will grow within a few days. However, because of its severity and persistence, seek expert assistance if Rosellinia root rot is suspected.

MANAGEMENT

The biology and management are much the same as described for *Armillaria*. Uproot and dispose of infected trees and roots. Remove immediately adjacent trees that may also be infected. Remove as many root pieces from soil as possible and trench around the infected site to break root grafts. Establish a dry zone and prevent soil movement or water runoff from that site. Fumigate or solarize the ground well before replanting.

SOOTY MOLD (09/16)

Pathogens: *Capnodium* spp. and related fungi.

SYMPTOMS AND SIGNS

Sooty mold consists of hyphae and spores of *Capnodium* spp. and related fungi. Sooty mold is black, somewhat felty fungal growth on the surface of fruit, leaves, or stems. Sooty molds grow on honeydew excreted by juice-sucking insects, including soft scales and whiteflies.

COMMENTS ON THE DISEASE

Sooty molds do not infect avocado and generally cause no damage. Exceptions are if leaves become so heavily covered that photosynthesis is significantly reduced, causing chlorosis and possible premature leaf drop. If fruit is noticeably fouled, it may be downgraded at the packing house.

MANAGEMENT

Manage sooty mold by controlling the insects that produce honeydew. Honeydew-producing insects in avocado are often well controlled by natural enemies. Control ants, minimize dust, and avoid broad-spectrum insecticides to conserve these beneficial parasites and predators. If direct insect control is required, use selective insecticides whenever possible.

SUNBLOTCH (09 / 16)

Pathogen: *Avocado sunblotch viroid* (ASBVD)

SYMPTOMS AND SIGNS

(View photos online)

Sunblotch causes a wide variety of symptoms or may exhibit no symptoms in some hosts. Symptoms of sunblotch include necrotic, red, yellow, or white discolorations on fruit, often in depressions or scars in the fruit surface. Twigs can develop narrow, necrotic, red or yellow streaks on their surface or in shallow lengthwise indentations along the twig. Leaves may have white or yellowish variegated areas and be deformed, but leaf symptoms are uncommon. Rectangular cracking and checking of the bark, called "alligator bark," often occurs on the trunk and larger branches. Infected trees may be stunted and have a disproportionate amount of horizontal growth or sprawling lateral low limbs. Trees with visible sunblotch symptoms often have reduced yields. Infected trees can also be symptomless, although large reductions in yield of previously vigorous trees may indicate the presence of the viroid in otherwise symptomless carriers.

COMMENTS ON THE DISEASE

Sunblotch is caused by dozens of variants of submicroscopic particles of genetic material (viroids) that alter development and growth of infected plants. Sunblotch viroid can move systemically within avocado, and it persists in host tissues. Trees that show no symptoms even though the viroid is present are known as "symptomless carriers." Nearly all cuttings and seed from symptomless carriers are infected with viroid. However, seedlings from symptomless carriers do not show symptoms of sunblotch when they are used as rootstocks, but the disease often appears on scions grafted to them. Conversely, most seed from trees with symptoms are not infected, and budwood and shoot cuttings from symptomatic trees often do not contain viroid.

Transmission of the viroid most often occurs during grafting by using infected budwood or rootstock seedlings from infected trees with or without symptoms. Natural root-to-root grafts are important in transmitting sunblotch in groves. Mechanical transmission through wounds caused by contaminated harvest clippers, pruning tools, and injection equipment may be important if infected trees are in the grove. Spread via pollen from an infected tree to the flower ovule of a noninfected avocado, resulting in infected seed, can cause fruit to be culled, but does not further spread the disease unless seed is propagated. There is no evidence of insect transmission.

MANAGEMENT

Careful propagation of nursery stock to eliminate viroid has greatly reduced sunblotch to a relatively minor disease. However, ongoing monitoring and management is required in nurseries and established groves. Sunblotch is easily overlooked, and there are many ways that trees can become infected. Look for disease and disease-promoting conditions regularly throughout the grove by MONITORING DISEASES AND DISEASE-PROMOTING CONDITIONS.

In the nursery:

- Carefully select disease-free scions and seed sources.
- Use stringent sanitation and frequent disinfection to avoid spreading pathogens.
- Periodically confirm that propagation sources are disease-free (indexing) by grafting propagative source material to young Mexican seedlings and observing leaves and twigs for sunblotch symptoms, or by performing a genetic test.

In the orchard:

- Plant only indexed nursery stock registered as disease-free.
- Promptly remove symptomatic trees from the grove and chemically kill the stumps.
- Do not retain infected, symptomless trees just because yield does not seem to be affected; symptomless carriers are a highly infective source that can dramatically reduce yield on other trees. If only fruit and seed are infected (from infected pollen), it may not be necessary to remove that tree if indexing indicates the rest of the tree is not infected. However, trees with only fruit and seed infection indicate that other infected (possibly symptomless) trees nearby need to be indexed or removed.

The danger of spreading viroid increases in established orchards where mature trees are pruned to reduce tree size and re-stimulate or maintain fruit production. Severe pruning of symptomless carriers, and perhaps other severe causes of tree stress, are suspected of causing viroid to become active in the new growth, inducing previ-

ously symptomless trees to exhibit symptoms. Disinfect pruning tools, harvest clippers, and injection equipment before beginning work on a new tree. Scrubbing tools clean and then soaking them in a 1.5% sodium hypochlorite solution is effective. Growers must use a registered disinfectant and follow label directions.

SUNBURN (09 / 16)

SYMPTOMS AND SIGNS

(View photos online)

Bark, fruit, and leaves exposed to direct sunlight are injured by heating and drying of tissue. Damage typically is most severe on the south and southwest sides of trees. Sunburn initially causes a pale yellowish area on the exposed side of fruit. The center of discoloration may turn black, brown, or red, then necrotic or withered. Sunburned leaves develop chlorotic then necrotic blotches, which initially form between veins. Sunburned twigs become cracked, discolored, purplish, or roughened on their exposed (usually upper) side. When severe, sunburned trunk and limb bark and the cambium underneath can discolor and die, causing cankers that can girdle and possibly kill limbs.

COMMENTS ON THE DISEASE

Sunburn, sometimes called sunscald, typically occurs when trees defoliate, exposing fruit or previously shaded bark. Newly planted trees that grew with bark shaded in the nursery, and trees that are unable to take up enough water because of unhealthy roots or inappropriate irrigation, are highly susceptible to sunburn.

Prevent sunburn by providing trees with good growing conditions and proper cultural care, especially appropriate amount and frequency of irrigation. Where feasible, prevent conditions that cause foliage to drop prematurely, including Phytophthora root rot and high persea mite numbers. If trees defoliate, do not irrigate until soil in the root zone approaches dryness. Defoliation reduces tree use of water, so soil will remain wet longer than with unaffected trees. Examine soil carefully and frequently and modify irrigation to prevent excess moisture in the root zone.

MANAGEMENT

Whitewash young trees routinely at planting. Whitewash the trunk and major limbs of older trees if they develop sparse canopies or are severely pruned, such as when cut back to trunks and grafted with new scion (stumped). Special whitewash products are available, or white interior latex paint diluted 50% with water can be applied. An inexpensive whitewash formula is 50 lbs hydrated lime and 4 lbs zinc sulfate to each 100 gallons of water. Certain white film kaolin clay particle products can be sprayed onto foliage to reduce sunburn and tree heat stress, apparently without interfering with leaf photosynthesis.

VERTICILLIUM WILT (09 / 16)

Pathogen: *Verticillium dahliae*

SYMPTOMS AND SIGNS

(View photos online)

The entire tree or only one or several branches wilt suddenly when affected by Verticillium wilt. Leaves turn brown and die, but the dead leaves usually remain on the tree for several months. Brown to gray-brown streaks are visible in the xylem of the branches or roots when the bark is removed. Trees with Verticillium wilt often send out new, vigorous shoots within a few months after the initial wilting. If well cared for, affected trees often recover completely with no reoccurrence of the disease. However, not all trees survive an infection and disease symptoms sometimes reoccur after an apparent recovery.

COMMENTS ON THE DISEASE

The fungal pathogen *Verticillium dahliae* infects many hosts, including various berry and flower crops, cotton, eggplant, olive, pepper, stone fruit trees, strawberry, and tomato. Verticillium wilt is present throughout the state but is less common in avocado than root rot and canker diseases. *Verticillium dahliae* persists for years as microsclerotia in soil. Microsclerotia spread in infested organic matter and soil that is moved. The fungus infects through feeder roots, and then moves up in the water-conducting xylem system, restricting or preventing water movement to foliage from the roots.

MANAGEMENT

No known methods are effective in curing infected trees. Trees often recover completely and display no further symptoms, even though they are still infected. After dieback ceases and new growth begins, prune off dead branches. Provide optimal irrigation and modest fertilization to promote new growth. If a tree dies from *Verticillium*, remove it.

In areas where *V. dahliae* is known to occur, plant Mexican rootstocks instead of the more *Verticillium*-susceptible Guatemalan rootstocks. Do not plant avocado on land where crops susceptible to Verticillium wilt have previously grown. Do not interplant avocado with other hosts of *Verticillium*, which are listed in publications such as *Plants Resistant or Susceptible to Verticillium Wilt*. Even if they have recovered, do not use trees infected with Verticillium wilt as a source of budwood or seed.

Weeds

(Section reviewed 09/16)

INTEGRATED WEED MANAGEMENT (09/16)

Integrated weed management uses multiple strategies to manage weed numbers in an economically and environmentally sound manner. Strategies usually include various combinations of cultural, mechanical, chemical, and biological methods.

Weeds compete with trees for water and nutrients, primarily during the grove's early years of growth. Weeds are usually a minor concern in healthy, mature groves that have thick mulch and a dense canopy that shades the ground. Weed competition may be a problem in nurseries and in older groves where trees have been heavily pruned or are unhealthy and have a sparse canopy, allowing more light to reach the soil surface. A dense canopy that shades the soil reduces the amount of sunlight that weeds need to grow to be competitive with the trees. Competition is strongest from perennial and summer annual weeds. If tall or dense weeds are allowed to excessively compete with young trees, the trees may start producing fruit much later than those with minimal competition. Weeds within groves, along orchard borders, and on roadsides may host or harbor pests that attack fruits or trees. Weeds on field margins can also serve as a reservoir for future weed problems, because seeds can enter the orchard with the wind or on equipment. Additionally, weedy vegetation along field margins can spread wildland fires into groves.

Effective management of orchard floor vegetation can provide benefits, such as reducing soil erosion, improving water infiltration, and limiting movement of potential contaminants off-site into surface or ground water. For example, waterlogged soil around young trees can lead to root asphyxiation. This problem can be reduced if weeds or cover crops are allowed to grow, reducing soil moisture in those areas. Proper vegetation management can also provide alternative hosts and shelter for parasites and predators of invertebrate pests and can reduce dust that favors mite outbreaks. Maintaining cover crops on slopes and in open areas between trees, and having vegetative filter strips along borders and roads, can be especially beneficial to limit undesirable surface water movement.

Integrated weed management strategies can vary from grove to grove. Practices are influenced by location in the state, climatic conditions, soil texture and profile, irrigation practices, topography, cost, and grower preferences. A good weed management program utilizes a combination of strategies, including prevention and monitoring.

PREVENTION

Preventing the introduction or establishment of weeds is the most effective method of managing weeds. Choose an appropriate growing site and prepare it properly before planting. Avocados are frequently grown on rocky slopes with limited mechanical access and care must be taken to minimize operations that compact or disturb soil around the shallow-rooted trees. New weed infestations from blown-in or carried-in weed seeds or propagules can be minimized, if not prevented, using herbicides, cultivating, and mowing during site preparation, when trees are small or widely spaced, and along roadsides and borders.

After planting, maintain a thick layer of organic mulch beneath the canopy to just beyond edge of the tree canopy (i.e. the the drip line). However, to avoid crown disease problems, keep mulch thin near the tree trunks. Mulching and hand-weeding provide the best and safest weed control around young trees in most situations. As groves become established, exclude weeds primarily by providing trees with appropriate cultural care and good growing conditions. Healthy and productive trees develop a dense canopy that shades the soil and produce a natural mulch through leaf drop.

MONITORING

Regular monitoring of weed species and numbers will help to select effective weed control methods and helps to determine when to take further action. Detect, identify, and keep a record of new weed species and weeds that escaped previous management actions. This will help to prevent new weed species from establishing or prevent shifts in weed populations. For monitoring to be effective, correctly identify the weed species present in and around the grove, especially when they are in the seedling stage. Most weeds are poor competitors for water and nutrients when they are small, but some can become very aggressive and difficult to manage as they become

large. It is easier to control annual weeds with tillage or herbicides when they are small and not well-established. Perennial weeds are more vulnerable to control at the early bud stage and during fall just before the plants begin to go dormant; systemic herbicides applied at these times will be translocated to the roots or rhizomes to better kill the weed.

Most management actions differ in effectiveness depending on the species of weeds. Regular monitoring will determine if your control actions are working. Because weeds often grow in patches, locating small infestations and managing these may save time and money while still achieving good control. Therefore, it is important to know which weed species are present, their growth stage, their abundance, and their location in the orchard. A handheld GPS (global positioning system) unit is useful for marking and recording patches of troublesome weeds for spot management and subsequent monitoring.

Monitor and manage weeds throughout the year
Monitor for weeds at least twice each year, midwinter and late spring. Additional monitoring in midsummer and late fall is desirable, especially before planting a new grove and during the first several years of tree growth, because this will help to reveal the full spectrum of weed species that are present. Record the results of your monitoring on a weed survey form.

Fall
Fall rains stimulate weed germination and growth. If fall rains occur early (in September and early October) during typically warm months, weeds develop sooner, grow larger, and require earlier or more vigorous control actions. If rains begin later after temperatures have cooled, winter annuals grow more slowly.

Future and new groves. After the first fall rains, look for and record the species of perennial seedlings or sprouts, winter annual seedlings, and mature summer annuals.
Established groves. Inspect the thickness and effectiveness of mulch and assess whether additional control efforts are warranted near trunks. Check row middles primarily for perennial seedlings and sprouts. If young trees are present, monitor if weeds are present near the trunk.

Winter
Cold, dry winters delay weed emergence. A warm, rainy winter means that winter annuals will grow large and will be capable of producing many seeds, perhaps requiring earlier and more vigorous control action than during drier winters. Examine untreated ground in February to observe the full range of winter annual species present and the vigor of their development.

Spring
Monitor in late spring, after summer annuals have germinated, when winter annuals are flowering, and perennial weeds are evident. Spring monitoring a year before planting indicates what species are present at a time when virtually all control methods can be used and most actions are more effective and easier to use. After the grove is planted, spring monitoring around trunks tells you which species have not been controlled by actions such as cover cropping, mulching, and preemergence herbicides.

Summer
Monitor in midsummer for perennial weeds, especially before planting. Monitor for perennial weeds at least 2 weeks before cultivation and for a few weeks after a management procedure to determine if retreatment is needed.

WEED MANAGEMENT BEFORE PLANTING

Begin weed management before you plant the grove. Do a weed survey at least twice a year as described above to learn what species are present before you clear, cultivate, or grade the site. Record your results on a weed survey form.

Choose an appropriate growing site and prepare it properly before planting. Provide proper drainage during site preparation, such as by ripping through any impervious soil layers or hardpan near the surface, installing drains, and grading soil to eliminate areas of standing water. Consider planting trees on a berm or mound of raised soil. Before planting on raised soil, prepare subsurface layers to encourage good rooting and avoid lodging.

Coordinate preplanting weed management with other site preparation activities such as amending soil to improve pH and installing the irrigation system. Be aware that weed problems can change or can be created anytime

when soil is disturbed. It is especially important to eliminate perennial species before planting or moving soil around the site; otherwise perennial weeds may be spread throughout the field.

Control perennial weeds. Controlling aggressive perennial weeds should be a focus of your vegetation management program. Where feasible, use of repeated cultivations of dry soil during the summer before planting exposes vegetative propagules (like rhizomes and stolons) of bermudagrass, dallisgrass, and johnsongrass to drying, killing them. Additionally, treating perennial weeds with a translocating herbicide 1 to 2 weeks before cultivation can help kill underground structures, preventing the spread of live weeds by cultivation. Monitor a few weeks after herbicide application and retreat any regrowth. Cultivation does not eliminate the reservoir of seeds, which will continue to germinate for a period of years.

1. Control emerging weed seedlings with cover cropping, cultivating, flaming, mulching, and herbicides to prevent seedlings from forming perennial structures.
2. In early fall, treat perennial weeds with a systemic postemergence herbicide when the plants are flowering.
3. Repeat cultivation 10 to 20 days after herbicide application to expose the root systems to further drying.
4. Monitor the next spring and spot-treat any regrowth.

If field bindweed is present, the above program will reduce the infestation, but because this weed has a deep perennial root system, it is likely to persist and require ongoing controls until a mature tree canopy heavily shades the ground. Even in mature groves, perennial weeds such as field bindweed and wild cucumbers can be common along borders and roadsides. In places where they receive light, these vinelike weeds often grow up into the canopy of trees.

Control annual weeds and perennial weed seedlings. Management strategies including cover cropping, cultivating, flaming, hand-weeding, mowing, mulching, spraying herbicides, and cultural practices that promote a dense tree canopy will provide good control of annual weeds.
Where adequate water is available and irrigation is feasible, the numbers of annual weeds and perennial weed seedlings can be greatly reduced by practicing a cultivation-irrigation cycle:

1. Cultivate.
2. Irrigate to germinate seeds near the surface.
3. Cultivate shallowly to destroy seedlings.
4. Repeat at least once to be effective

It is possible to apply preemergence herbicides before planting to the entire grove or to strips 4 to 6 feet wide where trees will be planted. If weeds have emerged, use methods such as cultivation or contact herbicides before planting trees. After trees are planted, a preemergence herbicide can be applied additionally. Be aware that some preemergence herbicides should not be applied before planting or near young trees because they can injure avocado trees. Be sure to follow the instructions of the current herbicide label.

WEED MANAGEMENT AFTER PLANTING

Continue to focus on controlling perennial weeds and any weeds near trunks after trees are planted. Apply and maintain a thick layer of organic mulch or a weed barrier fabric as discussed in the section on mulch below. Hand-weed or spot-treat any weeds growing in or near edges of mulch. Be careful not to injure trees when using herbicides or tools such as flamers, hoes, machetes, mowers, and weed trimmers. Management strategies include strip weed control, basal control, and total control.

Strip weed control. Strip weed control maintains a 2 to 6 foot wide weed-free area in the tree row. By allowing vegetation in middles, strip control improves soil structure, reduces erosion, and requires less effort than trying to control weeds over the entire grove floor. However, perennial weeds can establish quickly in the tree rows because there is no competition. Check regularly for perennial weeds and spot-treat small infestations as needed.

Basal weed control. Basal control eliminates weeds in a 4- to 8-square-foot area, or within a several foot diameter around each tree trunk. Allowing vegetative cover in middles and in rows (some distance back from trunks) minimizes the area where control actions are taken.

Total weed control. Attempting to keep the entire grove floor free of vegetation generally requires extensive herbicide use and is unrealistic and potentially detrimental. If attempting total weed control, herbicides should be used in combination with other methods, especially using mulching near trunks to economically manage weeds.

Soil compaction, erosion, reduced water infiltration, contaminant movement off-site, and injury to trees can be serious problems with total vegetation control. Because no single chemical can control all species of weeds, combinations of herbicides or sequential treatments usually must be made. Weeds must be more carefully monitored to determine which herbicides to apply and when to apply them. Perennial weeds such as bermudagrass and nutsedges may become established quickly in the absence of competition. Repeated applications may lead to the buildup of species tolerant of, or resistant to, that herbicide. It is very difficult to completely avoid injuring avocado trees with herbicide if groves are frequently sprayed.

WEED MANAGEMENT IN ESTABLISHED GROVES

As healthy trees develop a wide dense canopy, they naturally produce their own leaf mulch. As a result, canopy and mulch increasingly shade other vegetation. Borders and roadsides become the primary locations where weed control is needed. Weeds can also become a problem around trees that are extensively pruned or unhealthy (sparsely foliated), especially if soil is disturbed and not thickly covered with mulch.

The chosen control methods depend on the extent of canopy shading and mulching, irrigation frequency and method, need for erosion and runoff control, soil type and rockiness, spectrum of weeds present, terrain, tree spacing, and considerations such as economics and grower preferences. Combine several methods and take action at the appropriate time to obtain good control.

Sanitation. Avoid introducing weeds and eliminate conditions that favor weed development. Clean equipment after working infested ground to prevent the spread of weed seeds and perennial structures. When working several sites, work the most infested sites last or thoroughly clean equipment between sites.

Irrigation. Avocado groves are irrigated primarily with sprinklers, micro-sprinklers, or drip. The method and frequency of irrigation strongly affect weed growth. If sunlight reaches the soil, the frequency of weed management activities increases when water is applied over a larger surface area and when water is applied more frequently. Weed management is needed less often when trees are on berms because the soil surface within the tree row remains drier.

Mulch. Mulch is a layer of material covering the soil. Mulch controls weeds by excluding sunlight, and to some extent by providing a physical barrier to weed growth. Applying mulch is expensive, because it requires significant labor, especially if it is difficult for mechanical mulch spreaders or haulers to reach the site. However, the improved tree health and increased fruit yield from mulching provide substantial benefits.

In comparison with organic material, weed fabrics (water-permeable polypropylene or polyester mulches) have certain advantages and are occasionally used around young trees. Weed fabrics suppress perennials that can grow through organic mulch. They are relatively efficient to apply and are longer-lasting than organic mulch. However, weed fabrics are usually more expensive than wood chips or other natural materials. Unless covered with material, such as a coarse organic mulch, fabrics breakdown within a few years because of exposure to ultraviolet (UV) light.

A layer of coarse organic material, about 4 to 6 inches thick, provides the best weed control. Bark, greenwaste (residential yard trimmings), straw, and wood chips make good mulch. Apply organic mulch over a several foot wide area around newly planted avocado trees, taking care to keep mulch thin near trunks or about 6 inches away from the trunk. Reapply mulch annually during the first several years of tree growth. If later in the trees' life the natural leaf mulch is insufficient, consider applying additional organic mulch at least once every several years to maintain a thick enough layer to suppress weeds, especially if leaf mulch has been blown or washed away.

Avoid removing or disturbing dropped avocado leaves, because they act as a natural mulch. Take steps to retain leaves under trees. Keep tree skirts low. In addition to weed control, organic mulch provides many benefits, such as reducing Phytophthora root rot, conserving soil moisture, and gradually improving soil quality.

A planted cover crop or resident vegetation that produces a large amount of biomass can provide a living mulch. Where terrain and tree spacing permit, specially designed mowers can be used to blow cut vegetation from the middles into the tree rows to provide weed-suppressing mulch. Be sure to remove any vegetation near trunks before blowing mulch into tree rows. Cereal cover crops, such as forage oats, work particularly well for this "mow and throw" technique because cereal crop biomass does not degrade as quickly as broadleaf vegetation, such as

vetch. Plant the cover crop in about October and mow in late March (exact timing for best results depends on the location and weather).

Cover crops. Cover crops are useful in young groves and among older trees that have been extensively pruned. Vegetation along grove borders and roadsides can also be managed as a cover crop. A cover crop consists of the resident vegetation (the least expensive choice), one or more seeded annual species (such as commercially available self-seeding mixes), or a blend of resident and seeded vegetation. The best cover crop for your grove depends on the age of the grove, the irrigation system, location, soil conditions, and weather. For example, with sprinkler irrigation you have more cover crop options than with drip or micro-sprinkler systems.

Proper cover crop management minimizes the need for additional water, improves water infiltration, and reduces erosion and off-site movement of potential water contaminants. Cover crops provide habitat for beneficial insects and reduce dustiness that favors mite outbreaks. Competition from desirable cover crop species helps keep weeds from building up.

Mulching within the tree drip line and good cover crop species selection can reduce the need to manage the cover crop. Depending on the situation, cover crop management methods include herbicide application, cultivation, hand-weeding, mowing, utilization of a ring roller to injure the stems, and withholding irrigation. Keep cover crops away from tree trunks to minimize competition with the trees and to reduce the habitat for pests such as pocket gophers, snails, and voles. In comparison with bare soil, cover crops may increase frost hazard, especially in low-lying areas.

For information on choosing a cover crop, see Covercrops for California Agriculture, or UC ANR Publication 3338. Detailed information on a wide range of cover crops is also in the Cover Crops Database.

Hand-weeding. Cutting weeds with a portable string trimmer or mechanical weed whip, hoeing, using a machete, and hand-pulling large weeds are commonly used in avocado. Hand-weeding controls weeds near trunks, including scattered weeds that sprout in mulch and tall weeds or problem species growing near the edge of mulch. Avoid injuring trees by using careful technique, trunk guards, and reapplying mulch to maintain a thick layer of organic material within the drip line.

Cultivation. At level sites, cultivate before planting, along borders and possibly in the middles when trees are young. Spring is an ideal time, because cultivation can be combined with turning under a cover crop and weeds are small. Preferably, weeds should be less than 4 inches tall. Cultivation soon after emergence is especially important for perennials such as nutsedge, dallisgrass, and Johnsongrass. Once these weeds have developed more than a few leaves, they produce underground tubers or rhizomes from which they can regrow after cultivation. However, cultivation combined with an application of translocated herbicides can provide effective control of some established perennial weeds.

Rugged terrain, rocky soil, the presence of fixed irrigation systems, and the spreading shallow root system of avocado trees make cultivation not feasible or undesirable in many situations. Cultivating too closely to the tree row can cut feeder roots, reducing water and nutrients uptake. Cultivation may also spread the propagules of root pathogens and vegetative structures of perennial weeds. Excessive cultivation increases dust, erosion, and soil moisture loss, can damage soil structure, and may lead to reduced water infiltration. Once trees are about 6 to 8 feet tall, discontinue cultivation to avoid damage to root systems.

Mowing. Mow or flail before planting where it is feasible; along grove borders and edges, and in the middles between young trees. In comparison with cultivated or bare soil, mowing reduces erosion and allows the roots of cover crops or resident vegetation to maintain good water penetration. During dry weather, dusty conditions are reduced. Mowing equipment is less expensive and easier to operate than cultivators. Equipment is lighter, so soil compaction is less. Special mowers can be used in the tree row to mow weeds around trunks or to blow cuttings from middles into the tree row to provide mulch. When mowed, healthy cover crops are more resistant to invasion of new weeds than is resident vegetation. Be aware that repeated mowing promotes a shift to species that tolerate mowing, such as weeds with prostrate growth habits and grasses.

Flaming. Weeds can be controlled with specially designed flamers, most using propane. Other equipment, without an open flame, includes hot water or steam applicators and infrared devices. Flamers can be handheld or mounted on a handcart or tractor. Mechanized flamers have multiple burners, while small devices usually have a single flame source.

Fire is a serious hazard when flaming weeds. Only an experienced operator with demonstrated skill and good judgment should be allowed to flame weeds. Wet conditions during the rainy season or after a thorough irrigation are often good times to flame. Work in early morning or late evening when winds are lower and any open flame is more visible. Move the flamer slowly though the grove or briefly touch the basal stem area with the tip of a flame. Do not flame weeds to the point where they char and burn; only brief contact with high temperatures is needed to disrupt cells. Proper flaming should not create smoldering vegetation or air pollution other than fuel burning emissions.

Use good judgment to identify hazardous situations where flaming should not be conducted due to the risk of fire. Do not use flame weeders in dry areas or during the dry season when conditions are conducive to causing a fire. Be especially cautious around mulch and leaf litter. Keep fire suppression equipment, such as a fire extinguisher, shovel, and water handy in case of accidents. Keep flamers away from unguarded trunks to avoid crop injury. Consider flaming only during the rainy season and during or soon after precipitation when surfaces are moist and humidity is high.

The advantages of flaming include broad-spectrum control of broadleaf weeds, relatively low cost (depending on fuel and labor cost), and lack of chemical residue. Winter weeds, germinating after wet weather and after the end of the wildland fire season, are a good target for flaming. Disadvantages of flaming include a lack of residual control, poor control of some grasses and perennial weeds, critical timing requirement to ensure adequate weed control, hazards associated with handling pressurized flammable gas, the risk of damaging irrigation tubing, and the potential for fire associated particularly with use on steep hillsides.

Flame weeds while they are less than two inches tall. Broadleaved seedlings are most sensitive to flaming, while grasses and perennial weeds are less susceptible. Repeated flaming can lead to weed population shifts where perennial species and grasses dominate the orchard floor vegetation, unless other control techniques are used.

Determine the correct working pace or travel speed by checking weeds after flaming a test area. Weeds are being killed if gently pressing their leaves between your thumb and index finger creates a water-soaked appearance, indicating that cell membranes have ruptured. Plants may wilt, change color, or appear unaffected soon after flaming. Even if no change in the weeds is evident immediately, proper flaming causes plants to yellow and die within several days.

Herbicides. When using herbicides, choose materials and rates according to the weed species you need to control, your soil type, your irrigation method, and their risk of damaging trees. Where herbicides are relied upon, combinations of materials or sequential treatments with different materials are often needed, since no single herbicide controls all weed species.

Preemergence herbicides. Preemergence herbicides kill susceptible plants during and shortly after germination; most are not effective on emerged weeds. To be effective, most preemergence herbicides must be incorporated into the upper one or two inches of soil by rain, light irrigation of about 0.5 inch, or by cultivation. Some preemergence herbicides must be moved into the soil immediately to avoid a loss in effectiveness, others may remain on the surface for a short time before incorporation, and still other preemergence herbicides lose effectiveness if the soil is cultivated after application. Follow specific label directions regarding incorporation method and timing ahead of rainfall or irrigation.

Residual weed control from preemergence herbicides typically lasts for two to five months after application, but sometimes for more than a year. Persistence is affected by application rate, soil conditions, amount of rainfall or frequency of irrigation, and whether soil is disturbed or not. For example, herbicide activity dissipates more quickly during prolonged wet weather and in areas that remain wet, as around low-volume drip emitters.

Postemergence herbicides. Foliar-applied or postemergence herbicides are sprayed on the leaves and stems of weeds that have emerged. They are generally classified as either contact or systemic herbicides. Contact herbicides kill only the plant parts that are sprayed and thorough spray coverage is critical, especially for large weeds or dense infestations. Contact herbicides usually are most effective on seedlings and young weeds.

Translocated or systemic herbicides, such as glyphosate, are transported from the treated foliage to other parts of the plant, including roots and rhizomes, via the plant's vascular system. They are more effective on actively growing plants and are the most effective materials for controlling perennials weeds. However, in comparison with contact herbicides, translocated herbicides pose a greater risk of phytotoxicity to avocado.

A combination of preemergence and nonselective postemergence herbicides are often applied if some weeds have already emerged.

Phytotoxicity. Many herbicides can injure avocado. Nonselective, translocated (systemic) herbicides and certain preemergence herbicides can cause phytotoxicity by contacting the tree's shallow surface roots. Avoid applying most herbicides if they may contact avocado roots. Be sure not to spray postemergence herbicides onto cracked bark, green wood, leaves, or shoots. Do not use a material around trees or before planting unless phytotoxicity can confidently be avoided. Use herbicides primarily before planting, in areas away from trees, and to control perennial weeds.

Herbicide-resistant weeds. Tolerance and resistance to herbicides prevents some herbicides from controlling certain weeds. Tolerant plant species have a natural lack of susceptibility to certain herbicides. Crop tolerance to herbicides can be desirable because it allows the use of selective herbicides, such as those controlling grasses, but do not damage avocado or other broadleaves.

Resistance is present when a pest population is no longer controlled by pesticides that previously provided control. After repeated exposure of a weed population to the same herbicide or herbicides with the same mode of action, weed populations may be dominated by plant biotypes resistant to that class of herbicides. For example, in California, where glyphosate has been repeatedly applied to weed populations, rigid ryegrass (*Lolium rigidum*), Italian ryegrass (*Lolium multiflorum*), junglerice (*Echinochloa colona*), annual bluegrass (*Poa annua*), horseweed (*Conyza canadensis*), and hairy fleabane (*Conyza bonariensis*) have developed resistance to glyphosate (the active ingredient in Roundup).

Minimize development of herbicide resistance by integrating multiple other weed management methods such as cultivation, mulching, and hand-weeding. If herbicides are used, avoid repeatedly applying a single herbicide or herbicides with the same mode of action by either rotating or tank-mixing herbicide classes, or both. Scout orchards and field margins and note weed escapes or species shifts over time. Avoid spreading weed seed and propagules from infested areas by controlling runoff water and cleaning equipment before moving to another site.

Consult for guidelines on proper herbicide selection. Suspect herbicide resistance when a weed is not controlled by an appropriate herbicide that was properly applied and there is no obvious pattern that could be attributed to application errors (such as skips) or sprayer malfunction. For more suggestions on how to adjust management to avoid development of herbicide resistance, Herbicide Resistance: Definition and Management Strategies.

Repeated use of low rates of an herbicide can cause a shift in the weed population; careful monitoring is essential. Perennial or annual weeds not controlled by these lower-than-label rates may quickly take over because of the reduced competition; spot treat these according to label rates before they become dominant and extremely difficult to manage. Lower-than-label rates applications may select for herbicide-resistant plants. Use alternate strategies within a season or between seasons.

SPECIAL WEED PROBLEMS (09/16)

BARNYARDGRASS

Barnyardgrass is a summer annual that grows in dense, tall or spreading clumps. Several varieties that differ in growth habit and floral appearance occur in California. Each stout plant ranges from 6 inches to 6 feet tall. Plants often root at the lower nodes. Lower spikes of the flower head are spaced apart; top ones are crowded together. Management methods include cover cropping, cultivating, flaming, hand-weeding, mowing, mulching, and employing cultural practices that maintain and promote a dense tree canopy. Because barnyardgrass produces huge quantities of seed, it can be laborious to control without using herbicides.

BERMUDAGRASS

Bermudagrass is a drought-tolerant perennial grass and thrives in hot, sunny locations. It is less aggressive in dense shade. In cold locations it becomes dormant and turns brown during the winter. Bermudagrass reproduces from rhizomes, stolons, and seed. Depending on the situation, management of established infestations usually requires some combination of methods, including repeated dry cultivations and applications of a translocated herbicide. Complete control is difficult.

CRABGRASSES

Large crabgrass, also called hairy crabgrass, is a low-growing annual. It has a papery ligule, but no auricles, and there are small tufts of hairs where the leaf blade meets the sheath. Smooth crabgrass is a smaller species without hairs and it is less commonly a problem. Correctly distinguishing crabgrass from other species will help to identify effective management strategies. For example, large crabgrass roots deeply at the nodes, giving the appearance of stolons, which may cause crabgrass to be confused with perennials such as bermudagrass. Management methods include cover cropping, cultivating, flaming, hand-weeding, mowing, mulching, and employing cultural practices that maintain and promote a dense tree canopy. Crabgrasses tend to grow in moist areas due to its shallow root system. Managing irrigation, system leaks, and drainage will help reduce establishment and vigor. Most preemergence herbicides for grass management are highly effective at preventing crabgrass seedling establishment.

DALLISGRASS

Dallisgrass is a bunchgrass that is highly competitive with young trees for water. Mature plants typically form loose clumps about 1 to 4 feet tall. Dallisgrass reproduces from seed and very short rhizomes. Seed are easily transported in water or by machinery. Dallisgrass can become dominant in mowed groundcovers because mowing stimulates seed production. If dallisgrass becomes established in a young grove, repeated applications of a translocated herbicide may be needed to provide control.

FIELD BINDWEED

Field bindweed, also called perennial morningglory, competes with trees for moisture and nutrients during summer months. Established infestations are nearly impossible to eradicate because plants produce perennial roots and seed can remain dormant for up to 60 years. Take care not to transport viable rootstock fragments on field equipment. Kill seedlings before they have 5 leaves. Treating plants with a translocated herbicide, then cultivating, and treating regrowth when flowers begin to form reduces infestations substantially if repeated over a period of years.

LONGSPINE SANDBUR

Longspine sandbur seedlings closely resemble those of barnyardgrass. Seedling leaves are flattened and have a purplish tinge at the bottom. The most distinctive seedling characteristic is the bur from which the young plant emerges. This bur may be found by digging carefully around the roots. Management methods include cover cropping, cultivating, flaming, hand-weeding, mowing, mulching, spraying herbicides, and employing cultural practices that maintain and promote a dense tree canopy.

NUTSEDGES

Sedges resemble grasses, but grass stems are hollow, rounded, and have nodes (joints) that are hard and closed. Sedges have three-sided, solid stems that are triangular in cross-section. Grass specific herbicides such as fluazi-

fop are not effective in controlling nutsedges. Yellow nutsedge is the most common nutsedge in California, but purple nutsedge can be prevalent at warmer sites.

Nutsedges, sometimes called nutgrasses, reproduce from tubers (incorrectly called "nutlets") that form on their rhizomes. The tubers are spread easily by cultivation and when moving infested soil. Nutsedges may become troublesome in groves where herbicides are used for total weed control. Most herbicides do not control nutsedges well and nutsedges spread quickly in the absence of competition. To prevent the formation of tubers, kill the young plants before they reach the 5-leaf stage. Where herbicides are used, repeated applications are often needed.

PUNCTUREVINE

Puncturevine produces hard spiny fruit that can penetrate tires and are easily spread on shoes or tires. Plants are prostrate in open areas but somewhat erect in dense vegetation. Puncturevine is best managed at the seedling stage. Mature plants are much harder to control than the seedlings. There are species of seed and stem weevils that can generally suppress puncturevine in undisturbed and unirrigated areas, except if several years of freezing winter weather suppress weevil numbers. Avoiding cultivation and increasing drought stress through irrigation management can increase the weevils' effectiveness in biologically controlling puncturevine.

WILD CUCUMBER

Several species of wild cucumber may occur in California avocado. Cucamonga manroot (*Marah macrocarpus*) is the most common. These perennial vines develop a large tuber, which makes established plants difficult to eliminate. Wild cucumber vines have clinging tendrils. Stems climb up and entwine young trees and the sides of mature trees exposed along grove edges and roadsides. Cultivation, flaming, hand-weeding, or translocated herbicides must be applied repeatedly to kill regrowth until plants exhaust the energy stored in tubers.

COMMON AND SCIENTIFIC NAMES OF WEEDS (09/16)

Common Name	Scientific Name	Season and Type
barley, hare (wild barley)	*Hordeum leporinum*	winter annual grass
barnyardgrass	*Echinochloa crus-galli*	summer annual grass
bermudagrass	*Cynodon dactylon*	perennial grass
bindweed, field	*Convolvulus arvensis*	perennial broadleaf
bluegrass, annual	*Poa annua*	winter or summer annual grass
cacti, prickly pear	*Opuntia* spp.	perennial broadleaf
cocklebur	*Lolium* spp.	summer annual broadleaf
crabgrasses	*Digitaria* spp.	summer annual grass
dallisgrass	*Paspalum dilatatum*	perennial grass
fescues	*Festuca* spp.	perennial grass
fleabane, hairy	*Conyza bonariensis*	winter annual broadleaf
foxtails (yellow and green)	*Setaria* spp.	summer annual grass
goosefoot, nettleleaf	*Chenopodium murale*	summer annual broadleaf
horseweed (mare's tail)	*Conyza canadensis*	winter annual broadleaf
groundsel, common	*Senecio vulgaris*	winter or summer annual broadleaf
johnsongrass	*Sorghum halepense*	perennial grass
knotweed, common (prostrate knotweed)	*Polygonum aviculare*	winter or summer annual broadleaf
lambsquarters, common	*Chenopodium album*	summer annual broadleaf
lettuce, prickly	*Lactuca serriola*	summer annual broadleaf
mallow, little (cheeseweed)	*Malva parviflora*	winter annual broadleaf
mustards	*Brassica* spp.	winter annual broadleaf
nettles	*Urtica* spp.	winter or summer annual broadleaf
nightshades	*Solanum* spp.	summer annual broadleaf
nutsedges	*Cyperus* spp.	perennial sedge
oat, wild	*Avena fatua*	winter annual grass
pigweeds	*Amaranthus* spp.	summer annual broadleaf
puncturevine	*Tribulus terrestris*	summer annual broadleaf
purslane, common	*Portulaca oleracea*	summer annual broadleaf
ryegrasses	*Lolium* spp.	winter annual grass
sandbur, longspine	*Cenchrus longispinus*	summer annual grass
sowthistle, annual	*Sonchus oleraceus*	winter or summer annual broadleaf
sprangletop, bearded	*Leptochloa fascicularis*	summer annual grass
spurge, creeping	*Euphorbia serpens*	summer annual broadleaf
spurge, spotted	*Euphorbia maculata*	summer annual broadleaf
starthistle, yellow	*Centaurea solstitialis*	summer annual broadleaf
stinkgrasses (lovegrasses)	*Eragrostis* spp.	summer annual grass
thistle, Russian	*Salsola tragus*	summer annual broadleaf
velvetleaf	*Abutilon theophrasti*	summer annual broadleaf
wild cucumber	*Marah* spp.	perennial broadleaf
witchgrass (fall panicum)	*Panicum capillare*	summer annual grass

SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL (09/16)

	PREEMERGENCE						POSTEMERGENCE				
	FLU[3]	ISO[3]	NOR[1]	ORY	OXY	SIM[1]	CAR[2]	FLA[3]	GLY[2]	PAR[2]	SET[3]
ANNUAL WEEDS											
Grasses											
barley, hare (wild barley)	N	N	C	C	N	C	N	N	C	P	P
barnyardgrass	C	N	P	C	P	P	N	C	C	P	C
bluegrass, annual	C	N	C	C	P	C	N	N	C	P	N
crabgrasses	N	N	P	C	N	N	N	C	C	C	C
foxtail, yellow	C	N	C	C	C	C	N	C	C	C	C
lovegrasses (stinkweeds)	C	N	P	C	C	C	N	N	C	P	—
oats, wild	N	N	P	C	P	C	N	C	C	P	C
ryegrass	N	N	C	C	N	P	N	C	C[4]	P	C
sandbur, longspine	N	N	P	P	N	C	N	N	C	P	C
spangletop	N	N	P	C	N	N	N	N	C	N	C
witchgrass (fall panicum)	N	N	C	C	N	C	N	C	C	P	C
Broadleaves											
cocklebur	C	-	C	N	C	C	N	N	C	C	N
fleabane, hairy	C	C	C	N	C	C	P	N	C[4]	P	N
goosefoot	N	C	C	C	C	C	N	N	C	C	N
groundsel, common	C	C	P	N	C	P	N	N	C	C	N
horseweed (mare's tail)	C	C	C	N	C	C	P	N	C[4]	P	N
knotweed	N	C	P	C	P	C	N	N	P	P	N
lambsquarters	C	C	P	C	C	C	C	N	C	C	N
lettuce, prickly	C		P	N	C	C	C	N	C	C	N
mallow, little (cheeseweed, malva)	C	C	P	P	C	P	C	N	P	N	N
mustards	C	C	P	N	P	C	N	N	C	C	N
nettle, burning	N	C	C	P	C	C	N	N	N	P	N
nightshade, black	C	C	C	N	C	C	C	N	C	C	N
nightshade, hairy	C	C	C	N	C	C	C	N	C	C	N
pigweed	C	C	P	C	C	C	C	N	C	C	N
puncturevine	C	C	C	P	C	P	N	N	C	C	N
purslane	C	C	P	C	C	C	N	N	P	C	N
sowthistle	N	C	P	N	C	C	C	N	C	P	N
spurge, prostrate	N	C	P	C	P	N	N	N	C	C	N
starthistle, yellow	N	N	—	N	C	C	N	N	C	C	N
thistle, Russian	C	C	C	P	P	C	N	N	C	C	N
velvetleaf	C	C	—	N	—	—	C	N	P	C	N
PERENNIALS											
Seedling											
bermudagrass	N	N	C	C	N	P	N	C	C	N	C
bindweed, field	P	C	N	P	N	C	N	N	C	P	N
dallisgrass	N	N	N	C	N	C	N	N	C	N	C
johnsongrass	C	N	C	C	N	C	N	C	C	N	C

Established											
bermudagrass	N	N	P	N	N	N	N	P	C		P
bindweed, field	P	C	N	N	N	N	N	N	P	N	N
dallisgrass	N	N	N	N	N	N	N	N	C	N	—
fescue	N	—	C	N	—	—	N	—	C		—
johnsongrass	C	N	P	N	N	N	N	C	C	N	C
nutsedge, purple	N	N	P	N	N	N	N	N	P	N	N
nutsedge, yellow	N	N	P	N	N	N	N	N	P	N	N

CAR	= carfentrazone (Shark)	1	Considered to be a ground water contaminant and requires a use permit within Ground Water Protection Areas.
FLA	= fluazifop-p-butyl (Fusilade DX)	2	Contact with spray or drift can severely damage avocado.
FLU	= flumioxazin (Chateau)	3	For use on nonbearing trees only.
GLY	= glyphosate (Roundup, Touchdown etc.)	4	Some populations of rigid ryegrass, *horseweed, and hairy fleabane*) are resistant to glyphosate.
ISO	= isoxaben (Gallery)		
NOR	= norflurazon (Solicam)		
ORY	= oryzalin (Surflan)		
OXY	= oxyfluorfen (Goal, GoalTender)		
PAR	= paraquat (Gramoxone)		
SET	= sethoxydim (Poast)		
SIM	= simazine (Princep)		

HERBICIDE TREATMENT TABLE (09/16)

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)

The following materials are listed alphabetically. When choosing a pesticide, consider information relating to environmental impact, resistance management, the pesticide's properties, and application timing. Not all registered pesticides are listed. Always read the label of the product being used.

SITE PREPARATION – BEFORE PLANTING

Preemergence (before weeds emerge)

A. NORFLURAZON — Label rates — 12 — 60
(Solicam DF)
WSSA MODE-OF-ACTION GROUP NUMBER¹: 12
COMMENTS: Rate depends on soil texture (see label). Do not apply to the soil under young trees (trees less than about 3 years old). Apply to soil as a directed spray from fall to early spring. If no rainfall occurs within 4 weeks, incorporate with sprinkler irrigation. Can suppress yellow nutsedge or bermudagrass when used year after year. Remove existing weeds (e.g., with cultivation, hand-weeding, or a postemergence herbicide) because it has no postemergence activity. Avoid higher rates on sandy or gravelly soils to reduce risk of injury to trees. Considered to be a ground water contaminant and requires a use permit within Ground Water Protection Areas. Do not use in the Coachella Valley. Apply in 20 to 100 gal water/acre. Residual period: 6 to 12 months.

B. OXYFLUORFEN — 1.25–2 lb a.i. — 24 — 30
(Goal 2XL) — 5–8 pts
WSSA MODE-OF-ACTION GROUP NUMBER¹: 14
COMMENTS: Has pre- and some postemergence activity. Do not mechanically disturb the soil after application or poor residual weed control may result. Apply in a minimum of 20 gallons of water per acre. Do not apply between bud swell and final harvest or when fruit are present as injury may occur. Residual period: 4 to 10 months.

C. ORYZALIN — 2–6 lb a.i. — 24 — NA
(Surflan) — 2–6 qts
WSSA MODE-OF-ACTION GROUP NUMBER¹: 3
COMMENTS: Apply to the soil surface in 20 to 60 gal water/acre. If rain does not occur within 21 days after application, sprinkle irrigate with 0.5 to 2 inches of water. May be combined with a postemergence herbicide if weeds are present. The higher rates give the longest soil residual. Usually used at 4 lb a.i./acre. Chemigation with oryzalin is possible; see label for instructions. Residual period: 4 to 10 months.

D. SIMAZINE* — 2–4 lb a.i. — 12 — NA
(Princep 4L) — 2–4 qt
WSSA MODE-OF-ACTION GROUP NUMBER¹: 5
COMMENTS: Do not apply to the soil under avocado trees. Make one application per year, or split the application between fall and spring. Simazine is frequently used in combination with other preemergence herbicides. Use the high rate for heavy soils and the low rate for lighter soils. Do not use on gravel, sand, or loamy sand soils. Limit first irrigation after application to 0.5 inch. Considered to be a ground water contaminant and requires a use permit within Ground Water Protection Areas. Residual period: 8 to 12 months.

	Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
Postemergence (established weeds)				
A.	CARFENTRAZONE	0.024–0.31 lb a.i.		
	(Shark EW)	2.0 fl oz	12	3
	WSSA MODE-OF-ACTION GROUP NUMBER¹: 14			
	COMMENTS: For best activity, apply when weeds are still actively growing, less than 4 inches tall or rosettes less than 3 inches wide. Provides control of emerged annual broadleaves, but has no preemergence activity. A nonionic surfactant or crop oil concentrate or methylated seed oil is required. Can be mixed with other herbicides that have pre- or post-emergence activity for broader spectrum weed control. Can be applied anytime during the season. Apply in a minimum of 20 gallons of water per acre. Do not allow contact with desirable fruit, foliage, bloom, or bark, use hooded sprayers during application.			
B.	FLUAZIFOP-P-BUTYL	0.125–0.375 lb a.i.		
	(Fusilade DX)	16–24 fl oz	12	NA
	WSSA MODE-OF-ACTION GROUP NUMBER¹: 1			
	COMMENTS: **For use on nonbearing trees only**. Apply to actively growing grasses when they are 2 to 8 inches in height. Add a crop oil concentrate or a nonionic surfactant according to the label for the amount of water (5–40 gal / acre) added. For bermudagrass apply to 4- to 8-inch runners; for johnsongrass apply before boot stage. Do not apply to grasses, which are stressed due to moisture, temperature, low soil fertility, mechanical, or chemical injury. Do not apply more than 72 fl oz / acre per season.			
C.	GLYPHOSATE	0.7–3.7 lb a.e.		
	(Roundup)	11 fl oz–3.3 qt	See label	See label
	WSSA MODE-OF-ACTION GROUP NUMBER¹: 9			
	COMMENTS: Apply with a controlled applicator, low pressure flat fan nozzles, or with drift-reducing nozzles. For annual weed control use 10 to 40 gal water / acre with 1 lb / acre of glyphosate. Using the lower range of water (10-20 gal water / acre) with 1 lb / acre of glyphosate is generally more effective. Ammonium sulfate can also be added (1 to 2% by weight or 8.5 to 17 lbs per 100 gallon of water) to the spray solution to improve control in areas with hard water. It is important to add the ammonium sulfate to the water before adding the herbicide. Apply to young annuals or vigorously growing flowering perennial weeds. Some perennials require the high label rate for control. May be used on young weeds in strip that will be the tree row, followed by planting into the dead weeds. Weeds should not be cultivated for 7 to 14 days after treatment to obtain maximum control. New weeds usually do not establish for a month or more, because of the no-till effect. Residual period: less than 1 month.			
D.	PARAQUAT*	0.50 lb a.i.		
	(Gramoxone SL2.0)	2.5–4.0 pts	24	–
	WSSA MODE-OF-ACTION GROUP NUMBER¹:			
	COMMENTS: best control of annual weeds when they are in the two- to four-leaf stage. Less effective against perennials that will regrow (bermudagrass, dallisgrass, johnsongrass and bindweed). Older weeds require higher herbicide rates Apply in a minimum of 20 gallons of water per acre. Use 0.5% nonionic surfactant. Do not allow contact with desirable fruit, foliage, blooms, or bark, use hooded sprayers during application. Do not apply more than 4 times a year.			
E.	SETHOXYDIM	0.28–0.47 lb a.i.		
	(Poast)	1.5–2.5 pt	12	365
	WSSA MODE-OF-ACTION GROUP NUMBER¹: 1			
	COMMENTS: **For use on nonbearing trees only**. Apply to young annual or perennial grasses. Repeat applications will be required for the control of perennial grasses. Add 2 pt crop oil concentrate to the spray solution. Do not apply to grass that is stressed or poor control may result. Residual period: less than 1 month.			
AFTER PLANTING – NONBEARING TREES				
Premergence (before weeds emerge)				
A.	FLUMIOXAZIN	0.191–0.383 lb a.i.	12	1 year
	(Chateau)	6–12 oz		
	WSSA MODE-OF-ACTION GROUP NUMBER¹: 14			
	COMMENTS: **For use on nonbearing trees only**. Do not apply to trees established less than one year unless protected from spray contact. Best control is achieved when irrigation or rainfall follows within 21 days of application. It will not provide adequate control of emerged weeds unless tankmixed with a postemergence herbicide. Do not apply to row middles (area between berms).			
B.	ISOXABEN	0.66–0.9975 lb a.i.		
	(Gallery 75 dry flowable)	0.66–1.33 lb	12	1 year

	Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
	WSSA MODE-OF-ACTION GROUP NUMBER¹: 21 COMMENTS: **For use on nonbearing trees only**. Wait until soil has settled around transplant to apply. Treatments are most effective when adequate rainfall or irrigation is received within 21 days after application for incorporation. Will not control grasses or sedges.			
C.	NORFLURAZON (Solicam DF) WSSA MODE-OF-ACTION GROUP NUMBER¹: 12 COMMENTS: Rate depends on soil texture (see label). Do not apply to the soil under young trees (trees less than about 3 years old). Apply to soil as a directed spray from fall to early spring. If no rainfall occurs within 4 weeks, incorporate with sprinkler irrigation. Can suppress yellow nutsedge or bermudagrass when used year after year. Remove existing weeds with cultivation or a postemergence herbicide, because it has no postemergence activity. Avoid higher rates on sandy or gravelly soils to reduce risk of injury to trees. Considered to be a ground water contaminant and requires a use permit within Ground Water Protection Areas. Apply in 20 to 100 gal water / acre. Residual period: 6 to 12 months.	Label rates	12	60
D	ORYZALIN (Surflan) WSSA MODE-OF-ACTION GROUP NUMBER¹: 3 COMMENTS: Apply to the soil surface in 20 to 60 gal water / acre. If rain does not occur within 21 days after application, sprinkle irrigate with 0.5 to 2 inches water. May be combined with a postemergence herbicide if weeds are present. The higher rates give the longest soil residual. Usually used at 4 lb a.i. / acre. Chemigation with oryzalin is possible, see label for instructions. Residual period: 4 to 10 months. Can be tank-mixed with glyphosate.	2–6 lb a.i. 2–6 qt	24	NA
	Postemergence (established weeds)			
A.	CARFENTRAZONE (Shark EW) WSSA MODE-OF-ACTION GROUP NUMBER¹: 14 COMMENTS: For best activity, apply when weeds are still actively growing, less than 4 inches tall or rosettes less than 3 inches wide. Provides control of emerged annual broadleaves, but has no preemergence activity. A nonionic surfactant or crop oil concentrate or methylated seed oil is required. Can be mixed with other herbicides that have pre- or post-emergence activity for broader spectrum weed control. Can be applied anytime during the season. Apply in a minimum of 20 gallons of water per acre. Do not allow contact with desirable fruit, foliage, bloom, or bark, use hooded sprayers during application.	0.024–0.31 lb a.i. 2.0 fl oz	12	3
B.	FLUAZIFOP-P-BUTYL (Fusilade DX) WSSA MODE-OF-ACTION GROUP NUMBER¹: 1 COMMENTS: **For use on nonbearing trees only**. Apply to actively growing grasses when they are 2 to 8 inches in height. Add a crop oil concentrate or a nonionic surfactant according to the label for the amount of water (5–40 gal / acre) added. For bermudagrass apply to 4- to 8-inch runners; for johnsongrass apply before boot stage. Do not apply to grasses which are stressed due to moisture, temperature, low soil fertility, mechanical, or chemical injury. Do not apply more than 72 fl oz / acre per season.	0.125–0.375 lb a.i. See Label	12	NA
C.	GLYPHOSATE (Roundup) WSSA MODE-OF-ACTION GROUP NUMBER¹: 9 COMMENTS: Apply with a controlled applicator, ow pressure flat fan nozzles, or with drift-reducing nozzles. Contact with spray or drift can severely damage avocado. For annual weed control use 10 to 40 gal water / acre with 1 lb / acre of glyphosate. Using the lower range of water (10–20 gal water / acre) with 1 lb / acre of glyphosate is generally more effective. Ammonium sulfate can also be added (1 to 2% by weight or 8.5 to 17 lbs per 100 gallon of water) to the spray solution to improve control in areas with hard water. It is important to add the ammonium sulfate to the water before adding the herbicide. Apply to young annuals or vigorously growing flowering perennial weeds. Some perennial weeds require the high label rate for control. May be used on young weeds in strip that will be the tree row, followed by planting into the dead weeds. Weeds should not be cultivated for 7 to 14 days after treatment to obtain maximum control. New weeds usually do not establish for a month or more, because of the no-till effect. Can be tank-mixed with oryzalin.	0.7–3.7 lb a.e. 11 fl oz–3.3 qt	See label	See label
D.	PARAQUAT* (Gramoxone SL2.0) WSSA MODE-OF-ACTION GROUP NUMBER¹:	0.50 lb a.i. 2.5–4.0 pts	24	–

	Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
	COMMENTS: best control of annual weeds when they are in the two- to four-leaf stage. Less effective against perennials that will regrow (bermudagrass, dallisgrass, johnsongrass and bindweed). Older weeds require higher herbicide rates Apply in a minimum of 20 gallons of water per acre. Use 0.5% nonionic surfactant. Do not allow contact with desirable fruit, foliage, blooms, or bark, use hooded sprayers during application. Do not apply more than 4 times a year.			
E.	SETHOXYDIM	0.28–0.47 lb a.i.		
	(Poast)	1.5–2.5 pt	12	365
	WSSA MODE-OF-ACTION GROUP NUMBER¹: 1			
	COMMENTS: **For use on nonbearing trees only**. Apply to young annual or perennial grasses. Repeat applications will be required for the control of perennial grasses. Add 2 pt crop oil concentrate to the spray solution. Do not apply to grass that is stressed or poor control may result. Residual period: less than 1 month.			

ESTABLISHED TREES

Preemergence (before weeds emerge)

A.	NORFLURAZON	Label rates	12	60
	(Solicam DF)			
	WSSA MODE-OF-ACTION GROUP NUMBER¹: 12			
	COMMENTS: Rate depends on soil texture (see label). Do not apply to the soil under young trees (trees less than about 3 years old). Apply to soil as a directed spray from fall to early spring. If no rainfall occurs within 4 weeks, incorporate with sprinkler irrigation. Can suppress yellow nutsedge or bermudagrass when used year after year. Remove existing weeds (e.g., with cultivation, hand-weeding, or a postemergence herbicide) because it has no postemergence activity. Avoid higher rates on sandy or gravelly soils to reduce risk of injury to trees. Considered to be a ground water contaminant and requires a use permit within Ground Water Protection Areas. Do not use in the Coachella Valley. Apply in 20 to 100 gal water / acre. Residual period: 6 to 12 months.			
B.	ORYZALIN	2–6 lb a.i.		
	(Surflan)	2–6 qts	24	NA
	WSSA MODE-OF-ACTION GROUP NUMBER¹: 3			
	COMMENTS: Apply to the soil surface in 20 to 60 gal water / acre. If rain does not occur within 21 days after application, sprinkle irrigate with 0.5 to 2 inches water. May be combined with a postemergence herbicide if weeds are present. The higher rates give the longest soil residual. Usually used at 4 lb a.i. / acre. Chemigation with oryzalin is possible; see label for instructions. Residual period: 4 to 10 months.			
C.	OXYFLUORFEN	1.25–2 lb a.i.		
	(Goal 2XL)	5–8 pts	24	30
	WSSA MODE-OF-ACTION GROUP NUMBER¹: 14			
	COMMENTS: Has pre- and some postemergence activity. Do not mechanically disturb the soil after application or poor residual weed control may result. Apply in a minimum of 20 gallons of water per acre. Do not apply between bud swell and final harvest or when fruit are present as injury may occur. Residual period: 4 to 10 months.			
D.	SIMAZINE*	2–4 lb a.i.		
	(Princep 4L)	2–4 qt	12	NA
	WSSA MODE-OF-ACTION GROUP NUMBER¹: 5			
	COMMENTS: Do not apply to the soil under avocado trees. Make one application per year, or split the application between fall and spring. Simazine is frequently used in combination with other preemergence herbicides. Use the high rate for heavy soils and the low rate for lighter soils. Do not use on gravel, sand, or loamy sand soils. Limit first irrigation after application to 0.5 inch. Considered to be a ground water contaminant and requires a use permit within Ground Water Protection Areas. Residual period: 8 to 12 months.			

Postemergence (after weeds emerge)

A.	CARFENTRAZONE	0.024–0.31 lb a.i.		
	(Shark EW)	2.0 fl oz	12	3
	WSSA MODE-OF-ACTION GROUP NUMBER¹: 14			
	COMMENTS: For best activity, apply when weeds are still actively growing, less than 4 inches tall or rosettes less than 3 inches wide. Provides control of emerged annual broadleaves, but has no preemergence activity. A nonionic surfactant or crop oil concentrate or methylated seed oil is required. Can be mixed with other herbicides that have pre- or post-emergence activity for broader spectrum weed control. Can be applied anytime during the season. Apply in a minimum of 20 gallons of water per acre. Do not allow contact with desirable fruit, foliage, bloom, or bark, use hooded sprayers during application.			
B.	GLYPHOSATE	0.7–3.7 lb a.e.		

	Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
	(Roundup)	11 fl oz–3.3 qt	See label	See label
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 9			
	COMMENTS: Apply with a controlled applicator or with low pressure flat fan nozzles. Contact with spray or drift can severely damage avocado. For annual weed control use 10 to 40 gal water / acre with 1 lb / acre of glyphosate. Using the lower range of water (10 to 20 gal water / acre) with 1 lb / acre of glyphosate is generally more effective. Ammonium sulfate can also be added (1 to 2% by weight or 8.5 to 17 lbs per 100 gallon of water) to the spray solution to improve control in areas with hard water. It is important to add the ammonium sulfate to the water before adding the herbicide. Apply to young annuals or vigorously growing flowering perennial weeds. Some perennial weeds require the high label rate for control. May be used on young weeds in strip that will be the tree row, followed by planting into the dead weeds. Weeds should not be cultivated for 7 to 14 days after treatment to obtain maximum control. New weeds usually do not establish for a month or more, because of the no-till effect. Can be tank-mixed with oryzalin.			
C.	OXYFLUORFEN	1.25–2 lb a.i.		
	(Goal 2XL)	5–8 pts	24	30
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14			
	COMMENTS: Has pre- and some postemergence activity. Herbicide can be used on weed-free soil to prevent germination of a wide variety of weeds or it can be applied to existing weeds at seedling stage especially with a tank mix partner to increase the variety of weeds controlled and / or the length of residual control. Do not mechanically disturb the soil after application or poor residual weed control may result. Apply in a minimum of 20 gallons of water per acre. Do not apply between bud swell and final harvest or when fruit are present as injury may occur. Residual period: 4 to 10 months.			
D.	PARAQUAT*	0.50 lb a.i.		
	(Gramoxone SL2.0)	2.5–4.0 pts	24	–
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 22			
	COMMENTS: best control of annual weeds when they are in the two- to four-leaf stage. Less effective against perennials that will regrow (bermudagrass, dallisgrass, johnsongrass and bindweed). Older weeds require higher herbicide rates Apply in a minimum of 20 gallons of water per acre. Use 0.5% nonionic surfactant. Do not allow contact with desirable fruit, foliage, bloom, or bark, use hooded sprayers during application. Do not apply more than 4 times a year.			
E.	SETHOXYDIM	0.28–0.47 lb a.i.		
	(Poast)	1.5–2.5 pt	12	365
	WSSA MODE-OF-ACTION GROUP NUMBER[1]: 1			
	COMMENTS: **For use on nonbearing trees only.** Apply to young annual or perennial grasses. Repeat applications will be required for the control of perennial grasses. Add 2 pt crop oil concentrate to the spray solution. Do not apply to grass that is stressed or poor control may result. Residual period: less than 1 month.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use.

NA Not applicable.

1 Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode of action numbers are useful in planning mixtures or rotations of herbicides with different modes of action. For more information, see http://www.plantprotection.org/HRAC/.

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Precautions for Using Pesticides

Pesticides are poisonous and must be used with caution. **READ THE LABEL BEFORE OPENING A PESTICIDE CONTAINER.** Follow all label precautions and directions, including requirements for protective equipment. Apply pesticides only on the crops or in the situations listed on the label. Apply pesticides at the rates specified on the label or at lower rates if suggested in this publication. In California, all agricultural uses of pesticides must be reported. Contact your county agricultural commissioner for further details. Laws, regulations, and information concerning pesticides change frequently. This publication reflects legal restrictions current on the date next to each pest's name.

Legal responsibility

The user is legally responsible for any damage due to misuse of pesticides. Responsibility extends to effects caused by drift, runoff, or residues.

Transportation

Do not ship or carry pesticides together with food or feed in a way that allows contamination of the edible items. Never transport pesticides in a closed passenger vehicle or in a closed cab.

Storage

Keep pesticides in original containers until used. Store them in a locked cabinet, building, or fenced area where they are not accessible to children, unauthorized persons, pets, or livestock. **DO NOT** store pesticides with foods, feed, fertilizers, or other materials that may become contaminated by the pesticides.

Container disposal

Dispose of empty containers carefully. Never reuse them. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Consult your county agricultural commissioner for correct procedures for handling and disposal of large quantities of empty containers.

Protection of nonpest animals and plants

Many pesticides are toxic to useful or desirable animals, including honey bees, natural enemies, fish, domestic animals, and birds. Crops and other plants may also be damaged by misapplied pesticides. Take precautions to protect nonpest species from direct exposure to pesticides and from contamination due to drift, runoff, or residues. Certain rodenticides may pose a special hazard to animals that eat poisoned rodents.

Posting treated fields

For some materials, *restricted entry intervals* are established to protect field workers. Keep workers out of the field for the required time after application and, when required by regulations, post the treated areas with signs indicating the safe re-entry date. Check with your county agricultural commissioner for latest restricted entry interval.

Preharvest intervals

Some materials or rates cannot be used in certain crops within a specified time before harvest. Follow pesticide label instructions and allow the required time between application and harvest.

Permit requirements

Many pesticides require a permit from the county agricultural commissioner before possession or use. When such materials are recommended, they are marked with an asterisk (*) in the treatment tables or chemical sections of this publication.

Maximum residue levels

Before applying pesticides to crops destined for export, check maximum residue levels (MRLs) of importing country at http://www.mrldatabase.com.

Processed crops

Some processors will not accept a crop treated with certain chemicals. If your crop is going to a processor, be sure to check with the processor before applying a pesticide.

Crop injury

Certain chemicals may cause injury to crops (phytotoxicity) under certain conditions. Always consult the label for limitations. Before applying any pesticide, take into account the stage of plant development, the soil type and condition, the temperature, moisture, and wind. Injury may also result from the use of incompatible materials.

Personal safety

Follow label directions carefully. Avoid splashing, spilling, leaks, spray drift, and contamination of clothing. **NEVER** eat, smoke, drink, or chew while using pesticides. Provide for emergency medical care **IN ADVANCE** as required by regulation.