

UC IPM

Pest Management Guidelines:

WALNUT

February 2020

Contents (Dates in parenthesis indicate when each topic was updated)

Walnut Year-Round IPM Program (<i>Reviewed 7/17</i>)	iii
General Information (Section reviewed 7/17)	1
Dormant Monitoring (7/17).....	1
Using Ethephon (7/17).....	2
Relative Toxicities of Pesticides Used in Walnuts to Natural Enemies and Honey Bees (7/17).....	3
General Properties of Fungicides Used in Walnuts (6/17).....	5
Bactericide and Fungicide Efficacy—Conventional Products (3/22).....	6
Bactericide and Fungicide Efficacy—Biocontrols and Natural Products (3/22).....	7
Most Effective Treatment Timings for Key Diseases (3/22).....	8
Insects and Mites (Section reviewed 7/17)	9
Aphids (7/17).....	9
Codling Moth (7/17).....	12
European Red Mite (7/17).....	23
Fall Webworm (7/17).....	26
False Chinch Bug (7/17).....	27
Frosted Scale and European Fruit Lecanium (7/17).....	28
Fruittree Leafroller (7/17).....	30
Italian Pear Scale (7/17).....	30
Navel Orangeworm (7/17).....	32
Pacific Flatheaded Borer (7/17).....	35
Redhumped Caterpillar (7/17).....	36
San Jose Scale (7/17).....	38
Southern Fire Ant (7/17).....	40
Walnut Blister Mite (7/17).....	41
Walnut Husk Fly (7/17).....	42
Walnut Scale (7/17).....	47
Walnut Twig Beetle (7/17).....	49
Webspinning Spider Mites (7/17).....	52
Diseases (Section reviewed 6/17).....	56
Anthracnose (6/17).....	56
Armillaria Root Rot (Oak Root Fungus) (6/17).....	58
Blackline (6/17).....	59
Botryosphaeria and Phomopsis Cankers (6/17).....	61
Branch Wilt (6/17).....	64
Crown Gall (6/17).....	65
Deep Bark Canker (6/17).....	67
Paradox Canker (6/17).....	69
Phytophthora Root and Crown Rot (6/17).....	70
Shallow Bark Canker (6/17).....	72
Thousand Cankers Disease (6/17).....	73
Walnut Blight (2/20).....	74
Nematodes (Section reviewed 6/17)	76
Weeds (Section reviewed 8/17).....	80
IntEgrated Weed Management (8/17).....	80
Weed Management in Organic Orchard.....	89
Special Weed Problems (8/17).....	91

An illustrated version of this guideline is available online at ipm.ucanr.edu/agriculture/walnut/

Publication 3471

University of California

Agriculture and Natural Resources

UC Statewide Integrated Pest Management Program



Common and Scientific Names of Weeds (8/17).....	93
Susceptibility of Winter Weeds to Herbicide Control (8/17).....	95
Susceptibility of Spring and Summer Weeds to Herbicide Control (8/17).....	96
Herbicide Treatment Table (8/17).....	98
Vertebrates	110
Managing Vertebrates (7/16).....	110
California Ground Squirrels (7/16)	113
Deer (7/16)	118
Pocket Gophers	120
Tree Squirrel	125
Voles (Meadow Vole, Meadow Mice) (7/16)	126
Precautions for Using Pesticides	129

An illustrated version of this guideline is available online at ipm.ucanr.edu/agriculture/walnut/



Authors

Insects and Mites: J. A. Grant, UCCE, San Joaquin Co.; J. K. Hasey, UCCE, Sutter, Yuba, and Colusa counties; W. W. Coates, UCCE, San Benito Co.; R. A. Van Steenwyk, Insect Biology, UC Berkeley; E. J. Symmes, UC IPM Program, Butte Co.; S. J. Seybold, Entomology, UC Davis (walnut twig beetle); R. M. Bostock, Plant Pathology, UC Davis (walnut twig beetle)

Diseases: J. E. Adaskaveg, Plant Pathology, UC Riverside; R. P. Buchner, UCCE, Tehama Co.; G. T. Browne, USDA Crops Pathology and Genetics, Davis, CA; W. D. Gubler, Plant Pathology, UC Davis; T. J. Michailides, Kearney Agricultural Research and Extension Center, Parlier; J. K. Hasey, UCCE, Sutter, Yuba, and Colusa counties; E. J. Fichtner, UCCE, Tulare Co.; S. J. Seybold, Entomology, UC Davis (thousand cankers disease); R. M. Bostock, Plant Pathology, UC Davis (thousand cankers disease)

Nematodes: B. B. Westerdahl, Nematology, UC Davis; A. Westphal, Kearney Agricultural Research and Extension Center, Parlier; J. K. Hasey, UCCE, Sutter, Yuba, and Colusa counties

Weeds: J. A. Roncoroni, UCCE, Napa Co.; B. D. Hanson, Plant Sciences, UC Davis; K.J. Hembree, UCCE Fresno Co.; R. B. Elkins, UCCE, Lake Co.; J. K. Hasey, UCCE, Sutter, Yuba, and Colusa counties

Vertebrates: R. Baldwin, Wildlife, Fish and Conservation Biology, UC Davis

Crop Leadership Team: E. J. Symmes, UC IPM Program and UCCE, Butte Co. (crop team leader); J.P. Rijal, UC IPM and UCCE Modesto Co. (IPM facilitator); R. DeBiase (coordinator); R. Baldwin, Wildlife, Fish and Conservation Biology, UC Davis; E. J. Fichtner, UCCE, Tulare Co.; J. A. Roncoroni, UCCE, Napa Co. and UC IPM Program; B. B. Westerdahl, Nematology, UC Davis

Acknowledgments for contributions

Insects and Mites: W. J. Bentley, UC IPM Program, Kearney Agricultural Research and Extension Center, Parlier (Emeritus); L. C. Hendricks, UCCE, Merced Co. (Emeritus); W. H. Olson, UCCE, Butte Co. (Emeritus); C. Pickel, UC IPM Program, Sutter and Yuba counties (Emeritus); G. S. Sibbett, UCCE, Tulare Co. (Emeritus); D. Light, USDA, Albany, CA (Emeritus)(Codling Moth)

Diseases: B. L. Teviotdale, Kearney Agricultural Research and Extension Center, Parlier (Emeritus)

Nematodes: U. C. Kodira, Plant Pathology, UC Davis; M. V. McKenry, Kearney Agricultural Research and Extension Center, Parlier (Emeritus)

Weeds: K. K. Anderson, UCCE, Stanislaus Co.; C. L. Elmore, Weed and Plant Sciences, UC Davis; J. A. Grant, UCCE, San Joaquin Co.; W. O. Reil, UCCE, Yolo Co.; T. S. Prather, Plant, Soil, and Entomological Sciences, University of Idaho, Moscow, ID; A. Shrestha, UC IPM Program, Kearney Agricultural Research and Extension Center, Parlier; G. S. Sibbett, UCCE, Tulare Co.; J. J. Stapleton, UC IPM Program, Kearney Agricultural Research and Extension Center, Parlier

Year-Round IPM Program: W. J. Bentley, UC IPM Program, Kearney Agricultural Research and Extension Center, Parlier (Emeritus); W. H. Krueger, UCCE Glenn Co.; D. Light, USDA, Albany, CA; M. V. McKenry, Kearney Agricultural Research and Extension Center, Parlier; C. Pickel, UC IPM Program, Sutter and Yuba counties (Emeritus); A. Shrestha, UC IPM Program, Kearney Agricultural Research and Extension Center, Parlier

About this publication

Produced and edited by:

UC Statewide IPM Program

University of California Agriculture and Natural Resources

Guidelines Coordinator: R. DeBiase, C. McKerracher

Production: F. Rosa



This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by the ANR Associate Editor for Agricultural Pest Management.

The UC IPM Pest Management Guidelines are available from:

- Online: ipm.ucanr.edu
- UC Cooperative Extension County Offices
- University of California
ANR Communication Services
2801 Second Street
Davis, CA 95618-7779
530-750-1213; 800-994-8849

Updates: These guidelines are updated regularly. Check with your University of California Cooperative Extension Office or the UC IPM website for information on updates.

Note to readers: These guidelines represent the best information currently available to the authors and are intended to help you in making the best choices for an IPM program. Not all formulations or registered materials are mentioned. Always read the label and check with local authorities for the most up-to-date information regarding registration and restrictions on pesticide use. Check with your agricultural commissioner for latest restricted entry intervals.

This material is partially based on work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, Crop Protection and Pest Management Competitive Grants Program.

To be used with UC ANR Publication 3270, <i>Integrated Pest Management for Walnuts, 3rd edition</i>
--



Walnut Year-Round IPM Program (Reviewed 7/17)

ANNUAL CHECKLIST

Use these guidelines for a monitoring-based IPM program to effectively manage pests, while reducing 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 walnut in California. Details on carrying out each practice, example monitoring forms, and information on additional pests can be found in the Pest Management Guidelines. Track your progress through the year with this annual checklist form. Color photo identification pages and examples of monitoring forms can be found online at: ipm.ucanr.edu/FORMS/.

✓ Done	<h3>Dormancy</h3> <p>Special issues of concern related to environmental quality: none identified.</p>
	<p>Manage orchard floor vegetation:</p> <ul style="list-style-type: none"> • Continue postharvest weed assessment in late fall to identify those that were not controlled by fall treatment. • Keep records (example form weed survey form available online)
	<p>Assess levels on the ground and in trees for navel orangeworm management.</p>
	<p>Look for scale pests and mites and evidence of parasitism.</p> <ul style="list-style-type: none"> • Examine scaffolds, limbs, branches, spurs and prunings, for scale pests (walnut scale, San Jose scale, frosted scale, European fruit lecanium) and European red mite eggs. • Note areas of concern for possible treatment.
	<p>Other pests you may see:</p> <ul style="list-style-type: none"> • Fruittree leafroller egg masses • Italian pear scale • San Jose scale

✓ Done	<h3>Delayed-dormancy</h3> <p>Special issues of concern related to environmental quality: none identified.</p>
	<p>If a significant number of mummy nuts are still on trees or on the ground at the end of February:</p> <ul style="list-style-type: none"> • Remove mummy nuts from trees before mid-March. • Flail mow to destroy mummy nuts.
	<p>Mow ground cover before bloom.</p>
	<p>If dormant scale monitoring indicated need, manage according to the Pest Management Guidelines:</p> <ul style="list-style-type: none"> • European fruit lecanium and frosted scale • Walnut scale • San Jose scale
	<p>Look for the following pests if they have been a problem in the past:</p> <ul style="list-style-type: none"> • European red mite • Italian pear scale <p>Manage if needed according to the Pest Management Guidelines.</p>

✓ Done	<h2>Delayed-dormancy</h2> <p>Special issues of concern related to environmental quality: none identified.</p>
	Manage squirrels before April, if needed.

✓ Done	<h2>Budbreak through bloom</h2> <p>Special issues of concern related to environmental quality: pesticide runoff.</p>
	If conditions favor walnut blight, Manage according to the Pest Management Guidelines.
	Place codling moth pheromone traps in mid-March to determine first moth emergence. <ul style="list-style-type: none"> • Check traps twice weekly until biofix, and weekly thereafter. • Use degree-days for monitoring pest development. • Keep records (example degree day monitoring form available online).
	If using mating disruptants for codling moth, place them in orchards using female biofix according to the Pest Management Guidelines.
	Look for dead and Botryosphaeria and Phomopsis infected branches. Flag trees for pruning in summer or after rainfall ceases. Consider using the Leaf Wetness Model (LWM) to time fungicide sprays if rainfall is greater than 0.25 inch and temperatures are greater than 50°F.
	Look for crown gall and manage if needed according to the Pest Management Guidelines.
	Keep records of other pests you may see: <ul style="list-style-type: none"> • Phytophthora • Armillaria (oak root fungus) • Gophers • Ground Squirrels • Tree Squirrels

✓ Done	<h2>Nut development (fruit set to harvest)</h2> <p>Special issues of concern related to environmental quality: pesticide runoff.</p>
	If conditions favor for walnut blight development: <ul style="list-style-type: none"> • Manage according to the Pest Management Guidelines if rainy conditions continue beyond bloom. • Or use the Xanthocast model to determine the need for and timing of blight sprays.
	Maintain codling moth management program: <ul style="list-style-type: none"> • Check traps and keep records (example degree day monitoring form available online). • If using sprayable mating disruptants, reapply according to the Pest Management Guidelines instructions. • Check traps and canopy nut counts to determine the need for supplemental sprays. • If not using mating disruptants apply pesticides only if necessary according to the Pest Management Guidelines.
	If dormant monitoring indicated infestations of walnut scale: <ul style="list-style-type: none"> • Monitor for crawlers. • Manage if needed according to the Pest Management Guidelines.
	Begin examining leaves for aphids. <ul style="list-style-type: none"> • Look for aphids, aphid mummies, and natural enemies. • Manage if needed according to the Pest Management Guidelines.
	Take leaf samples in July for nutrition analysis.
	Initiate fertilizer application and establish a nitrogen budget.
	If Botryosphaeria and Phomopsis infection are a concern: <ul style="list-style-type: none"> • Manage if needed according to Pest Management Guidelines beginning in mid-May

✓ Done	<h2 style="margin: 0;">Nut development (fruit set to harvest)</h2> <p>Special issues of concern related to environmental quality: pesticide runoff.</p>
	<ul style="list-style-type: none"> • Look for dead and infected branches. Consider pruning for Botryosphaeria and Phomopsis cankers to reduce inoculum during dry summer months.
	<p>Start monitoring for webspinning mites when the weather warms up, once per week through August.</p> <ul style="list-style-type: none"> • Keep records (example mite monitoring form available online). • Manage if needed according to the Pest Management Guidelines.
	<p>Assess weeds in late spring, and identify those not controlled by fall and winter treatments. Keep records (example late-spring weed survey form available online).</p>
	<p>Manage weeds in tree rows with preemergence or postemergence herbicides or nonchemically in organic orchards. Manage weeds in row middles with mowing, cultivation or herbicides.</p>
	<p>Monitor for walnut husk fly.</p> <ul style="list-style-type: none"> • Set out supercharged walnut husk fly traps by June 1 and mid-May in coastal areas and check traps at least twice a week. • If using GF120 bait sprays, apply at first fly catch and use only in orchards with low numbers. • Keep records (example walnut husk fly monitoring form available online). <p>If using insecticide and bait sprays:</p> <ul style="list-style-type: none"> • Manage according to the Pest Management Guidelines when there is a sudden increase in trap catches, when the first flies are caught or when the first egg is detected. <p>Don't apply insecticides within 3 weeks of harvest.</p>
	<p>Consider using the plant growth regulator ethephon to hasten husk split for early harvest if navel orangeworm is a problem. Consult with your pest control adviser (PCA) or crop consultant about the need for pre-harvest insecticide applications.</p>
	<p>Bait ground squirrels, if needed, when vegetation begins to dry.</p>
	<p>Other pests you may see:</p> <ul style="list-style-type: none"> • Crown gall • Fall webworm • Ground squirrel • Phytophthora root and crown rot • Redhumped caterpillar • Tree squirrel
✓ Done	<h2 style="margin: 0;">Harvest</h2> <p>Special issues of concern related to environmental quality: none.</p>
	<p>Harvest nuts promptly to reduce potential for navel orangeworm damage and to preserve kernel quality.</p>
	<p>Sample nuts at harvest to evaluate your pest management program.</p> <ul style="list-style-type: none"> • Distinguish codling moth from navel orangeworm damage. <ul style="list-style-type: none"> ◦ Navel orangeworm has brown, crescent-shaped marks behind the head, and leaves copious frass and webbing inside the shell. ◦ Mushy black hulls with no kernel damage and black stained shells indicates walnut husk fly. • Black hulls with peduncle (stem) still attached may indicate Botryosphaeria infection. <p>Be aware that nuts with dried black hulls can also indicate a water management problem. Evaluate this season's management program and plan for the next season's management.</p>
✓ Done	<h2 style="margin: 0;">Postharvest</h2> <p>Special issues of concern related to environmental quality: herbicide runoff.</p>
	<p>Look for dead and infected branches from Botryosphaeria and Phomopsis cankers. Only prune to reduce inoculum if there is a dry period predicted. Otherwise prune during summer.</p>

	<p>Manage orchard floor vegetation.</p> <ul style="list-style-type: none"> • Assess weeds and keep records (example weed survey form available online). • Plant cover crops after harvest to reduce water runoff and improve nitrogen management. Select an appropriate late planting mix that will succeed after harvest.
	<ul style="list-style-type: none"> • Apply preemergence herbicides in-row before fall weeds emerge and include a post-emergence herbicide if weeds have started to emerge. Consider blowing or sweeping leaf debris immediately before applying preemergence herbicides to facilitate herbicide contact with soil.
	Remove huller waste materials to reduce navel orangeworm overwintering sites.

✓ Done	<h2 style="margin: 0;">Pesticide application checklist</h2> <p>When planning for possible pesticide applications in an IPM program, consult the Pest Management Guidelines, and review and complete this checklist to consider practices that minimize environmental and efficacy problems.</p>
	✓ Choose a pesticide from the Pest Management Guidelines for the target pest, considering:
	<ul style="list-style-type: none"> • Impact on natural enemies and pollinators. For more information see Protecting Natural Enemies and Pollinators at http://ipm.ucanr.edu/mitigation/protect_beneficials.html.
	<ul style="list-style-type: none"> • Potential for water quality problems using the UC IPM WaterTox database. See http://ipm.ucanr.edu/TOX/simplewaternox.html.
	<ul style="list-style-type: none"> • Impact on aquatic invertebrates. For more information, see <i>Pesticide Choice</i>, UC ANR Publication 8161 (PDF), http://anrcatalog.ucanr.edu/pdf/8161.pdf.
	<ul style="list-style-type: none"> • Chemical mode of action, if pesticide resistance is an issue. For more information, see <i>Herbicide Resistance: Definition and Management Strategies</i>, UC ANR Publication 8012 (PDF), http://anrcatalog.ucanr.edu/pdf/8012.pdf.
	<ul style="list-style-type: none"> • Endangered species that may be near your site. Find out using the Department of Pesticide Regulation's PRESCRIBE program. (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. See http://ipm.ucanr.edu/training/incorporating-calibration.html .
	Use appropriate spray nozzles and pressure to minimize off-site movement of pesticides.
	<p>Avoid spraying during these conditions to avoid off-site movement of pesticides.</p> <ul style="list-style-type: none"> • Wind speed over 10 and under 3 mph • Temperature inversions • Just prior to rain or irrigation (unless it is an appropriate amount, such as when incorporating a soil-applied pesticide) • 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 labeling for pesticide handling, personal protection equipment (PPE) requirements, storage, and disposal guidelines.
	Check and follow restricted entry intervals (REI) and preharvest intervals (PHI).
	✓ After an application
	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:

✓ Done	Pesticide application checklist
	<ul style="list-style-type: none"> • <i>Reducing Runoff from Irrigated Lands: Orchard Floor Management Practices to Reduce Erosion and Protect Water Quality</i>, UC ANR Publication 8202 (PDF), http://anrcatalog.ucanr.edu/pdf/8202.pdf. • <i>Reducing Runoff from Irrigated Lands: Causes and Management of Runoff from Surface Irrigation in Orchards</i>, UC ANR Publication 8214 (PDF), http://anrcatalog.ucanr.edu/pdf/8214.pdf. • <i>Protecting Surface Water from Sediment-Associated Pesticides in Furrow-Irrigated Crops</i>, UC ANR Publication 8403 (PDF), http://anrcatalog.ucanr.edu/pdf/8403.pdf.
	Consult the Department of Pesticide Regulation Groundwater Protection Program (GWPA) website for pesticide information and mitigation measures. (http://cdpr.ca.gov)
	Install an irrigation recirculation or storage and reuse system. Redesign inlets into tailwater ditches to reduce erosion. For more information, see these publications: <ul style="list-style-type: none"> • <i>Reducing Runoff from Irrigated Lands: Tailwater Return Systems</i>, UC ANR Publication 8225 (PDF), http://anrcatalog.ucanr.edu/pdf/8225.pdf. • <i>Reducing Runoff from Irrigated Lands: Storing Runoff from Winter Rains</i>, UC ANR Publication 8211 (PDF), http://anrcatalog.ucanr.edu/pdf/8211.pdf.
	Use drip rather than sprinkler or flood irrigation.
	Limit irrigation to amount required using soil moisture monitoring and evapotranspiration (ET). For more information, see: <ul style="list-style-type: none"> • <i>Reducing Runoff from Irrigated Lands: Understanding Your Orchard's Water Requirements</i>, UC ANR Publication 8212 . • <i>Using the Pressure Chamber for Irrigation Management in Walnut, Almond, and Prune</i>, UC ANR Publication 8503.
	Consider using cover crops.
	Consider vegetative filter strips or ditches. (For more information, see <i>Vegetative Filter Strips</i> , UC ANR Publication 8195 (PDF), http://anrcatalog.ucanr.edu/pdf/8195.pdf .)
	Apply polyacrylamides in furrow and sprinkler irrigation systems to prevent off-site movement of sediments.
	✓ 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 fumigants and emulsifiable concentrate (EC) formulations.
For more about mitigating the effects of pesticides, see the Mitigation page: http://ipm.ucanr.edu/mitigation/ .	

General Information

(Section reviewed 7/17)

DORMANT MONITORING (7/17)

Monitor during the dormant period to determine the need for a spring sprays to manage populations of walnut scale, frosted scale, European fruit lecanium scale, San Jose scale, Italian pear scale, and European red mite.

HOW TO MONITOR

- Examine scaffolds, limbs, branches, and prunings for the following pests: walnut scale, San Jose scale, frosted scale nymphs, Italian pear scale, and European red mite eggs.
- If they have been a problem in the past, monitor for European fruit lecanium scale.
- Look for evidence of parasitization as characterized by emergence holes in the body of the dead, mature scale. A high level of parasitization may keep numbers down, thus eliminating the need for insecticide applications.
- Map out areas of concern for spring monitoring and possible insecticide applications.

TREATMENT THRESHOLDS

These scale treatment thresholds are based on direct damage from scale; they do not reflect thresholds if *Botryosphaeria* is a concern in your orchard.

Walnut Scale

Natural enemies often cannot be relied on to keep walnut scale from causing damage. If scales are present but a high degree of parasitization is observed, insecticide applications probably are not needed.

Frosted Scale

If you find 5 or more nymphs per foot of last year's wood throughout the orchard and less than 90% parasitized nymphs, an insecticide application is warranted.

European Fruit Lecanium Scale

Same as frosted scale.

San Jose Scale

If you find 5 or more black caps per foot of last year's wood and less than 90% parasitism, an insecticide application is warranted.

Italian Pear Scale

No damage threshold levels are available to determine if an insecticide application is needed. The key to managing Italian pear scales is to control the lichens. Regular blight treatments in spring will provide control of moss and lichens.

European Red Mite

No damage threshold levels are available to determine if an insecticide application is needed. Avoid spraying low to moderate levels of European red mites because they can be important in maintaining predators of other mites.

USING ETHEPHON (7/17)

Walnut kernels are mature and of lightest color and highest quality when the packing tissue between the kernel halves turns brown. To maximize kernel quality and minimize insect and mold damage, harvest as close as possible to the time when the most nuts have reached the packing tissue brown stage. The problem often encountered is that hull dehiscence (separation of the hull from the nut) occurs later than kernel maturity, and hot weather can further delay this process. To speed up hull dehiscence, accelerate maturity, and promote fruit abscission, ethephon is often used. The use of ethephon on the earlier-maturing varieties avoids the late season walnut husk fly and navel orangeworm flights.

Walnuts are either harvested with one or two shakes. When two shakes are planned, ethephon advances hullsplit and allows harvest to be conducted closer to the time when most nuts are at the packing tissue brown stage and of highest quality.

For a two-shake harvest, ethephon is applied when 100% of the nuts have reached packing tissue brown. Harvest can usually begin 7 to 10 days earlier than the normal harvest date, followed by a second shake about two weeks later.

For a one-shake harvest, ethephon is applied 10 to 14 days before the normal harvest date. With this application timing, nut removal is increased and a second shake is not needed.

NOTES ON THE USE OF ETHEPHON

- Harvest is normally 14 to 23 days after application; hot weather will cause it to be longer. It is recommended that test shakes be made to determine when the trees are ready to harvest.
- Do not spray low-vigor, stressed, or diseased trees, and do not apply when temperatures are below 60°F or above 90°F.
- Apply the spray within 4 hours of mixing the application.
- It is essential that you cover nuts thoroughly. Ethephon is not translocated from leaves to nuts.
- Only spray at one time the acreage that you can harvest in a reasonable amount of time.
- Recommended rates of ethephon may cause slight yellowing of leaves and some leaf drop on healthy trees.
- Make sure ethephon sprays only hit the target walnut crop. Since ethephon is a plant growth regulator, drift onto nearby fruit crops such as kiwifruit can have unintended consequences, including fruit drop.

RELATIVE TOXICITIES OF PESTICIDES USED IN WALNUTS TO NATURAL ENEMIES AND HONEY BEES

(7 / 17)

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, leafminers)	H	L	M/H	I	long to predatory mites and affected insects
acequinocyl (Kanemite)	20B	narrow (mites)	L	—	—	III	—
acetamiprid (Assail)	4A	moderate (sucking insects, larvae)	— ⁷	—	—	II	moderate
<i>Bacillus thuringiensis</i> ssp. <i>kurstaki</i>	11A	narrow (caterpillars)	L	L	L	III	short
bifenazate (Acramite)	20D	narrow (mites)	L	L	L	II	short
bifenthrin (Brigade)	3A	broad (insects, mites)	H	H	H	I	long
buprofezin (Centaur)	16	narrow (sucking insects, beetles)	L	H ⁸	L	II	long
carbaryl (Sevin)	1A	broad (insects, mites)	L/H	H	H	I	long
chlorantraniliprole (Altacor)	28	narrow (primarily caterpillars)	L	L	L/M	III	short
clofentezine (Apollo)	10A	narrow (mites)	L	L	L	III	short
<i>Cydia pomonella granulovirus</i> (Cyd-X)	—	narrow (codling moth)	none	none	none	III	none
cyfluthrin (Baythroid)	3A	broad (insects, mites)	H	H	H	I	moderate
dicofol (Dicofol)	un	narrow (pest mites and mites)	H	M	M	III	long to beneficial mites
diflubenzuron (Dimilin)	15	—	L	H ⁹	L	II	—
emamectin benzoate (Proclaim)	6	narrow (caterpillars)	—	—	—	I	—
esfenvalerate (Asana)	3A	broad (insects, mites)	H	M	H	I	moderate
etoxazole (Zeal)	10B	narrow (mites)	— ¹⁰	—	—	II	short
fenbutatin oxide (Vendex)	12B	narrow (pest mites)	L	L	L	III	short
fenpropathrin (Danitol)	3A	broad (insects, mites)	H	H	H	I	—
hexythiazox (Onager)	10A	narrow (mites)	L	L	L	II	short to moderate
imidacloprid (Admire Pro)	4A	narrow (sucking insects)	—	—	H	I	short to moderate
lambda cyhalothrin (Warrior)	3A	broad (plant bugs, beetles, caterpillars)	H	H	H	I	moderate
malathion	1B	broad (insects, mites)	H	H	H	I	moderate
metaflumizone (Altrevin bait)	22B	narrow (ants)	—	—	—	III	—
methoxyfenozide (Intrepid)	18	narrow (caterpillars)	L	L	L	II	none
methyl parathion (PennCap-M)	1B	broad (insects)	M	M	M	I	—
permethrin (Ambush, Pounce)	3A	broad (insects, mites)	L	H	H	I	long
petroleum oils	—	broad (exposed insects, mites)	L	L	L	II	short to none
phosmet (Imidan)	1B	broad (insects, mites)	H	H	H	I	moderate to long
propargite (Omite)	12C	narrow (pest mites)	M ¹¹	L	L	III	short
pyriproxyfen (Seize)	7C	narrow (scale, beetles)	L	H ¹²	L	II	long
rosemary oil/peppermint oil (Ecotrol)	—	broad (exposed insects, mites)	L	L	L	III	—
s-methoprene (Extinguish)	7A	narrow (ants)	—	—	—	III	—
spinetoram (Delegate)	5	narrow (caterpillars, aphids, scales)	L/H	M ¹³	L/M	II	moderate ¹⁴
spinosad (Entrust, Success)	5	narrow (caterpillars, aphids, scales)	L/H	M ¹³	L/M	II	short to moderate
spinosad (GF-120)	5	narrow (husk fly)	—	—	—	II	—
spirodiclofen (Envidor)	23	narrow (mites)	—	—	—	II	—

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
-------------------------------------	-----------------------------	---	------------------------------	--------------------------------	------------------------	-------------------------	--

H = high M = moderate L = low —= no information un = unknown or uncertain mode of action

- 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/>.
- 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 or 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 label and regulations; III-No bee precaution, except when required by the label or regulations. For more information about pesticide synergistic effects, see Bee Precaution Pesticide Ratings (*available online at <http://ipm.ucanr.edu/beepr-caution/>*).
- 6 Duration: *short* means hours to days; *moderate* means days to 2 weeks; and *long* means many weeks or months.
- 7 May cause flare-ups of spider mite populations.
- 8 Use lowest rates for best management of western predatory mite/spider mite ratio (propargite).
- 9 High toxicity to juvenile stages of predators and reduces fertility of adult green lacewings.
- 10 Acute toxicity low but reproductive capacity is impacted.
- 11 Use lowest rates for best management of western predatory mite/spider mite ratio (propargite).
- 12 Kills lady beetles.
- 13 Toxic against some natural enemies (predatory thrips, syrphid fly larvae) when sprayed and shortly thereafter (8-24 hours).
- 14 Residual is moderate if solution is between pH of 7 to 8.

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.

GENERAL PROPERTIES OF FUNGICIDES USED IN WALNUTS (6/17)

Common name (Example trade name)	Chemical class ¹	Mode of action (FRAC ¹ group number)	Activity	Resistance potential	Comments
azoxystrobin/difenoconazole (Quadris Top)	QoI ² /DMI ³ -triazole	single-site/single-site (11/3)	contact, systemic (local)	medium	
azoxystrobin/propiconazole (Quilt Xcel)	QoI ² /DMI ³ -triazole	single-site/single-site (11/3)	contact, systemic (local)	medium	
copper	inorganic	multi-site (M1)	contact	low	
difenoconazole/cyprodinil (Inspire Super)	DMI ³ -triazole /AP ⁷	single-site/single-site (3/9)	contact, systemic	medium	
fluopyram/tebuconazole (Luna Experience)	SDHI ⁴	single-site/single-site (7/3)	contact, systemic	medium	
fluopyram/trifloxystrobin (Luna Sensation)	SDHI ⁴ /QoI ²	single-site/single-site (7/11)	contact, systemic (local)	medium to high	
flutriafol (Rhyme)	DMI ³ -triazole	single-site (3)	systemic (local)	high	
mancozeb (Dithane, Manzate)	carbamate (EBDC) ⁵	multi-site (M3)	contact	low	
mefenoxam (Ridomil Gold)	phenylamide	single-site (4)	contact, systemic	high ⁸	
metconazole (Quash)	DMI ³ -triazole	single-site (3)	systemic (local)	high	
penthiopyrad (Fontelis)	SDHI ⁴	single-site (7)	contact	high ⁸	
phosphorous acid (Fosphite)	phosphorous acid and salts	unknown, multi-site? (P 07, 33)	systemic	medium	
polyoxin-D (Ph-D)	chitin synthesis inhibitor	single-site (19)	contact	medium	
pyraclostrobin/boscalid (Pristine)	QoI ² /SDHI ⁴	single-site/single-site (11/7)	contact, systemic (local)	medium to high	
pyraclostrobin/fluxapyroxad (Merivon)	QoI ³ /SDHI ⁴	single-site/single-site (11/7)	contact, systemic	medium to high	
tebuconazole (Tebuзол)	DMI ³ -triazole	single-site (3)	systemic (local)	high	

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

² QoI = quinone outside inhibitor or strobilurin

³ DMI = demethylation (sterol) inhibitor

⁴ SDHI = succinate dehydrogenase inhibitor

⁵ EBDC = ethylene bisdithiocarbamate

⁶ MBC = methyl benzimidazole carbamate

⁷ AP = anilinopyrimidine

⁸ Resistance has been found in California for certain fungicides with a single-site mode of action. To reduce the risk of resistance development, take the mode of action into account when choosing a fungicide. At the beginning of a treatment program, use a fungicide with a multi-site mode of action; for subsequent applications rotate or mix fungicides with different mode of action FRAC numbers. Use labeled rates (preferably the upper range) of the single-site fungicides, and limit the total number of applications per season.

Acknowledgment: Adaskaveg et al., 2022. *Fungicides, Bactericides, Biocontrols, and Natural Products for Deciduous Tree Fruit and Nut, Citrus, Strawberry, and Vine Crops in California*. (PDF)

BACTERICIDE AND FUNGICIDE EFFICACY— CONVENTIONAL PRODUCTS (3/22)

Pesticide	Resistance risk (FRAC group number) ¹	Walnut blight ²	Anthraco-nose	Botryosphaeria blight ^{***}	Kernel mold ^{***}
Bactericides					
Bordeaux ²	low (M1)	4	0	0	0
Copper + mancozeb (Manzate, Dithane)	low (M1 + M3)	5	5	3(2)	0
Copper + mancozeb + surfactant ⁴	low (M1 + M3)	2	ND	ND	0
Fixed coppers ^{2,3}	medium (M1)	4	0	0	0
Kasumin	high (24)	4	0	0	0
Kasumin + copper	low (24 + M1)	5	0	0	0
Kasumin + mancozeb	low (24 + M3)	5	0	0	0
Syllit + copper	high (U12 + M3)	4	ND	0	0
Syllit + Kasumin	high (U12 + 24)	4	ND	0	0
Zinc sulfate + copper + hydrated lime (Zinc Bordeaux)	low (M1)	4	0	ND	0
Fungicides					
Abound	high (11)	0	ND	ND	ND
Cevya	high (3)	0	ND	4	ND
Fontelis	high (7)	0	ND	4	ND
K-Phite ³	low (P07, 33)	2	ND	5	ND
Luna Experience	medium (3/7)	0	5	5	ND
Luna Experience + Regalia	medium (3/7 + (BM 01, P 05)	3	5	5	ND
Luna Privilege	high (7)	0	ND	ND	ND
Luna Sensation	medium (7/11)	0	5	5	ND
Merivon	medium (7/11)	0	5	5	3
Miravis Duo	medium (3/7)	0	ND	4	ND
Ph-D	medium (19)	0	5	4	ND
Pristine	medium (7/11)	0	5	5	ND
Quadris Top	medium (3/11)	0	5	4	ND
Quash	high (3)	0	5	5	ND
Quilt Xcel	medium (3/11)	0	5	5	ND
Rhyme	high (3)	0	5	ND	3
Teb, Tebuconazole, Toledo	high (3)	0	ND	4	3
Viathon	medium (3/P07, 33)	ND	ND	4	ND

Rating: 5 = excellent and consistent, 4 = good and reliable, 3 = moderate and variable, 2 = limited and/or erratic, 1 = minimal and often ineffective, 0 = ineffective, NL = not on label, and ND = no data.

***** Research is ongoing to determine the most efficacious materials and the optimum timing of treatments for management of botryosphaeria blight and kernel mold of walnut. Fungicides rated for kernel mold may have to be mixed (e.g., Merivon—FRAC group 7/11 and Teb—FRAC group 3) and rotated to another fungicide (e.g., Rhyme—FRAC group 3). This mixture rotation is 4 (good and reliable).**

- Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action (for more information, see www.frac.info). Fungicides with different group numbers are suitable to alternate in a resistance management program. In California, make no more than one application of a fungicide with a mode-of-action group number associated with high resistance risk before rotating to a fungicide with a different mode-of-action group number; for other fungicides, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.
- Copper resistance occurs within sub-populations of *Xanthomonas arboricola* pv. *juglandis*.
- Phytotoxicity may occur. For fixed coppers, injury can be reduced by the addition of lime or agricultural oils to the tank mixture.
- A single application with a surfactant is not recommended because of buildup of populations on buds that may increase disease in subsequent years.

Acknowledgment: Adaskaveg et al., 2022. *Fungicides, Bactericides, Biocontrols, and Natural Products for Deciduous Tree Fruit and Nut, Citrus, Strawberry, and Vine Crops in California*. (PDF)

BACTERICIDE AND FUNGICIDE EFFICACY— BIOCONTROLS AND NATURAL PRODUCTS (3/22)

Organic treatments	Resistance risk (FRAC group number) ¹	Walnut blight ²
Actinovate	low (BM 02)	3
Blossom Protect	low (BM 02)	2/3
Bordeaux ² (organic with approved copper)	low (M1)	4
Fixed coppers ^{2, 3} (organic with approved copper)	medium (M1)	4
Regalia	low (BM 01, P 05)	3
Regalia + Copper (organic with approved copper)	low (BM 01, P 05 + M1)	3
Serenade (organic)	low (BM 02)	2
Zinc sulfate + copper + hydrated lime (Zinc Bordeaux) (organic with approved copper)	low (M1)	4

Rating: 5 = excellent and consistent, 4 = good and reliable, 3 = moderate and variable, 2 = limited and/or erratic, 1 = minimal and often ineffective, 0 = ineffective, NL = not on label, and ND = no data.

- ¹ Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action (for more information, see www.frac.info). Fungicides with different group numbers are suitable to alternate in a resistance management program. In California, make no more than one application of a fungicide with a mode-of-action group number associated with high resistance risk before rotating to a fungicide with a different mode-of-action group number; for other fungicides, make no more than two consecutive applications before rotating to fungicide with a different mode-of-action group number.
- ² Copper resistance occurs within sub-populations of *Xanthomonas arboricola* pv. *juglandis*.
- ³ Phytotoxicity may occur. For fixed coppers, injury can be reduced by the addition of lime or agricultural oils to the tank mixture.

Acknowledgment: Adaskaveg et al., 2022. *Fungicides, Bactericides, Biocontrols, and Natural Products for Deciduous Tree Fruit and Nut, Citrus, Strawberry, and Vine Crops in California*. (PDF)

MOST EFFECTIVE TREATMENT TIMINGS FOR KEY DISEASES (3/22)

Note: Timings listed are effective, but not all may be required for disease control. Timings used will depend upon orchard history of disease and weather conditions each year.

Disease	Catkin emergence	Terminal bud break	7–10 day intervals	Apr.	May	June	July	Aug. (3-wk before hull split)	Sept. (20–30% hull split)	Oct.	Nov. (1 st wk)
Anthracnose ¹	0	0	0	2 ⁴	3	2	0	0	0	0	0
Botryosphaeria blight	0	0	0	1	2	3	3	2	0	1	1
Kernel mold ²	0	0	0	0	0	0	0	2	2	0	0
Walnut blight ^{3, 4, 5}	2 ⁵	3	3	3	2	1	0	0	0	0	0

Rating: 3 = most effective, 2 = moderately effective, 1 = least effective, and 0 = ineffective

- ¹ Make the first application when the size of the expanding leaves is about half of its final size. This first application stage is critical.
- ² Timing for kernel mold is based on a mixture rotation of Merivon (FRAC group 7/11) and Teb (FRAC group 3) followed by Rhyme (FRAC group 3) at the timings indicated. This mixture rotation is '3' based on the ratings in the efficacy table above.
- ³ A temperature-leaf wetness model (e.g., Xanthocast) is available for determining optimum timing of bactericide applications.
- ⁴ Late spring rains are less conducive to disease, provided bloom is not delayed by low chilling.
- ⁵ Male and female flowers are susceptible beginning with their emergence, depending on wetness and temperatures conducive to disease development.

Acknowledgment: Adaskaveg et al., 2022. *Fungicides, Bactericides, Biocontrols, and Natural Products for Deciduous Tree Fruit and Nut, Citrus, Strawberry, and Vine Crops in California*. (PDF)

Insects and Mites

(Section reviewed 7/17)

APHIDS (7/17)

Scientific Names: Walnut aphid: *Chromaphis juglandicola*
Dusky-veined aphid: *Callaphis juglandis*

DESCRIPTION OF THE PESTS

Two aphid species that may damage walnut trees are the walnut aphid and the dusky-veined aphid. Their seasonal development is very similar, but their appearance and behavior are quite different. The walnut aphid was once a major pest in walnuts but now is mostly controlled by an introduced parasitic wasp. Since the biological control of the walnut aphid, the dusky-veined aphid has become a pest in some orchards.

Walnut aphids are easily distinguishable from dusky-veined aphids. They are much smaller and are typically found scattered on the lower side of leaves. In the last few years, a white form (morph) of the walnut aphid has been found in the Sacramento Valley. Populations of the white morph build later in the season than normal-colored ones.

Dusky-veined aphids feed in rows along the midvein on the upper leaf surface. During spring and summer, adult females are commonly winged, and their wings have distinctive dusky markings along the veins. Nymphs of the dusky-veined aphid have dark, banded spots on the back. These spots are much less pronounced or absent on the nymphs of the walnut aphid.

The life cycle of these two species is basically the same. Both aphids overwinter in the egg stage on twigs. Eggs hatch as soon as leaf buds of early cultivars begin to open. These aphids settle on the leaflets, mature, and reproduce without mating, giving birth to live nymphs. The aphids pass through many generations a year, depending upon temperature. In fall, wingless females mate with smaller, winged males and lay the overwintering eggs.

DAMAGE

Aphid feeding can reduce tree vigor, nut size, yield, and quality. High numbers of aphids may lead to leaf drop, exposing nuts to sunburn, which darkens or shrivels the kernels and increases nut susceptibility to other pests and pathogens. Aphids excrete honeydew. Sooty mold growing on the honeydew turns the husk surface black, also increasing the chance for sunburn on exposed nuts.

Over 15 walnut aphids per leaflet early in the season reduce nut yield and quality and cause an increase in nuts with perforated shells. An infestation in summer lowers the nut quality. Some late cultivars, such as Franquette, may tolerate heavy numbers.

Feeding by dusky-veined aphids causes the midribs of leaves to turn black. A correlation has been established between infestation of dusky-veined aphids and nut quality. If 10 to 15% of the leaflets are infested for 3 to 4 weeks before shell hardening, nut size is decreased. The same level of infestation during late summer will result in shriveled kernels at harvest time.

MANAGEMENT

In most orchards, walnut aphids are kept below damaging levels by an introduced parasitic wasp in combination with other naturally occurring biological control agents. However, if broad-spectrum insecticides are applied to control other pests such as codling moth, outbreaks of walnut aphid may occur. Predation often effectively controls the dusky-veined aphid as well, but an insecticide application may be required in some orchards in some years. A monitoring program is available below for assessing the numbers of both aphid species and detecting damaging levels that may require an insecticide application.

Biological Control

The introduced parasitic wasp, *Trioxys pallidus*, has reduced the need for insecticide applications for walnut aphid. When the parasite is disrupted by applications of broad-spectrum pesticides that are used to control other

pests found in walnut orchards, walnut aphid sprays may be required. The use of oil during the growing season has also been shown to be destructive to *Trioxys*.

The female *Trioxys* wasp lays eggs inside the small walnut aphid. Eggs hatch and the parasitic larva consumes the insides of the aphid, which turns tan and becomes "mummified." The presence of aphid mummies is an indication the parasite is present. After the parasite pupates, the adult wasp emerges from the aphid mummy by chewing a small exit hole. Although the dusky-veined aphid is occasionally parasitized, rates of parasitism are not high enough to effectively control this aphid; however, predators can be effective.

Trioxys can be reduced by native hyperparasites. Hyperparasitism (the parasitism of a parasite) has been found to be greatest in unsprayed orchards and orchards with codling moth-tolerant tree varieties that require fewer insecticide applications than other walnut varieties. Pesticides used for other pests, such as codling moth and walnut husk fly, that may reduce hyperparasite numbers include: esfenvalerate (Asana), phosmet (Imidan), and spinosad (Entrust, Success). However, all of these pesticides also harm the primary parasitoid *Trioxys* as well as predatory mites, leading to an increase in spider mite numbers.

Predators such as lady beetles, including the Asian multicolored lady beetle and ashy gray lady beetle, lacewings, and flies play an important role in the natural control of the dusky-veined aphid. Predators also feed on walnut aphid, but *Trioxys* keeps the numbers of walnut aphid so low that predators seldom build up to large numbers on walnut aphids alone.

Organically Acceptable Methods

Reliance on biological control is the main management method in an organically certified crop. Oil sprays may suppress aphids, but are also harmful to natural enemies. In addition, be aware of phytotoxicity with oils especially when temperatures are high.

Monitoring and Treatment Decisions

Begin sampling in May and continue throughout shoot and nut growth.

1. Take 5 first-subterminal leaflets (each compound leaf has five leaflets) from 10 trees for a total sample of 50 leaflets.
2. Check the upper surface of each leaflet for dusky-veined aphids and the lower surface for walnut aphids.

Walnut Aphid

Walnut aphid numbers often increase rapidly if chemicals are applied that interfere with biological control or if the hyperparasites are numerous. Consider an insecticide application for walnut aphid if the average number of healthy (non-parasitized) aphids found on the underside of subterminal leaflets of early, heavy-bearing varieties is over 15 per leaflet. Keep records of your observations (*example form available online*).

Dusky-Veined Aphid

Consider an insecticide application for dusky-veined aphid when an average of 10% of the subterminal leaflets have dusky-veined colonies of six or more feeding on their upper surface along the midvein.

Common name (Example trade name)	Amount to use** (conc.)	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. IMIDACLOPRID (Admire Pro) MODE-OF-ACTION GROUP NUMBER ¹ :4A COMMENTS:	1.2–2.4 fl oz —	12	7
--	-----------------	----	---

Review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.

B. ACETAMIPRID (Assail 70WP)	1.1–4.1 oz 0.271–1 oz	12	14
---------------------------------	-----------------------	----	----

Common name (Example trade name)	Amount to use**		REI# (hours)	PHI# (days)
	(conc.)	(dilute)		
MODE-OF-ACTION GROUP NUMBER ¹ : 4A COMMENTS: Make no more than four applications per season. Do not exceed 0.72 lb a.i./acre per season. Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.				
C. PHOSMET (Imidan 70-W)	6 lb	1–2 lb	168 (7 days)	28
MODE-OF-ACTION GROUP NUMBER ¹ : 1B COMMENTS: Do not apply after husk split. Has a residual of about 21 days. Buffer to a pH of 5.5–6.0.				
D. NARROW RANGE OIL#	1%	—	See label	See label
MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: Use of oil during the growing season can be harmful to the aphid parasite, <i>Trioxys pallidus</i> . Helps to suppress aphids. More effective on dusky vein aphid than walnut aphid. Oils should not be used on walnut during the dormant season, between bud break and shoot elongation, or on drought-stressed trees; also, do not apply after husk split. Check with certifier to determine which products are organically acceptable.				

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/>.

** For concentrate application, use the amount given in 80 to 100 gal water/acre, or lower if the label allows; for dilute application, amount is per 100 gal water to be applied in 300 to 500 gal water/acre, according to label.

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

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

Acceptable for use on organically grown crops.

CODLING MOTH (7/17)

Scientific Name: *Cydia pomonella*

DESCRIPTION OF THE PEST

Codling moths overwinter as full-grown larvae in thick, silken cocoons under loose scales of bark or in trash on the ground near the trunk. Moth emergence usually coincides with the leafing out of early walnut cultivars. During the day, moths rest on branches and trunks. Codling moths can be distinguished from other small moths likely to occur in the orchard by the coppery markings on their wing tips.

The first flight of codling moth typically starts sometime from early March to early April and is from the overwintered generation. The flight of the overwintered generation may have two peaks (often referred to as 1A and 1B) and can last several months. These moths lay eggs that signal the beginning of the first generation. The second moth flight results when the larvae of the first generation complete their development. When the moths in the second flight lay their eggs, this starts the second generation. The following table outlines the life history of codling moth:

Generation	Resulting moth flight	Lay eggs for
overwintered	first	first generation
first	second	second generation
second	third	third generation
third	fourth*	

* Only occurs in warm growing locations

Each overwintered female deposits about 30 eggs singly on leaves near nuts. Later generations of females will lay an average of 60 eggs on leaves or nuts. Eggs are disk-shaped and opaque white. Eggs of the overwintered generation hatch after 5 to 20 days, depending on the temperature, and young larvae bore into nutlets through the blossom end. Most nuts with codling moth damage from the overwintered generation drop to the ground along with blighted nuts. However, if damage occurs from second flight peak (1B) of overwintered codling moths and the weather is cool, all damaged nuts do not drop. So only use nut drop thresholds when there is no second peak in the flight of the overwintered generation.

Codling moth egg hatch period is dependent on temperatures but typically the egg hatch period for the overwintered generation lasts 4 to 6 weeks and 4 weeks for later generations. The egg hatch period is important for timing sprays. In cool springs or cool locations, the flight of the overwintering generation lasts longer than subsequent flights and has two peaks.

The larvae leave the nut after completing their development and pupate under loose bark on the tree. Adults of the first generation begin to emerge from the end of May to as late as the last week of June in the Central Valley, depending on the season. In coastal areas, emergence begins in late June to early July. Because of the higher temperatures, eggs and larvae of the first generation develop faster than those laid by the overwintered generation.

Newly-hatched second-generation larvae bore into walnuts anywhere on their surfaces but prefer the spot where two nuts touch. If the nut has hardened, it may take them up to a week to enter the nut. The larvae develop into adults that begin to emerge by late July or the beginning of August. In most valley locations they produce a third generation; in warmer locations a partial fourth generation may be produced in September. These later generations can cause significant damage. Older larvae leave the nuts and move to tree trunks or debris to spin cocoons and overwinter. Occasionally some may be present in nuts if they are harvested before the larvae have matured. However, most larvae found in nuts at harvest are navel orangeworm.

It is important to distinguish between codling moth and navel orangeworm damage. In harvest samples, it is easy to tell codling moth damage from navel orangeworm damage when the worms are present. Navel orangeworm has a brown crescent-shaped marking behind the head capsule on both sides of the first thoracic segment; this mark is absent in codling moth larvae. There can be multiple navel orangeworm larvae but only one codling moth larva per nut. If the worm is not present, look at the damage: navel orangeworm leaves behind more webbing and frass. However, navel orangeworm frequently infest nuts that were previously infested by codling moth, so if navel orangeworm is present, it doesn't mean codling moth wasn't previously there.

DAMAGE

The damage caused by the codling moth is different with each generation. First-generation larvae reduce yield directly by causing nutlets to drop from the tree. Codling moth-damaged nutlets have frass at the blossom end. Be careful not to confuse nuts damaged by codling moths with unpollinated nutlets or blight-infected nutlets, which have dark lesions but no frass and drop at the same time. Damage is generally most severe on early-season cultivars, although it has been increasing steadily over the years on late-season cultivars such as Chandler.

Nuts attacked by larvae from the last part of the first generation and from the second and third generations remain on the trees but are unmarketable because of the feeding damage to the kernel. These damaged nuts can also serve as a breeding site for the navel orangeworm. Feeding that is confined to the husk results in minor shell staining but no damage to the kernel.

You can often detect codling moth infestations by looking for frass produced by the larvae at the point of entry into the husk. Second-generation larvae often enter through the side of the husk where the two nuts touch. After the shell hardens, the larvae enter the nuts through the soft tissue at the stem end.

MANAGEMENT

Management options for codling moth in walnut orchards include both pheromone mating disruption and insecticide sprays. The options that work best for a given orchard depends on the size of the orchard and the trees and the degree of codling moth infestation. In all cases, monitor with pheromone (codlemone), pheromone plus kairomone (CM-DA combo), or both and check for damage. Monitoring and checking for damage is necessary to follow codling moth generations, assess the degree of infestation, and assess the effectiveness of control actions. Programs that use mating disruption alone or in combination with sprays of least-toxic insecticides or parasite releases pose fewer water quality and environmental risks than programs that rely on organophosphate or pyrethroid insecticides.

Biological Control

Natural enemies alone do not keep codling moth numbers below economic levels. In orchards where mating disruptants are used, augmentative releases of the tiny, naturally-occurring parasitic wasp *Trichogramma platneri*, which attacks codling moth eggs, can be helpful to control eggs laid by mated female moths immigrating into the area from surrounding areas, but this may not be economically feasible. They are most effective when the orchard's codling moth population is low.

Organically Acceptable Methods

Organically approved insecticides and some pheromone mating disruption products are acceptable for use in organically certified crops. While certain oil products are organically certified and will supply 30–40% egg kill, there is a concern of phytotoxicity with oils, especially when weather is hot. Oils have also been shown to kill the walnut aphid parasite, *Trioxys pallidus*. **Always check with your organic certifier to determine what products are approved for organic certification.**

Degree-Days

Degree-days (DD) are an important tool in managing many pests. There is an online plant model to calculate degree-days for codling moth in walnut at <http://ipm.ucanr.edu/calludt.cgi/DDMODEL?MODEL=CM&CROP=walnuts>. To learn more about using degree-days to time insecticide applications, watch the degree-days video at <http://ipm.ucanr.edu/WEATHER/degreedays>.

Establishing Biofix and Accumulation of Degree-Days

In early March, place traps in your orchards to determine first moth emergence.

- If using traps with standard 1 mg pheromone (1X) lures, put traps in the southeast quadrant of the tree about 6 to 7 feet high. Traps placed higher in the tree canopy catch more moths, which may be useful in orchards with low codling moth numbers.
- Traps with CM-DA lures should be hung mid-canopy and are most useful in orchards that are either using mating disruption or near other orchards using mating disruption.

Biofix is the first date that moths are consistently found in traps and sunset temperatures have reached 62°F. All moths caught in traps with standard 1 mg pheromone lures will be males. Traps with CM-DA combo lures, which contain codlemone pheromone (the male attractant used in 1 mg lures) and a kairomone made of pear

volatiles, attract only males before females emerge and both males and females thereafter. The first sustained catch of female moths in these traps is referred to as "female biofix", but degree-day calculations and the treatment timings are all based on the biofix established using male trap captures, regardless of the lure used for monitoring. To predict egg hatch, begin accumulating degree-days from the biofix, using a lower threshold of 50°F and an upper threshold of 88°F. (For assistance in calculating degree-days, see "Degree-days" on the UC IPM website at <http://ipm.ucanr.edu/WEATHER/degreedays/>.)

Because biofix points vary from orchard to orchard, monitor each orchard separately to determine the biofix point for that orchard. See Table 1 for information on setting biofix points for subsequent generations.

MONITORING AND TREATMENT DECISIONS IN A MATING DISRUPTION ORCHARD

Unless the orchard is isolated, mating disruption is most successful in large, uniform orchards on flat ground, with a square shape (as opposed to a narrow rectangular shape), and with relatively low to moderate numbers of codling moths. It is less effective in orchards with susceptible varieties (e.g., Ashley, Payne, Serr, Vina) or in orchards that have a history of high numbers of codling moths or economically significant codling moth damage. In these situations, make the transition to a mating disruption program using both mating disruption and chemical control the first year or two to reduce codling moth damage.

Air currents entering the windward (upwind) sides of orchards adjacent to open areas may reduce the effectiveness of mating disruption along orchard edges. In addition, the edges of orchards adjacent to other walnuts not under mating disruption may have immigration of mated females from those blocks. Monitor these situations closely, especially in puffer-treated orchards where the distance between dispensers is large. An insecticide spray applied 4 to 5 trees deep along the affected edge of the orchard may help reduce the risk of damage in these areas.

Setting Out Traps

Traps using standard 1 mg pheromone lures catch few or no moths when mating disruption is present. Therefore, in mating disruption orchards, use codling moth traps with CM-DA combo lures to monitor development and moth numbers.

- Place CM-DA combo traps (1 trap per 25 acres) in the mid-canopy of trees. High counts of codling moths in these traps will help determine the need for supplementing mating disruption with insecticides.
- Also, hang a smaller number of standard 1 mg traps (1 trap per 50 acres or per block) to assess the effectiveness and longevity of the mating disruptant. Hang these traps at 6 to 8 feet in the trees. If moths are caught in these traps consistently for 2 consecutive weeks, the mating disruptant may have broken down or expired, and insecticides may be necessary.

Change trap lures and bottoms at the frequency recommended by the manufacturer.

Setting Out Mating Disruptants

There are three types of pheromone mating disruption products available for use in walnuts:

- **Sprayable liquid formulations** designed to be applied with standard orchard sprayers, which contain pheromones in tiny microcapsules that release pheromones into the air once they are deposited on leaves.
- **Hand-applied dispensers** of various sorts that are hung in the orchard at rates ranging from 20 to 200 units per acre. Pheromones are released into the orchard continuously over a prolonged period of time.
- **Aerosol dispensers** hung in the orchard at low densities, typically one unit per 1.5 to 2 acres. These mechanically dispense small amounts of pheromones into the orchard air at programmed intervals.

Aerosol or plastic dispensers: Hang in the upper quarter of the tree canopy before the historic date of first-flight biofix: typically mid-March in the central and southern San Joaquin Valley to early April further north.

Sprayable pheromone: Apply at or after biofix when leaves have started growing and are partially expanded. Sprayable formulations have short residual activity. They must be applied at 3- to 4-week intervals for sustained mating disruption, as applications at longer intervals have not been proven effective. Make additional applications shortly after the biofix of the second and third flights. When large moth numbers are present in an orchard, sprayable pheromones have been shown to reduce codling moth damage when added to a conventional spray program. As with hand-applied dispensers, standard 1 mg trap catches are helpful for deciding when sprayable pheromones need to be re-applied.

Nut Sampling

Check nuts for damage during each codling moth generation, particularly near the end of the generation when it is easier to see the frass (excrement). Examine 1,000 mid-canopy nuts in each block (20 nuts per tree on 50 trees per block) for signs of codling moth larval entry. Damaged nuts exceeding 1% after the first generation or 2% after the second indicate an infestation that may exceed 5% at harvest. In these cases supplement the mating disruption treatment with insecticide spray during the egg hatch of the next flight, which is 300 degree-days after the biofix.

At harvest, collect and crack out 1,000 nuts to assess damage and plan for next year.

Supplemental Treatments

When making the transition from managing codling moth with insecticides to mating disruption:

- **High codling moth numbers** (i.e., where damage from previous season's harvest sample was over 4%): supplement mating disruption with insecticide applications to reduce the codling moth numbers.
- **Moderate numbers of moths** (i.e., where the previous season's damage was 2 to 4% at harvest) or in the second year of transition: supplement mating disruption with sprays of insecticides that will not disrupt natural enemies.
- **Low moth numbers** (where the harvest damage was less than 1% the previous season): mating disruption alone can be used.

Where insecticide sprays are needed, use degree-day calculations (see below) to apply insecticides at the most effective time.

MONITORING AND TREATMENT DECISIONS IN A CONVENTIONAL ORCHARD

In orchards sprayed with contact or ingested insecticides (e.g., spinosad and oil, organophosphates, pyrethroids, and carbamates), time all insecticide applications to kill larvae as they emerge from eggs. If insect growth regulators are used, apply insecticides before egg laying (Dimilin) or egg hatch (Confirm, Intrepid), depending on label instructions. If using a diamide insecticide (e.g., Altacor or Exirel), apply at or before peak egg laying of the targeted generation. Use pheromone (1 mg) or CM-DA combo traps, degree-days (DD), and sunset temperatures to monitor codling moth activity and determine when egg hatch occurs. If nearby orchards are using mating disruptants, use the CM-DA combo lure traps for monitoring.

Treatment Decisions

The need for treatment and the timing of sprays is different for the different generations of codling moth. The degree-day model used in this guideline for codling moth reflects the concept that each subsequent codling moth generation time is longer than the preceding one.

First Generation

The first flight of codling moth can last a long time and have two peaks (1A and 1B). To minimize interference with the walnut aphid parasite and, in most cases, avoid the necessity for aphid insecticide applications, it is best to delay sprays until the second generation or the end of the first generation (1B), especially in later-season varieties.

Low populations

If damage did not exceed 3% the previous season and less than an average of two moths per trap per night are being caught with 1 mg traps, delay insecticide applications until the second flight peak (1B). If you see an increase in trap catches, spray when 600 to 700 degree-days have accumulated from biofix.

Moderate to high populations

If damage exceeded 3% the previous season or more than an average of two moths per trap per night are being caught with 1 mg traps, plan to spray both the 1A and 1B larvae:

TREATING 1A LARVAE

Apply a pesticide when 300 degree-days accumulate after biofix, using a short-residual material to minimize disruption of the aphid parasite, *Trioxys pallidus*.

TREATING 1B LARVAE

When you see an increase in moths caught in traps around 600 to 700 degree-days from the first biofix, apply a second spray when the residual period (i.e., the length of time the insecticide controls the pest) of the first pesticide ends. Residual periods for many of the pesticides are listed in the treatment table below. In most cases, a range of days is given. The actual length of a residual period is influenced by several factors, including the pH of the solution and the susceptibility of the population to that material. If the population has developed any resistance to the material, then the residual period will be shorter than it would be for a highly susceptible population.

Second and Later Generations

Codling moth has two to four generations a year. Continue monitoring with traps and accumulating degree-days (as outlined in TABLE 1) until the crop is harvested or numbers decline to below damaging levels in September. At the beginning of each generation, determine the biofix point for that generation in order to predict the best treatment timing during egg hatch for that generation.

To time an insecticide application for second-generation larvae, determine the biofix for the second generation. This generally occurs around 1060 degree-days from the first biofix point. However, any increase in trap catches after 800 degree-days can be considered the biofix. To better determine this biofix, clean and service the traps around 700 degree-days and start checking traps more frequently.

If there was no second peak in the first flight of codling moth, the number of dropped nuts can be used to determine if the second generation requires an insecticide application. All nuts damaged by codling moth early in the season drop, except when there is a second peak of the first flight or if the weather is not hot enough.

1. Look for frass at the blossom end of nuts to confirm that codling moth caused the drop.
2. Examine all the nuts under the same 10 trees in an orchard block each week during the nut drop period (4 to 6 weeks from the end of bloom).
3. Record the total number of damaged nuts per tree (not the percent damaged).
 - If an average of 4 or less infested nuts are found per tree, you can expect less than 5% codling moth damage by harvest without a spray.
 - If there are between 4 and 24 infested nuts per tree, spray at 250 degree-days from the second biofix and use a short residual pesticide.
 - If you collect more than 24 codling moth-damaged nuts per tree, apply an insecticide as soon as eggs of the second generation start hatching (250 degree-days from the second biofix), and use a long residual pesticide to cover the entire hatch period (about 1 month).

Third-generation Egg Hatch

A third (or fourth) generation of codling moth eggs does not occur every year in every location. Codling moth larvae normally go into diapause (winter dormant state) around August 22, but in warm years and warm locations they will have already started pupation before August 22, and these pupae will soon emerge as adults to produce a third generation. If 650 degree-days have accumulated between the peak of the second-generation flight and August 22, most of the codling moth will not go into diapause but will pupate and emerge in August to early September, depending on climate.

If degree-day accumulation data indicates a third generation will occur, use pheromone traps to establish a third biofix point around 1100 to 1200 degree-days from the second biofix. Apply a spray when 200 to 250 degree-days have accumulated from the third biofix unless trap catches are high, in which case spray at 160 degree-days. If needed, apply the second spray when the residual of the previous spray ends.

Table 1. Codling Moth Management in Walnuts.

EVENT	ACTION
FLIGHT OF OVERWINTERED GENERATION	<ul style="list-style-type: none"> • Hang traps out at bud break (first week in March) and determine first-flight biofix
Low populations	<ul style="list-style-type: none"> • If damage did not exceed 3% the previous season and less than an average of 2 moths per trap per night are being caught with 1 mg traps, delay treatment until the second flight peak (1B); When you see an increase in trap catches, treat when 600 to 700 degree-days (DD) have accumulated from biofix.

EVENT	ACTION
Moderate to high populations	<ul style="list-style-type: none"> If damage exceeded 3% the previous season or more than an average of 2 moths per trap per night are being caught with 1 mg traps, treat both the 1A and 1B larvae.
First treatment (1A) ¹	<ul style="list-style-type: none"> Spray at 300 DD² (or 250 DD if using an insect growth regulator) from first-flight biofix or when small nutlets first appear, whichever is later.
Second treatment (1B) ¹	<ul style="list-style-type: none"> Look for second peak about 600 to 700 DD from first biofix by checking traps frequently. If a second peak occurs, spray when residual effectiveness of first treatment ends.
SECOND FLIGHT	<ul style="list-style-type: none"> Determine second biofix to time sprays for second-generation egg hatch. Use trap catch data to detect resumption of moth flight activity and establish biofix. The second biofix will be when an increase occurs in trap catches between 800 to 1300 DD from first biofix (average is 1060 DD). Begin accumulating degree-days from second biofix Check traps frequently; trap maintenance important.
Visual monitoring	<ul style="list-style-type: none"> If there is a second peak in the first flight, use visual inspection. Look at a minimum of 10 nuts on each of 10 trees at least 10 feet up in the canopy. If less than 2% infestation in visual inspection, don't treat. If more than 3% infestation in visual inspection, spray at 250 DD² from second biofix and use a short residual insecticide. If there is more than 5% infestation in visual inspection, spray at 250 DD² from second biofix and use a long residual pesticide to cover entire hatch period (about 1 month).
Monitoring nut drop	<ul style="list-style-type: none"> If there is no second peak in the first flight (overwintered generation), monitor nut drop to determine the need to spray. If there are 4 or less infested nuts that have dropped from the tree, don't treat. If there are 4 to 24 infested nuts per tree, spray at 250 DD from second biofix and use short residual insecticide. If there are more than 24 infested nuts per tree, spray at 250 DD from second biofix and use long residual pesticide to cover entire hatch period (about 1 month).
THIRD FLIGHT	<ul style="list-style-type: none"> Time sprays for third generation egg hatch. Use trap catch data to detect resumption of moth flight activity. Third biofix is when trap increase occurs between 800 to 1300 DD from second biofix (average is 1100 DD). Check traps frequently; trap maintenance important.
Low populations	<ul style="list-style-type: none"> Do not treat if there is no or little (less than 2%) evidence of canopy infestation.
Moderate to high populations	<ul style="list-style-type: none"> Spray at 300 DD² (or 250 DD if using an insect growth regulator) from 3rd biofix when there is obvious canopy infestation (more than 2%).
FOURTH FLIGHT	<ul style="list-style-type: none"> Time sprays for fourth generation egg hatch. Use trap catch data to detect resumption of moth flight activity. Fourth biofix is when trap increase occurs between 800–1300 DD from third biofix (average is 1200 DD). Check traps frequently, trap maintenance important.

EVENT	ACTION
Low populations	<ul style="list-style-type: none"> Do not treat if there is no or little (less than 2%) evidence of canopy infestation.
Moderate to high populations	<ul style="list-style-type: none"> Spray at 300 DD² from fourth biofix when there is obvious canopy infestation (more than 2%).
HARVEST SAMPLE	<ul style="list-style-type: none"> Collect and crack out 1,000 nuts to assess damage and to plan for next year.

¹ 1A and 1B refer to the two flight peaks of the first codling moth flight

² Timing is 50 to 100 DD earlier for growth regulators

Additional Treatment Considerations

If there was a second peak in the first flight, not all of the infested nuts will have dropped, so visually inspect the tree canopy for infested nuts.

- Look at a minimum of 10 nuts on each of 10 trees at least 10 feet up in the canopy.
 - If less than 2% are infested, don't spray.
 - If greater than 2% infested nuts are found, a pesticide application is necessary.
- Apply an insecticide as soon as eggs of the second generation start hatching (250 degree-days from the second biofix).
 - Use a short residual material if the percent infestation is between 3 and 5, or
 - If greater than 5% infestation is found a long residual material to cover the entire hatch period (about 1 month).

For the third and fourth generation, the decision to spray must be based on a combination of factors including previous pesticide applications, number of nuts infested in the previous generation, trap catches, and the ability to harvest early. To determine the number of nuts infested in the previous generation, visually inspect 20 nuts at least 10 feet up in the canopy on 50 trees.

- If less than 2% are infested, don't spray.
- If greater than 2% are infested, spray.

If you spray, it is important to determine a biofix for third and fourth generations. The generation times get longer with each generation. Look for the third biofix around 1100 degree-days from the second biofix and for the fourth biofix around 1200 degree-days from the third biofix (the range for both biofix points is 800 to 1300 degree-days). Pesticide applications are often not needed at this time; but if stings are found on nuts, apply sprays 300 degree-days after the biofix.

Common name (Example trade name)	(conc.)	Amount to use** (dilute)	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.

Note: Residual periods mentioned in the comments will be influenced by many variables, including spray coverage, weather, resistance, population pressure, etc. and may vary from the actual effective control period, depending upon these variables.

MATING DISRUPTION

A. MATING DISRUPTANTS

COMMENTS: Most effective in isolated blocks or larger blocks that have a squarish shape and low to moderate codling moth numbers, with trees of uniform size and moderate height. Consult with a crop advisor for help deciding whether specific orchards are suitable for mating disruption and information on how to deploy dispensers for maximum effectiveness. Apply just prior to first-flight biofix in mid-March to mid-April. Reapply if needed at the interval recommended on the label. Hang 1 mg pheromone traps at 6 to 8 feet high in the canopy and assess them weekly to ensure mating disruption product has not expired. Use traps baited with CM-DA combo lures high in the canopy to

Common name (Example trade name)	(conc.)	Amount to use** (dilute)	REI# (hours)	PHI# (days)
monitor population development. Check nuts for damage after each generation and treat with insecticides if needed to ensure a low level of damage at harvest. Be sure to monitor for other pests such as walnut husk fly, aphids, and redhumped caterpillar normally controlled by codling moth sprays.				
AEROSOL DISPENSERS#				
(Isomate-CM Mist, Isomate CM-Mist Walnut)		1 dispenser / 1.5–2 acres	0	<i>Period of effectiveness (days)</i> Up to 200
(CheckMate Puffer CM-O, CheckMate CM-O-Pro)		1 dispenser / 1.5–2 acres	0	Up to 200
COMMENTS: Hang aerosol dispensers in the upper third of tree canopies. Hang aerosol dispensers at a spacing of one per 180 to 200 linear feet in trees around the perimeter; within the orchard's interior, place units in a roughly square grid pattern to achieve an interior density of one per 2 acres. This will result in an overall density of one dispenser per 1.5 to 2 acres. Although densities of less than 1 unit per acre are not recommended by either manufacturer, research has demonstrated that densities of 1 unit per 1.5 to 2 acres provides good suppression where a substantial monitoring program (as described above) is carried out and supplemental sprays are applied in the first few years, if needed, to lower codling moth numbers. The pheromone plume released by aerosol dispensers is large and has been shown to reduce 1 mg trap catches up to 2000 feet downwind. Use CM-DA combo traps (as well as standard 1 mg traps) to monitor conventionally managed orchards near orchards with aerosol dispensers to provide an accurate assessment of codling moth numbers and activity.				
HAND-APPLIED DISPENSERS#				
(Isomate-CTT)		100–200 dispensers/acre	0	<i>Period of effectiveness (days)</i> 160+
(Isomate-CM Ring)		20–40 dispensers/acre	0	160+
(CheckMate CM-XL1000)		120–200 dispensers/acre	0	Up to 150 days
COMMENTS: Attach dispensers to branches in the upper third of tree canopies. Apply dispensers individually in trees at a rate sufficient to give the recommended number of dispensers per acre. Hang lower density products such as the CM-Ring in a uniform pattern (e.g., every other tree in every row) to ensure even distribution of pheromone throughout the orchard. Make application shortly before first biofix.				
SPRAYABLE FORMULATIONS				
(CheckMate CM-F)		2.4–4.8 oz	4	NA
COMMENTS: Sprayable formulations have short residual activity and should be applied at 3- to 4-week intervals for continuous suppression. Delay the first application until leaves have emerged and are partially expanded.				
Common name (Example trade name)	(conc.)	Amount to use** (dilute)	REI# (hours)	PHI# (days)

INSECTICIDE CONTROLS

Moderate to High Codling Moth Numbers

- A. SPINETORAM
(Delegate WG) 4.5–7 oz — 4 1
MODE-OF-ACTION GROUP NUMBER¹: 5
COMMENTS: Larvicide. The best time to apply is at egg hatch (about 200 DD). Do not make more than four applications per year. To reduce the development of resistance, do not make more than three consecutive applications of any group 5 insecticides (spinosad or spinetoram) per season and do not apply to more than one generation per season.
- B. CHLORANTRANILIPROLE
(Altacor) 3–4.5 oz — 4 10
MODE-OF-ACTION GROUP NUMBER¹: 28
COMMENTS: Larvicide. The best timing is to apply before egg hatch (about 200 DD). Do not make more than four applications per year. To reduce the development of resistance do not make more than three consecutive applications of any group 28 insecticides (anthranilic diamide) per generation per season.
- C. CYANTRANILIPROLE
(Exirel) 10–20.5 fl oz — 12 5
MODE-OF-ACTION GROUP NUMBER¹: 28
COMMENTS: To reduce the development of resistance do not make more than three consecutive applications of any group 28 insecticides (anthranilic diamide) per generation per season.
- D. LAMBDA-CYHALOTHRIN*

Common name (Example trade name)	(conc.)	Amount to use** (dilute)	REI‡ (hours)	PHI‡ (days)
(Warrior II with Zeon) MODE-OF-ACTION GROUP NUMBER ¹ : 3A COMMENTS: Larvicide. Residual at the acre rate is about 21 days. Addition of oil improves coverage and aids in suppressing mites. During the first codling moth generation, add oil at 1% if the 1A eggs are being treated and at 0.5% for the 1B eggs. During the second generation add oil at 0.25%.	2.56 fl oz	—	24	14
E. CYFLUTHRIN* (Baythroid XL) MODE-OF-ACTION GROUP NUMBER ¹ : 3A	2–2.4 fl oz	0.5–0.6 fl oz	12	14
F. BIFENTHRIN* (Brigade WSB) MODE-OF-ACTION GROUP NUMBER ¹ : 3A COMMENTS: Provides about a 21- to 28-day residual at the high label rate.	8–32 oz	2–8 oz	12	7
Moderate Codling Moth Numbers				
A. ACETAMIPRID (Assail 70WP) MODE-OF-ACTION GROUP NUMBER ¹ : 4A COMMENTS: Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.	2.3–4.1 oz	0.271–1 oz	12	14
B. EMAMECTIN BENZOATE* (Proclaim) MODE-OF-ACTION GROUP NUMBER ¹ : 6 COMMENTS: REI is 48 hours for poling, pruning, and thinning; 12 hours for all other activities.	3.2–4.8 oz	0.8–1.2 oz	See comments	14
C. PHOSMET (Imidan 70W) MODE-OF-ACTION GROUP NUMBER ¹ : 1B COMMENTS: Do not apply after husk split. Provides a residual of about 21 days. Buffer to a pH of 5.5–6.0.	5 lb	1–2 lb	7 days	28
D. METHOXYFENOZIDE / SPINETOR AM (Intrepid Edge) MODE-OF-ACTION GROUP NUMBER ¹ : 18/5 COMMENTS: Apply at the beginning of egg hatch, which is earlier than organophosphorous or carbamate insecticide timings. It is recommended that methoxyfenozide be applied at 200 degree-days after the first biofix.	10–18 fl oz	—	4	7
E. METHOXYFENOZIDE (Intrepid 2F) MODE-OF-ACTION GROUP NUMBER ¹ : 18 COMMENTS: An insect growth regulator that provides 10 to 18 days of residual protection depending on the rate of application and nut expansion. Kills young larvae but does not kill adult moths. It is a reduced risk insecticide that has little or no effect on beneficial insects and mites. Only use in orchards with low to moderate codling moth populations. Spray coverage is extremely important. Do not apply to large trees unless adequate spray coverage can be verified. Use no less than 100 gal water/acre for ground applications. Sprayer speed should not exceed 1.5 mph. The use of Latron B-1956, CS-7, or similar sticker-spreader is highly recommended. Apply at the beginning of egg hatch, which is earlier than organophosphorous or carbamate insecticide timings. It is recommended that methoxyfenozide be applied at 200 degree-days after the first biofix.	16–24 fl oz	—	4	7
F. ESFENVALERATE* (Asana XL) MODE-OF-ACTION GROUP NUMBER ¹ : 3A COMMENTS: Residual of about 14 to 21 days (lower rates have less residual activity). This is a broad-spectrum pesticide that is harmful to beneficials at higher rates and can cause outbreaks of aphids and mites. Lower rates may also be harmful to beneficials, but the effects of secondary pest outbreaks are less obvious. It is best to use broad-spectrum pesticides late in the season. Provides control of the hyperparasite that attacks the aphid parasite <i>Trioxys pallidus</i> , and it does not kill <i>Trioxys</i> . This pesticide is not effective on scales, so if you have a scale problem choose another chemical.	9.6–19.2 fl oz	4 fl oz	12	21
G. PERMETHRIN				

(Ambush)*	12.8–25.6 oz.	0.05–0.1 lb a.i.	12	1
(Pounce 25WP)*	12.8–16 oz.	0.05–0.0625 lb a.i.	12	1

MODE-OF-ACTION GROUP NUMBER¹: 3A

COMMENTS: Residual of about 14 to 21 days (lower rates have less residual activity). There is no university data on the effectiveness of this material on codling moth in walnuts; follow information for esfenvalerate. This is a broad-spectrum insecticide and the high rate will be harmful to beneficials. This material is not effective on scales, so if you have a scale problem choose another chemical. It also may cause mite outbreaks. Do not graze livestock in sprayed area.

H. CARBARYL*				
(Sevin)	Label rates		12	14

MODE-OF-ACTION GROUP NUMBER¹: 1A

COMMENTS: There has been little research on this pesticide in walnuts, but in apples carbaryl is a good codling moth material and has a residual period of about 28 days. Carbaryl causes mites to reproduce more rapidly, possibly resulting in mite outbreaks, so monitor for mites if carbaryl is used. This pesticide is best used later in the season. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

Low Codling Moth Numbers

A. DIFLUBENZURON*				
(Dimilin 2L)	16 fl oz	—	12	28

MODE-OF-ACTION GROUP NUMBER¹: 15

COMMENTS: An insect growth regulator that has a residual of about 21 days. **It kills eggs, does not kill adult moths**, and is safer to some beneficials than organophosphates and carbamates. Only use in orchards with low to moderate codling moth numbers. Coverage is extremely important: it is not recommended for the first generation because the rapid growth of leaves in spring does not allow for leaves to remain completely covered during the residual period (21 days.) Apply in a minimum of 125 gal water/acre and the ideal amount is 250 gal water/acre for mature trees. Ground speed should not exceed 1.5 mph. Diflubenzuron must be applied earlier than the other pesticides because it needs to be on the leaf before eggs are laid. Treatment timing is before the start of the second generation flight, which is about 800–900 degree-days from the first biofix and before the start of the third generation flight, which is 1800 to 1900 degree-days from the first biofix. Diflubenzuron is not a stand-alone material and should be used in combination with another control.

Supplemental Control in Organic Orchards

A. CYDIA POMONELLA GRANULOVIRUS#				
(Cyd-X, etc.)	1–6 fl oz	—	4	0

COMMENTS: A larvicide; time to egg hatch at 200 to 250 degree-days; larvae must ingest to become infected by this virus. Make a second application 7 to 10 days later, a third application at 600 degree-days, and a fourth 7 days later for a total of 4 applications per flight.

B. SPINOSAD				
(Entrust)#	1.25–3 oz	0.3–0.75 oz	4	1

MODE-OF-ACTION GROUP NUMBER¹: 5

COMMENTS: A short-residual insecticide. When combined with 1% spray oil to improve spray coverage, this insecticide is best used as a supplement to mating disruption. May be used without oil but may not be as effective. Only higher rates of spinosad have been tested for codling moth control. Spray coverage is extremely important. At best, controls 50 to 60% of population. Do not use more than 9 oz. of Entrust/acre per crop. Do not apply spinosad sprays less than 7 days apart. Limited experience with use in California walnuts.

... PLUS ...

NARROW RANGE OILS#	See label	See label	4	0
--------------------	-----------	-----------	---	---

MODE OF ACTION: Contact including smothering and barrier effects.

COMMENTS: Do not apply if trees have suffered from a lack of adequate soil moisture or other stressing factors (insect, disease damage, etc.) at any time during the year or if temperatures are expected to exceed 90°F at time of application. Do not apply after husk split. Not all oils are organically acceptable: check label and your organic certifying agency.

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/>.

** For concentrate application, use the amount given in 80 to 100 gal water/acre, or lower if the label allows; for dilute application, amount is per 100 gal water to be applied in 300 to 500 gal water/acre, according to label.

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

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

Acceptable for use on organically grown crops.

NA Not applicable.

EUROPEAN RED MITE (7/17)

Scientific Name: *Panonychus ulmi*

DESCRIPTION OF THE PEST

The European red mite overwinters in the egg stage on twigs and branches. The red orange eggs have a long spike that is visible with a hand lens. Eggs hatch in early spring when the walnuts leaf out. Immature mites are bright red; adult females have a brick red, globular body with four rows of long, curved hairs arising from white dorsal spots. Newly molted mites may appear greenish. Adult males are brownish and smaller than the females. European red mites produce little or no webbing.

Usually red mite numbers build slowly during spring and do not become damaging until summer. They have multiple generations each season.

DAMAGE

European red mites feed on the cell contents of leaf tissue. Initially, the feeding causes light stippling of the leaves. Prolonged feeding by high numbers of mites gradually gives leaves a bronzed appearance. Feeding by European red mite does not result in leaf drop, as does feeding by web-spinning mites, but severe repeated bronzing of leaves for several years can reduce nut yields significantly. Damage by European red mite is generally rare, but damage is more common in cooler coastal areas than in hot, inland orchards.

MANAGEMENT

European red mite can serve as a food source for predatory mites early in the season and help numbers of beneficial mites develop to levels sufficient to assist in controlling web-spinning spider mites. A pesticide application is not recommended for low to moderate numbers of this mite.

Biological Control

In low numbers, the European red mite can be beneficial by providing a food source for predatory mites in spring. These predators can build to numbers that may be sufficient to control web-spinning mites, which appear later in the season. The other predators described in the section on web-spinning mites also attack European red mite.

Organically Acceptable Methods

Biological control and sprays of narrow range oils can be used in an organically certified crop. Caution should be taken when applying oils in walnuts to avoid injuring trees (see narrow range oil comments in the table below).

Monitoring and Treatment Decisions

Look for European red mites during the dormant period by examining leaf and growth scars on twigs for clusters of red eggs. To combine monitoring for European red mites and other pests see DORMANT MONITORING. A dilute, delayed-dormant oil spray may aid in the control of European red mite. (Do not apply oils to walnut during dormant season.)

During spring, look for buildup of European red mite numbers and stippling or bronzing on leaves, especially in the shady, central parts of trees. You can check for European red mites when sampling for web-spinning mites. Because damage by this mite is rare, no damage threshold levels are available to determine when to treat. Avoid spraying low to moderate levels of European red mites because they can be important in maintaining predators of other mites.

Common name (Example trade name)	Amount to use** (conc.)	(dilute)	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.

Oils are not recommended for use during the dormant season on walnut trees.

Common name (Example trade name)	Amount to use**		REI‡ (hours)	PHI‡ (days)
	(conc.)	(dilute)		
A. NARROW RANGE OIL# MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: Provides short-term control. Must be applied in a dilute application of at least 300 gal/acre. In most areas, oils can be applied to walnuts during the delayed-dormant period (as buds begin to swell) and in summer. Do not apply after husk split. However to avoid injury, the trees must not have suffered from a lack of adequate soil moisture or other stressing factor (insects, disease damage, etc.) at any time during the year and the temperature must not exceed 90°F at or shortly after time of application. If in doubt, check with your farm advisor. In any case, do not apply oils to walnuts during the dormant season or between bud break and shoot elongation. Check with certifier to determine which products are organically acceptable.	—	4 gal	4	0
B. CYFLUMETOFEN (Nealta) MODE-OF-ACTION GROUP NUMBER ¹ : 25 COMMENTS: To prevent resistance, do not make more than one Nealta application before using an effective miticide with a different mode of action.	13.7 fl oz	—	12	7
C. FENBUTATIN-OXIDE* (Vendex 50WP) MODE-OF-ACTION GROUP NUMBER ¹ : 12B COMMENTS: Do not apply more than twice per season.	2 lb	0.5 lb	48	14
D. BIFENAZATE (Acramite 50WS) (Vigilant 4SC) MODE-OF-ACTION GROUP NUMBER ¹ : 20D COMMENTS: Do not apply more than once per season.	0.75–1 lb 16–24 fl oz	— —	12 12	14 14
E. CLOFENTEZINE (Apollo SC) MODE-OF-ACTION GROUP NUMBER ¹ : 10A COMMENTS: Is effective against mites that are resistant to propargite. Apply after sampling indicates pest mites are increasing <i>but before significant damage is present</i> . Kills eggs and young larval stages. Good coverage is a must; use a minimum of 50 gal water/acre for concentrate sprays and a maximum of 400 gal water/acre for dilute. To delay development of resistance, use only once per season.	2–4 oz	0.5–1 oz	12	30
F. HEXYTHIAZOX (Onager) MODE-OF-ACTION GROUP NUMBER ¹ : 10A COMMENTS: Do not apply more than once per year.	12–24 oz	—	12	7
G. ABAMECTIN* (Agri-Mek SC) MODE-OF-ACTION GROUP NUMBER ¹ : 6 COMMENTS: Use in combination with a horticultural spray oil at a minimum of 1 gal/acre. Is effective against mites that are resistant to propargite. Apply after sampling indicates pest mites are increasing, <i>but before significant damage is present</i> . A locally systemic material that is most effective if applied before July when foliage is still young and tender enough to absorb it. To delay development of resistance, use only once per season. Certain formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations. Regulations affect use for the San Joaquin Valley from May 1 to October 31, 2019. Review the Department of Pesticide Regulation's updated fact sheet.	2.25–4.25 fl oz	0.5–1 fl oz	12	21
H. PROPARGITE* (Omite 30WS) MODE-OF-ACTION GROUP NUMBER ¹ : 12C COMMENTS: Propargite cannot be used more than twice per season, nor can animals be grazed on vegetation under treated trees. Propargite should never be used within 14 days before or after the application of any oil, or phytotoxicity may occur. These rates are lower than the manufacturer's label rate.	4–6 lb	1.5 lb	See label	21
I. ETOXAZOLE (Zeal) MODE-OF-ACTION GROUP NUMBER ¹ : 25 COMMENTS: Kills eggs and larval stages. Best used when mite numbers are low.	2–3 oz	—	12	28

Common name (Example trade name)	Amount to use**		REI‡ (hours)	PHI‡ (days)
	(conc.)	(dilute)		

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 (un = unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at <http://irac-online.org/>.

** For concentrate application, use the amount given in 80 to 100 gal water/acre, or lower if the label allows; for dilute application, amount is per 100 gal water to be applied in 300 to 500 gal water/acre, according to label.

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

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

Acceptable for use on organically grown crops.

FALL WEBWORM (7/17)

Scientific Name: *Hyphantria cunea*

DESCRIPTION OF THE PEST

Larvae of the fall webworm are pale brown or gray caterpillars. Their bodies are covered with long white hairs arising from black and orange spots. Fall webworms spend the winter as pupae. Moths emerge in late spring and lay eggs that hatch into caterpillars in late summer. There is one generation each year.

DAMAGE

From July to September, fall webworm caterpillars can be found forming silken tents and skeletonizing leaves, leaving behind only leaf veins. The silken tents are often filled with fecal pellets and cast larval skins.

MANAGEMENT

On small trees, infested twigs may be cut out and destroyed. Insecticide sprays applied for other pests often keep these leaf-eating caterpillars in check. Monitor by checking for hatched larvae. If insecticide sprays are required (high webworm numbers are found), generally all that is necessary are localized sprays on individual trees applied when evidence of caterpillars is first observed. Spray must penetrate silken tents for effective control. Most insecticides that are effective against codling moth and navel orangeworm are also effective on fall webworm.

Organically Acceptable Methods

Sprays of *Bacillus thuringiensis* are acceptable for use in an organically certified crop.

Common name (Example trade name)	Amount to use	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. CHLORANTRANILIPROLE
(Altacor)
MODE-OF-ACTION GROUP NUMBER ¹ : 28
COMMENTS: Larvicide. Webworm damage is typically limited; only apply insecticide if webworm numbers are high. Do not apply more than 0.2 lb a.i. (9 oz)/acre per year or make more than four applications per year. To reduce the development of resistance do not make more than three consecutive applications of any group 28 insecticides (anthranilic diamide) per generation per season. | 3–4.5 oz | 4 | 10 |
| B. <i>BACILLUS THURINGIENSIS</i> ssp. <i>KURSTAKI</i> [#]
(various products)
MODE-OF-ACTION GROUP NUMBER ¹ : 11A
COMMENTS: Most effective on small caterpillars. Does not kill natural enemies. Webworm damage is typically limited; only apply insecticide if webworm numbers are high. | Label rates | 4 | 0 |
- 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/>.
- [‡] 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 these two intervals is the minimum time that must elapse before harvest may occur.
- [#] Acceptable for use on organically grown crops.

FALSE CHINCH BUG (7/17)

Scientific Name: *Nysius raphanus*

DESCRIPTION OF THE PEST

The false chinch bug is an occasional pest of young walnut orchards. It hibernates as an adult and moves in late winter to preferred weeds, primarily mustard family weeds such as London rocket, shepherd's purse, and common peppergrass, where it stays to lay eggs in early spring. Nymphs are dull gray or brownish red and collect in great numbers on the host plants.

DAMAGE

When weed hosts dry up in late spring, chinch bugs move into orchard trees where they may kill new foliage. This damage can occur within hours because the nymphs apparently inject a toxin while feeding. The leaves dry up and are covered with fecal spots. Damage may be substantial on trees that are 1 to 3 years old. Several generations are produced each year, but damage in orchards usually occurs only in spring.

MANAGEMENT

- Where damage has occurred, control weed hosts in and adjacent to the orchard to prevent populations from developing in future years.
- Begin checking weed hosts for false chinch bug in late February and early March, especially in years when moisture is abundant.
- Mowing and discing cover crops before walnut trees begin to leaf out prevents false chinch bug development and migration.
- If potentially harmful numbers are found on weeds or cover crops after walnut trees have leafed out, consider spraying the weeds or cover crop with a broad-spectrum insecticide, such as a pyrethroid; avoid mowing or discing at this time to prevent migration to walnut foliage.
- If nymphs are found on trees, apply a broad-spectrum insecticide, such as a pyrethroid.

Common name (Example trade name)	Amount to use	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. LAMBDA-CYHALOTHRIN* (Warrior II with Zeon) MODE-OF-ACTION GROUP NUMBER ¹ : 3A COMMENTS: Larvicide.	1.28–2.56 fl oz	24	14
B. BIFENTHRIN* (Brigade WSB) MODE-OF-ACTION GROUP NUMBER ¹ : 3A	8–32 oz	12	7

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/>.

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

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

— Not recommended or not on label.

FROSTED SCALE AND EUROPEAN FRUIT LECANIUM

(7/17)

Scientific Names: Frosted scale: *Parthenolecanium prunosum*
European fruit lecanium: *Parthenolecanium corni*

DESCRIPTION OF THE PESTS

The frosted scale is the most important soft scale pest of walnuts. This scale has one generation per year. It overwinters as a nymph on twigs and small branches. In spring it grows rapidly, becomes convex, forms a frostlike waxy cover. It is only during this period that frosted scale can be easily distinguished from European fruit lecanium. In late spring females lay many eggs, which fill the entire space beneath their cover, and die after egg production. The white waxy substance weathers away, leaving oval dark brown covers that may be present for a year or more.

Newly hatched nymphs, or crawlers, emerge from beneath the scale cover from late May through June and settle mostly on the underside of leaves. Here they feed for the rest of the summer. In fall, the nymphs molt and move back to twigs.

The European fruit lecanium has essentially the same life cycle. The immature stages closely resemble those of the frosted scale, but the adults do not form the thick, frostlike cover in spring. Instead, the cover is domed, shiny brown, and about 0.25 inch (6 mm) in diameter with several ridges along the back.

DAMAGE

Soft scales suck plant juices from leaves and twigs. Low to moderate numbers apparently are not damaging, but heavy numbers reduce terminal growth and vigor, resulting in smaller nuts and poor kernel quality. Soft scales, such as frosted scale and European fruit lecanium, can secrete large amounts of honeydew that cover nuts and favor the growth of sooty mold, increasing the chances for sunburn damage.

MANAGEMENT

Parasites play an important role in controlling these soft scales. If this natural control is disrupted by adverse weather or by insecticides applied for other pests, a pesticide application may be required.

Biological Control

The most important of the parasitic wasps that attack these soft scales are *Coccophagus*, *Encyrtus*, and *Metaphycus* spp. The *Metaphycus* wasps produce several generations a year, compared with one generation of the scale, and they parasitize all stages of the frosted scale except the eggs. Parasitized nymphs are almost black and have convex covers; unparasitized nymphs are flat and opaque. Several parasites commonly emerge from a single parasitized adult scale, leaving a perforated cover.

Organically Acceptable Methods

Biological control and sprays of narrow range oils can be used in an organically certified crop. Caution should be taken when applying oils in walnuts to avoid injuring trees (see narrow range oil comments in the table below).

Monitoring and Treatment Decisions

Monitor scales during the dormant period. For details on how to monitor these scales with other pests see DORMANT MONITORING. High numbers of soft scales often result from the use of pesticides that are disruptive to parasites and predators. If a high degree of parasitization is observed, either do not apply insecticides or delay insecticide applications until after crawlers are detected in late spring.

During the dormant period, examine the previous season's growth on randomly selected trees throughout the orchard. If you find more than five nymphs per foot of last year's wood throughout the orchard and parasitism is not significant, apply an insecticide. Apply during the delayed-dormant period before rapid scale growth begins in early spring. Insecticides applied to crawlers (spring) or first-instar scales on leaves (summer) are also effective. Place double-sided sticky tape near adult scales in early spring (mid- to late April) to monitor for crawler emergence and time treatments.

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.

Oils are not recommended for use during the dormant season on walnut trees and use with caution during the delayed dormant period.

A. PYRIPROXYFEN (Seize 35WP) MODE-OF-ACTION GROUP NUMBER ¹ : 7C COMMENTS: During the growing season, a nonionic surfactant may be added to increase efficiency. Apply concentrate applications in a minimum of 100 gal water/acre.	4–5 oz	12	21
B. BUPROFEZIN (Centaur WDG) MODE-OF-ACTION GROUP NUMBER ¹ : 16	34.5–46 oz	12	60
C. NARROW RANGE OIL# MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: Moderately effective on these scales during the delayed dormant period. Apply only after buds begin to swell as a dilute application in at least 300 gal/acre. An application in summer will suppress low to moderate populations. In most areas, oils can be applied to walnuts during the delayed dormant period (as buds begin to swell) and in summer. Do not apply after husk split. However to avoid injury, the trees must not have suffered from a lack of adequate soil moisture or other stressing factor (insects, disease damage, etc.) at any time during the year and the temperature must not exceed 90°F at or shortly after time of application. If in doubt, check with your farm advisor. In any case, do not apply oils to walnuts during the dormant season or between bud break and shoot elongation. Check with certifier to determine which products are organically acceptable.	Label rates	4	0

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/>.

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

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

Acceptable for use on organically grown crops.

FRUITTREE LEAFROLLER (7/17)

Scientific Name: *Archips argyrospila*

DESCRIPTION OF THE PEST

The fruittree leafroller overwinters in the egg stage on limbs. The eggs are laid in masses on limbs and twigs and are covered with a gray secretion that turns white upon aging. Eggs hatch in early spring. Larvae are green with black heads and are about 1 inch long when fully grown. The intensity of the green color varies from a light green in young larvae to a darker green as they mature.

Adult moths emerge in June or July and deposit overwintering eggs. Adult moths are about 0.5 inch (12 mm) long, with rusty brown wings marked with areas of white and gold. When at rest the adults appear bell shaped and have dark brown bands running at oblique angles across their wings. The wings are mottled with gold and white flecks. There is one generation each year.

DAMAGE

Larvae may enter young walnuts and devour the kernel. By May, the damaged nuts are dry and collapsed with large slotlike holes. The number of nuts attacked is usually insignificant and rarely requires control measures.

MANAGEMENT

No controls are recommended. However, first-generation codling moth treatment will kill fruittree leafroller caterpillars.

ITALIAN PEAR SCALE (7/17)

Scientific Names: *Epidiaspis leperii*

DESCRIPTION OF THE PEST

Italian pear scale overwinters mostly as a mature scale. The cover is circular, about 0.06 inch (1.5 mm) in diameter, and light gray, with a brown, slightly off-center peak. Underneath the covering, the female's body is reddish, purple, or pink, a trait that helps distinguish the Italian pear scale from other armored scales found in walnut orchards. The scale is hidden under moss and lichens and cannot survive without this natural shelter.

DAMAGE

This scale does not attack nuts, but feeds directly on the wood of the tree, affecting tree vigor. Light to moderate infestations do not seem to harm trees, but heavy scale aggregations may cause the bark to crack and can reduce tree vigor. Such large numbers are seldom encountered, however, in orchards that are regularly treated for blight.

MANAGEMENT

Look for Italian pear scale during the dormant period when you monitor other scale insects. Pay particular attention to scaffold limbs and branches that are covered with lichens. Scrape the lichens away to look for the gray scale covers and the pink scale bodies beneath. To monitor Italian pear scale with other pests, see DORMANT MONITORING. The key to managing Italian pear scales is to control the lichens. Regular blight treatments in spring will provide control of moss and lichens.

Organically Acceptable Methods

Remove moss and lichen or treat them with Bordeaux mixture when Italian pear scale is a problem. Not all copper compounds are organically acceptable, so be sure to check the label of the product used.

Treatment Decisions

Generally, delayed-dormant sprays applied for other scales control Italian pear scale and blight sprays control the moss and lichens. If moss and lichen are present, add a pesticide such as Bordeaux mixture or hydrated lime to

the delayed-dormant spray to kill them. For information on making a Bordeaux mixture, see UC IPM *Pest Note: Bordeaux Mixture*, ANR Publication 7481 (available online).

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.

Oils are not recommended for use during the dormant season on walnut trees and use with caution during the delayed dormant period.

- | | | | | |
|----|----------------------|-------------|-----------|---|
| A. | BORDEAUX#
8-5-100 | Label rates | See label | — |
|----|----------------------|-------------|-----------|---|
- MODE-OF-ACTION GROUP NAME (NUMBER¹): Multi-site contact (M1)
 COMMENTS: Adding 0.5 gal summer oil emulsion can reduce phytotoxicity. The objective is to apply 4 lb metallic copper and 5 lb of calcium hydroxide in 100 gal water/acre. If using basic copper sulfate, which is 50% copper, apply 8 lb/acre. For hydrated copper sulfate, which is 25% copper, use 16 lb/acre. Not all copper compounds are approved for use in organic production; be sure to check individual products. For information on making Bordeaux mixtures, see UC IPM *Pest Note: Bordeaux Mixture*, ANR Publication 7481 (available online).

NAVEL ORANGEWORM (7/17)

Scientific Name: *Amyelois transitella*

DESCRIPTION OF THE PEST

Navel orangeworm overwinters as larvae inside mummy nuts on the tree and in trash nuts left on the ground and around hullers. Pupation begins in March and may continue through early May. Moths of the overwintered brood start emerging in April, and peak emergence usually occurs from late April to mid-May, depending on season and locality. Females of the overwintered generation lay their eggs singly on mummy nuts, codling moth-infested nuts, or blighted nuts. The first generation, and most of the second, is completed in these nuts. In late summer, some of the second-generation larvae infest the new crop as the husks begin to split. Females emerging at this time prefer to lay eggs on the opened husk or on the exposed nutshell. In later-harvested varieties, nuts may also be exposed to infestation by third generation larvae.

The moth is silver gray with irregular black patches on the forewings. The snoutlike palps in front of the head help distinguish this moth from the codling moth.

Eggs of the navel orangeworm are opaque white when first laid. After about a day, they turn pink, then reddish orange.

The navel orangeworm larva has a pair of brown, crescent-shaped marks on the second segment behind the head. These marks are absent on codling moth larvae. After hatching, the tiny caterpillars enter nuts through the soft tissue at the stem end and do not emerge until they are adults. Several larvae may infest one nut and produce substantial webbing. In contrast, only a single codling moth is found in each nut, and codling moth larvae produce little webbing.

DAMAGE

Nuts infested with navel orangeworm are unmarketable because the larvae feed on the nutmeats and produce webbing and frass. Navel orangeworm do not damage sound walnuts until the husks begin to split. Nuts infested only by the navel orangeworm may show no external signs of webbing or frass, but shells of heavily infested nuts will have an oily appearance.

MANAGEMENT

Sanitation, reducing damaged nuts, and prompt harvest are the most reliable approaches to avoid navel orangeworm damage. Use sanitation practices to reduce overwintering and development sites. Good control of codling moth, walnut blight, and sunburn is also essential because navel orangeworm attacks only damaged walnuts prior to husk split. Harvest as soon as nuts are ready to limit egg laying and infestation by larvae.

Biological Control

Two wasps that parasitize navel orangeworm, *Copidosoma* (= *Pentalitomastix*) *plethorica* and *Goniozus legneri*, are established in many walnut and almond growing areas and account for some larval mortality. A ground cover maintained during wet winters aids in decomposing trash nuts by molds and other microorganisms.

Cultural Control

A good sanitation program is essential for navel orangeworm management.

1. Reduce the number of overwintering navel orangeworm by removing remaining nuts from trees and flailing them and destroying all crop waste containing nuts before mid-March. This includes removing all mummy nuts found in the trees during the dormant period, all windfall and huller waste materials found in the field, and all waste materials cleaned up from bins, hulling and drying equipment, and buildings after harvest and dehydration.
2. Reduce damaged nuts that allow entry of navel orangeworm and increase in their numbers during the season by controlling walnut blight, sunburn, and codling moth, especially the second generation.
3. Harvest as early as possible. Use of ethephon to advance husk splitting is advantageous, particularly during heavy worm populations or prolonged dry falls. (For more information, see USING ETHEPHON.)
4. Dry nuts immediately and either fumigate on the farm, if stored, or ship immediately to a facility for fumigation.

Organically Acceptable Methods

Use biological and cultural controls in an organically certified crop.

Monitoring and Treatment Decisions

Insecticide treatments may not be necessary in most orchards where a good cultural program has been carried out, depending on proximity to external sources of navel orangeworm.

Monitor once husk split has begun. Examine split nuts and nuts on the ground for egg laying from the second and third generations or from moths that may be immigrating into the orchard. If egg laying is occurring at husk split, consider an insecticide treatment and harvest promptly to avoid damage.

At harvest, collect and crack out 1,000 nuts to assess damage, properly identify the pest responsible for the damage and to plan for next year. In harvest samples, it is easy to identify codling moth damage from navel orangeworm damage when the worms are present. Navel orangeworm has a brown crescent-shaped marking behind the head capsule on both sides of the first thoracic segment; this mark is absent in codling moth larvae. There can be multiple navel orangeworm larvae but only one codling moth larva per nut. If the worm is not present, look at the damage: navel orangeworm leaves behind more webbing and frass. However, navel orangeworm frequently infest nuts that were previously infested by codling moth, so if navel orangeworm is present, it doesn't mean codling moth wasn't previously there.

Common name (Example trade name)	Amount to use** (conc.)	(dilute)	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.

THIRD FLIGHT AND THIRD GENERATION LARVAE

A. BIFENTHRIN* (Brigade WSB) MODE-OF-ACTION GROUP NUMBER ¹ : 3A COMMENTS: Provides approximately 21 to 28 days of residual protection at the high label rate.	8–32 oz	—	12	21
B. LAMBDA-CYHALOTHRIN* (Warrior II with Zeon) MODE-OF-ACTION GROUP NUMBER ¹ : 3A COMMENTS: Larvicide.	2.56 fl oz	—	24	14
C. METHOXYFENOZIDE/SPINETORAM (Intrepid Edge) MODE-OF-ACTION GROUP NUMBER ¹ : 18 COMMENTS: Apply at the beginning of egg hatch, which is earlier than organophosphate or carbamate insecticide timings.	10–18 fl oz	—	4	7
D. METHOXYFENOZIDE (Intrepid 2F) MODE-OF-ACTION GROUP NUMBER ¹ : 18 COMMENTS: An insect growth regulator that provides 10 to 18 days of residual protection depending on the rate of application and nut expansion. Kills young larvae but does not kill adult moths. It is a reduced risk insecticide that has little or no effect on beneficial insects and mites. Spray coverage is extremely important. Do not apply to large trees unless adequate spray coverage can be verified. Use no less than 100 gal water/acre for ground applications. Sprayer speed should not exceed 1.5 mph. The use of Latron B-1956, CS-7, or similar spreader-sticker is highly recommended. Apply at the beginning of egg hatch, which is earlier than organophosphate or carbamate insecticide timings.	8–16 fl oz	—	4	7
E. CHLORANTRANILIPROLE (Altacor) MODE-OF-ACTION GROUP NUMBER ¹ : 28 COMMENTS: Larvicide. The best timing is to apply before egg hatch. Do not make more than four applications per year. To reduce the development of resistance do not make more than three consecutive applications of any group 28 insecticides (anthranilic diamide) per generation per season.	3–4.5 oz	—	4	10

F.	SPINETORAM (Delegate WG) MODE-OF-ACTION GROUP NUMBER ¹ : 5	6–7 oz	1.5–1.75 oz	4	1
G.	PHOSMET (Imidan 70W) MODE-OF-ACTION GROUP NUMBER ¹ : 1B COMMENTS: Do not apply after husk split. Buffer to a pH of 5.5 to 6.0.	5 lb	1–2 lb	168 (7 days)	28
H.	ESFENVALERATE* (Asana XL) MODE-OF-ACTION GROUP NUMBER ¹ : 3A COMMENTS: This is a broad-spectrum pesticide that is harmful to natural enemies at higher rates and can cause outbreaks of aphids and mites.	9.6–19.2 fl oz	4 fl oz	12	21
I.	CARBARYL* (Sevin) MODE-OF-ACTION GROUP NUMBER ¹ : 1A COMMENTS: Carbaryl causes mites to reproduce more rapidly, so monitor for the mites if this is used. This insecticide is best used later in the season. Highly toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.	Label rates	—	12	14

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/>.

** For concentrate application, use the amount given in 80 to 100 gal water/acre, or lower if the label allows; for dilute application, amount is per 100 gal water to be applied in 300 to 500 gal water/acre, according to label.

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

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

— Not recommended or not on label.

PACIFIC FLATHEADED BORER (7/17)

Scientific Name: *Chrysobothris mali*

DESCRIPTION OF THE PEST

Pacific flatheaded borer adults are generally present in May and June. When spring months are warm, borers may be seen as early as March or early April. The adult beetle has a dark bronze body with coppery spots on the wing covers and is about 0.4 inch (10 mm) long. A full-grown larva is light colored, with a prominent, flat enlargement of the body just behind the head. There is one generation each year.

Related flatheaded borers with similar habits have also been found to infest walnut in California. They include *Chrysobothris analis* (a relatively rare invasive species); *Chrysobothris wintu* (medium abundance); and *Dicerca horni* (abundant). The latter species is the largest and has two extended horn-like tips on the end of its wing covers that are described by its Latin name (*Di cerca* = two horns).

DAMAGE

The Pacific flatheaded borer is attracted to diseased (e.g., *Phytophthora*, *Armillaria*, etc.) or injured limbs, such as those affected by sunburn, scale insects, or major pruning cuts, where it lays eggs. When larvae hatch they excavate large caverns just beneath the bark; just before pupating they bore tunnels deep into the wood. Excavations are usually filled with finely powdered sawdust. Feeding by Pacific flatheaded borers may cause a portion of the bark to die, and may girdle and kill young trees. Infested branches on older trees often die. Dead, brown leaves remain on these branches during summer and fall.

MANAGEMENT

- Flatheaded borers often invade sunburned areas on the trunk of newly planted first-year trees. At planting time protect the trunks of newly planted trees from sunburn and flatheaded borer invasions by painting them with interior, white latex paint by itself or mixed with water. Paint the tree trunk above and 1 inch below the soil line. Repaint if soil settling occurs.
- In older trees the best way to avoid infestations is to keep your trees sound and vigorous.
- Prune out all badly infested wood, and burn or remove it from the orchard before the growing season starts.
- Do not apply pesticides for this insect.

REDHUMPED CATERPILLAR (7/17)

Scientific Name: *Schizura concinna*

DESCRIPTION OF THE PEST

The redhumped caterpillar is easily recognized because of its striking appearance: the main body color is yellow and is marked by longitudinal reddish and white stripes. The head is bright red, and the fourth abdominal segment is red and enlarged. Redhumped caterpillars pass the winter as full-grown larvae in cocoons on the ground. In early summer, moths lay egg masses on the under surface of leaves. Eggs hatch into larvae that begin feeding on leaves. There are at least three generations each year.

DAMAGE

Redhumped caterpillars skeletonize leaves, leaving behind only leaf veins. They form no webbing on the leaves.

MANAGEMENT

A number of natural enemies attack redhumped caterpillar and often prevent it from becoming a destructive pest. Isolated infestations on small trees may be pruned out and destroyed. Occasional insecticide applications may be required on young trees.

Biological Control

Among the parasites that help prevent redhumped caterpillars from becoming destructive pests are two parasitic wasps, *Hyposoter fugitivus* and a species of *Apanteles*. The larvae of both parasites develop inside the caterpillar and pupate on the leaf surface in groups of silken cocoons. General predators include spiders, lacewings, bigeyed bugs, and damsel bugs.

Organically Acceptable Methods

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

Monitoring and Treatment Decisions

Monitor for redhumped caterpillar during nut and shoot development.

Generally, control of redhumped caterpillar is only necessary on young trees. If 80 to 90% of the larvae in the second brood are parasitized, no insecticide application is necessary. However, if no parasitism is observed and four or more colonies are found per tree, an insecticide application is warranted.

Insecticide sprays applied for other pests often keep these leaf-eating caterpillars in check. If insecticide applications are required, all that is generally necessary are localized sprays with a handgun on individual trees when evidence of caterpillars is first observed.

Common name (Example trade name)	Amount to use	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. <i>BACILLUS THURINGIENSIS</i> ssp. <i>KURSTAKI</i> # (various products) MODE-OF-ACTION GROUP NUMBER ¹ : 11A COMMENTS: Most effective on small caterpillars. Does not destroy natural enemies.	Label rates	4	0
B. CHLORANTRANILIPROLE (Altacor) MODE-OF-ACTION GROUP NUMBER ¹ : 28 COMMENTS: Larvicide. Do not apply more than 0.2 lb a.i. (9 oz)/acre per year. Do not make more than four applications per year. To reduce the development of resistance do not make more than three consecutive applications of any group 28 insecticides (anthranilic diamide) per generation per season.	3–4.5 oz	4	10

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)
<p>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/.</p> <p>‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.</p> <p># Acceptable for use on organically grown crops.</p>			

SAN JOSE SCALE (7/17)

Scientific Name: *Diaspidiotus (=Quadraspidotus) perniciosus*

DESCRIPTION OF THE PEST

Female San Jose scale give birth to living young that emerge from under the edge of the scale covering. These tiny yellow crawlers wander in a random fashion until they find a suitable place to settle. Immediately upon settling, the crawlers insert their mouthparts into the host plant and begin feeding and secreting a white waxy material (white cap stage); eventually the waxy covering turns black and is known as the black cap stage.

San Jose scales overwinter predominantly in the black cap stage, although in mild years some adult mated females may also survive. In late January, these nymphs resume their growth. Immature male and female scales are indistinguishable until the first molt. At this time, the male scale covering begins to elongate, while the female's remains circular. Males molt a total of four times. Following the final molt, adult male scales emerge from the scale covering as tiny, yellow winged insects. They mate with the females, who remain under the scale covering. After about two months, crawlers begin to emerge from the females, usually in April; peak emergence is generally in early May.

There are usually four generations a year. Summer generations overlap and crawlers are present throughout summer and fall.

DAMAGE

Infested trees look water stressed, and fruiting wood encrusted with scale insects may die back. The infested bark often cracks and dies, and heavily-infested scaffold limbs and branches die within 1 to 2 years.

MANAGEMENT

In many orchards, San Jose scale is kept below damaging levels by natural enemies. High numbers of this scale often result from the use of chemicals that are disruptive to parasites and predators; generally San Jose scale is sporadically seen in Northern California. Where damaging populations do develop, the preferred method of control is to target the sensitive crawler stage with an oil spray during the growing season.

Biological Control

Many parasites and predators have been observed feeding on San Jose scale, including most of those listed for walnut scale. In undisturbed situations, these beneficials play a significant role in keeping San Jose scale numbers below economic levels. However, in situations where heavy numbers exist, these parasites and predators may not respond before severe damage occurs, so sprays may be needed.

Organically Acceptable Methods

Biological control and sprays of certain narrow range oils can be used in an organically certified crop. Caution should be taken when applying oils in walnuts to avoid injuring trees (see narrow range oil comments in the table below).

Monitoring and Treatment Decisions

Monitor scales in the dormant period. For details on how to monitor San Jose scale with other pests, see DORMANT MONITORING. Examine scaffold limbs, branches, and prunings for the characteristic black caps and old scale bodies.

Apply an insecticide when there are more than an average of 5 black caps per foot of last year's wood and less than 90% parasitism. If numbers surpass the threshold, consider spraying during delayed dormancy to achieve the best coverage and control and to avoid killing natural enemies.

Insect growth regulators are good choices in an IPM program because they do not cause water quality problems. Pyriproxyfen (Seize) and buprofezin (Centaur) may be applied during dormancy (without oil) and during delayed dormancy.

Common name (Example trade name)	Amount to use	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.

Note: Oils are not recommended for use during the dormant season on walnut trees and should be applied with caution during the delayed dormant period. Do not apply between bud break and shoot elongation because they can injure the tree.

A.	PYRIPROXYFEN (Seize 35WP) MODE-OF-ACTION GROUP NUMBER ¹ : 7C COMMENTS: Apply concentrate applications in a minimum of 100 gal water/acre. Timing of this product can be adjusted to provide some early-season control of codling moth.	4–5oz	12	21
B.	BUPROFEZIN (Centaur WDG) MODE-OF-ACTION GROUP NUMBER ¹ : COMMENTS:	34.5–46 oz	12	60
C.	NARROW RANGE OIL# MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: An option primarily for organic growers; oil is destructive to the walnut aphid parasite, <i>Trioxys pallidus</i> . Apply as a dilute application in at least 300 gal/acre if applied in the delayed-dormant period. An application in summer will suppress low to moderate numbers. In most areas, oils can be applied in summer. However to avoid injury, the trees must not have suffered from a lack of adequate soil moisture or other stressing factor (insects, disease damage, etc.) at any time during the year and the temperature must not exceed 90°F at or shortly after time of application. Do not apply after husk split. If in doubt, check with your farm advisor. In any case, do not apply oils to walnuts during the dormant season or between bud break and shoot elongation. Check with certifier to determine which products are organically acceptable.	Label rates	4	0

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/>.

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

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

Acceptable for use on organically grown crops.

SOUTHERN FIRE ANT (7/17)

Scientific Name: *Solenopsis xyloni*

DESCRIPTION OF THE PEST

The southern fire ant is 0.07 to 0.25 inch (1.7–6 mm) long, has an amber head and thorax with a black abdomen. It has a painful sting that causes visible swelling. Anthills often appear as small diffuse mounds or patches of loose soil.

Nests in orchards with low-volume irrigation tend to be located around the edges of the wetted areas. In flood-irrigated orchards with heavy soils, nests tend to be concentrated on the berms. Where lighter soils are present, nests are located both on the berms and in the middles. Frequently, southern fire ants nests are associated with clumps of weeds, such as nutsedge or spotted spurge.

Activity of these ant pests peaks in the morning and again just before sunset. Do not confuse southern fire ant with the pyramid ant, which is a beneficial species that is similar in size but active during mid-day and found in sandy, weed-free areas. Fire ants vigorously swarm from the nest entrance when disturbed; nondamaging species, such as the pyramid ant, do not.

DAMAGE

The southern fire ant has a wider distribution and generally causes more damage than the pavement ant. Ants are more prevalent in drip- or sprinkler-irrigated orchards than flood irrigated orchards. Ants feed on other hosts and are principally a problem after walnuts are on the ground; nut damage increases in relation to the length of time they are on the ground. They enter nuts through the soft tissue at the stem end or through a codling moth injury.

MANAGEMENT

If prolonged nut drop occurs and ants have been a problem in the past, a bait application may be needed in August.

Common name (Example trade name)	Amount to use**	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. PYRIPROXYFEN (Esteem Ant Bait) MODE-OF-ACTION GROUP NUMBER ¹ : 7C	Label rates	12	1
B. ABAMECTIN (Clinch Ant Bait) MODE-OF-ACTION GROUP NUMBER ¹ : 6	Label rates	12	0
C. S-METHOPRENE (Extinguish Professional Fire Ant Bait) MODE-OF-ACTION GROUP NUMBER ¹ : 7A	Label rates	4	0
D. METAFLUMIZONE (Altrevin Fire Ant Bait) MODE-OF-ACTION GROUP NUMBER ¹ : 22B	Label rates	12	5

** For concentrate application, use the amount given in 80 to 100 gal water/acre, or lower if the label allows; for dilute application, amount is per 100 gal water to be applied in 300 to 500 gal water/acre, according to label.

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

WALNUT BLISTER MITE (7/17)

Scientific Name: *Eriophyes erinea*

DESCRIPTION OF THE PEST

The walnut blister mite occasionally occurs in walnut orchards. Adult mites are very small and cannot be seen without a 14 to 20X hand lens. They have a white, slender, striated body with a few long hairs. Immature forms resemble adults but are smaller. Eggs are spherical and pearly white.

DAMAGE

Blister mite feeds on the lower surface of leaflets, causing characteristic blister-like swellings on the upper surface of leaflets. It occurs in yellow to orange felty masses in depressions on the underside of blistered leaves. Later in the season, these areas turn brown. The blisters can be large and unsightly, but damage caused by the walnut blister mite is primarily aesthetic.

MANAGEMENT

Blister mites do not cause economic damage to walnut trees and no control is necessary.

WALNUT HUSK FLY (7/17)

Scientific Name: *Rhagoletis completa*

DESCRIPTION OF THE PEST

The adult walnut husk fly is about the size of a housefly and very colorful. A yellow spot just below the area where the wings are attached and a dark triangular band at the tip of the wings distinguishes the husk fly from other flies likely to be found in orchards.

Husk flies have one generation per year. They overwinter as pupae in the soil and emerge as adults from early June until early September (in coastal areas emergence can begin as early as mid-May). Peak emergence is usually from July to mid-August. The female deposits eggs in groups of about 15 below the surface of the husk. Eggs hatch into white maggots within 5 days. Older maggots are yellow with black mouthparts. After feeding on the husk for 3 to 5 weeks, mature maggots drop to the ground and burrow several inches into the soil to pupate. Most emerge as adults the following summer but some remain in the soil for 2 years or longer.

Adult female husk flies can be distinguished from males by their slightly larger size, a pointed abdomen with an ovipositor, and by the color of the first leg segment. On females, the first leg segment is straw colored, whereas on males it is brown to black. This can be readily seen with the use of a 10X hand lens.

DAMAGE

The walnut husk fly is a mid- to late season pest. It occurs in all walnut-growing areas in California. Black walnut and all cultivars of English walnut are suitable hosts for the husk fly. Some cultivars Tulare, Hartley, Serr, and Franquette are very susceptible to husk fly damage; black walnut is also a preferred host. Different cultivars differ in the time of year they are susceptible; for example, earlier damage occurs in Payne, Serr, and Hartley than in Chandler.

The first signs of an infestation are small stings caused by females depositing eggs in the husk. After hatching, the maggots feed inside the husk, turning it very soft and black. The outer skin of the husk usually remains intact, but its fleshy parts decay and stain the nutshell. These stains cannot be removed by normal bleaching procedures, and the nut is therefore unsatisfactory for in-shell sale.

A husk fly infestation early in the season (late July to mid-August) leads to shriveled and darkened kernels, increased mold growth, and lower yields. Other pests and pathogens (walnut blight and aphids) and environmental stresses (sunburn and water stress) also may cause this damage. Early walnut husk fly damage can result in a 30% loss in value of the nuts. Late infestations do less damage to the kernels but may stain the shells and make hull removal difficult.

MANAGEMENT

Not every orchard requires an insecticide application for walnut husk fly every year. When chemical treatment is needed, precise timing is critical. Correct timing is not the same in every orchard and varies depending on insecticide and monitoring method used. Husk flies are not a problem after husk split. Growers with a history of severe late damage from this pest may want to use ethephon (for more information see USING ETHEPHON) to hasten maturity and husk split.

Organically Acceptable Methods

The use of GF-120 is acceptable in organically certified orchards. The Entrust formulation of spinosad is also organically acceptable but must be mixed with an organically acceptable bait.

Monitoring and Treatment Decisions

Trapping

Use an unbaited yellow sticky trap (Pherocon AM (apple maggot) NB (no-bait)), super-charged with ammonium carbonate to attract adult flies for monitoring. Be sure **not** to use baited apple maggot traps.

1. Hang traps in the orchard by June 1, as high as possible, within an area of dense foliage on the north side of trees. If they are not hung high enough, they will not provide an accurate assessment of when the flight begins.

2. Use at least two traps per 10 acres and place the traps in orchard hot spots: large shaded trees, trees growing in damp areas or near black walnut trees, and trees that were damaged by walnut husk fly the previous season.
3. Monitor traps at least twice a week, and preferably three times a week to avoid damage before the first insecticide is applied. Each orchard must be monitored separately, with the treatment timing based on the monitoring results for that orchard.
4. Write down the numbers caught in traps each time, and keep records (PDF) of your results (example form available online).
5. Treatment timing can be based on one of three monitoring methods described below. The first two are most effective.

Using trap catches to time sprays (overall trap numbers)

- In low- to moderate-pressure orchards, spray when a sharp increase occurs in traps.
- In high-pressure orchards or if using GF-120, spray when any flies are detected rather than waiting for a sharp increase in catches.

Using trap catches to time sprays (detection of eggs in trapped females)

Recently emerged flies only require a short period of time to become sexually mature, mate, and begin laying eggs. As such, it is possible to more precisely time insecticide treatments to match the onset of egg laying by examining female flies caught on traps for the presence of eggs. This is a simple process that requires slightly more time than counting overall trap catches. Only monitor for eggs in orchards that use standard insecticide-plus-bait sprays. For orchards using GF-120, see: Using trap catches to time sprays, above.

Examine female flies caught on traps for the presence of eggs.

1. Remove all flies from the trap and place them on a dark-colored surface, which makes it easier to see the white eggs.
2. Using a hand lens, identify the female flies (light-colored first leg segment, pointed abdomen and slightly larger in size) and use a pointed object to press on the abdomen and squeeze out the contents. (This can be easily done with a blunt pencil.) If eggs are present, they are pearly white and resemble small grains of rice.
3. Apply insecticide when the first female with eggs is found. While past guidelines have stated that the treatment window is one week after egg detection, in practice trap checks (even 2 to 3 checks per week) may not be frequent enough to represent initial egg development in the female population and there is often a lag time in getting the treatments. Therefore, treat as soon as possible after eggs are detected to minimize infestation.

Monitoring for stings

Monitoring for stings on nuts is the least useful method to determine treatment timing, as damage has already occurred. However, examining nuts for stings can provide indication of effectiveness of your insecticide applications. Check periodically for stings (female egg-laying punctures) once flies have begun to emerge and they are detected in traps.

- Carefully inspect at least 10 nuts on the north side of 20 trees, for a total of 200 or more nuts. Females prefer the stem end but may lay eggs anywhere on the nut. Dark juice flows from the puncture, leaving a teardrop-shaped stain.
- The presence of fresh stings, with or without trap captures or a recent insecticide application may be an indication of inadequate control.
- If treatment timing is based on sting detection, apply an insecticide at the first sting. Full cover neonicotinoids that have some ovicidal (egg-killing) activity mixed with an adulticide will provide best control (see table below).

Continued monitoring

Continue to monitor traps weekly after an insecticide application.

- If the infestation occurred early, a second spray may be necessary 3 to 4 weeks later.
- Short-residual insecticides plus bait will generally kill walnut husk fly for 7 to 10 days. With the egg development period added to this time, there is about 3 weeks of protection after an application.
- Target subsequent applications at 2 to 4 week intervals based on the efficacy of the previous spray. Clean traps the day after an application and check 3 to 4 days later. If the number of flies drops to near zero, the spray was highly effective and a longer treatment interval may be used.

- If post-treatment catches from traps placed high in the tree increase, eggs are present in the trapped females, and the spray residue of the first treatment has run out, an insecticide application will be required if harvest is more than 3 weeks away.

Before harvest, sample 100 nuts from each variety, block, or high damage area to assess damage and to plan for next year's management program. Survey areas with the highest damage as sites for next year's traps.

Insecticides

Use all insecticides with a bait except GF-120, which contains its own bait. For low- to moderate-populations, coverage is not critical; partial coverage (e.g., alternate row) or low-volume applications of bait with insecticide (or both) can be effective. However, in high population orchards with extensive previous damage, high-volume, full coverage, or multiple applications of bait with insecticide (or a combination of these approaches) may be necessary to achieve adequate control. If treatments are timed in response to sting detection, full cover neonicotinoids that have some ovicidal (egg-killing) activity mixed with an adulticide will provide partial control of eggs if applied immediately after stings are observed (see table below).

Generally a short-residual insecticide-plus-bait will kill walnut husk fly for 10 days. With the egg development period added to this time, there is about 3 weeks of protection after an application. GF-120 treatments often must be applied more frequently.

Common name (Example trade name)	Amount to use** (conc.)	(dilute)	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.

BAITS (TO BE COMBINED WITH AN INSECTICIDE BELOW)

A. MOLASSES	4 gal/100 gal spray mixture		NA	NA
B. CORN GLUTEN MEAL (NU-Lure Bait)	1–3 pt	1 pt	0	NA
C. CORN STEEP LIQUOR (Brandt Insect Bait)	Label rates	—	0	NA

COMMENTS: Baited sprays are the preferred treatment and are aimed at killing adults before eggs are laid. Baits attract flies to spray material and enhance control. If significant egg laying has occurred before treatments, however, adequate control will not be attained. Generally the residual period of the bait is about 7 to 10 days.

INSECTICIDES WITH ADULTICIDAL ACTIVITY (TO BE COMBINED WITH A BAIT ABOVE)

A. ACETAMIPRID (Assail 70WP)	2.7–3.4 oz	0.271–1 oz	12	14
MODE-OF-ACTION GROUP NUMBER ¹ : 4A COMMENTS: Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.				
B. BIFENTHRIN* (Brigade WSB)	32 oz	2–8 oz	12	21
MODE-OF-ACTION GROUP NUMBER ¹ : 3A COMMENTS: Provides approximately 21 to 28 days of residual protection at the high label rate.				
C. BETA-CYFLUTHRIN (Baythroid XL)	2.4–2.8 fl oz	—	12	14
MODE-OF-ACTION GROUP NUMBER ¹ : 3A				
D. LAMBDA-CYHALOTHRIN (Warrrior II with Zeon)	1.28–2.56 fl oz		24	14
MODE-OF-ACTION GROUP NUMBER ¹ : 3A				
E. FENPROPATHRIN (Danitol 2.4EC)	21.33 oz	2–5.33 oz	24	3
MODE-OF-ACTION GROUP NUMBER ¹ : 3A COMMENTS: Provides approximately 21 to 28 days of residual protection at the high label rate.				

Common name (Example trade name)	Amount to use**		REI# (hours)	PHI# (days)
	(conc.)	(dilute)		
F. ESFENVALERATE* (Asana XL) MODE-OF-ACTION GROUP NUMBER!: 3A	9.6–19.2 fl oz	4 oz	12	21
G. SPINETORAM (Delegate WG) MODE-OF-ACTION GROUP NUMBER!: 5	3–7 oz	0.75–1.75 oz	4	1
H. SPINOSAD (Success) MODE-OF-ACTION GROUP NUMBER!: 5 COMMENTS: When numbers are high, be sure to use high label rates and shorter treatment intervals. Buffer spray solution of either formulation so that pH is in the range of 6.0 to 8.0.	4–10 fl oz	1–2.5 fl oz	4	1
I. SPINOSAD (Entrust)# MODE-OF-ACTION GROUP NUMBER!: 5 COMMENTS: When numbers are high, be sure to use high label rates and shorter treatment intervals. For organic growers use Entrust with an organically acceptable bait. Buffer spray solution of either formulation so that pH is in the range of 6.0 to 8.0.	1.25–3 oz	0.3–0.75 oz	4	1
J. PHOSMET (Imidan 70W) MODE-OF-ACTION GROUP NUMBER!: 1B COMMENTS: Do not apply after husk split. Buffer to a pH of 5.5-6.0.	5 lb	1.25 lb	7 days	28
K. MALATHION 8 MODE-OF-ACTION GROUP NUMBER!: 1B COMMENTS: Can increase mite problems. Resistance to malathion may be present in some areas.	1.5–2.5 pt	0.4–0.625 pt	24	7

**NEONICOTINOIDS WITH OVICIDAL ACTIVITY
(TO BE COMBINED WITH A BAIT AND ADULTICIDE ABOVE IF STINGS ARE OBSERVED)**

A. IMIDACLOPRID (Admire Pro) MODE-OF-ACTION GROUP NUMBER!:4A COMMENTS: Apply as a full coverage spray tank mixed with a bait and any adulticide above (except Assail) when treatment timing is based on sting detection and ovicidal activity is desired.	Label rates	—	12	7
--	-------------	---	----	---

Review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.

B. CLOTHIANIDIN (Belay) MODE-OF-ACTION GROUP NUMBER!:4A COMMENTS: Apply as a full coverage spray tank mixed with a bait and any adulticide above (except Assail) when treatment timing is based on sting detection and ovicidal activity is desired.	3–6 fl oz	—	12	21
---	-----------	---	----	----

Review and follow the California neonicotinoid regulations effective January 1, 2024. Permissible application rates of this insecticide may be lower than label rates if applying more than one neonicotinoid active ingredients or using more than one application method in the same season.

INSECTICIDE PLUS BAIT COMBINATION (PRE-MIX)

A. SPINOSAD (GF-120 NF Naturalyte Fruit Fly Bait)#	20 fl oz	—	4	0
---	----------	---	---	---

Common name (Example trade name)	Amount to use** (conc.)	(dilute)	REI‡ (hours)	PHI‡ (days)
-------------------------------------	----------------------------	----------	-----------------	----------------

MODE-OF-ACTION GROUP NUMBER¹: 5

COMMENTS: A pre-mixed spinosad and bait formulation. Check label and organic certifying agency for organic acceptability. Start applications at first fly emergence and repeat every 7 to 14 days, shortening the interval during rainy periods and as fruit ripens. Use in 30 to 80 oz of water/acre and apply as a spot spray. Continue treatments until fly numbers begin to drop in traps or 3 weeks before harvest. May be more effective in the Central Coast than in hot areas with low humidity.

- 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/>.
- ** For concentrate application, use the amount given in 80 to 100 gal water/acre, or lower if the label allows; for dilute application, amount is per 100 gal water to be applied in 300 to 500 gal water/acre, according to label. Much lower rates of water/acre have been used with handgun applications of bait sprays.
- ‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.
- * Permit required from county agricultural commissioner for purchase or use.
- # Acceptable for use on an organically certified crop.
- NA Not applicable.

WALNUT SCALE (7/17)

Scientific Name: *Quadraspidiotus juglansregiae*

DESCRIPTION OF THE PEST

The walnut scale is often found in daisy-shaped groups that develop when male crawlers settle under the margin of the circular female cover and begin forming their elongated covers. If the circular scale covering is lifted off the female, the body underneath is yellowish and has indented margins; these two characteristics help distinguish walnut scale from other armored scales on walnuts.

The walnut scale has two generations a year in the Central Valley. It overwinters as second-instar females and males. In spring, both sexes resume development and mature at the same time. Adult males emerge from the scale covering as tiny winged insects to mate with the mature females, who remain under the scale covering. After mating, females lay eggs in May; eggs hatch in 2 to 3 days. Female crawlers move around the branches for a short time before they settle down, begin feeding, and secrete the scale cover. Male crawlers move to the margins of a female cover and settle. Initially the scale cover is white (white cap stage), but it changes to gray or brown after about a week. The first generation completes development by mid-July; females lay eggs in mid-August. These eggs hatch and the crawlers settle and molt once before winter.

DAMAGE

Armored scales suck plant juices from the inner bark by inserting their mouthparts into twigs and branches. Infested trees look water stressed, and inside fruiting wood on lateral bearing cultivars may die back when encrusted with scale insects. Extremely heavy numbers can cause the bark to crack. What is of greater economic concern is that scale insects can increase *Botryosphaeria* infection and canker development.

MANAGEMENT

Natural enemies parasitize some scale but cannot be relied on to keep walnut scale from causing damage. If scale insects are present, apply pesticides to reduce both scale and *Botryosphaeria* in orchards. Depending on the insecticide, apply either at delayed dormant (typically March in the Sacramento Valley or February in the San Joaquin Valley) or after crawlers emerge (typically May).

Biological Control

Several natural enemies can reduce the numbers of walnut scale. Two predators—the twicestabbed lady beetle, *Chilocorus orbis*, and another small beetle, *Cybocephalus californicus*—often occur in large numbers and may control low numbers of the walnut scale. Two parasitic wasps, an *Aphytis* and an *Encarsia* species, may be present in walnut orchards and parasitize this pest.

Organically Acceptable Methods

Use biological control and sprays of narrow range oils in an organically certified crop. Caution should be taken when applying oils in walnuts to avoid injuring trees (see narrow range oil comments in the table below).

Monitoring and Treatment Decisions

Start monitoring for walnut scale during the dormant season to determine the need for an insecticide application. Walnut scale monitoring can be combined with the monitoring of other pests as described in DORMANT MONITORING.

If an insecticide application becomes necessary, make it during the delayed-dormant period before shoot growth begins, especially if using certain insect growth regulators (IGRs). If a high degree of parasitization is observed or when using an insecticide that must have foliage present, consider delaying applications until after crawlers emerge in late spring. Place double-sided sticky tape around limbs near adult scales in early spring (mid- to late April) to monitor for crawler emergence and time treatments.

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.

DELAYED DORMANT

Note: Oils are not recommended for use during the dormant season on walnut trees and should be applied with caution during the delayed dormant period. Do not apply between bud break and shoot elongation because they can injure the tree.

A. BUPROFEZIN (Centaur WDG) MODE-OF-ACTION GROUP NUMBER ¹ : 16	46 oz	12	60
B. PYRIPROXYFEN (Seize 35WP) MODE-OF-ACTION GROUP NUMBER ¹ : 7C COMMENTS: A nonionic surfactant may be added to increase efficacy. Apply concentrate in a minimum of 100 gal water/acre.	4–5 oz	12	21

CRAWLER STAGE

A. BUPROFEZIN (Centaur WDG) MODE-OF-ACTION GROUP NUMBER ¹ :16	46 oz	12	60
B. SPIROTETRAMAT (Movento) MODE-OF-ACTION GROUP NUMBER ¹ : 23	9 fl oz	24	7
C. BIFENTHRIN /IMIDACLOPRID (Brigadier)* MODE-OF-ACTION GROUP NUMBER ¹ : 3A/4A	12.8 fl oz	12	7
D. NARROW RANGE OIL# MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: Oils will suppress low to moderate numbers during the summer months, but oils can be destructive to the walnut aphid parasite, <i>Trioxys pallidus</i> . Do not apply if trees have suffered from a lack of adequate soil moisture or other stressing factors (insects, disease damage, etc.) at any time during the year or if temperatures are expected to exceed 90°F at time of application. Check with certifier to determine which products are organically acceptable.	Label rates		
E. ACETAMIPRID (Assail 70WP) MODE-OF-ACTION GROUP NUMBER ¹ : 4A COMMENTS: Toxic to bees; do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.	2.7–3.4 oz	12	14

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/>.

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

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

Acceptable for use on organically grown crops.

WALNUT TWIG BEETLE (7/17)

Scientific Name: *Pityophthorus juglandis*

DESCRIPTION OF THE PEST

Field Identification Guide

Walnut twig beetles are very small, about 1/16 inch (1.5 mm), reddish-brown bark beetles that bore through the outer bark and into the phloem of the branches and main stems of walnut trees. This species is characterized by four to six concentric ridges on the upper surface of the pronotum (the shield-like cover behind and over the head).

In California walnut trees, the only other related insect that might be confused with walnut twig beetle is the fruit tree pinhole borer, *Xyleborinus saxeseni*, which is an ambrosia beetle. Although *X. saxeseni* resembles walnut twig beetle in size and shape, there are clear morphological differences visible under a dissecting microscope or hand lens (see Figure 21 in *Detecting and Identifying Walnut Twig Beetle: Monitoring Guidelines for the Invasive Vector of Thousand Cankers Disease of Walnut* for more details). *X. saxeseni* bores into the xylem of walnut trees and colonizes trees that are typically in a later stage of decline than those favored by walnut twig beetle.

Walnut twig beetle larvae are white, C-shaped, and found in the phloem. Egg galleries created by adults are generally horizontal (across the grain) and the larval galleries tend to be vertical (along the grain). Male beetles bore into the bark first, creating a push-pin-sized hole in the tiny cracks and corky furrows of the otherwise smooth bark surface of English walnut. Several females then join the male and create the gallery system.

Males produce an aggregation pheromone, which attracts more males and females to the colonization site and results in a mass attack. The insect is present throughout California walnut orchards and in black walnut trees growing in windbreaks and surrounding riparian areas. It colonizes standing trees, fallen branches, and prostrate trees. Beetles do not bore through bark below the soil line to start their galleries.

The beetle is completely dependent on walnut, butternut, or wingnut trees as hosts. Although walnut twig beetle appears to prefer certain species of *Juglans*, all cultivars of English walnut seem to be susceptible to colonization by the beetle. Exhaustive and specific host suitability tests of English walnut cultivars have not been carried out. Walnut twig beetles colonize branches of all sizes, but generally not those smaller than 0.5 to 0.75 inch in diameter; they will successfully colonize the trunk of a tree when the trees has begun to decline. Even in its presumed native host (*Juglans major*) and range (Arizona and New Mexico), it also colonizes the larger branches and trunk of trees, rather than solely infesting “twigs.”

In California, adult walnut twig beetle is active in flight nearly year-round. There are likely two to three overlapping generations per year. It has been caught in pheromone-baited flight traps during every month, although at extremely low levels in December and January. Flight appears to be triggered when ambient air temperatures exceed 65°F (18–19°C). Other physical factors such as wind speed, light intensity, and relative humidity also appear to play a role in mediating flight. The beetle prefers to fly when temperature is moderate and wind speed, light intensity, and relative humidity are low; it can be particularly active at dusk. Maximum flight occurs in May and June and then again in September and October. Adult flight activity declines drastically in November. Walnut twig beetles overwinter primarily as larvae and adults beneath the bark.

DAMAGE

In addition to the physical damage from adult and larval feeding, the walnut twig beetle also carries spores of a pathogenic fungus, *Geosmithia morbida*. Numerous spores have been observed on the surface of the beetle’s wing covers. As beetles penetrate the bark, the spores are transferred to the phloem. The infection of the phloem results in necrotic lesions (cankers) that encircle the gallery system. Because of the aggregation behavior of walnut twig beetle and the multiple inoculations, many cankers form and the ensuing disease has been called thousand cankers disease (see the THOUSAND CANKERS DISEASE section for signs and symptoms).

The numerous regions of necrotic (dead) tissue from gallery construction and fungal infection may overlap over time and girdle individual branches and main scaffolds, leading to branch flagging and crown decline. Presumably the flow of carbohydrates is disrupted as a result of the phloem necrosis.

The pattern of decline generally begins in the crown and moves downward as beetles colonize larger and larger portions of the trees. However, in some instances (e.g., in trees previously impacted at the base by crown gall or other diseases), walnut twig beetle first colonizes the Paradox or black walnut rootstock or the lower portion of the main trunk of the scion. As the crown is gradually killed in black walnut trees, epicormic branches (water shoots) may sprout from the trunk and larger branches. This has rarely been observed in English walnut trees.

Colonization of walnut trees by walnut twig beetle is a progressive process that can take many years. Trees that are over- or underwatered or that have various root diseases or mistletoe infections may be more susceptible to colonization and may experience an accelerated decline. Ultimately, it appears that colonization by walnut twig beetle and infection by *G. morbida* initiates a decline that will kill the tree. Death caused by the disease has not been quantified in California orchards because in most instances, growers remove walnut twig beetle and thousand-canker-disease-infested walnut trees from orchards before the trees succumb. Decline and mortality are more obvious in landscape black walnut trees, which are often left unattended for many years along California's rural roads and highways.

MANAGEMENT

Capturing and identifying the tiny beetle is the key to early detection of the disease in new areas. If walnut twig beetle is detected in traps, survey nearby walnut trees to assess the extent of the beetle infestation and symptoms of thousand cankers disease. The outer bark can be peeled away to reveal walnut twig beetle galleries in the phloem, a key feature for diagnosing the thousand cankers disease complex.

Biological Control

Two parasitic wasps, an *Neocalosoter* and an *Plastonoxus* species, are prevalent in walnut orchards and help control this pest. Predaceous beetles such as *Narthecius simulator*, *Parandrita cephalotes*, and *Temnochila chlorodia*, and snakeflies (*Agulla*) may also contribute to biological control of walnut twig beetle.

Cultural Control

Currently, orchard sanitation is the primary strategy for walnut twig beetle management within orchards. Remove infested wood piles and prunings during the winter months in advance of the primary period of walnut twig beetle emergence and flight activity in the spring (April–June). When possible, burn infested material to reduce the build-up of beetle populations.

Once a tree becomes infested, no control is available, so it is critically important that growers, practicing arborists, and landscapers be aware of this beetle and the accompanying disease and not move any infested wood.

The tiny beetles can survive undetected beneath the bark in dry walnut wood; they may emerge later and transmit the disease to other walnut trees. It can take up to 7 months for the walnut twig beetle to leave firewood-sized pieces of English walnut wood. It may take even longer to disinfest larger pieces of wood with thicker phloem and rough and convoluted (folded in on itself) bark.

Organically Acceptable Methods

Use cultural control in an organically certified crop.

Monitoring and Treatment Decisions

The purpose of trapping (see videos on the set up and maintenance of traps at <http://ipm.ucanr.edu/IPMPROJECT/videolibrary.html#WTB>) is to detect the spread of walnut twig beetles or delimit (determine the boundaries of) a known presence of walnut twig beetle where it has been recently discovered. The trap and guidelines were developed in Northern California native black walnut and English walnut orchard ecosystems with a relatively high presence of walnut twig beetle.

A small multiple-funnel trap is baited with the male-produced aggregation pheromone lure. The Walnut Twig Beetle Lure and the Four-Unit Funnel Trap are available from Forestry Distributing, Inc., Boulder, Colorado (303-747-6414 or 800-603-6271). The baited trap captures both sexes of the walnut twig beetle while attracting few other insect species; it includes only low numbers of most other bark or ambrosia beetles, making detection of walnut twig beetle easier. Baited traps have been used primarily to detect the presence of walnut twig beetles; little information is available on how to use traps to assess the population density of the beetle.

Ideally, deploy pheromone-baited walnut twig beetle traps from March through November when ambient air temperatures exceed 65°F (18–19°C). Depending on available resources, more targeted detection protocols may include:

1. Trapping for about six weeks from late August through mid-October or late April through mid-June
2. Trapping for three weeks during May and June and three weeks during September and October

A primary consideration when selecting locations for traps and choosing a density of traps in the landscape is whether the objective is to detect a new presence or delimit a known population. Use a higher density of traps to assess the extent of an introduced population. If the goal is to detect a new population of walnut twig beetle over a large land area (e.g., an entire county), only a much lower density of traps would be economically feasible. Whatever the overall goal, traps must be placed near walnut trees [within 9.8 to 16.4 feet (3–5 meters) of the trunk].

Currently, no insecticides have been shown to reduce mortality rates of trees infested with walnut twig beetle; do not use chemical control at this time. Research is proceeding with systemic insecticides injected into the base of trees, but this is unlikely to be practical in orchards.

Take down infested trees and grind or burn (where allowed) on-site. Do not move or ship freshly-cut walnut branches, logs, or burls from infested areas; do not move even for woodworking purposes, because the beetles are very small and difficult to detect. Infested wood should not be moved off-site either.

Seasoning wood on-site for 2 to 3 years should allow walnut twig beetle and other woodborers time to leave the wood. However, it is still best to have all wood inspected by a knowledgeable entomologist or cooperative extension advisor prior to movement of the material from the site, even when properly seasoned and debarked. The disinfestation of burl and lower stem pieces destined for woodworking can be accelerated by steam heating the wood to a minimum outer sapwood temperature of 56°C maintained for 40 minutes. This wood should be shipped promptly, however, as walnut twig beetles may re-colonize steam-treated wood if the phloem is still fresh.

For a brief review of how to install and service of walnut twig beetle traps, see *Quick Guide: Installing and Maintaining Walnut Twig Beetle Pheromone-baited Traps*. For detailed guidelines on using pheromone-baited traps to detect and monitor walnut twig beetle, see *Detecting and Identifying Walnut Twig Beetle: Monitoring Guidelines for the Invasive Vector of Thousand Cankers Disease of Walnut*.

WEBSPINNING SPIDER MITES (7/17)

Scientific Names: Twospotted spider mite: *Tetranychus urticae*
Pacific spider mite: *Tetranychus pacificus*

DESCRIPTION OF THE PESTS

Pacific and twospotted mites overwinter as reddish orange, mature females in protected places on the tree, in soil, and in trash on the ground. During warm weather in spring, overwintered females begin feeding on walnut leaves and ground cover in the orchard. During periods of active feeding twospotted mites have a dark spot on each side of the body. Pacific mites have a second pair of dark spots near the posterior end. Often, however, the spots are barely visible or may coalesce to large dark areas, making it difficult to distinguish the two species.

Colonies develop on the underside of leaves and also on the upper sides when heavy numbers build up. Eggs are spherical and translucent when first laid, becoming opaque soon before hatching. Immature mites molt three times before becoming adults. The first stage mites have six legs; later stages and adults have eight legs. These mites reproduce rapidly in hot weather and may become numerous in June or July. They produce many generations per year. If temperature and food supply are favorable, a generation can be completed in 7 days.

DAMAGE

Mite feeding causes stippling and browning of leaves. Clusters of brown leaves are often the first sign of an increasing mite numbers. High numbers produce copious webbing, and their feeding causes leaves to desiccate and drop. Defoliation early in the season can reduce nut yield and quality; defoliation late in the season will interfere with harvest.

MANAGEMENT

Natural enemies usually keep spider mites below damaging levels unless broad-spectrum pesticides are used. Use selective pesticides when treating other pests and monitor carefully for mites, predators, and mite damage.

Biological Control

The most dependable mite predator of spider mites is the western predatory mite, *Galendromus* (= *Metaseiulus*) *occidentalis*. Under optimal conditions, this predatory mite can produce a generation in 7 days. Because walnut orchards often lack an alternate food source such as European red mites early in the season, the western predatory mite sometimes may be late in building to numbers sufficient to control web-spinning mites, which become abundant later in the season.

Sixspotted thrips can be very effective in reducing high numbers of web-spinning mites. Thrips, however, usually do not move into orchards until mite populations are high. Both the adults and the small, yellowish larvae prey on mites.

The spider mite destroyer, *Stethorus picipes*, is a small lady beetle that feeds on mites. The larvae are small, dull black and have a velvety appearance. The spider mite destroyer, like the sixspotted thrips, generally does not become numerous until spider mite numbers are high. But it is an active feeder and can reduce mite numbers quickly when it is abundant. Minute pirate bugs also feed on spider mites.

Cultural Control

Orchard management practices can reduce mite problems. Minimize dust by oiling orchard roads and maintaining a ground cover. Well-irrigated, vigorous trees are less troubled by mite infestations. Choose selective pesticides when controlling other pests and try to avoid pyrethroids, organophosphates, and carbamates until later in the season.

Organically Acceptable Methods

Biological and cultural controls and sprays of narrow range oil are acceptable for use in an organically certified crop. Caution should be taken when applying oils in walnuts to avoid injuring trees (see narrow range oil comments in the table below).

Monitoring and Treatment Decisions

Begin looking for spider mites in late spring. Map out areas of concern for summer monitoring.

In June or early July start sampling for spider mites once a week through August:

- Select randomly 10 trees in the orchard and pick 5 leaflets from low branches and 5 leaflets from high branches in each tree.
- Look for the presence of webspinning spider mites, predator mites, and sixspotted thrips and record your observations separately for low and high branch leaves (*example form available online*). If predaceous mites are present on at least half of the leaflets that have mites, then there is a good probability that natural enemies will suppress the population unless broad-spectrum sprays are used for codling moth management. Monitor again in one week.
- If predaceous mites are not present on at least half the leaflets that have mites, monitor again in 3 to 4 days (3 days if weather is hot) to determine if the webspinning mite population is increasing or declining. If mites do not build up in walnuts by mid-August, then a pesticide application may not be warranted.

Treatment Thresholds

Take into consideration populations of predators and whether or not you plan to apply an organophosphate or pyrethroid treatment against other pests later in the season, before you make a treatment decision.

For orchards where NO organophosphate or pyrethroid applications are used:

- Predators present on fewer than 10% of mite-infested leaves: spray if 30 to 40% of leaves are mite infested.
- Predators present on 20 to 50% infested leaves: spray if 40 to 50% of leaflets are mite infested.
- Predators present on more than 50% mite-infested leaves: don't spray.

For orchards where organophosphate or pyrethroid applications are used: (If these materials are used, a tank-mix with a miticide may be warranted in warmer, dry areas on light soils.)

- Predators present on fewer than 10% of mite-infested leaves: spray when 10% of leaves have spider mites.
- Predators present on more than 10% of mite-infested leaves: spray when 20% of leaves have spider mites.

Common name (Example trade name)	Amount to use** (conc.)	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.	BIFENAZATE (Acramite 50WS) (Vigilant 4SC) MODE-OF-ACTION GROUP NUMBER ¹ : 20D COMMENTS: Apply in a minimum of 50 gal/acre. Do not apply more than once per season.	0.75–1 lb 16–24 fl oz	— —	12 12	14 14
B.	CYFLUMETOFEN (Nealta) MODE-OF-ACTION GROUP NUMBER ¹ : 25	13.7 fl oz	—	12	7
C.	SPIRODICLOFEN (Envidor 2SC) MODE-OF-ACTION GROUP NUMBER ¹ : 23 COMMENTS: Kills all mite stages, but most effective on juveniles.	16–18 fl oz	4–4.5 fl oz	12	7
D.	ETOXAZOLE (Zeal Miticide) MODE-OF-ACTION GROUP NUMBER ¹ : 10B COMMENTS: Acts as a contact toxin to eggs, inhibits molting of juveniles, and causes adult females to produce sterile eggs. Do not apply more than once per season. Use for bearing trees allowed under a Supplemental Label.	2–3 oz	0.5–0.75 oz	12	28
E.	FENPYROXIMATE (FujiMite 5EC) MODE-OF-ACTION GROUP NUMBER ¹ : 21 COMMENTS: Contact toxin to juveniles and adults with long residual activity. Residues are toxic to both pest and predator mites for several weeks. A good choice under extreme mite pressure in the absence of natural enemies.	2–4 pt	—	12	14
F.	FENBUTATIN-OXIDE* (Vendex 50WP)	2 lb	0.5 lb	48	14

Common name (Example trade name)	Amount to use** (conc.)		REI† (hours)	PHI‡ (days)
MODE-OF-ACTION GROUP NUMBER ¹ : 12B COMMENTS: Do not apply more than twice per season.				
G. ABAMECTIN* (Agri-Mek SC)	2.25–4.25 fl oz	0.5–1 fl oz	12	21
MODE-OF-ACTION GROUP NUMBER ¹ : 6 COMMENTS: Use in combination with a horticultural spray oil at a minimum of 1 gal oil/acre. Is effective against mites that are resistant to propargite. Apply after sampling indicates pest mites are increasing but before significant damage or webbing is present. A locally systemic material that is most effective is applied before July when foliage is still young and tender enough to absorb it. To delay development of resistance, use only once per season. Certain formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations. Regulations affect use for the San Joaquin Valley from May 1 to October 31, 2019. Review the Department of Pesticide Regulation's updated fact sheet.				
H. HEXYTHIAZOX (Onager)	16–24 oz	4–6 oz	12	7
MODE-OF-ACTION GROUP NUMBER ¹ : 10B COMMENTS: A growth regulator that is a contact toxin to eggs and juveniles; adult females lay sterile eggs. For resistance management, do not apply more than once per year.				
J. PROPARGITE* (Omite 30WS)	4–6 lb	1.5 lb	720 (30 days)	21
MODE-OF-ACTION GROUP NUMBER ¹ : 12C COMMENTS: Do not use within 14 days before or after an oil treatment or damage may occur. Do not apply more than twice per season. Do not graze animals on vegetation under treated trees. The twospotted spider mite is resistant to this material in the San Joaquin Valley. These rates are lower than the manufacturer's label rate.				
J. NARROW RANGE OIL#	See label		See label	See label
MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: Provides short-term control. Use label rate in 200 to 400 gal water/acre. Apply oil to walnuts only when soil moisture is adequate and trees have not been water stressed at anytime during the growing season. Should also provide control of frosted scale but is destructive of the walnut aphid parasite, <i>Trioxys pallidus</i> . Do not apply when temperatures exceed 90°F; make applications in evening or at night. Check with certifier to determine which products are organically acceptable.				
K. ACEQUINOCYL (Kanemite 15SC)	21–31 fl oz	5.25–7.75 fl oz	12	7
MODE-OF-ACTION GROUP NUMBER ¹ : 20B COMMENTS: Do not apply more than twice per year and more than 62 fl oz (0.6 lb a.i.)/acre per season.				
L. CLOFENTEZINE (Apollo SC)	2–4 oz	0.5–1 oz	12	30
MODE-OF-ACTION GROUP NUMBER ¹ : 10A COMMENTS: Is effective against mites that are resistant to propargite. Apply after sampling indicates pest mites are increasing but before significant damage or webbing is present. Kills eggs and young larval stages. Good coverage is a must; use a minimum of 50 gal water/acre for concentrate sprays and a maximum of 400 gal water/acre for dilute. To delay development of resistance, use only once per season.				
M. ROSEMARY OIL/PEPPERMINT OIL# (Ecotrol EC)	2–4 pt	1 pt	0	0
MODE OF ACTION: Contact including smothering and barrier effects. COMMENTS: Kills all stages, but good coverage is essential.				

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 (un = unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at <http://irac-online.org/>.

** For concentrate application, use the amount given in 80 to 100 gal water/acre, or lower if the label allows; for dilute application, amount is per 100 gal water to be applied in 300 to 500 gal water/acre, according to label.

Common name (Example trade name)	Amount to use** (conc.) (dilute)		REI‡ (hours)	PHI‡ (days)
-------------------------------------	--	--	-----------------	----------------

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

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

Acceptable for use on organically grown crops.

Diseases
(Section reviewed 6/17)

ANTHRACNOSE (6/17)

Pathogen: *Marssonina juglandis* or *Marssonina californica* (*Gnomonia leptostyla*)

SYMPTOMS AND SIGNS

The initial symptoms on leaves are small specks of necrotic lesions that expand with time and become necrotic blotches. Similar lesions can also develop on leaf petioles, stems, spurs, shoots, and fruit. The lesions on shoots and fruit develop a whitish layer on top, most likely caused by the waxy remnants of the separated cuticle from the killed lesion tissues underneath. All leaf, shoot, and fruit lesions are covered with solitary, dark acervuli (the conidia producing fruiting structures of the pathogen).

Under favorable disease conditions (excess rain in the spring), initial infections can be found as small necrotic lesions on the basal leaflets. Large necrotic lesions form when there are multiple lesions per blade or when the infection point is on the mid rib. Infections on the mid rib result in broken blades and torn leaf tissues. Lesions can result in leaflet yellowing and defoliation during the season, especially if the lesion is located at the base of the leaflet or there are multiple lesions. Sometimes when the petiole (leaf stem) is infected, leaflets beyond the point of infection can drop.

Severe infections of fruit can lead to patches of merged lesions.

COMMENTS ON THE DISEASE

Anthracnose occurred sporadically for several years on black walnut in Butte, Sutter, Stanislaus, and Tehama counties. The reports of anthracnose on English walnut are generally rare in California. On English walnut, anthracnose was seen only in Lake, San Benito, and Stanislaus counties, and in recent years, reported in Sutter and Tehama counties.

The fungus overwinters on the dropped leaves. In Northern California (Hollister area), mature ascospores are produced by early April. If there is rain in April, ascospores become airborne and first infect the leaflets and later the shoots and fruit. Ascospores released from dropped leaves under the walnut trees cause primary infections, while conidia produced on leaf, stem, shoot, and fruit lesions can initiate a secondary cycle of infection. This is only when rains continue in the spring and when there is rainfall in the fall. Evidence for secondary infection includes leaf lesion infection seen in early October. Both ascospores and conidia directly infect the current growth tissues; a wound is not needed for infection to occur.

Black walnut can also be infected with the pathogen causing leaf and fruit lesions. In an orchard where Paradox and Black walnut were side by side, the black walnuts were almost entirely defoliated by early October, while the Paradox trees were only about 50% defoliated. Observations of walnut cultivars planted in the Hollister area (Northern California) indicated that Serr and Payne were the most susceptible, Howard and Tulare the least susceptible, and Hartley and Chandler showed intermediate susceptibility.

MANAGEMENT

Removal of leaves from the ground should reduce primary inoculum (ascospores) and subsequently reduce disease. However, no specific cultural experiments have been done with the anthracnose pathogen in walnut.

Fungicide sprays in the spring control the disease efficiently. Sprays should start when the leaf size is about half its final size and continue every 2 to 3 weeks. Three sprays in the spring are sufficient to control this disease.

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, /PMG/r881902111.html#TREATMENT 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 listed.

PREPLANT

A.	PYRACLOSTROBIN/BOSCALID (Pristine)	10.5–14.5 oz	12	14
	MODE-OF-ACTION GROUP NAME (NUMBER ¹): Quinone Outside Inhibitors (11) and Succinate Dehydrogenase Inhibitors (7)			
B.	AZOXYSTROBIN/PROPICONAZOLE (Quilt Xcel)	14–21 fl oz	12	60
	MODE-OF-ACTION GROUP NAME (NUMBER ¹): Quinone Outside Inhibitors (11) and Demethylation Inhibitors (3)			
C.	FLUOPYRAM/TEBUCONAZOLE (Luna Experience)	8.8–17 fl oz	12	35
	MODE-OF-ACTION GROUP NAME (NUMBER ¹): Succinate Dehydrogenase Inhibitors (7) and Demethylation Inhibitors (3)			

‡ 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.

ARMILLARIA ROOT ROT (OAK ROOT FUNGUS) (6/17)

Pathogen: *Armillaria mellea*

SYMPTOMS AND SIGNS

Trees with Armillaria root rot have thin canopies with yellow leaves and twig, shoot, or limb dieback. Infected roots have white rot wood decay with white to yellowish fan-shaped mycelial mats (plaques) between the bark and the wood. Dark brown to black rhizomorphs sometimes can be seen on the root surface.

COMMENTS ON THE DISEASE

Armillaria survives on dead roots. Paradox, Northern California Black, and English rootstocks are susceptible, but disease response is variable. It is common to see circular patterns (i.e., infection centers) of dead or missing trees in orchards with an *A. mellea* problem. These centers expand outward as roots of bordering trees come in contact with infected roots.

MANAGEMENT

Management of Armillaria root and crown rot relies primarily on preventing infection of new trees. You can reduce the chances of infection by carefully preparing planting sites for new orchards and by practicing good sanitation and early detection. Do not rip or disc in infected orchards to avoid spreading the inoculum. Overly wet soil conditions favor development of this disease, so take measures to correct this condition throughout the orchard.

Tolerant Rootstocks

Choose a less-susceptible rootstock if Armillaria root rot is present. Avoid using English rootstock, which is highly susceptible, in sites known to be infested with *A. mellea*. Paradox rootstock is generally more tolerant of Armillaria root rot than Northern California Black rootstock. However, neither of these rootstocks is tolerant if an extremely aggressive strain of *Armillaria* is present.

Fumigation

No effective fumigants are currently available for managing *Armillaria* in walnut.

Sanitation

Be careful not to introduce *Armillaria* into an established orchard via diseased root pieces that may be transported on equipment or in surface water.

Monitoring

Check trees for symptoms of Armillaria root rot in late summer when dead or declining trees are most obvious. Look for mycelial plaques under bark or mushrooms at the bases of trees after a rain, generally from October to April.

Saving Infected Trees

Once symptoms of Armillaria root rot appear, it may be possible to slow or stop spread of the pathogen within an infected tree by exposing the crown and upper roots and allowing them to dry out.

1. Remove soil from the base down to a depth of 9 to 12 inches in spring.
2. Keep the crown and upper roots exposed to the air and avoid wetting them for the duration of the growing season.
3. Fill the soil back in before rains start in the fall.

This procedure may allow the diseased tree to regrow, but is not always successful.

If trees cannot be saved, remove infected and dead trees without delay. The fungus can transmit more quickly through roots of dead trees to nearby healthy trees. The disease spreads as healthy roots come in contact with infected roots of adjacent trees.

BLACKLINE (6/17)

Pathogen: *Cherry leafroll virus*

SYMPTOMS AND SIGNS

Blackline causes symptoms in the tree canopy that are similar to those caused by soilborne pathogens such as *Phytophthora* and *Armillaria*, nutrient deficiencies, and scion-rootstock incompatibilities. The first symptoms of the disease are poor terminal growth, yellowing and drooping leaves, and premature defoliation, particularly in the top branches. Later, diseased trees show dieback of terminal shoots and decline, often accompanied by profuse suckering from the rootstock (mainly black walnut)

Blackline disease kills the tissues that transport nutrients and water between the rootstock and scion. The black line is usually exactly at the graft union on black walnut rootstock and will eventually completely girdle the tree, killing the scion in 2 to 6 years. In addition to the black line, however, Paradox rootstock typically develops a canker that extends into the rootstock. Blackline canker does not extend upward into the scion, as cankers produced by *Phytophthora* often will. Because of the extensive bark cankering, scions on Paradox decline faster than on black walnut rootstock.

Trees may become infected at any age once tree blossoms, but blackline is more common in trees 15 to 40 years old. All walnut cultivars are susceptible to the virus, but the rate of viral spread varies by cultivar.

Positive diagnosis of blackline requires careful examination of the union between scion and rootstock. Trees with blackline usually have small holes and cracks in the bark at the graft union. If you remove a piece of the bark, you can see a narrow black line or strip of dead tissue at the union on black walnut rootstock, or a downward canker on Paradox rootstock. You may need to check several places around the circumference of the trunk because the black line or canker does not extend all the way around the graft union until later in disease development.

COMMENTS ON THE DISEASE

Blackline was first a major problem in coastal areas of California but spread to the inland valleys decades ago. Although it occurs in all walnut-growing areas of California, it is most prevalent in coastal orchards and orchards in the northern San Joaquin Valley and southern Sacramento Valley.

Blackline is caused by *Cherry leafroll virus* and occurs on English walnut cultivars grown on northern California black walnut or Paradox rootstock. English walnut grown on English walnut rootstock or own-rooted English walnut trees can be infected by the pathogen but remain asymptomatic (trees do not show disease symptoms).

The virus may be introduced into an orchard through graft wood or pollen from infected trees. Within the orchard, the pathogen is probably transmitted by infected pollen because it does not spread from diseased to healthy trees until the pistillate flowers are receptive for pollination. In addition, blackline spreads more rapidly in mixed-cultivar orchards, where pollen shedding overlaps with pistillate bloom for a longer time. Spread of the pathogen through the soil or by nematodes is unlikely because black walnut and Paradox rootstocks are immune to the virus.

Once a tree is infected, the virus spreads through the scion and eventually reaches the rootstock. If the tree is on black walnut rootstock, a thin layer of rootstock cells, or in Paradox rootstock, the area that forms cankers, react to the presence of *Cherry leafroll virus* by dying. If the tree is on English rootstock, no reaction occurs. The virus spreads into the rootstock and the tree becomes a symptomless carrier of the virus. Pollen or graft wood from the tree will spread the disease.

MANAGEMENT

At present, trees with blackline cannot be cured. No practical method is available to detect blackline before symptoms appear. A few management practices can help reduce the spread of the disease.

- In areas known to be affected by blackline, consider using clonal own-rooted English walnut trees that will escape the disease. These trees can be productive when planted in good, loamy soils. Avoid planting in poor soils, or where there are known nematodes, *Phytophthora*, or salt problems.
- Interplants should always be the same as the main cultivar.
- Carefully select grafting material for top-working established trees from healthy virus-free English walnut trees.

- Monitor the orchard for blackline symptoms in late summer or fall. Look for declining trees with sucker shoots on rootstocks. To confirm disease presence, examine the graft union for the characteristic black line or canker by making small cuts and removing the bark. Cut at about 4-inch (10-cm) intervals around the circumference of the tree because the black line may not be continuous.

BOTRYOSPHAERIA AND PHOMOPSIS CANKERS (6/17)

Pathogens: *Lasiodiplodia citricola*, *Neofusicoccum parvum*, *N. mediterraneum*, *N. nonquaesitum*, *N. vitifusiforme*, *Botryosphaeria dothidea*, *Diplodia seriata* and *Dothiorella iberica* (Botryosphaeriaceae spp.); *Diaporthe rhusicola* and *D. neitheicola* (*Phomopsis* spp.)

SYMPTOMS AND SIGNS

The initial symptom of branch infection is often wilting and flagging of leaves on branches distal to the canker. Cutting away the bark reveals the discolored, brown to black cortical and cambial tissues. If the infection is old enough, peeling away the bark will reveal well-developed embedded black pycnidia (asexual fruiting bodies that contain fungal spores) or occasionally perithecia (sexual fruiting bodies) of the Botryosphaeriaceae species, *Phomopsis* species, or sometimes both. In young trees, infected stems usually turn black, while in older trees major branches can be killed. Killing of large branches is often associated with shading and heavy numbers of walnut scales and possibly other scales.

Infected green fruit do not immediately show symptoms. Fruit develop disease symptoms when mature in August and September. Infections start as decay lesions on the hull of a fruit and decay can spread to the neighboring fruit. The lesions spread and invade the peduncle (the stalk that bears the fruit) and subsequently the spurs, resulting in black cankers and dead buds. Hulls of infected fruit turn black initially and then brown to beige after drying. Areas of fruit with pycnidia are light beige. Infected fruit may fall prematurely. Cankers on spurs continue growing during fall and are covered with a dense layer of pycnidia and sometimes perithecia of both Botryosphaeriaceae and *Diaporthe* (*Phomopsis*) spp. fungi. If sprinkler irrigation wets leaves and shoots, necrotic lesions can form on the leaves.

COMMENTS ON THE DISEASE

Since the late 1990's, *Botryosphaeria* and *Phomopsis* species have been isolated from a large number of blighted shoots of Chandler, Howard, Payne, Tulare, Vina and other walnut varieties from Butte, Colusa, Glenn, Fresno, Kern, Kings, Placer, Sacramento, San Benito, San Joaquin, Solano, Stanislaus, Sutter, Tehama, Tulare, Yolo and Yuba counties.

The fungi overwinter on dead branches and shoots, and can develop both water-splashed and airborne spores. Pycnidia of *Phomopsis* spp. and fungi in the *Botryosphaeriaceae* family can be found year-round on diseased branches and may sometimes occur together on the same branch. The same fungi also occur on woody trees and shrubs in riparian areas next to walnuts, thus serving as inoculum sources. Some of the Botryosphaeriaceae species that cause panicle and shoot blight of pistachio and band canker of almond also cause Botryosphaeria canker of walnuts.

Fungi in the family *Botryosphaeriaceae* and in the genus *Phomopsis* generally indirectly infect through wounds such as pruning or sunburn wounds, leaf scars, and peduncle scars. Pruning wounds are susceptible to infection for four months. These fungi can also directly infect walnut fruit. Under favorable environmental conditions, Botryosphaeriaceae fungi can directly infect shoots as well.

MANAGEMENT

Reduce Botryosphaeria and Phomopsis cankers in walnut orchards with fungicide sprays applied in mid-May, mid-June, and mid-July. Evidence is inconclusive of the efficacy of bloom and postharvest sprays.

Ensure good sanitation and use cultural practices to reduce inoculum.

- Prune out diseased limbs, cutting back into healthy wood (where the wood is no longer discolored); at least 2 to 3 inches beyond the lower canker is sufficient to remove the pathogen.
- Remove dead wood and destroy it (shred, chip, or burn) during a dry period. Remove all large dead branches out of the orchard when there is not severe Botryosphaeria blight, but shred branches in the orchard floor when there is very heavy Botryosphaeria blight.
- Walnut scale, and probably other species of scales attacking walnuts, predisposes branches to infection from *Botryosphaeria* fungi. Control scale pests to minimize entry points for the fungi.

Chemical management of this disease depends on the application of protective sprays to prevent infections of pruning wounds and developing fruit, leaves, leaf and bud scars, and buds.

- Consider the presence of riparian woody vegetation next to the orchards (a source of inoculum) and adjust disease management approaches accordingly.

- In orchards with high inoculum levels (a lot of dead wood and pycnidia of *Botryosphaeria* and *Phomopsis* are commonly found), apply protective fungicides in mid-May, mid-June, and mid-July.
- In orchards where the inoculum is light, follow a lighter program when conditions favor disease development (temperatures above 50°F and at least 0.25 inch of rain). Disease is favored during frequent rains, when sprinkler irrigation water wets the foliage, or when orchards are next to rivers or creeks since this can result in higher humidity and dew formation.

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 listed.

A. POTASSIUM PHOSPHITE (K-Phite 7LP)	3 qt	4	0
B. AZOXYSTROBIN/DIFENOCONAZOLE (Quadris Top) MODE-OF-ACTION GROUP NAME (NUMBER ¹): Quinone outside Inhibitors (11) and Demethylation Inhibitors (3)	12–14 fl oz	12	45
C. METCONAZOLE (Quash) MODE-OF-ACTION GROUP NAME (NUMBER ¹): Demethylation Inhibitors (3)	3.5 oz	12	25
D. PYRACLOSTROBIN/FLUXAPYROXAD (Merivon) MODE-OF-ACTION GROUP NAME (NUMBER ¹): Quinone outside Inhibitors (11) and Succinate Dehydrogenase Inhibitors (7)	6.5 fl oz/100 gal water	12	14
F. PYRACLOSTROBIN/BOSCALID (Pristine) MODE-OF-ACTION GROUP NAME (NUMBER ¹): Quinone outside Inhibitors (11) and Succinate Dehydrogenase Inhibitors (7)	14.5 oz	12	25
F. FLUOPYRAM/TEBUCONAZOLE (Luna Experience) MODE-OF-ACTION GROUP NAME (NUMBER ¹): Succinate Dehydrogenase Inhibitors (7) and Demethylation Inhibitors (3)	8.8–17 fl oz	12	35
G. PENTHIOPYRAD (Fontelis) MODE-OF-ACTION GROUP NAME (NUMBER ¹): Succinate Dehydrogenase Inhibitors (7)	20 fl oz	12	14
H. POLYOXIN D ZINC SALT (PH-D WDG) MODE-OF-ACTION GROUP NAME (NUMBER ¹): 19	6.2 oz	4	0
I. TEBUCONAZOLE (Tebucon 45DF) MODE-OF-ACTION GROUP NAME (NUMBER ¹): Demethylation Inhibitors (3)	4 oz	12	35
J. FLUOPYRAM/TRIFLOXYSTROBIN (Luna Sensation) MODE-OF-ACTION GROUP NAME (NUMBER ¹): Succinate Dehydrogenase Inhibitors (7) and Quinone outside Inhibitors (11)	7.6 fl oz	12	60

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

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.

BRANCH WILT (6/17)

Pathogen: *Neoscytalidium dimidiatum* (= *Scytalidium dimidiatum*, *Hendersonula toruloidea*)

SYMPTOMS AND SIGNS

Early symptoms of branch wilt are yellowing and withering of leaves on the outermost branches typically with a southwest exposure during midsummer to early fall. Next, leaves on larger infected limbs suddenly wither, turn dull green, then dark brown, and then they become dry. These leaves remain attached well after healthy leaves have fallen. Blighted fruit due to branch wilt can also be colonized by the pathogen (frequently the pathogen can be isolated from the shriveled kernel of these fruit). Portions of the thin outer layer of bark peel away, exposing a black sooty, dusty mass of fungal spores (arthrospores). Diseased limbs have a gray to dark brown discoloration in the shape of a cylinder or wedge extending into the center of the wood.

COMMENTS ON THE DISEASE

Branch wilt develops only under warm temperatures. It affects English walnut throughout the interior valley of California but not in the coastal areas of the state. All commercial cultivars of walnut grown in California are susceptible to the disease. The fungus invades branches only through splits, frost damage, and sunburn injury from spores spread by windblown rain. The branch wilt pathogen has also been found on almond, apple, apricot, chestnut, citrus, fig, peach, poplar, grape, and black walnut and can cause similar wilt symptoms in some of these hosts. Frequently, additional Botryosphaeriaceae fungi colonize branches killed by the branch wilt fungus, so sections of these branches may be covered with pycnidia of other Botryosphaeriaceae species. Also, the pathogen can infect sunburned trunks of newly planted trees and kill them.

MANAGEMENT

- Remove infected limbs when the weather is dry to avoid infection by Botryosphaeriaceae fungi through pruning wounds. Prune out diseased limbs, cutting back into healthy wood (where the wood is no longer discolored); at least two inches beyond the lower canker is sufficient to remove the pathogen. Where permitted, burn these branches.
- Avoid sunburn by maintaining vigorous trees through adequate irrigation, fertilization, and pest control.

CROWN GALL (6/17)

Pathogen: *Agrobacterium tumefaciens*

SYMPTOMS

Crown gall appears as rough, abnormal tumors or galls at or below the soil surface on roots, the crown, or trunk. Live galls are not hard but soft and spongy; the centers of older galls decay. Young trees become stunted. Older trees often develop secondary wood rots.

COMMENTS ON THE DISEASE

Crown gall is caused by a bacterium, *Agrobacterium tumefaciens*, that survives in soil and gall tissue. Bacteria enter primarily through wounds. Crown gall is most damaging to trees that are 1- to 8-years old. Seedling Paradox rootstock is especially susceptible.

MANAGEMENT

Reduce the incidence of crown gall by planting noninfected "clean" trees. For seedling rootstocks, nurseries should collect the seed so it never contacts the soil where the *Agrobacterium* resides. Before planting, make sure trees stay moist and the roots do not dry out. It is also important to carefully handle trees to avoid injury as much as possible, both at planting and during the life of the tree in the orchard. Although preplant preventive dips or sprays with a biological control agent are available, their effectiveness can be variable on walnut trees. Strains of *Agrobacterium tumefaciens* (formerly *A. radiobacter*) strain K-84 are available as commercial products. However, it is effective only as a preventive treatment and does not eradicate galls. Use as a root dip or spray before heeling in (covering with moist soil until trees are planted) or planting.

Look for and manage crown gall during the growing season when the orchard is not wet because moisture favors the bacterium. When established orchard trees are infected with crown gall, you can use a combination of surgery, flaming, or a bactericide to treat the tumors. The best time to treat is in the spring or early summer because with rapid tree growth occurring, new callous tissue is formed relatively quickly.

Management is most effective for small galls on young trees. The procedure, however, can be expensive and difficult to carry out, depending on the size and location of the galls.

- It is always best to remove galls when they are small. Usually by the time they're seen at ground level, there may be extensive galling on crown area beneath soil. Only treat trees that are vigorous. Stunted trees should be removed.
- If trees less than 4 years old are severely affected with galls, it is more economical to remove the trees and replant.
- Treatment may be effective on older trees. The decision whether to treat galls or remove trees depends on tree vigor, the severity of galling, and the cost of treatment relative to the cost of replacing trees.

To treat crown galls:

1. First remove soil away from the crown and roots to completely expose the gall. Soil can be safely removed using pneumatic equipment such as air compressors. Because no water is used, treatment can be done immediately after removal.
2. To flame the gall, use a propane cylinder or bottle and slowly move the torch tip around the margin of the gall, creating a red-hot zone that is about 1 inch wide. It is advantageous to surgically remove the main part of gall in order to gain access to all parts of the gall margin. If surgery is used, be sure to sterilize the tools with heat before advancing to the next tree. Flaming should never be used on very young trees.
3. As an alternative to flaming, galls can be treated with a bactericide such as Gallex, but treatment success is dependent upon complete removal of the gall first and then applying the treatment.
4. Leave the treated areas uncovered for the summer and re-treat if galls begin to regrow. Treatment success is about 80%.

When replanting a previously affected site:

- Remove as many of the old tree roots as possible.
- Grow a grass rotation crop to help degrade leftover host material and reduce pathogen levels.

- Fumigate with Telone C35
- Consider rootstock’s resistance. Clonal Paradox RX1 has moderate resistance to crown gall. Clonal Paradox Vlach and VX211 have low resistance to crown gall. Although seedling black rootstock is not as susceptible to crown gall as seedling Paradox, walnut varieties on black rootstock generally aren’t as vigorous so should be planted on loamy soils.
- Offset the new trees from the previous tree spacing to minimize contact of healthy new roots with any infested roots and soil that may remain.
- Keep the crown area dry to help reduce disease severity.

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 listed.

PREPLANT

A.	1,3-DICHLOROPROPENE* / CHLOROPICRIN* (Telone C-35)	Label rates	0	0
	COMMENTS: The maximum allowable rate of Telone C-35 in California is 46.7 gal/ acre, regardless of label rates.			
B.	AGROBACTERIUM TUMEFACIENS STRAIN K-84 (Galltrol A)	Label rates	12	0
	COMMENTS: Applied at planting to tree roots. This biological control is marketed as Galltrol A, Norbac 84C, Nogall, or Diegall and is a preparation of <i>Agrobacterium tumefaciens</i> strain K-84 (formerly <i>A. radiobacter</i>). It is effective only as a preventative treatment. Effectiveness can be variable on walnut trees. Use as a root dip or spray before heeling in or planting. It does not eradicate galls.			

POSTPLANT

A.	GALLEX	Label rates	24	0
	COMMENTS: For removal of existing galls, apply to the crown where large galls were physically removed or directly to small galls on roots during winter and spring. After removing the gall from the tree, allow the tissue to dry 2 to 3 days before directly applying Gallex to injury. Overlap treatment to healthy tissue by 1 inch.			

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

DEEP BARK CANKER (6/17)

Pathogen: *Brennaria (=Erwinia) rubrifaciens*

SYMPTOMS

The symptoms that characterize deep bark canker are the deep cracks running down scaffolds and trunks. A reddish brown to dark brown substance oozes from these cankers from late spring through early fall, giving them a "bleeding" appearance. Internally, dark brown to black streaks of varying width extend through the inner bark and may run for many feet up and down the scaffolds and trunks of affected trees. These streaks occur deep in the bark, in the region of the phloem. As a result, the disease was named phloem canker or deep bark canker to distinguish it from shallow bark canker, which is restricted to the outer layers of bark.

Another typical internal symptom of deep bark canker is the numerous small, round, dark spots that extend into the wood beneath the cankered areas.

Deep bark canker infections develop first on the trunk or lower scaffold; only one or two scaffold limbs are affected. As the disease progresses upward, the branch weakens slowly over time. After many years, most branches are affected, and the tree becomes less productive. The symptoms do not extend into the rootstock.

COMMENTS ON THE DISEASE

Deep bark canker occurs in all walnut-growing areas of the Central Valley but is rarely a problem in coastal growing areas. Deep bark canker is most common and most severe on the Hartley cultivar. The canker does not kill trees, but it may further debilitate trees already weakened by other factors, including inadequate irrigation, poor water infiltration, restrictive soils, as well as insect and disease pests.

The deep bark canker pathogen is most commonly transmitted in symptomless graft wood used to develop new trees. The disease may also be spread when the bacterial pathogen is introduced into a deep wound that exposes the phloem, such as shaker damage and possibly woodpeckers. Shallow wounds and pruning cuts are not infected.

The pathogen survives the winter in cankers or dried exudate on the tree surface. The bacteria become active in late spring and begin to ooze from the cankers, together with plant sap. At this time bacteria may be spread by windblown rain to wounds on uninfected trees. Trees are susceptible to infection from April to October and almost completely resistant in winter. Cankers may lengthen by about 1 foot in spring and about 2 feet in summer. The bacteria spread within the tree through nonconducting parts of the phloem tissue. Movement of nutrients in the phloem is impaired, slowly weakening the affected branches. As the trees lose vigor, they become more susceptible to sunburn injury and infection by the branch wilt fungus.

Because high temperatures favor the development of the disease, deep bark canker is more prevalent in the Central Valley than in coastal areas. The disease sometimes develops on trees that have not been injured. It is thought that these are latent infections that were introduced when the tree was grafted.

MANAGEMENT

To avoid predisposing trees to infection by deep bark canker, keep them healthy by practicing good water management, fertilization, pruning, and pest control. These management practices also reduce canker development in infected trees and keep them in production in most cases. Only trees growing on poor soils or under particularly adverse conditions may never fully recover. Infected trees may remain free of symptoms unless stressed.

The following guidelines can help identify stress factors that promote disease development:

- Dig a hole 6 to 10 feet deep in several areas of the orchard. Select sites that represent different soil types or differences in tree growth and vigor. Study the soil profile for hardpans, claypans, compaction, or layers of differing texture. Check the rooting depth and health of the root system.
- Maintain adequate moisture in the root zone and avoid over- or under-irrigating by using stem water potential measurements, water marks, water budgeting based on evapotranspiration (ET) estimates, tensiometers, or other established methods to monitor orchard water status and schedule irrigations.
- Check soils a few days after an irrigation to evaluate water infiltration and penetration. Problems can have physical or chemical causes. Contact your UC Cooperative Extension advisor for information on corrective procedures.

- Avoid saturated soil conditions for longer than 18 to 24 hours to minimize Phytophthora crown and root rot development.
- Avoid injuries that expose the inner phloem, like those that may be caused when shaking trees.
- Avoid introducing the pathogen into the orchard; thoroughly scrub and drench shaker pads in a 1:10 dilution of bleach before bringing the shaker in from another orchard.

Deep bark canker cannot be cured by any known chemical means. Cutting away the cankered areas, both with and without applying copper or bleach, has not proven successful and is harmful to the trees. Attempts to halt the disease by injecting antibiotics have also failed.

PARADOX CANKER (6/17)

Pathogen: Unknown (under investigation)

SYMPTOMS

Paradox canker manifests as a bleeding bark canker that originates below the soil surface and spreads up and around the root crown and tree trunk. It produces profuse black viscous fluid from the dead bark. As the canker expands, shoot growth ceases, and tree defoliation (leaf drop) and dieback occur. An affected tree typically dies within 1 to 2 years of the appearance of the canker aboveground.

Paradox canker disease cankers superficially resemble cankers caused by *Phytophthora* and *Cherry leafroll virus* (blackline disease cause), but the cankers can be distinguished after removal of their outer bark as follows:

- Paradox canker disease cankers tend to be more rounded or lobed at their margins than those caused by *Phytophthora*, which tend to have relatively irregular or jagged advancing margins. Paradox canker disease cankers tend to generate light-brown, rounded lobes of dead tissue that spread out from dark-brown lobes. The lobes, especially the lighter colored ones, may exhibit concentric rings of color change.
- In contrast to cankers caused by *Cherry leafroll virus* on Paradox rootstock, Paradox canker disease cankers do not begin at the graft union and move toward the soil line.

COMMENTS ON THE DISEASE

Paradox canker has been observed in walnut orchards throughout California's Central Valley, typically at a low incidence (less than 1%). It predominately affects 8- to 15- year-old trees on seedling Paradox rootstock and has not been observed conclusively on black walnut rootstock. Affected trees occur randomly in the orchard. The cause of Paradox canker, although unknown, is being investigated.

MANAGEMENT

It is unknown whether some seedling Paradox rootstocks are more prone to Paradox canker than others; however, trees on clonal Paradox rootstock can be used to replace those killed by Paradox canker. Although it is unknown whether dragging symptomatic root systems through the orchard can spread Paradox canker disease, it is advisable to remove dead trees without spreading any of the dead tissue in the orchard.

There is no evidence that preplant soil fumigation reduces Paradox canker.

PHYTOPHTHORA ROOT and CROWN ROT (6/17)

Pathogen: *Phytophthora* spp.

SYMPTOMS

Symptom expression of Phytophthora root and crown rot depends upon how much of the root or crown tissues are affected and how quickly they are destroyed. Generally, crown rots advance rapidly and trees collapse and die soon after the first warm weather of spring. Chronic infections, usually of the roots, cause reduction in growth and early senescence and leaf fall. These trees may have decreased yield and vigor for several years before succumbing to the disease.

COMMENTS ON THE DISEASE

Periods of 18 to 24 hours or more of water-saturated soil favor *Phytophthora* infections. Conversely, good soil water drainage reduces the risk of root and crown rot. Rootstocks vary in susceptibility to the different *Phytophthora* species; none are resistant to all pathogenic species of *Phytophthora*. Thus, the success of a rootstock may depend in part upon the species of *Phytophthora* present in the orchard. In general, Paradox rootstock is more tolerant of several *Phytophthora* species than is Northern California black walnut or English walnut.

MANAGEMENT

The most effective management strategies for Phytophthora on walnut include careful management of soil water, prudent rootstock selection, and good general sanitation practices.

Cultural Practices

- Plant on berms.
- Avoid soil compaction.
- Do not allow irrigation water to run or stand for more than 24 hours; limiting run times to under 18 hours will limit spore production. Pulse irrigation at short durations is best.
- If using sprinklers, do not allow water to splash on trees (use water guards).
- Use practices that promote good water infiltration and penetration.

Rootstock Selection

Rootstocks differ in their ability to tolerate different *Phytophthora* species.

- Use clonal Paradox RX1 rootstock, which has high resistance to *P. cinnamomi* and moderate to high resistance to *P. citricola*, in soils infested with *Phytophthora* or conditions favorable to *Phytophthora* development (heavy soil or restricted root zone).
- Seedling Paradox has variable resistance to some *Phytophthora* species.
- Northern California Black rootstock and English rootstock are both susceptible to *Phytophthora*.

Eradicating *Phytophthora* from orchard soil is generally not possible. Fumigating the soil after you have removed a diseased tree typically results in a beneficial, though incomplete, reduction in the population of *Phytophthora* in the soil. The population can rebuild quickly under conditions conducive to disease.

Chemical control

Phosphonate fungicides (FRAC Group 33) such as phosphorous acid (KPO₃) may be used to manage the disease in an integrated management program. The exact mode of action is not known, but direct toxicity to the pathogen occurs as inhibition of mycelial growth and sporulation. Applications are typically made one to two times a growing season, such as in spring and early fall as preventative treatments. Additional applications may be needed as a curative treatment. The fungicide is systemic following phosphate (PO₄) pathways in the plant.

- Phosphite (PO₃) residues persist for months after treatment. Because the fungicide is systemic, residues can be found in the harvested crop.
- In the United States the fungicide is a biofungicide and as such is exempt from tolerance. However, some export countries may have maximum residue limits (MRLs) that prevent marketing crops from treated orchards that exceed tolerances.
- Resistance has been detected in some *Phytophthora* spp. on other crops but not in walnut. Rotation with other fungicides is recommended.

Mefenoxam (FRAC Group 4) is registered for walnut and can be applied as a broadcast, band, or irrigation application to soil around the tree to cover the root zone. Apply 90 days after planting or in the spring before root growth in established orchards. Additional applications may be made in 2- to 3-month intervals but no more than three applications per year. Use before symptoms develop. Applications made to trees with moderate to severe symptoms may not be effective. Resistance to mefenoxam has been reported in some *Phytophthora* spp.

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 listed.

- | | | | |
|----|---|----|---|
| A. | <p>PHOSPHOROUS ACID
(Fosphite)</p> <p style="text-align: right;">1–3 qt/100 gal water</p> <p>MODE-OF-ACTION GROUP NAME (NUMBER¹): Phosphonate (33)</p> <p>COMMENTS: Most effective as a foliar spray; apply at 2- to 4-week intervals after trees become established. Early fall treatments, before leaves begin to senesce, and trees that are actively translocating from leaves to roots, are most effective. If treatments are applied earlier in season, best applied after foliage has fully emerged. Do not apply more than six times per crop cycle or year. Do not apply with copper-based fungicides or fertilizers. Do not apply to trees that are heat or moisture stressed. Thought to provide protection by direct toxicity, blocking the phosphorus starvation response, or by systemic acquired resistance (increasing ability of the plant to produce its own defense chemicals).</p> | 4 | 0 |
| B. | <p>MEFENOXAM
(Ridomil Gold SL)</p> <p style="text-align: right;">See comments</p> <p>MODE-OF-ACTION GROUP NAME (NUMBER¹): Phenylamide (4)</p> <p>COMMENTS: Application rate varies with method of application and size of tree. Applied when trees are actively transpiring, up to three times per season (e.g., March, June or July, late August or September). Do not apply to trees within 90 days of planting. The effectiveness of this pesticide may not warrant its use and expense.</p> | 48 | 0 |

-
- 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.
- ‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

SHALLOW BARK CANKER (6/17)

Pathogen: *Brennaria* (=Erwinia) *nigrifluens*

SYMPTOMS

The most characteristic symptoms of shallow bark canker are brownish to black round spots or areas, usually several in a group, on the trunk or lower scaffolds. Newly infected areas have a margin of water-soaked bark and a central spot of black ooze that later dries, leaving a tarlike black spot. Just under the surface, dark brown areas of dying tissue are formed in the outer bark. These superficial cankers can be extensive, but they seem to cause little damage to the tree. Shallow bark canker rarely extends into the inner bark, as does deep bark canker.

COMMENTS ON THE DISEASE

Shallow bark canker affects many commercial walnut cultivars, but the full range of susceptible hosts has not been determined. Because the damage is superficial and does not result in economic loss, shallow bark canker is not considered a major disease of walnut. It is not known how the pathogen infects walnut trees or how it develops and spreads.

MANAGEMENT

As with deep bark canker, shallow bark canker is often severe in stressed trees. Improving tree vigor may help contain the disease. There is no need to cut cankers away because the disease is not serious enough to warrant possible wound damage and other infections.

THOUSAND CANKERS DISEASE (6/17)

Pathogen: *Geosmithia morbida*

Vector: *Pityophthorus juglandis*

SYMPTOMS AND SIGNS

As the name suggests, symptoms of thousand cankers disease include numerous cankers resulting from fungal infection at multiple points of pathogen introduction. The pathogen is introduced to the inner bark by the walnut twig beetle, *Pityophthorus juglandis*, a phloem-feeding insect that completes its life cycle in the tree. A small, push pin-sized hole is associated with each canker, usually denoting the entrance hole for the walnut twig beetle vector. Cankers often bleed, leaving dark ooze and staining on the outer bark surface. These cankers may coalesce over time and girdle individual branches and main scaffolds, leading to decline of the tree crown. The outer bark can be peeled away to see walnut twig beetle galleries in the phloem, a key feature for diagnosing the thousand cankers disease complex.

COMMENTS ON THE DISEASE

The pathogen responsible for thousand cankers disease has not been found on walnut trees in the western USA in the absence of the walnut twig beetle vector. Walnut twig beetle attacks all species of walnut and wingnut, and the disease has been observed on Northern California black and Paradox rootstocks as well as on English walnut. The disease has been recorded throughout the commercial walnut-growing regions in California.

MANAGEMENT

Currently, good cultural practices and sanitation of infested materials are the primary strategies for disease management within orchards and also for prevention of spread of the disease and vector to regions with low rates of infection.

- Prevent tree stress through proper irrigation and fertilization.
- Remove trees with less than 50% live crown to reduce the buildup of walnut twig beetles and inoculum in the trunk and larger scaffold branches.
- Remove infested woodpiles and prunings during the winter months in advance of the primary period of walnut twig beetle emergence and flight activity in the spring (April–June).
- When possible, burn infested material to reduce the presence of primary inoculum in the vicinity of orchards.

Chemical control with either fungicides or insecticides is not recommended for management of thousand cankers disease.

WALNUT BLIGHT (2/20)

Pathogen: *Xanthomonas arboricola* (=X. campestris) pv. *juglandis*

SYMPTOMS

In walnut blight, one to several black lesions may appear on catkins. Infected nuts develop black, slightly sunken lesions at the flower end (end blight) when young; more lesions will develop on the sides of the nut as it matures (side blight). Shoots develop black lesions, and leaves show irregular lesions on blade.

COMMENTS ON THE DISEASE

All green tissue is susceptible to walnut blight. Economically significant damage occurs when the developing nut is infected. The bacterium that causes walnut blight overwinters primarily in dormant buds. Rain is important for spreading bacteria and aiding infection. Early-leaving varieties are most severely affected, and the disease tends to be more severe in Northern California.

MANAGEMENT

Management of this disease depends on the application of protective sprays to buds, flowers, and developing nuts. In orchards with histories of walnut blight damage, protective treatments at 7- to 10-day intervals during prolonged wet springs are necessary for adequate disease control. In areas or years with less intensive rainfall, spray intervals can be stretched, and weather forecasts can help with spray timing. Full coverage sprays are recommended and important to resistance management.

Infection of *Xanthomonas arboricola* pv *juglandis* bacterium depends upon environmental conditions, the amount of the pathogen in individual buds (inoculum), and in the amount of walnut blight cankers present on some walnut varieties. Blight treatments are timed to coincide with early shoot emergence, which places a protective layer of bactericide on emerging green tissue. In most years, the first bactericide application can be delayed and should be applied when 30 to 40% of the buds reach the "prayer" stage (when terminal leaves of pistillate flower buds first unfold and appear like hands in a prayer position). A second spray should be done 7 to 10 days later to effectively treat the pistillate flowers that weren't sufficiently open during the initial application. Additional treatments can be timed using inoculum, disease history, variety, and weather forecasts. A spray prediction model (XanthoCast) is available at <http://agtelemetry.com/> to help determine the need for additional treatment.

Estimates of inoculum levels can be done by collecting 50 to 100 buds per orchard block and having them evaluated in a microbiology lab or by using the disease levels in the previous growing season. A disease rating scale can be used annually (e.g., each June: Low disease risk: less than 50 total blighted nuts per tree; moderate disease risk: 50 to 150 blighted nuts per tree; and high disease risk: 150 blighted nuts per tree or more). In orchards with varieties where catkins emerge before the pistillate flowers (e.g., Chandler), if there is disease incidence in the previous season and forecasted rainfall during bloom, consider bactericide application when 30 to 40% of the catkins emerge (note: this is usually 7 to 10 days before pistillate flowers emerge).

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 listed.

A.	MANCOZEB			
	(Dithane F-45, Manzate Max)	58 fl oz	24	75
	(Manzate Prostick)	2.4 lb	24	75
	MODE-OF-ACTION GROUP NAME (NUMBER ¹): Multi-site contact (M3)			
	COMMENTS: This product must be tank mixed with a fixed copper product that is registered for use on walnuts. Do not apply more than 10 applications (18 lb a.i.) per season.			
B.	KASUGAMYCIN			
	(Kasumin 2L)	64 fl oz	12	100

Common name (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
<p>MODE-OF-ACTION GROUP NAME (NUMBER¹): 24 COMMENTS: Do not make more than two applications per year in California or four applications per year elsewhere (CA approval for 4 applications pending). Do not apply aerially or in orchards using non-composted manure. For optimum results, tank mix with mancozeb or a fixed copper product that is registered for use on walnuts.</p>			
C. FIXED COPPER# (Kocide 3000, Badge X2 and others)	Label rates	See label	0
<p>MODE-OF-ACTION GROUP NAME (NUMBER¹): Multi-site contact (M1) COMMENTS: Resistance to copper is common in Sacramento Valley orchards and has been found in a few San Joaquin Valley orchards. The use of surfactants does not increase the efficacy of copper materials. Wettable powders with 50% metallic copper: rates equivalent to 4 lb or higher metallic copper/acre are effective. Dry flowable formulations with less than 50% metallic copper (Kocide 3000, Badge X2, ChampION⁺, Cuprofix Ultra, Nordox) or liquid formulations (Copper-Count N, Champ, etc.): use label rates. If resistance is known to occur in the orchard, use higher label rates. Some liquid formulations of copper require less than 4 lb metallic copper/acre. When used at recommended label rates, some of these formulations provide the same control as that of wettable powders with 4 lb metallic copper. Not all copper compounds are approved for use in organic production; be sure to check individual products.</p>			
D. BORDEAUX# 8-5-100	Label rates	See label	0
<p>MODE-OF-ACTION GROUP NAME (NUMBER¹): Multi-site contact (M1) COMMENTS: The three hyphenated numbers (8-5-100) represent the amount of copper sulfate, hydrated lime, and water respectively in the Bordeaux formula. The objective is to apply 4 lb metallic copper and 5 lb of calcium hydroxide in 100 gal water/acre. If using basic copper sulfate, which is 50% copper, apply 8 lb/acre. For hydrated copper sulfate, which is 25% copper, use 16 lb/acre. Not all copper compounds are approved for use in organic production; be sure to check individual products. For information on making Bordeaux mixtures, see <i>UC IPM Pest Note: Bordeaux Mixture</i>, ANR Publication 7481 (<i>available online</i>). Adding 0.5 gal summer oil emulsion can reduce phytotoxicity.</p>			

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.

Acceptable for use on organically grown crops.

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

Nematodes

(Section reviewed 6/17)

Scientific Names: Lesion nematode: *Pratylenchus vulnus*
 Ring nematode: *Mesocriconema* (= *Criconemella*, *Criconemoides*) *xenoplax*
 Root-knot nematodes: *Meloidogyne* spp.

DESCRIPTION OF THE PESTS

Plant-parasitic nematodes are microscopic roundworms that feed on plant tissues. On walnut, the most notorious species live in soil and roots. In California, the species of nematode most commonly found in orchard soils causing problems on walnuts is the lesion nematode, *Pratylenchus vulnus*. Ring nematode (*Mesocriconema xenoplax*) is also damaging to walnuts, and root-knot nematodes (*Meloidogyne* spp.) cause problems on Paradox and English walnut rootstocks.

DAMAGE

The severity of nematode damage depends on the age of the tree and density of the nematode population. Do not replant young trees in a heavily infested site. The roots will be severely damaged and the trees stunted and weak. Mature trees can tolerate somewhat higher numbers of nematodes. Even more mature trees show a lack of vigor, poor growth, and reduced cropping when nematode numbers are very high; trees cannot regenerate new roots.

SYMPTOMS

Symptoms described below are indicative of a nematode problem, but are not diagnostic since they could result from other causes as well.

- Damage to roots will restrict their ability to take up water and nutrients. Aboveground symptoms of nematode damage include lack of vigor, and a decline in growth and yield that cannot be corrected by management practices. The decline in vigor predisposes the tree to sunburn, branch wilt, = "flatheaded borer, and deep bark canker.
- Lesion nematodes feed and migrate inside roots causing black lesions. These lesions can sometimes be seen in large roots by scraping off a thin layer of the outer covering.
- Ring nematode infestation will result in stunted roots, which sometimes proliferate and form dense mats.
- Root-knot nematodes cause swelling of roots, called galls, mainly on Paradox and English walnut rootstocks.

FIELD EVALUATION

To make management decisions, it is important to know the nematode species present and to have an estimate of their numbers. If a previous orchard or crop had problems caused by nematodes that infect walnut trees, numbers may be high enough to damage young trees. If nematode species have not previously been identified, soil and root samples should be taken and sent to a diagnostic laboratory for identification.

To sample for nematodes:

1. Divide the field into sampling blocks that are representative of cropping history, crop injury, or soil texture. Blocks should be no smaller than 5 acres for smaller parcels (less than 100 acres), and no larger than 20 acres for larger parcels (greater than 100 acres). For parcels less than 20 acres, a minimum of 4 samples should be taken.
2. Take soil and small root subsamples from within the root zone where there is soil moisture, the area of the root system where the highest nematode activity is expected.
3. Take several subsamples randomly from each sampling block and mix them thoroughly in a container to make a composite sample. About one quart of soil is needed for each sample.
4. Place the samples in separate plastic bags, seal them, and place a label on the outside with your name, address, location, and the current or previous crop and the crop you intend to grow. (See *IPM for Walnuts*, UC ANR Publication 3270, for more details.)
5. Keep the samples cool (do not freeze) and out of direct sunlight, as drying out and heat exposure will make it difficult to extract the nematodes from soil. Transport the samples to a diagnostic laboratory as soon as possible.
6. Request a species identification for the lesion nematodes that are found.

Contact your farm advisor for more details about sampling, to help you find a laboratory for extracting and identifying nematodes, and for help in interpreting sample results. Sampling strategies will vary depending on whether they are taken for diagnostic purposes for an established orchard with a suspected nematode problem or in preparation of a new orchard planting. The general soil conditions will also impact the sampling strategy. For example, deeply rooting soils need to be sampled deeper (0–5 foot depth) than those where rooting depth is restricted.

MANAGEMENT

Prevent nematode damage by planting nematode-free certified rootstock. Try to prevent introduction or spread of nematodes through contaminated soil, equipment, or runoff water. As nematodes can actively move only very short distances, the passive transport in these materials is a critical vehicle for them to be introduced to a new field site.

If nematode infestations are suspected, rigorous soil sampling should be done to design management strategies, and inform planting decisions.

If the field was previously planted to trees or vines, sample for nematodes before planting because the soil is likely to have high numbers. Importantly, one *P. vulnus* per soil sample is the threshold value for a problem with this nematode if the field is a replant site.

When removing old walnut orchards, it is important to reduce nematode numbers as much as possible and destroy the old roots that may harbor nematodes and other pathogens. It is best to plan for pre-plant soil fumigation 3 to 4 months prior to re-establishing the new orchard.

1. Apply triclopyr (Garlon) to the cut trunks in October, which kills the roots.
2. Remove treated stumps and roots no sooner than 60 days after the application to allow for proper herbicide translocation.
3. Leave the land fallow for ripping and cultivation the next season, and follow a fallow period with deep, dried soil where fumigation is planned.
4. Alternatively, plant a cover crop the summer after Garlon application that is not a host for nematodes, such as true sudangrass (*Sorghum bicolor*) or safflower. This treatment may reduce *P. vulnus* and *Meloidogyne* spp. numbers by 30% within the surface 3 feet of the soil profile.
5. Apply a fall fumigation.

Be mindful of the fact that plant-parasitic nematodes are only one part of the problem when establishing a new walnut orchard following another nut crop. For information on this complex problem, including management considerations, see *The Replant Problem and its Management* - part 1; part 2; part 3 (available online).

Rootstock Selection

Rootstocks differ in their ability to tolerate different nematode species:

1. Use clonal Paradox VX211 rootstock where lesion or root-knot nematodes are suspected or present. This rootstock has the ability to tolerate the presence of these nematodes, even though the nematodes can still reproduce.
2. English and black walnut are very susceptible to lesion nematode, but Paradox, with its hybrid vigor, is more tolerant to infestation by lesion nematodes. However, it can be damaged when nematode numbers are very high.
3. English and Paradox are vulnerable to root-knot nematode.

For a comparison of rootstock susceptibility to nematodes and disease, see *Walnut Trees in the Nursery Trade: Understanding Terminology, How they are Propagated, Availability and Clonal Rootstock Pest Interactions* (available online at <http://ucanr.edu/datastoreFiles/391-536.pdf>).

Chemical

Trees planted on fumigated orchard sites have improved growth and yields compared to those on nonfumigated sites. Broadcast fumigation can reduce nematode populations by 99.9%; thus, nematodes are not a problem for as long as 6 years. The result is excellent root establishment. Strip or spot fumigations may provide only 6 months to a year of nematode-free soil until the walnut roots grow into the untreated areas.

Research suggests that broadcast applications of Telone II, followed by tree row-stripping of chloropicrin, provides the best growth response, with the longest suppression of plant parasitic nematodes. Deeper fumigant placement, greater than the standard 24-inch injection shanks, also helps suppress nematodes.

Fumigation does not remove the need to plant on a nematode-tolerant rootstock.

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 listed.

PREPLANT

A. 1,3 DICHLOROPROPENE*/CHLOROPICRIN (Telone C-35) COMMENTS: Must be applied by a regulated commercial applicator. Fumigants such as 1,3-dichloropropene are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.	Label rates	See label	See label
B. 1,3 DICHLOROPROPENE* (Telone II) ... PLUS ... CHLOROPICRIN COMMENTS: Must be applied by a regulated commercial applicator. Fumigants such as 1,3-dichloropropene are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.	33.7 gal Label rates	120 (5 days) See label	NA See label
C. METAM SODIUM* (Vapam, Sectagon 42) COMMENTS: Must be applied by a regulated commercial applicator. Metam sodium can effectively control nematodes if applied properly to highly porous soils, but it does not penetrate plant roots very well, and it is very difficult to get 4 to 5 feet down from the surface. Apply in combination with a triclopyr (Garlon) trunk treatment. One week before treatment, preirrigate the field with 6 to 8 acre-inches of water in flood irrigation in basins. After treatment, do not plant for 30 days, or 60 days if the soil is high in organic matter or cold (below 50°F). Fumigants such as metam sodium are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone.	75 gal	48	NA

REPLANT

A. TRICLOPYR (Garlon 3A) COMMENTS: See MANAGEMENT section for information on using Garlon to address the replant problem.	Label rates	See label	See label
---	-------------	-----------	-----------

POSTPLANT

A. SPIROTETRAMAT (Movento) COMMENTS: Use once a year. Applying in May can also help prevent walnut scale.	6–9 fl oz	24	7
B. MYROTHECIUM VERRUCARIA (DiTera DF)# COMMENTS: Follow label directions.	13.5–104.5 lb	4	0
C. QUILLAJA SAPONARIA (Brandt Nema-Q)#	Label rates	24	0

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

Acceptable for use on organically grown crops.

NA Not applicable.

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

Weeds

(Section reviewed 8/17)

INTEGRATED WEED MANAGEMENT (8/17)

Weed management is an integral part of an overall orchard management system. A good weed management program should start before trees are planted. The more difficult-to-control weeds (particularly perennial species) are easier to manage before trees are planted. Weed control in orchards enhances the establishment of newly planted trees and can improve the growth and yield of established trees.

Competition is most severe during the first four years. Weeds can reduce tree growth and yield by competing for water, nutrients, and sunlight. They also interfere with irrigation uniformity and distribution and, once the trees reach bearing age, can reduce harvest efficiency by making it more difficult to recover nuts from the orchard floor. Maintain a weed-free strip at least 30 inches from the trunk on each side of the tree to prevent weeds from competing with the developing tree.

Plants growing on the orchard floor influence the presence of other pests such as vertebrates, insects, mites, nematodes, and diseases.

- Weeds growing around the trunk compete directly with young tree growth, and provide a good habitat for field mice or voles.
- Gophers are most often found in nontilled orchards and are common where broadleaf weeds, such as field bindweed and perennial clovers, predominate.
- Crown rot in trees can also be a problem when weeds are allowed to remain around the trunks. Weeds must be controlled around the trunks, preferably without disks or other mechanical control that may cut roots or hit the trunks or main roots and cause wounding. These wounds are often an entry point for crown or root pathogens, such as crown gall.

Weeds are usually controlled either chemically or mechanically in a 4- to 10-foot-wide strip (depending on crop and age) in the tree row. The area between the tree rows may be sprayed, mowed, or tilled. Mulches, subsurface irrigation, and flammables can also be used to control weeds in orchards. Growers have many weed management tools available to achieve this objective, but the method in which these tools are utilized varies from year to year and orchard to orchard.

Soil Type Considerations

Soil characteristics play an important role in weed management. Soil texture and organic matter influence the composition of weed species present, the number and timing of cultivations required, and the residual activity of herbicides.

- On light textured soils, annual species such as puncturevine, crabgrass, horseweed, and *Panicum* spp., and perennial weeds such as johnsongrass, nutsedge, and bermudagrass are more prevalent.
- On heavier-textured soils, perennial weeds such as curly dock, field bindweed, and dallisgrass are commonly found.
- Higher rates of preemergence herbicides may be needed in clay or clay loam soils to achieve the same level of weed control as a lower rate in light, sandy soils. Many herbicide labels recommend that lower rates of the product be used on soils considered high in sand or low in organic matter.
- Soil texture affects water-holding capacity, which influences irrigation frequency and amounts. Soil moisture and wet-dry cycles can influence weed germination and establishment as well as persistence of residual herbicides.

Irrigation System Considerations

Weed growth is affected by the method of irrigation, amount of water applied, amount and timing of rainfall received, frequency and timing of cultivation, the herbicides used and their residual soil activity.

- During dry winters or in orchards with limited irrigation capacity during certain times of the year, effective weed control can increase soil water that is available to the trees.
- Frequent wetting also promotes herbicide degradation in the soil and, thus, degradation is generally faster under drip emitters, or micro-sprinklers, than under furrow irrigation.

Areas around sprinklers and emitters may require additional weed control measures, such as a postemergence herbicide applications or removal by hand. However, in the dry area between the sprinklers, weeds are less of a problem than in orchards with other types of irrigation. The first irrigation following an herbicide application is the most critical in determining the depth the herbicide is moved into the soil; subsequent irrigation is less important to the movement of the herbicide.

Preemergence herbicides can be incorporated using tillage, rainfall, or sprinkler, but not drip or furrow, irrigation. Flood irrigation will provide uniform incorporation of herbicides ONLY when the water distribution is uniform. Even when distribution is uniform, more water is usually applied by flood irrigation than is needed for herbicide incorporation; in sandy soils, excess irrigation water may move the herbicide deeper in the soil than is desired for optimum weed control. In furrow and basin flood systems with berms, preemergence herbicides dissipate more slowly on the berms because the soil surface in this area remains drier. .

Choosing an Herbicide

Herbicides are traditionally discussed as belonging to two groups: those that are active against germinating weed seeds and very small seedlings (preemergence herbicides) and those active on emerged, growing plants (postemergence herbicides). Some herbicides have both pre- and postemergence activity. Herbicides vary in their ability to control different weed species. Before using any herbicide, identify the weed species to be controlled, then check the Susceptibility Of Weeds To Herbicide Control tables and carefully follow the product labels for specific weed control activity. In most situations, combinations or sequential applications of herbicides will be required to provide effective and economical year-round control of a broad spectrum of weeds.

MONITORING Detecting new weeds and weeds that escaped previous control efforts is essential for preventing weed establishment or identifying shifts in weed populations. Regular monitoring or scouting is a very important component of an integrated plan. For weed monitoring to be useful, it is important that it be done at the right time and to correctly identify the weed species present in and around the orchard. Annual weeds generally fall into those that germinate in the fall and early winter (November–January) and those that germinate in the spring and summer (March–August). Try to identify and control weeds when they are in the seedling stage. For assistance in identifying weeds in different stages of growth, consult the color photos in the online version of this guideline that are linked to the weeds listed in Common and Scientific Names of Weeds.

Many herbicides are effective only against certain weed species. Regular monitoring will help to properly choose and time treatments. Follow-up monitoring allows you to assess if treatments were successful. Weeds often grow in patches, so it may not be necessary to apply postemergence herbicides or use mechanical control in the whole orchard. A spot treatment may save time and money while still achieving good weed control. Use the susceptibility charts in this guideline to determine alternative herbicides to control the weeds that escaped previous herbicide treatments.

Weed species that are not controlled by herbicides listed as effective against these weeds should be a warning to the manager: if there is no obvious pattern that could be attributed to sprayer malfunction or a misapplication, then herbicide resistance could be developing. See *Herbicide Resistance: Definition and Management Strategies*, UC ANR Leaflet 8012 and *Preventing and Managing Glyphosate-Resistant Weeds in Orchards and Vineyards*, UC ANR Publication 8501, (*available online*) for suggestions on how to adjust management to avoid development of herbicide resistance.

How to Monitor

- Survey your orchard for weeds in late fall and again in late spring
- Monitor the orchard in a thorough and systematic manner. Include the entire orchard as well as field margins, ditch banks, and irrigation canals in your survey.
- Examine all areas that are susceptible to weed infestation, like areas of high moisture. Important information includes weed species, location in the field, degree of control achieved with current program, and herbicides and other options used (including timing, rates, and dates treated).
- Record observations on a survey form that includes a map so the infested sites can be revisited for weed control. Pay particular attention to perennial weeds and other problem weeds and note their location on the map.
- Record weeds found in rows and middles separately. Weeds in tree rows must be managed, but annual weeds in row middles may have some benefit as an orchard floor cover.

Maintain monitoring information for the life of the orchard. Over several years, this information will help in determining changes in the weed species that are present. Comparing this information with the past and current

weed management methods actions including timing, rates and dates of herbicide applications and cultivations can help in evaluating the success of the techniques used and in deciding future strategies.

Late fall weed survey

Survey your orchard after the first rains of the fall when winter annuals have germinated and started to emerge. Monitoring weeds in fall accomplishes several tasks. It will identify remaining summer species and perennial weeds that escaped the previous year's weed control program so that adjustments can be made to control these species in the next year. Fall monitoring will also identify winter species that are emerging. Keep records of your observations and use the map to show areas of problem weeds *example weed survey form (available online)*.

Late spring weed survey

Survey your orchard in late spring or early summer, after summer annuals have started emerging. By surveying weeds at this time, you can identify any species that escape control from earlier management and know what perennial weeds are present. If herbicides were used, monitoring can help identify any need for changing to another herbicide. Pay particular attention to perennial weeds and check for their regrowth a few weeks after a mechanical or chemical control operation. Keep records of your observations and use the map to show areas of problem weeds *example weed survey form (available online)*.

WEED MANAGEMENT BEFORE PLANTING.

- Grade the orchard site to ensure even drainage. Low spots within the orchard promote perennial weed growth that is difficult to control and causes continuing problems. Maintain proper drainage, which keeps puddles from forming within the tree row. Puddles accelerate the dissipation of herbicides; this leads to weed growth that competes with the young trees. Avoid fields known to be infested with perennial weeds such as johnsongrass, field bindweed, bermudagrass, and nutsedge whenever possible.
- Control annual and perennial weeds before planting an orchard to reduce competition during orchard establishment.
- Control annual weeds before they produce seeds and established stands of perennial weeds before trees are planted. This will also reduce potential injury to young trees from herbicides that would otherwise be used after planting the trees.

Nonchemical controls

Cultivation, followed by irrigation to germinate new weeds, and then cultivation again to kill weed seedlings is an especially effective weed control method that can be used before planting trees. Several cycles of germination and unsuccessful establishment reduces the number of weed seeds in the upper layers of the soil, thus reducing weed numbers. At least two cycles of cultivation, then irrigation, followed by a shallow cultivation are needed to achieve a marked reduction in weed seedlings. This method is not effective for established perennial weeds.

Cultivation when the soil is very dry is an effective method to control perennial grasses such as bermudagrass and johnsongrass. Cultivation cuts the rhizomes into small pieces so they can dry out. Rework the soil frequently with a spring tooth harrow to pull new rhizomes to the surface to dry out. If the site is irrigated, or rain occurs before total control of the perennial plant is achieved, the rhizome pieces may begin to grow, which can greatly reduce the effectiveness of this practice. Tillage in moist or wet soil can increase the number of perennial weeds because each piece of cut rhizome can root and develop into a new plant.

Field bindweed growth can be reduced for up to two years by deep plowing or using a reclamation blade (a large V-shaped blade) to cut the roots at a depth of 16 to 18 inches in dry soil. Nutsedge infestations can be reduced by deep plowing with large moldboard plows that bury the nutlets to a depth of at least 12 inches, but, subsequent deep plowing may bring viable seeds and nutlets back to the surface. Seedlings of annual and many perennial weeds can be controlled with repeated, timely cultivation.

Chemical control

Annual weeds can be controlled with preemergence herbicides before planting an orchard. Any established annual weeds should first be controlled with postemergence herbicides. Preemergence herbicides should be used in conjunction with a rotation crop, making sure the residual period of the herbicide is not so long that it will interfere with planting the trees. Most annual weeds can be controlled in a strip down the proposed tree row by using a preemergence herbicide (e.g., Treflan) and incorporating it into the soil. However, many growers prefer to use

preemergence herbicides only after the trees have been planted and soil has settled around the plants to avoid possible exposure to herbicides that may be in the backfill soil.

When planting trees, be careful not to mix preemergence herbicide-treated soil into the planting hole or severe injury can result. When planting the trees, place untreated soil (from the untreated middles) directly around the roots and then cover it with a surface layer of treated soil. Many growers use glyphosate before planting and then follow planting with an application of a preemergence herbicide after the soil has settled.

Follow all label plantback restrictions in orchard sites where preemergence herbicides have been used.

Postemergence herbicides generally have a little or no soil residual activity and typically are safer to use before planting trees. A common practice to control perennial weeds such as dallisgrass, bermudagrass, and johnsongrass is to apply glyphosate (Roundup) in summer when the weeds are growing vigorously and then follow with cultivation 2 weeks later. If the soil and plant material can be dried after treatment, increased control is achieved. Field bindweed can be suppressed, but usually is not eradicated with this method.

Soil solarization

Soil solarization is a nonpesticidal method of controlling soil-borne pests by placing clear plastic sheets on moist soil during periods of long day length. Soil solarization can be used in the area planned for tree rows to significantly reduce weed numbers and species. The plastic sheets trap the sun's radiant energy in the soil, heating the upper levels to temperatures (108–131°F at a depth of about 3 inches) that kill many disease-causing organisms (pathogens), nematodes, and weed seeds and seedlings.

In areas where summer fog is not a concern, solarization should be done when day length is as long as possible (from mid-June to mid-August), or at the latest by the beginning of August to have sufficient time (4 to 6 weeks) to complete the process. In areas where summer fog is prevalent, solarization should be done during the warm fall months when there are fewer foggy days. The soil in the area designated for solarization must be moist and the treated area should be at least 6 feet wide. Use 1.5 to 2 mil thick clear plastic that is impregnated with a UV-inhibiting component to ensure that it will not break down before solarization is completed. Black plastic suppresses weed-seed germination but will not heat the soil to the same degree as clear plastic.

Effective soil solarization begins with preparing a smooth seed bed so the plastic can be placed as close as possible to the soil surface.

- Disc to break up clods and then smooth the soil (e.g., with a roller).
- Remove any material that will puncture or raise the plastic sheets such as rocks and weeds.
- Irrigate before or after applying the plastic because wet soil conducts heat better than dry soil.
- If irrigating before applying the plastic: cover the soil with plastic as soon as feasible after irrigating. After irrigation, allow the soil to dry somewhat to avoid compaction by heavy equipment.
- To irrigate after laying the plastic: install the drip system or microsprinkler line (with only the spaghetti tubing) before planting or use furrow irrigation under the plastic. (If the entire site is irrigated, weed growth will occur in the untarped centers and will be difficult to control without disturbing the plastic.) The plastic should be buried on all sides to create a seal on the soil and help prevent the plastic from being blown away by wind. Implements are available that assist in laying down the plastic and automate this otherwise labor-intensive process.
- Remove plastic before planting.
- Cultivate solarized soil less than 3 inches deep to avoid bringing viable weed seeds to the surface where they can germinate and establish.

The effect of solarization diminishes at greater depths, and it does not control perennial species as well as annuals. Seeds and seedlings of bermudagrass, johnsongrass, and field bindweed are controlled, but established plants are more difficult to control. Yellow nutsedge is partially controlled, while purple nutsedge is not significantly affected. Solarization leaves no toxic residues and can be used on a small or large scale. Soil solarization may also improve soil structure and increases the availability of nitrogen (N) and other essential plant nutrients.

For additional information see
Soil Solarization, U.C. Publications, 21377.

WEED MANAGEMENT IN TREE ROW

Newly Planted Orchards

Weed control is especially important during the first few years of orchard establishment. Competition from weeds during this period can result in reduced tree vigor and productivity. Weedy orchards may require several more years to become economically productive than orchards with effective weed management. Regardless of the method to control weeds, care must be taken not to injure the young trees with herbicides or to mechanically damage the trunk or roots. As the orchard becomes established, competition from weeds is lessened as shade from the tree canopy, especially in densely-planted orchards or in orchards with large-stature trees, reduces weed growth.

Weeds growing directly around the bases of trees can be controlled using a number of methods. A selective preemergence herbicide can be applied in a strip down the tree row or around the tree as soon as the soil has settled following planting. Do not let the spray contact tree leaves or the bark of trees less than 3 years old. Cardboard cartons are often used to protect trees at this stage. Trees are most sensitive to herbicides when they are young. In walnut orchards planted on Paradox rootstocks, the use of herbicides instead of mechanical control reduces the danger of wounding young trees with a disk or hoe and creating an entry for crown gall bacteria.

The area around young trees may also be hand hoed until the trees are 3 to 4 years old, at which point a swing mower or disc can be used to control the weeds between the tree rows. Other in-row mechanical tools available include discs, weed knives, cultivators, and rotary tillers. It is best to hoe when the weeds are a few inches tall; hoeing becomes difficult when weeds are allowed to get larger. Another alternative is the use of synthetic mulches made of polyethylene, polypropylene, or polyester around the base of trees to discourage weed growth; the weeds between the tree rows can be mowed or disced. However use these mulches with caution, since they may harbor voles that may feed on tree trunks.

Cultivation.

Hand-held weed eaters can be used to kill small weeds around the trees, but take care not to injure the bark of young trees. Cartons, sleeves, or wraps can help to protect trees from string trimmers. Damage to either the bark or the roots can allow soil pathogens in, causing further damage to the trees.

Herbicides

Some weeds are best controlled during the nonbearing period (normally four–six years) before the trees are at full production. Certain herbicides are registered for use only during this nonbearing period.

Preemergence herbicides If using preemergence herbicides to control weeds in a newly planted orchard, apply them to the soil only after the soil has completely settled around the trees in to reduce the likelihood of tree damage. The risk of damage is greater if the trees settle after treatment because the herbicide has a greater chance of coming into direct contact with tree roots. Refer to the HERBICIDE TREATMENT TABLE for herbicides registered, tree age restrictions, and general label recommendations.

Postemergence herbicides Regardless of the postemergence herbicide used, protect the foliage and bark of young trees from direct spray or spray drift in order to avoid tree injury. Young trees are very susceptible to damage from herbicides. Placing plastic or cardboard wraps, cartons, or sleeves around the tree trunks is helpful in preventing herbicide contact with young trees.

Established Orchards

Depending on the species and variety, it usually takes about 3 to 7 years in most situations for nut trees to come into production. Once the orchard is established, the area around the base of the tree should continue to be kept weed-free. By removing weeds from around the base of the tree, weed competition and the potential for rodent damage are reduced. In conventional orchards weeds are generally controlled between the tree rows by discing or mowing (see middles management) and in the tree row with an herbicide strip or with cultivation.

Herbicides

Herbicides are traditionally discussed as belonging to two groups: those that are active against germinating weed seeds (preemergence herbicides) and those active on emerged plants (postemergence herbicides). Some herbicides have both pre- and postemergence activity. In most orchards, herbicides are only used on a 4- to 10-foot-wide strip (depending on crop) centered on the tree row.

Preemergence herbicides Preemergence herbicides are active in the soil against germinating weed seedlings. These herbicides should be applied to bare soil and then moved into the soil with rain or irrigation, where they can affect germinating weed seeds. If herbicides remain on the soil surface without being activated by rain or irrigation, some will degrade rapidly from sunlight and the resulting weed control will be reduced. Large weed seeds, such as wild oat, may germinate in the soil below the herbicide zone and not be controlled by the treatment.

For best results, most preemergence herbicides should be applied to the soil just prior to an irrigation or rainfall (0.25-0.5 inches) to be moved into the soil where the weed seeds germinate. Do not make an application if a large amount of precipitation is expected in a short period, as runoff or leaching of the herbicide may occur.

Preemergence herbicides can provide control for several months or up to a year, depending on the soil type, solubility of the material, adsorption of the material to soil, the weed species present, and the dosage applied. Leaching from the soil is more extensive on sandy than on clay soils. Leaves or other debris covering the tree row can prevent the herbicide from contacting the soil; performance can often be increased by blowing or sweeping the rows right before application of preemergence herbicides.

Proper incorporation is important for the effectiveness of preemergence herbicides. This may be achieved mechanically (power incorporation or disking) or through irrigation. Rainfall may also be used for herbicide incorporation; however, weeds may germinate before a consistent rainfall pattern is established. As a result, postemergence herbicides are often used in combination with preemergence herbicides to control weeds that have germinated and emerged before the preemergence herbicide is properly incorporated.

Postemergence herbicides Postemergence herbicides are applied to control weeds that have germinated and emerged. They can be combined with preemergence herbicides early in the season, alone as a broadcast treatment, or as spot treatments during the growing season. The trunks and foliage of young trees need to be protected from contact with some postemergence herbicides. Be sure to check and follow individual label instructions. Select the appropriate postemergence herbicide that best controls the weeds present. A tank mix of one or more herbicides may be required to control all the weeds.

Apply postemergence herbicides when weeds are small and not under moisture stress. If the weed population is sparse or patchy, the amount of herbicide needed can be reduced by making spot applications or by using a visual weed-seeking sprayer. Some weeds, like spotted spurge, set seed soon after emergence, so they must be treated frequently to provide adequate control if a postemergence-only strategy is used.

Postemergence herbicides are used on established weeds. Contact herbicides, such as paraquat, kill those parts of the plant that are actually sprayed, making good coverage and wetting essential. A single treatment can kill susceptible annual weeds but re-treatment is necessary if perennial weeds regrow from roots or other underground structures or if new germination of annual weeds occurs after the initial application. Translocated herbicides, such as glyphosate, move into the plant and are moved to other above- and below-ground portions of the plant and kill them. (glyphosate, however, does not translocate into mature nutsedge tubers.) Complete coverage with translocated herbicides is not as essential as with contact herbicides but better coverage will often result in better weed control efficacy with both types of herbicides.

Postemergence herbicides usually require the addition of an adjuvant (either a nonionic surfactant or a nonphyto-toxic oil) to be effective. Ammonium sulfate is often added to the spray water first, before adding herbicide(s), to condition the water and help improve herbicide uptake by weeds, particularly where water high in calcium, sodium, magnesium, and iron is used. Many factors affect the performance of postemergence herbicides including: dust, spray volume, and hard water. For more information on the effective use of postemergence herbicides, see *Glyphosate Stewardship: Maintaining the Effectiveness of a Widely Used Herbicide*, ANR Publication 8492.

Application equipment must be accurately calibrated to apply the proper amount of herbicide to the soil and young growing weeds. For safe application and to minimize drift, spray equipment should be equipped with a short boom that has nozzles designed to minimize the amount of very small spray particles generated. Nozzle technology has advanced significantly in recent years and many manufacturers have developed nozzles, or attachments to decrease the proportion of very small droplets in the spray pattern.

Herbicides and irrigation In established orchards, chemical weed control must be adjusted to the irrigation method used. In California, nut trees are irrigated by several methods such as low-volume drip, micro-sprinklers, misters, solid-set sprinkler, furrow, or basin flood. Low-volume irrigation is common in California orchards because it provides better uniformity in irrigation application and efficiency when compared to other methods.

However, low-volume irrigation water applied too frequently can, under certain circumstances, increase the chance of leaching and herbicide degradation, often leaving the areas around the emitters with vigorously growing weeds. It is important to monitor these areas closely and spot treat, when necessary, with postemergence herbicides. Prolonged moist conditions during winter in furrow bottoms or around low-volume emitters during irrigation favor the breakdown and leaching of herbicides.

Cultivation

Cultivation can be used to manage annual and biennial weeds both between and within tree rows. Large weeds, perennial species, or weeds with hardy roots or crowns (like cheeseweed) may not be completely controlled mechanically and require postemergence herbicide treatments. Mechanical methods of weed control include hoeing or using weed knives in the row and cultivating between rows. Mechanical cultivators, such as a Weed Badger, will be effective if used on loose soil that does not contain large rocks. These practices need to be done frequently when weeds are small to reduce competition and seed production. If weeds are allowed to mature the plants often become a fire hazard, but more importantly, can produce enough seeds to ensure many years of weeds.

Weeds within the tree row can be managed with a second pass of the cultivator. However, cross discing must be carefully done to avoid damaging the trees and their roots. Injury to trees can lead to invasion by crown-rotting organisms. Leave a 1- to 2-foot strip next to the trees to prevent injury. Weeds in this undisturbed area can be removed by hand or spot treated with postemergence herbicides where appropriate (see section above). In-row mulching cultivators also can be used as long as the trees are not damaged. Shallow (less than 2 inches deep) mulching will destroy most annual and seedling biennial weeds.

MIDDLES MANAGEMENT

Weed management in orchards is often separated into two categories: weed control in the tree row and weed control in the middles. Weed control in the middle is often combined with cover cropping and known as “middles management.”

Some growers prefer to maintain a planted cover crop or resident vegetation because of problems that can develop with repeated discing including:

- soil compaction
- dust
- reduced water infiltration
- soil erosion in hilly terrains and sloping lands

Discing may also bring some buried weed seeds to the surface or spread rhizomes, tubers, or stolons throughout the orchard.

If resident vegetation does not grow uniformly enough to compete well with newly-invading weeds, consider planting a cover crop in the area between the tree rows. An annual cover crop, such as sub-clovers that reseed themselves, will compete against weeds; however, it may also require occasional reseeding to maintain a uniform cover crop stand. Where resident vegetation is maintained, a flail mower is used as needed to maintain the plants in a low-growing state. Mowing too close to the soil surface creates dust and should be avoided. If self-reseeding of a cover crop is desired, a final mowing should not be made until the plants have set seed.

Cover Crops

Two primary reasons for planting a cover crop are: to enhance soil quality by adding organic matter and to increase soil nitrogen with legume cover crops. Other benefits cover crops can provide include:

- improved orchard access during the rainy season
- enhanced water infiltration
- suppression of winter weed species (and summer species if cover crop remains or regrows through late spring)
- reduction of:
 - soil compaction and crusting
 - irrigation and rain runoff
 - off-site movement of pesticides and nitrogen
 - erosion on slopes

- dust (reduced dust minimizes spider mite infestations)

Plan for the additional water needs of the cover crop so that it does not compete with trees for available water, or, in the case of dryland orchards, disc under the cover crop in spring to maximize the amount of water available to the tree.

Newly established cover crops may be seriously damaged by fall and winter orchard traffic during operations such as pruning, brush removal, chipping and shredding, and spraying. In orchards where these operations are planned, cover crops may be seeded in alternate middles and these operations carried out in the nonseeded middles. Or, plant cover crops in years when these operations are not planned in the orchard.

Although cover crops will be most competitive if mowing is avoided, mowing once before bloom is recommended, especially in almonds, to reduce frost hazard and eliminate pollination competition during flowering. The cover crop will regrow and flower later in the season. However, cover crops that are not mowed or are mowed infrequently in order to reseed also provide excellent cover for gophers. Gopher populations can frequently build up in cover-cropped orchards, and during harvest they have nothing to feed on except tree roots. Thus, it is imperative that gopher control is maintained, regardless of the middles management system employed, but particularly if cover crops are utilized.

An alternative to mowing is to let a cover crop grow until it is nearly mature and then roll it with a ring-roller to press the vegetation down. This accelerates the senescence process but allows for some seeds to mature. In addition, the intact mulch shades the soil and may prevent some weed seeds from germinating. This mulch usually degrades by harvest, but if it hasn't degraded at least 3 weeks before harvest, a close mowing with a flail mower will chop the cover crop into pieces that will degrade or not interfere with harvest operations.

A once common practice was 'chemical mowing' in which the vegetation middles, consisting of either resident plants or a planted cover crop were treated with low rates of postemergence herbicide to stunt the plants rather than killing them. This practice is no longer recommended due the potential selection for herbicide-resistant weeds.

For more information on choosing a cover crop, how and when to plant, and suggestions of cover crop mixes, consult UC ANR Publication 21471, *Covercrops for California Agriculture* or *Cover Crops for Walnut Orchards*, ANR Publication No. 21627 (*available online*)

HERBICIDE RESISTANCE

Herbicide resistance is the inherited ability of weeds to survive and grow at herbicide dosages many times greater than what is usually needed for control of that species. The potential risk for the development of herbicide resistance is greatest when the same herbicide is used repeatedly, as is often done in orchards. To prevent the development of herbicide resistance, use a variety of weed-control strategies, including cultural practices and alternating herbicides with different modes of action. Failure to do this can result in the rapid loss of herbicides as an effective pest management tool, although cultivation remains an option.

If resistant populations are observed, avoid moving resistant weeds from one field to another by cleaning equipment before moving out of a field with known herbicide-resistant weeds. Consider scheduling fields with known resistance problems as the last ones for field operations. Some populations of annual bluegrass (*Poa annua*), horseweed (*Conyza canadensis*), annual or Italian ryegrass (*Lolium multiflorum*), junglerice (*Echinochloa colona*), and hairy fleabane (*Conyza bonariensis*) have developed resistance to glyphosate in California.

Detection

The first step in preventing herbicide resistance is early detection. Be on the lookout when monitoring for patterns that indicate resistance including:

- patches of dense weeds, with less dense populations radiating out from the central patch
- weeds that have escaped control scattered in no particular pattern throughout the field.

Prevention and Management

One of the most important control strategies in managing resistant populations of these weeds is to not let the plants produce seed. To help prevent the development of resistance to herbicides in orchards:

- Rotate herbicides that have different modes of action and WSSA Group numbers
- Monitor for weed survival after an herbicide application

- Include nonchemical weed-control methods such as cultivation or hand weeding
- Clean equipment after working in weed-contaminated orchards to prevent the spread of weed seeds
- Control weeds suspected of herbicide resistance before they can produce seed
- If weeds escape treatment, use shovels, hoes, and other hand tools to cut the plants below the soil surface to prevent flowering.
- Use a preemergence herbicide before weeds emerge. Where the weeds emerge in fall and spring, consider splitting applications to meet the multiple emergence windows.

For more information on herbicide resistance, see *Selection Pressure, Shifting Populations, and Herbicide Resistance and Tolerance*, UC ANR Publication 8493 and *Preventing and Managing Glyphosate-Resistant Weeds in Orchards and Vineyards*, UC ANR Publication 8501

If horseweed and hairy fleabane are already growing in the orchard, either treat them with a postemergence herbicide or use mechanical cultivation before they get larger than 18 to 21 leaves. In established orchards, use 2,4-D, glufosinate (Rely 280), or saflufenacil (Treevix) to control these weeds early. Glyphosate can also work well for the non-resistant horseweeds if rates are 1 to 2 lb a.i./acre but even on the susceptible populations, control is best when plants are small. Mixing 2,4-D or glufosinate with glyphosate will improve control if resistance is suspected. Similarly, glyphosate-resistant ryegrass can be controlled with alternative herbicides such as paraquat (Gramoxone) or glufosinate if used at the appropriate stage. Closely monitor the weeds following treatment to assess the treatment's effectiveness.

WEED MANAGEMENT IN ORGANIC ORCHARD (8/17)

Weed control in organically managed orchards requires special attention to prevent problems before they start. Any method that reduces the amount of weed seed in the orchard will diminish weed numbers over time. One of the best ways to prevent weed problems is to control existing weeds before they go to seed. It is usually best to use conventional tactics, including synthetic herbicides, for one or two years after planting; this helps reduce the weed seed bank and weed numbers, and makes weed control by organically-approved means less expensive later. However, this approach will require three more years of *not* using synthetic herbicides in the orchard for it to be certified as organic. If the site is not already certified organic, herbicides can be used until the transition time to organic begins, which can be very helpful in ridding the area of these hard-to-control perennial weeds.

It is essential to correctly identify the diversity of weeds infesting the orchard or planting site. Become familiar with each weed's growth and reproductive habits in order to choose the most effective management options. See the weed photos linked to the weeds in the list of Common And Scientific Names Of Weeds.

Transitioning mature, full-canopied trees to organic production will require less intensive weed management than starting out as a new organic orchard. Mature, shady orchards often have limited weed growth, whereas weeds can more effectively compete with trees in newly planted orchards where there is more sunlight available to the weeds.

WEED MANAGEMENT BEFORE PLANTING

The season before trees are planted is a critical period for weed management, so young trees can become established with reduced competition from weeds. Two methods of managing weeds at this time are cultivation and soil solarization.

Cultivation

Repeating a cycle of irrigation followed by cultivation several times to germinate and destroy young weeds can reduce the amount of weed seed in the orchard soil. Cultivation works well with summer annuals but not as well with perennial weeds such as nutsedge, field bindweed, bermudagrass, and johnsongrass. If the site is not already certified organic, herbicides can be used until the transition time to organic begins. This can be very helpful in ridding the area of these hard-to-control perennial species. Or, if most of the weed seeds are located in the surface 4 inches of soil, a soil-inverting plow can be used to bury them deeply so that they cannot germinate or successfully emerge. Use a soil-inverting plow such as a Kverneland plow because a standard moldboard plow will not sufficiently invert the soil in most cases.

Soil solarization. Soil solarization can significantly reduce weed numbers in the planned tree rows. For more information on solarization, see the Soil Solarization section above.

WEED MANAGEMENT AFTER PLANTING

Controlling weeds while they are small is important for the most effective organic weed control.

Tree-row management

During the non-bearing years, mulch may be used to control weeds in the orchards. Maintain the mulch layer throughout the year. In-row mulches of woven fabric or a 4-inch layer of organic materials including compost, newspaper, straw, hay, and wood chips control weeds by preventing light penetration necessary for weed growth. The weed fabrics typically last 4 to 5 years. Since organic mulches may reduce the soil temperature slightly, it is often better to apply these materials when the trees have been in the ground for at least one full year to avoid the possibility of reduced tree growth. Both organic and fabric mulches may need to be removed when production starts, as they can interfere with harvest operations. Be sure to monitor for voles and gophers, as mulches provide cover for them and these vertebrate pests can be severely damaging to young trees. Once the trees are established, weeds in the tree row may be managed with shallow in-row cultivation, cross discing, cross mowing, hand hoeing, flaming, organically acceptable herbicides, or mulches. The choice of method depends in part on costs, tree spacing, the use of berms, orchard floor management practices, and the type of irrigation system.

In-row cultivation

In-row cultivators are equipped with a sensor or trigger mechanism that pivots the cutting arm around the tree to avoid injury. Several companies make cultivation equipment; those that have performed well include equipment from Bezzerides, Kimco, and L & H Manufacturing. They are more effective on smaller weeds.

- Sprinkler-irrigated orchards require extra precautions to ensure proper operation of the trigger mechanism on the cultivator so that it moves away from the sprinkler head in the same way as it does for the tree.
- Microsprinkler irrigation lines and emitters can be protected from damage by suspending the surface lines, with the microsprinklers positioned upside down, in the trees or on stakes.
- Drip lines may be buried or suspended above the soil to avoid damage.
- Furrow-irrigated orchards are amenable to in-row cultivation.

Flaming

Flaming can effectively manage in-row weeds that are smaller than eight leaves.

- Protect the trunks of young trees from flamers to avoid injury to the cambium layer of the tree.
- Keep flamers away from the plastic irrigation tubing.
- Flamer should be used on green vegetation and not in orchards with dried vegetation in order to avoid fires that may injure trees and irrigations systems or spread out of control. The flamer is passed quickly over the green vegetation to damage cells, not to start the plant on fire.
- Suspend microsprinkler irrigation lines and emitters in the trees or on stakes with the emitters positioned upside down, and bury drip lines to prevent damage to irrigation equipment.

When flaming is used repeatedly, grasses will eventually become the dominant weeds because their growing points are at or below soil level and are not readily killed with flaming. Also, perennial weeds can be suppressed, but usually are not controlled with flaming.

Organically-Approved Herbicides

Check with the organic licensing organization to determine current status and any use restrictions for organically acceptable herbicides. As with any contact herbicides, good coverage is essential. In most cases, a spray volume of at least 60 gallons per acre will be required when using these products.

- Repeated applications are necessary to control newly emerged weeds.
- Efficacy is greatest on seedlings or small weeds.
- Add an organically-acceptable surfactant to improve efficacy.
- Avoid spraying tree foliage to prevent injury to green tissue.

Broadcast application of organic herbicides is usually not economical. However, organic herbicides are useful for spot treatments, particularly to control weeds in mulches, because this will help to preserve the mulch and increase its useful life span.

Weeding animals

Before using any animals, check federal, state, and local food safety regulations and comply with them. Consult the University of Idaho and University of Missouri websites for further information on grazing animals.

Weeder geese. Geese can be used to manage grass weeds in orchards. Geese prefer grass species and will only eat other weeds and crops after the grasses are gone. If confined, they will even dig up and eat johnsongrass and bermudagrass rhizomes, which they prefer. These grasses are otherwise difficult to manage in organic systems.

Young geese are best because they eat larger quantities of food, although having at least one older goose helps to protect the younger birds. Generally, about four geese per acre are needed. Provide geese with drinking water and shade. Protect them from dogs and other predators; portable fencing works well. Consult the Metzger Farms website for further information on geese.

Other animals. Sheep and goats are sometimes used in organic orchards as well. Sheep will effectively remove all weeds down to ground level. Goats are browsers and must be carefully managed to avoid damage, especially to young trees. Both sheep and goats are generally used during the time when trees are dormant and the chance of grazing damage is minimal. Because of the need to maintain animal health and condition, grazing animals generally suppress weeds rather than fully control them. Use of animals for weed control in tree nut orchards raises some concerns about food borne illness and should be considered and managed carefully if used.

SPECIAL WEED PROBLEMS (8/17)

Currently registered preemergence herbicides will control only seedlings of annual and some perennial weeds. Repeated postemergence treatments are required to control perennials. While they are best controlled (preferably eradicated) before planting, if these weeds are still present after planting, a program is needed for their control. With these treatments, there is always some concern of injury to trees from careless application.

HERBICIDE-RESISTANT WEEDS

Some populations of annual bluegrass (*Poa annua*), horseweed (*Conyza canadensis*), annual or Italian ryegrass (*Lolium multiflorum*), junglerice (*Echinochloa colona*), and hairy fleabane (*Conyza bonariensis*) have developed resistance to glyphosate in California. For more information on treating herbicide-resistant weeds, see INTEGRATED WEED MANAGEMENT.

PERENNIALS

Primary species that are difficult to control are the perennial grasses and broadleaf weeds. In mature orchards with heavy shade, perennial weeds will be a minimal problem. It will be necessary to control seedlings of these weeds with preemergence materials or spot treatments of glyphosate (Roundup) or paraquat before they become established. Seed from the grass species can last at least 2 years in soil, while seeds of the broadleaf weeds may last 10 to 60 years in the soil, depending upon species. Therefore, frequent monitoring is necessary for continued control. Do not allow perennial plants to reestablish or to produce seed.

BERMUDAGRASS

Bermudagrass is a vigorous spring- and summer-growing perennial grass. It grows from seed but, because of its extensive system of rhizomes and stolons, can also be spread during cultivation. It frequently becomes a problem in mowed orchards because mowing increases the amount of light that the stolons receive, thus stimulating their growth. This grass is very competitive with the trees for moisture and nutrients. Seedlings can be controlled with preemergence herbicides. If bermudagrass develops in localized areas, immediately spot-treat it with postemergence herbicides such as glyphosate (Roundup).

CURLY DOCK, DANDELION, and JOHNSONGRASS

Johnsongrass, dandelion, and curly dock may be controlled with multiple applications of glyphosate (Roundup, Touchdown), but use carefully around newly planted trees.

To achieve the best control with postemergence contact herbicides, cultivate the weeds to chop the stems, crowns, and rhizomes into small pieces, then irrigate to encourage regrowth and a lot of leaf area on the weeds. Spray before the weeds flower or set seed. Good coverage is important and spot treatment of regrowth may be needed. In young trees, fluazifop or sethoxydim can be used to control grasses without risk of tree injury. Curly dock can also be suppressed with 2,4-D applications, while dandelion can be controlled with 2,4-D. A permit is required for this material. Use 2,4-D with caution in tree nut orchards to prevent tree damage.

DALLISGRASS

Dallisgrass is a common perennial weed and can be highly competitive in newly-planted orchards. Dallisgrass seedlings germinate in spring and summer; this species can also form new plants on short rhizomes that develop from the original root system. Seedlings can be controlled with cultivation or with preemergence herbicides. Dallisgrass has a clumpy growth habit that gives it a bunchgrass appearance. Like bermudagrass, it tends to become dominant in mowed areas because mowing stimulates seed set. It also grows in areas with standing water. The plants are heavy seed producers. Treatment with glyphosate has been successful in controlling dallisgrass infestations.

FIELD BINDWEED

Field bindweed is a vigorous perennial weed that either grows from seed (which can survive for up to 30 years in the soil) or from stolons, rhizomes, or extensive roots. Because of the seed's longevity in the soil, it is critical to destroy plants before they can produce seed. The plants may spread from stem or root sections that are cut during cultivation: however, cultivation when the soil is dry controls seedlings. If field bindweed appears in or around the orchard, spot-treat with high label rates of glyphosate, especially when the bindweed is actively growing.

NUTSEEDGE

Yellow nutsedge is a difficult-to-control perennial weed that reproduces from underground tubers, which survive for 2 to 5 years in the soil. The tubers are easily spread by cultivation equipment. Each tuber contains several buds that are capable of producing plants. One or two buds germinate to form new plants; however, if the plant is destroyed by cultivation or an herbicide, then a new bud in the tuber may be activated.

In established orchards, if nutsedge develops, spot-treat it with glyphosate (Roundup). Then re-treat it before the plant reaches the five-leaf stage. New nutlets do not form if the plants are re-treated at or before this stage. As with seedling bindweed, young nutsedge can be controlled by cultivating when the soil is dry.

Nutsedge is a particular problem in young orchards or around replacement trees because it does best in full sun conditions.

COMMON PURSLANE

Common purslane is a prostrate summer annual that reproduces from seed, which germinate in April to early May. Common purslane grows into a plant with fleshy stems, which can root and continue to grow after cultivation or mowing if sufficient moisture is present. Common purslane can cause problems with both nut drying and pick-up during harvest operations.

This weed predominates in sunny areas of the orchard, especially if low rates of translocated herbicides (e.g., glyphosate) are used as preharvest sprays. If problems develop with this weed, use higher rates of glyphosate to control it.

A low-rate preemergence herbicide program can also effectively manage this weed and reduce the need for preharvest treatments. Pendimethalin (Prowl H2O) at 1 quart/acre applied with glyphosate in April to the area between the tree rows in the orchard can provide season-long control. Monitor the rates used and adjust them so that populations of winter annual vegetation such as annual bluegrass are preserved.

HAIRY FLEABANE

Hairy fleabane is an annual plant that normally emerges in late fall and early spring but can also emerge during winter if temperatures are relatively warm. This plant can withstand several mowings and still produce seed. It is not a good plant to have in a ground cover because its hard stem does not degrade easily and can cause harvest problems. In addition, it can interfere with moving sprinkler and drip irrigation lines. Simazine is an effective preemergence herbicide for hairy fleabane. Paraquat and saflufenacil can control this species when it is small, but once plants bolt (when they send up flowering stalks), they may not be completely effective. Glyphosate at 1 lb a.e./acre will control susceptible plants up to 13 leaves; for plants with 14 to 19 leaves 2 lb a.e./acre is required. Plants larger than 19 leaves are not adequately controlled. Most populations of hairy fleabane in California are not well controlled with glyphosate; some are also resistant to paraquat.

LITTLE MALLOW (CHEESEWEED)

Little mallow is an annual or biennial weed that is sometimes not effectively controlled with many common preemergence herbicides. High rates of oxyfluorfen (Goal) can provide acceptable control. Once established, little mallow becomes woody and forms a thick crown and root, making it difficult to control mechanically or with postemergence herbicides. Plants that are less than 4 to 6 inches tall are easiest to control with a tank mix of oxyfluorfen plus glyphosate. Smaller plants can also be controlled with carfentrazone (Shark) or saflufenacil (Treevix). Repeated mowing is usually not an effective means of control.

COMMON AND SCIENTIFIC NAMES OF WEEDS (8/17)

Common Names	Scientific Names
Asparagus	<i>Asparagus officinalis</i>
Barley, hare	<i>Hordeum leporinum</i>
Barnyardgrass	<i>Echinochloa crus-galli</i>
Bermudagrass	<i>Cynodon dactylon</i>
Bindweed, field	<i>Convolvulus arvensis</i>
Blackberries	<i>Rubus spp.</i>
Bluegrass, annual	<i>Poa annua</i>
Bromegrasses	<i>Bromus spp.</i>
Burclover, California	<i>Medicago polymorpha</i>
Canarygrass	<i>Phalaris canariensis</i>
Catsear, common	<i>Hypochaeris radicata</i>
Chickweed, common	<i>Stellaria media</i>
Clovers	<i>Trifolium spp.</i>
Cockleburs	<i>Xanthium spp.</i>
Crabgrasses	<i>Digitaria spp.</i>
Cudweeds	<i>Gnaphalium spp.</i>
Dallisgrass	<i>Paspalum dilatatum</i>
Dandelion	<i>Taraxacum officinale</i>
Dock, curly	<i>Rumex crispus</i>
Fiddlenecks	<i>Amsinckia spp.</i>
Filarees	<i>Erodium spp.</i>
Fleabane, hairy	<i>Conyza bonariensis</i>
Foxtails	<i>Setaria spp.</i>
Goosefoot, nettleleaf	<i>Chenopodium murale</i>
Groundcherries	<i>Physalis spp.</i>
Groundsel, common	<i>Senecio vulgaris</i>
Henbit	<i>Lamium amplexicaule</i>
Horseweed	<i>Conyza canadensis</i>
Johnsongrass	<i>Sorghum halepense</i>
Junglerice	<i>Echinochloa colona</i>
Knotweed, common	<i>Polygonum arenastrum</i>
Knotweed, prostate	<i>Polygonum aviculare</i>
Lambsquarters, common	<i>Chenopodium album</i>
Lettuce, miner's	<i>Claytonia perfoliata</i>
Lettuce, prickly	<i>Lactuca serriola</i>
Lovegrasses	<i>Eragrostis spp.</i>
Mallow, little (cheeseweed)	<i>Malva parviflora</i>
Mustards	<i>Brassica spp.</i>
Nettle, burning	<i>Urtica urens</i>
Nettles	<i>Urtica spp.</i>
Nightshades	<i>Solanum spp.</i>
Nutsedge, yellow	<i>Cyperus esculentus</i>
Oat, wild	<i>Avena fatua</i>
Onion, wild	<i>Allium canadense</i>
Pigweeds	<i>Amaranthus spp.</i>
Pineappleweed	<i>Chamomilla suaveolens</i>
Poison-oak, Pacific	<i>Toxicodendron diversilobum</i>

Common Names	Scientific Names
Polypogon, rabbitfoot	<i>Polypogon monspeliensis</i>
Puncturevine	<i>Tribulus terrestris</i>
Purslane, common	<i>Portulaca oleracea</i>
Radish, wild	<i>Raphanus raphanistrum</i>
Redmaids (desert rockpurslane)	<i>Calandrinia ciliate</i>
Rocket, London	<i>Sisymbrium irio</i>
Ryegrasses	<i>Lolium spp.</i>
Sandburs	<i>Cenchrus spp.</i>
Shepherd's-purse	<i>Capsella bursa-pastoris</i>
Sorrel, red	<i>Rumex acetosella</i>
Sowthistles	<i>Sonchus spp.</i>
Speedwells	<i>Veronica spp.</i>
Sprangletops	<i>Leptochloa spp.</i>
Spurges	<i>Euphorbia (=Chamaesyce) spp.</i>
Star of Bethlehem	<i>Ornithogalum umbellatum</i>
Thistle, Russian	<i>Salsola tragus</i>
Witchgrass	<i>Panicum capillare</i>

SUSCEPTIBILITY OF WINTER WEEDS TO HERBICIDE CONTROL (8/17)

	PREEMERGENCE							POSTEMERGENCE					
	DIU	NOR	ORY	OXY	PEN	SIM	TRI	24D*	FLU	GLY	OXY	PAR*	SET
Mode of Action	7	12	3	14	3	5	3	4	1	9	14	22	1
ANNUAL WEEDS													
barley, hare	C	C	C	P	C	C	C	N	C	C	P	C	C
bluegrass, annual	C	C	C	P	C	C	C	N	N	C	P	C	N
bromegrasses	C	C	C	P	C	C	C	N	C	C	N	C	C
canarygrass	C	C	C	P	C	C	C	N	C	C	N	C	C
clovers	P	N	N	C	P	C	N	P	N	C	P	P	N
cudweeds	C	C	N	N	N	C	N	P	N	C	P	N	N
fiddlenecks	C	C	C	C	C	C	P	P	N	C	C	C	N
filarees	C	C	N	C	C	C	P	C	N	P	P	P	N
groundsel, common	P	P	N	C	P	C	N	C	N	C	C	C	N
henbit	C	P	P	C	C	C	C	C	N	C	C	C	N
lettuce, miner's	C	C	C	C	C	C	C	C	N	C	C	C	N
mustards	C	C	N	C	N	C	N	C	N	C	P	C	N
nettles	C	C	P	C	N	C	N	C	N	C	P	C	N
oat, wild	P	P	C	P	P	C	P	N	C	C	N	C	C
polypogon, rabbitfoot	C	C	C	P	C	C	C	N	C	C	N	C	C
radish, wild	C	P	N	C	N	C	N	P	N	C	P	P	N
redmaids (desert rockpurslane)	C	C	C	C	C	C	C	C	N	C	C	C	N
rocket, London	C	C	N	C	C	C	N	C	N	C	C	C	N
ryegrasses	C	C	C	P	C	C	C	N	C	C	N	C	C
shepherd's-purse	C	C	N	C	N	C	N	C	N	C	P	C	N
sowthistles	C	P	N	C	N	C	N	C	N	C	P	C	N

C = control, P = partial control, N = no control, — = no information

24D = 2,4-D* (Orchard Master)

GLY = glyphosate (Roundup)

OXY = oxyfluorfen (Goal)

SET = sethoxydim (Poast)

DIU = diuron (Diuron)

NOR = norflurazon (Solicam)

PAR = paraquat* (Gramoxone)

SIM = simazine (Princep)

FLU = fluazifop-p-butyl (Fusilade DX)

ORY = oryzalin (Surflan)

PEN = pendimethalin (Prowl)

TRI = trifluralin (Treflan)

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

¹ At rates used for annual weeds, control of perennials is less than expected with high label rates.

SUSCEPTIBILITY OF SPRING AND SUMMER WEEDS TO HERBICIDE CONTROL (8/17)

	PREEMERGENCE							POSTEMERGENCE					
	DIU	NOR	ORY	OXY	PEN	SIM	TRI	24D*	FLU	GLY	OXY	PAR*	SET
Mode of Action	7	12	3	14	3	5	3	4	1	9	14	22	1
ANNUAL WEEDS													
barnyardgrasses	C	C	C	P	C	P	C	N	C	C	N	P	C
chickweed, common	C	C	C	P	C	C	C	P	N	C	P	C	N
cocklebur	P	N	N	P	N	P	—	C	N	C	C	C	N
crabgrasses	C	C	C	P	C	N	C	N	C	C	P	C	C
cudweeds	C	C	N	N	C	C	N	P	N	C	P	N	N
fleabane, hairy	C	P	N	P	N	C	N	C	N	C	P	C	N
foxtails	C	C	C	N	C	C	C	N	C	C	N	C	C
goosefoot, nettleleaf	C	C	C	C	P	C	C	C	N	C	P	C	N
groundcherries	N	C	C	C	C	C	N	C	N	C	C	C	N
horseweed	P	P	N	P	N	C	N	C	N	C	P	C	N
knotweed, prostrate	C	C	C	C	C	C	C	N	N	C	P	P	N
lambsquarters, common	C	P	C	C	C	C	C	C	N	C	C	P	N
lettuce, prickly	C	P	N	C	N	C	N	C	N	C	C	C	N
lovegrasses	C	C	C	P	C	P	C	N	C	C	N	C	C
mallow, little (cheeseweed)	P	C	N	C	P	N	P	C	N	P	C	N	N
nettles	C	C	P	C	C	C	N	C	N	C	P	C	N
nightshades	C	C	N	C	P	C	N	C	N	C	C	C	N
pigweeds	C	P	C	C	C	C	C	C	N	C	C	C	N
pineapple-weed	P	C	N	C	C	C	P	C	N	C	P	C	N
polypogon, rabbitfoot	C	C	C	—	C	C	C	N	C	C	N	C	C
puncturevine	C	C	P	P	P	P	P	C	N	C	P	C	N
purslane, common	C	P	C	C	C	C	C	C	N	C	C	C	N
sandburs	C	C	C	N	C	P	C	N	C	C	N	P	C
sowthistles	P	P	N	C	N	C	N	C	N	C	C	C	N
speedwells	P	—	P	C	P	C	—	P	N	C	P	C	N
spurges	C	C	P	P	C	C	C	P	N	C	P	C	N
thistle, Russian	C	C	P	P	P	C	P	P	N	C	P	P	N
witchgrass	P	C	C	P	C	C	C	N	C	C	N	C	C
PERENNIAL SEEDINGS													
bermudagrass	C	C	C	N	C	P	C	N	C	C	P	C	C
bindweed, field	N	N	C	C	P	N	C	C	N	C	C	C	N
dallisgrass	C	C	C	N	C	C	C	N	C	C	N	C	C
dandelion	C	N	N	C	N	C	N	C	N	C	C	N	N
dock, curly	C	N	P	C	C	C	C	C	N	C	C	C	N
johnsongrass	C	C	P	N	P	P	C	P	C	C	N	C	C
ESTABLISHED PERENNIALS													
asparagus	N	N	N	—	N	N	N	N	N	P	N	N	N
bermudagrass	N	P	N	N	N	N	N	N	P	C	N	P	P
bindweed, field	N	N	P	N	N	N	P	P	N	P	N	P	N

	PREEMERGENCE							POSTEMERGENCE					
	DIU	NOR	ORY	OXY	PEN	SIM	TRI	24D*	FLU	GLY	OXY	PAR*	SET
blackberries	N	N	N	N	N	N	N	P	N	C	N	N	N
clovers	N	N	N	N	N	N	N	P	N	P	N	N	N
dallisgrass	N	N	N	N	N	N	N	N	P	C	N	N	P
dandelion	N	N	N	N	N	N	N	C	N	P	N	N	N
dock, curly	N	N	N	N	N	N	N	C	N	P	N	N	N
false dandelion	N	C	N	N	N	N	N	C	N	P	N	N	N
johnsongrass	N	N	N	N	N	N	P	N	P	C	N	N	P
nutsedge, yellow	N	P	N	N	N	N	N	P	N	P	N	N	N
onion, wild	—	—	N	N	—	—	N	—	N	—	N	—	N
poison-oak, Pacific	N	N	N	N	N	N	N	P	N	C	N	N	N
sorrel, red	N	N	N	N	N	N	N	N	N	P	N	N	N

C = control, P = partial control, N = no control, — = no information

24D = 2,4-D* (Orchard Master) GLY = glyphosate (Roundup) OXY = oxyfluorfen (Goal) SET = sethoxydim (Poast)

DIU = diuron (Diuron) NOR = norflurazon (Solicam) PAR = paraquat* (Gramoxone) SIM = simazine (Princep)

FLU = fluazifop-p-butyl (Fusilade DX) ORY = oryzalin (Surflan) PEN = pendimethalin (Prowl) TRI = trifluralin (Treflan)

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

¹ At rates used for annual weeds, control of perennials is less than expected with high label rates.

HERBICIDE TREATMENT TABLE (8/17)

Herbicide (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
<i>The following 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.</i>			
PREPLANT			
<i>Preemergence (before weeds germinate)</i>			
A. ORYZALIN (Surflan A.S.) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 3	2–6 lb a.i. 2–6 qt	24	0
COMMENTS: May be applied preplant incorporated or preplant surface before transplanting or after transplanting trees. If using prior to planting, plant tree roots below treated soil and do not place treated soil near roots during planting. Considered safe for young or newly planted trees and on sandy or sandy loam soils. Do not apply over the foliage or buds to avoid crop injury. If rainfall of 0.5 to 1 inch does not occur within 21 days of treatment, sprinkle irrigate with 0.5 to 2 inches of water. Will not control emerged weeds. Chemigation is allowed: see label for instructions. Residual period: 4 to 10 months.			
B. PENDIMETHALIN (Prowl H2O) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 3	1.9–5.985 lb a.i. 2–6.3 qt	24	60
COMMENTS: May be applied preplant incorporated or preplant surface before transplanting or after transplanting trees. If using prior to planting, plant tree roots below treated soil and do not place treated soil near roots during planting. Do not apply to newly seeded nursery stock. Do not apply over the foliage or buds to avoid crop injury. Best control is achieved when irrigation or rainfall occurs within 7 days. Will not control emerged weeds. Chemigation is allowed: see label for instructions. Residual period: 4 to 10 months.			
C. TRIFLURALIN (Treflan HFP) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 3	0.5–1 lb a.i. 1–2 pt	12	0
COMMENTS: Can be used preplant incorporated by power tillage or irrigation. Plant tree roots below treated soil. Do not place treated soil near roots during planting. Recommended rate depends on soil type. Can use spray blade applicator for suppression of field bindweed. Residual period: 2 to 12 months.			
<i>Postemergence (after weeds emerge)</i>			
A. AMMONIUM NONANOATE (AXXE)# WSSA MODE-OF-ACTION GROUP NUMBER ¹ : –	6–15% v/v	24	NA
COMMENTS: Do not apply to weeds wet from dew rain or irrigation or if rain or irrigation is expected within 2 hours.			
B. CAPRIC ACID/CAPRYLIC ACID (Suppress)# WSSA MODE-OF-ACTION GROUP NUMBER ¹ : –	3–9% v/v	24	NA
COMMENTS: Apply as a directed spray; avoid green bark. Do not apply to weeds wet from dew rain or irrigation or if rain or irrigation is expected within 4 hours.			
C. GLYPHOSATE (Roundup PowerMax)	0.387–3.713 lb a.e. 11 fl oz–3.3 qt	4	3

Herbicide (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 9			
COMMENTS: Can be applied prior to planting, within or between tree rows, with shielded or wiper equipment, or as directed spot sprays. Apply to young, actively growing annual weeds or perennial weeds when flowering. Some perennials may require the higher label rate for acceptable control. Add ammonium sulfate to spray solution at 5 to 10 lb per 100 gal water prior to adding glyphosate to improve control. Use 10 to 40 gal water/acre with 1 lb a.e./acre for annual weeds. Avoid applications to foliage or green bark, or mechanical wounds as injury can occur.			
D. NONANOIC ACID (Scythe)#	1–10% v/v	12	NA
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 26			
COMMENTS: Apply as a directed spray; avoid green bark.			
E. PARAQUAT* (Gramoxone SL 2.0)	0.3125–1 lb a.i. 2.5–4 pt	24	—
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 22			
COMMENTS: Use in 20 to 60 gal water/acre when weeds are in the seedling stage with good cover of the weed foliage. Add a non-ionic surfactant at 0.5% volume by volume. Repeated applications will be required as new weeds emerge or surviving plants regrow. Do not allow spray to contact foliage or green bark (except suckers); shields or wraps recommended for young trees.			

NEWLY PLANTED ORCHARDS (3 YEARS OR LESS SINCE PLANTING)*Preemergence*

A. DIURON (Drexel Diuron 80) (Diuron 4L)	1.6–3 lb ai 2–3.75 lb 1.6–3 qt	12 12	See label See label
WSSA MODE-OF-ACTION GROUP NUMBER ⁷			
COMMENTS: Do not apply more than 3.75 lb of Diuron 80 or 3 qt Diuron 4L per year. Use on trees established in orchard at least 1 year. See label for soil restrictions			
B. FLUMIOXAZIN (Chateau)	0.1913–0.3825 lb a.i. 6–12 oz	12	60
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 14			
COMMENTS: Do not use in nut trees established less than one year, unless protected from spray contact by non-porous tree protectors. Check supplemental label for additional restrictions in Merced, San Joaquin, and Stanislaus Counties. Residual period: approximately 1 month for each 2 oz/acre product used.			
C. HALOSULFURON (Sanda)	0.0309–0.0607 lb a.i. 0.66–1.33 oz	12	1
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 2			
COMMENTS: Use on trees established by being transplanted into their final growing location for a period of at least 12 months. See label for further extensive soil restrictions and cautions, especially if within 4 miles of prunes and 1 mile of cotton.			
D. INDAZIFLAM (Alion)	0.046–0.085 lb a.i. 3.5–6.5 fl oz	12	14
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 29			
COMMENTS: Can be used in tree nuts established in the orchard at least one year. Recommended rate depends on soil organic matter content. Do not use on soils with greater than 20% gravel content. In southern San Joaquin Valley counties, applications are limited to between harvest and emergence of green leaf tissue. Requires rainfall or irrigation within 21 days following treatment. Residual period: 5 to 8 months.			
E. ISOXABEN (Trellis SC)	0.52–1 lb a.i. 16–31 fl oz	12	60
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 21			

Herbicide (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
<p>COMMENTS: Can be used in new plantings and established tree nut orchards. In new plantings, soil must be settled around transplants by packing and irrigation or rainfall and no cracks present. Do not apply over the top of young trees as bud injury can occur. When replanting, ensure that planting holes are not refilled with treated soil. Isoxaben controls broadleaf weeds only. Rainfall or irrigation of at least 0.5 inch should occur within 21 days of treatment to activate herbicide. Residual period: 4 to 6 months.</p>			
F. NORFLURAZON (Solicam DF) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 12 COMMENTS: The maximum rate is determined by soil texture. Use only on trees planted at least 18 months. Norflurazon is known to leach through soil into ground water under certain conditions.	1.965–3.93 lb a.i. 2.5–5 lb	12	60
G. ORYZALIN (Surflan A.S.) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 3 COMMENTS: May be applied preplant incorporated or preplant surface before transplanting or after transplanting trees. If using prior to planting, plant tree roots below treated soil and do not place treated soil near roots during planting. Considered safe for young or newly planted trees and on sandy or sandy loam soils. Do not apply over the foliage or buds to avoid crop injury. If rainfall of 0.5 to 1 inch does not occur within 21 days of treatment, sprinkle irrigate with 0.5 to 2 inches of water. Will not control emerged weeds. Chemigation is allowed: see label for instructions. Residual period: 4 to 10 months.	2–6 lb a.i. 2–6 qt	24	0
H. OXYFLUORFEN (Goal 2XL) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 14 COMMENTS: Rate range differs for dormant and non-dormant orchards and for different methods of application; see label for use period, cut-off dates, and other restrictions. Oxyfluorfen can be used after transplanting nut trees or in established orchards. Has both preemergence and postemergence activity; lower rates typically used for postemergence control while higher rates provide longer residual control. At least 0.75 inch rainfall or irrigation must be received within 3 to 4 weeks after treatment. Do not disturb with mechanical equipment or poor weed control will result. Certain formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations. Regulations affect use for the San Joaquin Valley from May 1 to October 31, 2019. Review the Department of Pesticide Regulation’s updated fact sheet. Chemigation is allowed: see label for instructions. Residual period: 4 to 10 months.	0.5–2 lb ai 1–8 pts	24	7
I. PENDIMETHALIN (Prowl H2O) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 3 COMMENTS: May be applied preplant incorporated or preplant surface before transplanting or after transplanting trees. If using prior to planting, plant tree roots below treated soil and do not place treated soil near roots during planting. Do not apply to newly seeded nursery stock. Do not apply over the foliage or buds to avoid crop injury. Best control is achieved when irrigation or rainfall occurs within 7 days. Will not control emerged weeds. Chemigation is allowed: see label for instructions. Residual period: 4 to 10 months.	1.9–5.985 lb a.i. 2–6.3 qt	24	60
J. PENOXSULAM/OXYFLUORFEN (Pindar GT) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 2/14	0.016–0.031 lb a.i. (penoxsulam) /0.74–1.47 lb a.i. (oxyfluorfen) 1.5–3 pt	24	60

Herbicide (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
<p>COMMENTS: Can be used in walnuts established at least 9 months. Rainfall or irrigation of at least 0.5 inches needed within 21 days of application for most effective performance. Use lower rates on lighter soils and higher rates on heavier soils. When replacing trees, make sure clean soil is used around the roots of replants. Use tree protectors to avoid contact with foliage or green bark. Applications recommended between harvest and emergence of green leaf tissue. Residual period: 5 to 8 months.</p>			
K. RIMSULFURON	0.0625 lb a.i.		
(Matrix SG)	4 oz	4	14
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 2			
<p>COMMENTS: Preplant and postemergence control of certain grasses and broadleaf weeds in trees at least 12 months since transplanting. Apply as a broadcast or band treatment directed at the base of the trunk in 10 to 20 gal water/acre. Best results when applied to moist soil or about 0.5 inch rainfall or irrigation occurs within 2 weeks after application. Add nonionic surfactant to increase postemergence activity. Avoid contact with foliage or fruit. Spray solutions below pH 4 or above pH 8 may reduce performance. Chemigation is allowed: see label for instructions. Residual period: 2 to 4 months.</p>			
L. SULFENTRAZONE			
(Zeus)	See comments	12	3
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 14			
<p>COMMENTS: Do not apply more than 12 oz (0.375 lb ai) in 12 months. Apply only to trees established one full year; avoid green bark: young trees should be protected. Delay replanting into established orchards at least 30 days after applying Zeus and use untreated soil. See label for California Specific restrictions on applications of Zeus herbicide, especially if in runoff or leaching ground water protection area.</p>			
M. TRIFLURALIN	0.5–1 lb a.i.		
(Treflan HFP)	1–2 pt	12	0
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 3			
<p>COMMENTS: Can be used preplant incorporated by power tillage or irrigation. Plant tree roots below treated soil. Do not place treated soil near roots during planting. Recommended rate depends on soil type. Rate range for new plantings is 1 to 2 pt/acre while established orchard rate range is 2 to 4 pt/acre. Can use spray blade applicator for suppression of field bindweed. Residual period: 2 to 12 months.</p>			
Postemergence			
A. 2,4-D	1–1.4 lb ae		
(Orchard Master)	2–3 pt	48	60
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 4			
<p>COMMENTS: For use in orchards established at least one year. Selective control of most annual broadleaf species and control or suppression of perennial broadleaf weeds. May be used as a broadcast treatment to middles or banded within the tree row. Use caution to avoid contact with tree fruit, foliage, stems, lower limbs, and exposed roots. Do not use on sandy or shallow soils and do not apply immediately before an irrigation.</p>			
B. AMMONIUM NONANOATE			
(AXXE)#	6–15%	24	See label
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : –			
COMMENTS: Do not apply to weeds wet from dew rain or irrigation or if rain or irrigation is expected within 2 hours.			
C. CAPRIC ACID/CAPRYLIC ACID			
(Suppress)#	3–9% v/v	24	See label
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : –			
COMMENTS: Apply as a directed spray; avoid green bark. Do not apply to weeds wet from dew rain or irrigation or if rain or irrigation is expected within 4 hours.			
D. CARFENTRAZONE	0.03 lb a.i.		
(Shark EW)	2 fl oz	12	3
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 14			

Herbicide (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
COMMENTS: Selective on small, vigorously growing broadleaf weeds. Do not allow spray droplets to contact desirable fruit, foliage, flowers, or green stem tissue as injury can occur. Thorough coverage is needed for best performance.			
E. CLETHODIM SelectMax WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 1	0.068–0.121 lb a.i. 9–16 fl oz	24	365
COMMENTS: For use only in nonbearing tree nut orchards (no harvest within one year). For selective control of annual grasses that are actively growing, before tillering, and not stressed for moisture. Repeated applications may be needed on perennial grasses. A crop oil concentrate (1% volume by volume) or nonionic surfactant (0.25% volume by volume) must be added. Use in 20 to 40 gallons water/acre.			
F. DIQUAT (Reglone) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 22	0.375–0.5 lb a.i. 1.5–2 pt	24	365
COMMENTS: For use only in nonbearing tree nut orchards (no harvest within one year). Can be used prior to planting and up to one year before first harvest for non-selective burndown of grasses and broadleaf weeds. Do not allow spray droplets to contact desirable fruit, foliage, flowers, or green stem tissue as injury can occur. Thorough coverage is needed for best performance.			
G. FLUAZIFOP-P-BUTYL (Fusilade DX) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 1	0.25–0.375 lb a.i. 16–24 oz	12	365
COMMENTS: For use only in nonbearing tree nut orchards (no harvest within one year). For selective control of annual grasses that are actively growing, before tillering, and not stressed for moisture. Repeated applications may be needed on perennial grasses. A crop oil concentrate (1% volume by volume) or nonionic surfactant (0.25% volume by volume) must be added.			
H. GLUFOSINATE (Rely 280) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 10	0.878–1.5 lb a.i. 48–82 fl oz	12	1
COMMENTS: Nonselective control of annual broadleaf and grass weeds and burndown of perennial weeds. Can be used as banded, broadcast, or spot treatments. Add ammonium sulfate to spray solution prior to adding glyphosate to improve control. Use higher rates and greater application volume for large weeds or dense vegetation. Use tree protectors until trunks have mature, calloused brown bark and avoid contact with green bark, stems, foliage or fruit as injury can occur.			
I. GLYPHOSATE (Roundup PowerMax) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 9	0.387–3.713 lb a.e. 11 fl oz–3.3 qt	4	3
COMMENTS: Can be applied prior to planting, within or between tree rows, with shielded or wiper equipment, or as directed spot sprays. Apply to young, actively growing annual weeds or perennial weeds when flowering. Some perennials may require the higher label rate for acceptable control. Add ammonium sulfate to spray solution at 5 to 10 lb per 100 gal water prior to adding glyphosate to improve control. Use 10 to 40 gal water/acre with 1 lb a.e./acre for annual weeds. Avoid applications to foliage or green bark, or mechanical wounds as injury can occur.			
J. HALOSULFURON (Sanda) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 2	0.0309–0.0607 lb a.i. 0.66–1.33 oz	12	1
COMMENTS: Use on trees established by being transplanted into their final growing location for a period of at least 12 months. See label for further extensive soil restrictions and cautions, especially if within 4 miles of prunes and 1 mile of cotton.			
K. MESOTRIONE (Broadworks) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 27	See comments	12	30

Herbicide (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
<p>COMMENTS: Only for use on trees established at least 12 months. Do not apply more than 6 oz. (0.188 lb a.i.) in the first application or more than 12 oz (0.376 lb a.i.) per 12 months, with no more than three applications per year. Do not apply to trees under stress.</p>			
L. NONANOIC ACID (Scythe)# WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 26	1–10% v/v	12	See label
<p>COMMENTS: Apply as a directed spray; avoid green bark.</p>			
M. OXYFLUORFEN (Goal 2XL) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 14	0.5–2 lb ai 1–8 pts	24	7
<p>COMMENTS: Rate range differs for dormant and non-dormant orchards and for different methods of application; see label for use period, cut-off dates, and other restrictions. Oxyfluorfen can be used after transplanting nut trees or in established orchards. Has both preemergence and postemergence activity; lower rates typically used for postemergence control while higher rates provide longer residual control. At least 0.75 inch rainfall or irrigation must be received within 3 to 4 weeks after treatment. Do not disturb with mechanical equipment or poor weed control will result. Certain formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations. Regulations affect use for the San Joaquin Valley from May 1 to October 31, 2019. Review the Department of Pesticide Regulation's updated fact sheet. Chemigation is allowed: see label for instructions. Residual period: 4 to 10 months.</p>			
N. PARAQUAT* (Gramoxone SL 2.0) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 22	0.625–1 lb a.i. 2.5–4 pt	24	—
<p>COMMENTS: Use in 20 to 60 gal water/acre when weeds are in the seedling stage with good cover of the weed foliage. Add a non-ionic surfactant at 0.5% volume by volume. Repeated applications will be required as new weeds emerge or surviving plants regrow. Do not allow spray to contact foliage or green bark (except suckers); shields or wraps recommended for young trees.</p>			
O. PYRAFLUFEN-ETHYL (Venue) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 14	0.0027–0.0053 lb a.i. 2–4 fl oz	12	0
<p>COMMENTS: Selective on small, vigorously growing broadleaf weeds. Add crop oil concentrate and ensure thorough coverage for best performance. Use higher rates for large weeds and for sucker control. Do not allow spray droplets to contact desirable fruit, foliage, flowers, or green stem tissue as injury can occur; shields or tree wraps recommended for young trees.</p>			
P. RIMSULFURON (Matrix SG) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 2	0.0625 lb a.i. 4 oz	4	14
<p>COMMENTS: Preplant and postemergence control of certain grasses and broadleaf weeds in trees at least 12 months since transplanting. Apply as a broadcast or band treatment directed at the base of the trunk in 10 to 20 gal water/acre. Best results when applied to moist soil or about 0.5 inch rainfall or irrigation occurs within 2 weeks after application. Add nonionic surfactant to increase postemergence activity. Avoid contact with foliage or fruit. Spray solutions below pH 4 or above pH 8 may reduce performance. Chemigation is allowed: see label for instructions. Residual period: 2 to 4 months.</p>			
Q. SAFLUFENACIL (Treevix) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 14	0.04375 lb a.i. 1 oz	12	7
<p>COMMENTS: Selective control of annual broadleaf weeds. Can be used as banded, broadcast, or spot treatments. Add methylated seed oil and ammonium sulfate or ammonium nitrate for best performance. Spray contact with tree foliage, flowers, buds or fruit can result in crop injury.</p>			

Herbicide (Example trade name)	Amount per acre	REI† (hours)	PHI† (days)
R. SETHOXYDIM (Poast) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 1	0.281–0.375 lb a.i. 1.5–2 pt	12	15
<p>COMMENTS: For selective control of annual grasses that are actively growing, before tillering, and not stressed for moisture. Can be used as banded, broadcast, or spot treatments. Can be sprayed over the top of small nonbearing trees. Repeated applications may be needed on perennial grasses. Add crop oil concentrate or methylated seed oil for best performance; ammonium sulfate or ammonium nitrate will enhance activity on some grass weeds.</p>			

ESTABLISHED ORCHARDS

Preemergence

A. DIURON (Drexel Diuron 80) (Diuron 4L) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 7	1.6–3 lb a.i. 2–3.75 lb 1.6–3 qt	12 12	See label See label
<p>COMMENTS: Do not apply more than 3.75 lb of Diuron 80 or 3 qt Diuron 4L per year. Use on trees established in orchard at least 1 year. See label for soil restrictions</p>			
B. FLAZASULFURON (Mission) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 2	0.033–0.0445 lb a.i. 2.14–2.85 oz	12	130
<p>COMMENTS: Do not use on trees established less than three years; protective sleeves must be used on 3-year-old trees. Direct spray to soil beneath trees, but do not apply where roots are exposed. Do not apply to saturated soils or mechanically incorporate into the soil.</p>			
C. FLUMIOXAZIN (Chateau) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 14	0.1913–0.3825 lb a.i. 6–12 oz	12	60
<p>COMMENTS: Do not use in nut trees established less than one year, unless protected from spray contact by non-porous tree protectors. Check supplemental label for additional restrictions in Merced, San Joaquin, and Stanislaus Counties. Residual period: approximately 1 month for each 2 oz/acre product used.</p>			
D. HALOSULFURON (Sanda) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 2	0.0309–0.0607 lb a.i. 0.66–1.33 oz	12	1
<p>COMMENTS: Use on trees established by being transplanted into their final growing location for a period of at least 12 months. See label for further extensive soil restrictions and cautions, especially if within 4 miles of prunes and 1 mile of cotton.</p>			
E. INDAZIFLAM (Alion) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 29	0.046–0.085 lb a.i. 3.5–6.5 fl oz	12	14
<p>COMMENTS: Can be used in tree nuts established in the orchard at least one year. Recommended rate depends on soil organic matter content. Do not use on soils with greater than 20% gravel content. In southern San Joaquin Valley counties, applications limited to between harvest and emergence of green leaf tissue. Requires rainfall or irrigation within 21 days following treatment. Residual period: 5 to 8 months.</p>			
F. ISOXABEN (Trellis SC) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 21	0.52–1 lb a.i. 16–31 fl oz	12	60

Herbicide (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
<p>COMMENTS: Can be used in new plantings and established tree nut orchards. In new plantings, soil must be settled around transplants by packing and irrigation or rainfall and no cracks present. Do not apply over the top of young trees as bud injury can occur. When replanting, ensure that planting holes are not refilled with treated soil. Isoxaben controls broadleaf weeds only. Rainfall or irrigation of at least 0.5 inch should occur within 21 days of treatment to activate herbicide. Residual period: 4 to 6 months.</p>			
G. ORYZALIN	2–6 lb a.i.		
(Surflan A.S.)	2–6 qt	24	0
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 3			
<p>COMMENTS: May be applied preplant incorporated or preplant surface before transplanting or after transplanting trees. If using prior to planting, plant tree roots below treated soil and do not place treated soil near roots during planting. Considered safe for young or newly planted trees and on sandy or sandy loam soils. Do not apply over the foliage or buds to avoid crop injury. If rainfall of 0.5 to 1 inch does not occur within 21 days of treatment, sprinkle irrigate with 0.5 to 2 inches of water. Will not control emerged weeds. Chemigation is allowed: see label for instructions. Residual period: 4 to 10 months.</p>			
H. OXYFLUORFEN	0.5–2 lb a.i.		
(Goal 2XL)	1–8 pts	24	7
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 14			
<p>COMMENTS: Rate range differs for dormant and non-dormant orchards and for different methods of application; see label for use period, cut-off dates, and other restrictions. Oxyfluorfen can be used after transplanting nut trees or in established orchards. Has both preemergence and postemergence activity; lower rates typically used for postemergence control while higher rates provide longer residual control. At least 0.75 inch rainfall or irrigation must be received within 3 to 4 weeks after treatment. Do not disturb with mechanical equipment or poor weed control will result. Certain formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations. Regulations affect use for the San Joaquin Valley from May 1 to October 31, 2019. Review the Department of Pesticide Regulation's updated fact sheet. Chemigation is allowed: see label for instructions. Residual period: 4 to 10 months.</p>			
I. PENDIMETHALIN	1.9–5.985 lb a.i.		
(Prowl H2O)	2–6.3 qt	24	60
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 3			
<p>COMMENTS: May be applied preplant incorporated or preplant surface before transplanting or after transplanting trees. If using prior to planting, plant tree roots below treated soil and do not place treated soil near roots during planting. Do not apply to newly seeded nursery stock. Do not apply over the foliage or buds to avoid crop injury. Best control is achieved when irrigation or rainfall occurs within 7 days. Will not control emerged weeds. Chemigation is allowed: see label for instructions. Residual period: 4 to 10 months.</p>			
J. PENOXSULAM/OXYFLUORFEN	0.016–0.031 lb a.i. (penox- sulam)		
	/0.74–1.47 lb a.i. (ox- yfluorfen)		
(Pindar GT)	1.5–3 pt	24	60
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 2/14			
<p>COMMENTS: Can be used in walnuts established at least 9 months. Rainfall or irrigation of at least 0.5 inches needed within 21 days of application for most effective performance. Use lower rates on lighter soils and higher rates on heavier soils. When replacing trees, make sure clean soil is used around the roots of replants. Use tree protectors to avoid contact with foliage or green bark. Applications recommended between harvest and emergence of green leaf tissue. Residual period: 5 to 8 months.</p>			
K. RIMSULFURON	0.0625 lb a.i.		
(Matrix SG)	4 oz	4	14

Herbicide (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 2 COMMENTS: Preplant and postemergence control of certain grasses and broadleaf weeds in trees at least 12 months since transplanting. Apply as a broadcast or band treatment directed at the base of the trunk in 10 to 20 gal water/acre. Best results when applied to moist soil or about 0.5 inch rainfall or irrigation occurs within 2 weeks after application. Add nonionic surfactant to increase postemergence activity. Avoid contact with foliage or fruit. Spray solutions below pH 4 or above pH 8 may reduce performance. Chemigation is allowed: see label for instructions. Residual period: 2 to 4 months.			
L. SIMAZINE (Princep 4L) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 5	2–4 lb a.i. 2–4 qt	12	0
COMMENTS: Can be used in walnuts established at least 3 years. On lighter soils, use lower rates. Do not use on gravel, sand, or loamy sand soils. If an irrigation is applied immediately after application, limit water 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.			
M. SULFENTRAZONE (Zeus) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 14	See comments	12	3
COMMENTS: Do not apply more than 12 oz (0.375 lb ai) in 12 months. Apply only to trees established one full year; avoid green bark: young trees should be protected. Delay replanting into established orchards at least 30 days after applying Zeus and use untreated soil. See label for 'California Specific restrictions on Applications of Zeus Herbicide' especially if in runoff or leaching ground water protection area.			
N. TRIFLURALIN (Treflan HFP) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 3	0.5–1 lb a.i. 1–2 pt	12	0
COMMENTS: Can be used preplant incorporated by power tillage or irrigation. Plant tree roots below treated soil. Do not place treated soil near roots during planting. Recommended rate depends on soil type. Rate range for new plantings is 1 to 2 pt/acre while established orchard rate range is 2 to 4 pt/acre. Can use spray blade applicator for suppression of field bindweed. Residual period: 2 to 12 months.			
ESTABLISHED ORCHARDS			
<i>Postemergence</i>			
A. 2,4-D (Orchard Master) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 4	1–1.4 lb ae 2–3 pt	48	60
COMMENTS: For use in orchards established at least one year. Selective control of most annual broadleaf species and control or suppression of perennial broadleaf weeds. May be used as a broadcast treatment to middles or banded within the tree row. Use caution to avoid contact with tree fruit, foliage, stems, lower limbs, and exposed roots. Do not use on sandy or shallow soils and do not apply immediately before an irrigation.			
B. AMMONIUM NONANOATE (AXXE)# WSSA MODE-OF-ACTION GROUP NUMBER ¹ : –	6–15% v/v	24	See label
COMMENTS: Do not apply to weeds wet from dew rain or irrigation or if rain or irrigation is expected within 2 hours.			
C. CAPRIC ACID/CAPRYLIC ACID (Suppress)# WSSA MODE-OF-ACTION GROUP NUMBER ¹ : –	3–9% v/v	24	See label
COMMENTS: Apply as a directed spray; avoid green bark. Do not apply to weeds wet from dew rain or irrigation or if rain or irrigation is expected within 4 hours.			
D. CARFENTRAZONE (Shark EW) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 14	0.03 lb a.i. 2 fl oz	12	3

Herbicide (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
COMMENTS: Selective on small, vigorously growing broadleaf weeds. Do not allow spray droplets to contact desirable fruit, foliage, flowers, or green stem tissue as injury can occur. Thorough coverage is needed for best performance.			
E. FLAZASULFURON (Mission) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 2	0.033–0.0445 lb a.i. 2.14–2.85 oz	12	130
COMMENTS: Do not use on trees established less than three years; protective sleeves must be used on 3-year-old trees. Direct spray to soil beneath trees, but do not apply where roots are exposed. Do not apply to saturated soils or mechanically incorporate into the soil.			
F. GLUFOSINATE (Rely 280) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 10	0.878–1.5 lb a.i. 48–82 fl oz	12	1
COMMENTS: Nonselective control of annual broadleaf and grass weeds and burndown of perennial weeds. Can be used as banded, broadcast, or spot treatments. Add ammonium sulfate to spray solution prior to adding glyphosate to improve control. Use higher rates and greater application volume for large weeds or dense vegetation. Use tree protectors until trunks have mature, calloused brown bark and avoid contact with green bark, stems, foliage or fruit as injury can occur.			
G. GLYPHOSATE (Roundup PowerMax) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 9	0.387–3.713 lb a.e. 11 fl oz–3.3 qt	4	3
COMMENTS: Can be applied prior to planting, within or between tree rows, with shielded or wiper equipment, or as directed spot sprays. Apply to young, actively growing annual weeds or perennial weeds when flowering. Some perennials may require the higher label rate for acceptable control. Add ammonium sulfate to spray solution at 5 to 10 lb per 100 gal water prior to adding glyphosate to improve control. Use 10 to 40 gal water/acre with 1 lb a.e./acre for annual weeds. Avoid applications to foliage or green bark, or mechanical wounds as injury can occur.			
H. HALOSULFURON (Sanda) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 2	0.0309–0.0607 lb a.i. 0.66–1.33 oz	12	14
COMMENTS: Use on trees established by being transplanted into their final growing location for a period of at least 12 months. See label for further extensive soil restrictions and cautions, especially if within 4 miles of prunes and 1 mile of cotton.			
I. MESOTRIONE (Broadworks) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 27	See comments	12	30
COMMENTS: Only for use on trees established at least 12 months. Do not apply more than 6 oz. (0.188 lb a.i.) in the first application or more than 12 oz (0.376 lb a.i.) per 12 months, with no more than three applications per year. Do not apply to trees under stress.			
J. NONANOIC ACID (Scythe)# WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 26	1–10% v/v	12	
COMMENTS: Apply as a directed spray; avoid green bark.			
K. OXYFLUORFEN (Goal 2XL) WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 14	0.5–2 lb ai 1–8 pts	24	7

Herbicide (Example trade name)	Amount per acre	REI‡ (hours)	PHI‡ (days)
<p>COMMENTS: Rate range differs for dormant and non-dormant orchards and for different methods of application; see label for use period, cut-off dates, and other restrictions. Oxyfluorfen can be used after transplanting nut trees or in established orchards. Has both preemergence and postemergence activity; lower rates typically used for postemergence control while higher rates provide longer residual control. At least 0.75 inch rainfall or irrigation must be received within 3 to 4 weeks after treatment. Do not disturb with mechanical equipment or poor weed control will result. Certain formulations emit high amounts of volatile organic compounds (VOCs); use low-VOC formulations. Regulations affect use for the San Joaquin Valley from May 1 to October 31, 2019. Review the Department of Pesticide Regulation's updated fact sheet. Chemigation is allowed: see label for instructions. Residual period: 4 to 10 months.</p>			
L. PARAQUAT*	0.3125–1 lb a.i.	—	—
(Gramoxone SL 2.0)	2.5–4 pt (walnut)	24	—
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 22			
COMMENTS: Use in 20 to 60 gal water/acre when weeds are in the seedling stage with good cover of the weed foliage. Add a non-ionic surfactant at 0.5% volume by volume. Repeated applications will be required as new weeds emerge or surviving plants regrow. Do not allow spray to contact foliage or green bark (except suckers); shields or wraps recommended for young trees.			
M. PYRAFLUFEN-ETHYL (Venu)	0.0027–0.0053 lb a.i. 2–4 fl oz	12	0
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 14			
COMMENTS: Selective on small, vigorously growing broadleaf weeds. Add crop oil concentrate and ensure thorough coverage for best performance. Use higher rates for large weeds and for sucker control. Do not allow spray droplets to contact desirable fruit, foliage, flowers, or green stem tissue as injury can occur; shields or tree wraps recommended for young trees.			
N. RIMSULFURON	0.0625 lb a.i.	—	—
(Matrix SG)	4 oz	4	14
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 2			
COMMENTS: Preplant and postemergence control of certain grasses and broadleaf weeds in trees at least 12 months since transplanting. Apply as a broadcast or band treatment directed at the base of the trunk in 10 to 20 gal water/acre. Best results when applied to moist soil or about 0.5 inch rainfall or irrigation occurs within 2 weeks after application. Add nonionic surfactant to increase postemergence activity. Avoid contact with foliage or fruit. Spray solutions below pH 4 or above pH 8 may reduce performance. Chemigation is allowed: see label for instructions. Residual period: 2 to 4 months.			
O. SAFLUFENACIL (Treevix)	0.04375 lb a.i. 1 oz	12	7
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 14			
COMMENTS: Selective control of annual broadleaf weeds. Can be used as banded, broadcast, or spot treatments. Add methylated seed oil and ammonium sulfate or ammonium nitrate for best performance. Spray contact with tree foliage, flowers, buds or fruit can result in crop injury.			
P. SETHOXYDIM (Poast)	0.281–0.375 lb a.i. 1.5–2 pt	12	15
WSSA MODE-OF-ACTION GROUP NUMBER ¹ : 1			
COMMENTS: For selective control of annual grasses that are actively growing, before tillering, and not stressed for moisture. Can be used as banded, broadcast, or spot treatments. Can be sprayed over the top of small nonbearing trees. Repeated applications may be needed on perennial grasses. Add crop oil concentrate or methylated seed oil for best performance; ammonium sulfate or ammonium nitrate will enhance activity on some grass weeds.			

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://hracglobal.com>.

‡ 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 these two intervals is the minimum time that must elapse before harvest may occur.

Acceptable for use on organically grown produce

Herbicide (Example trade name)	Amount per acre	REI† (hours)	PHI† (days)
-----------------------------------	--------------------	-----------------	----------------

— Information not available

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

Vertebrates

MANAGING VERTEBRATES (7/16)

Vertebrate pests are found in and around virtually every cropping system in the state, although they may not always present a significant problem. In some crops, damage caused by birds generally results in a loss of a portion of the current crop but does not decrease future yield potential. Some pests, however, can cause major problems by feeding on fruit and on tree bark, shoots, and roots, which can stunt growth or kill plants. Injury to trees by rodents or rabbits, for example, is often serious, killing the tree outright or causing permanent damage that lowers yields for years following the initial feeding.

Some pests will chew or destroy flexible irrigation lines and emitters. Other pests will dig holes through the soil surface, thereby channeling surface irrigation water to undesired areas. Food safety also becomes an issue if pest residues come into contact with the marketable commodity.

Manage your fields in order to keep pest numbers low and to discourage new invasions so that significant damage does not occur.

- Before planting, remove vertebrate pests and destroy habitats (such as burrows) within the field boundaries. Preventive measures cost less and are more successful before planting, when one can easily see the pests or their habitats.
- Be aware of the location, as vertebrate pests can easily reinvade if the field is adjacent to rangeland, waterways, or unmanaged areas. It is much easier to manage vertebrate pests by implementing controls on the perimeter versus inside.
- Baiting, fencing, fumigating burrows, shooting, and trapping are easier and usually more effective if employed before you plant instead of after.
- Where feasible, deep plow and disc to destroy burrows, disperse or kill resident populations, and reduce the risk of reinvasion by pocket gophers, voles, and (to a lesser extent) ground squirrels.

Guidelines for reducing vertebrate pest problems and making control more economical:

- Correctly identify the species causing the problem using damage signs, burrows or habitat, tracks, feces, etc.
- If feasible, alter the habitat to make the area less favorable to the pest species (e.g., eliminate cover crops and weeds or keep them mowed low.)
- Take early action and use the control methods appropriate for the crop and time of year. Consider the environment and nontarget species when choosing a control method.
- Establish a monitoring system to detect reinfestation so you can determine when additional corrective measures or controls are necessary.

A successful pest management program requires good records and regular monitoring. Some vertebrate pest populations can easily "explode" because of high reproductive rates and abundant food. Keep a record of the management procedures you use and their effectiveness. Good records will help you plan and improve future control strategies.

For most vertebrate pests, there is more than one control option for reducing numbers and damage. The following table summarizes the various control measures appropriate for common vertebrate pests. Details on how to use these controls are given in the individual pest sections.

Pest	Control Measures									
	Habitat modification	Trapping	Baiting	Fencing	Tree guards	Frightening	Shooting	Fumigating	Repellents	Eliminating
Deer				X	X	X	X ¹			X
Eastern fox squirrel		X					X			
California ground squirrel	X	X	X				X	X		

Pest	Control Measures								
	Habitat modification	Trapping	Baiting	Fencing	Tree guards	Frightening	Shooting	Fumigating	Repellents
Pocket gophers	X	X	X					X	
Rabbits	X	X ²	X	X	X		X		X
Rats	X	X	X					X	
Voiles	X		X	X	X				
Coyote		X					X		
Wild pig		X		X			X		
Birds ³	X	X		X		X	X		X

- 1 During hunting season or with a permit.
- 2 Cottontails are relatively easy to trap. Jackrabbits are difficult to trap, but trapping may be useful.
- 3 Not all of these techniques will be effective for all species. More specific information can be found in the bird section.

Adapted from Salmon and Lickliter 1984. Wildlife Pest Control Around Gardens and Homes. UC ANR Publication 21385.

Vertebrate control equipment and supplies (baits, fumigants, propane exploders, traps, etc.) are available at local retail outlets such as farm supply and hardware stores. In addition, some county agricultural commissioner’s offices make certain rodenticides and fumigants available to growers. For further information or sources of special control materials, consult your local Cooperative Extension advisor or agricultural commissioner’s office.

Legal aspects of vertebrate pest management

Under the California Fish and Game Code, if California ground squirrels, meadow voles, pocket gophers, eastern fox squirrels, roof rats, black-tailed jackrabbits, cottontail rabbits, American crows, house sparrows, starlings, and yellow-billed magpies are causing or are anticipated to cause crop depredation, the owner or tenant of a property may use lethal methods to remove them at any time.

For other pests such as deer, wild pigs, western gray squirrels, and most bird species, depredation permits are required for removal. However, these regulations can change at any time, so it is always a good idea to check current California Fish and Game Code (<http://leginfo.legislature.ca.gov/faces/codes.xhtml>) to ensure removal of a particular species is legal.

Pesticides

Only pesticides that are registered with the California Department of Pesticide Regulation (DPR) can legally be used for vertebrate pest control. Registered materials are listed in DPR’s databases that are available online (<http://www.cdpr.ca.gov/>). You may also contact your county agricultural commissioner for current product registrations and the latest information on legal pesticide use, including current information on restrictions that apply to pest control activities in order to protect endangered species. *Follow label directions carefully* and understand the hazards when using poison baits and fumigants.

The U.S. Environmental Protection Agency (EPA) has placed restrictions on most rodenticides used to control vertebrates in agricultural production. The applicator must have a permit to purchase and use the product. These products will be identified with an asterisk (*).

Trapping

Trapping is often used to control vertebrate pests. Mark all traps clearly with the owner’s name and contact address or phone number. In California, trapping mammals, even for pest purposes, requires a trapping license issued by the California Department of Fish and Wildlife. However, rats, mice, moles, voles, and pocket gophers do not have this requirement. Additionally, you do not need a trapping license for ground squirrels or rabbits if trapping on your own property for pest control purposes. However, if trapping either of these species for profit (e.g., pest control operator), a trapping license is required.

Protected species

In some areas of California, crop fields are located within the range of federally- and state-protected threatened or endangered species. Species likely to be of concern include the San Joaquin kit fox, several species of kangaroo rats, and, where burrow fumigants are used, the blunt-nosed leopard lizard, California red-legged frog, and California tiger salamander.

Typical guidelines

Special guidelines apply to the use of toxic baits and fumigants for vertebrate pest control in these areas. These include

- Modification of ground squirrel bait stations to exclude protected species
- Restrict broadcast applications of bait
- Prohibit fumigation at certain locations or during some times of the year
- Require that applications be supervised by someone trained to avoid harming endangered species

Your county agricultural commissioner has the latest detailed maps that show the ranges of endangered species and the latest information on restrictions that apply to pest control activities in those areas. You can also get more information on endangered species regulations from the DPR website (<http://www.cdpr.ca.gov/docs/end-spec/>).

For more information on vertebrate management, see the Vertebrate Pest Control Handbook online (<http://vpcrac.org/about/vertebrate-pest-handbook/>).

CALIFORNIA GROUND SQUIRRELS (7/16)

Scientific Name: *Otospermophilus beecheyi* and *O. douglasii*

DESCRIPTION OF THE PEST

The adult California ground squirrel:

- Head and body 9 to 11 inches long
- Somewhat bushy tail is about as long as its body
- Fur is mottled dark and light brown or gray

Ground squirrels live in colonies that may grow very large if left uncontrolled. They are active during the cooler times on hot days and sunny periods during the cooler months; they are usually most active in morning and late afternoon. In periods of high winds, ground squirrels retreat to their burrows.

California ground squirrels live in underground burrows and form colonies of 2 to 20 or more animals. Each ground squirrel burrow system can have several openings with scattered soil in front. Individual ground squirrel burrows may be 5 to 30 feet long, 2.5 to 4 feet below the surface, and about 4 to 6 inches in diameter. Burrows provide the ground squirrels a place to retreat, sleep, hibernate, rear their young, and store food. Ground squirrels often dig their burrows along ditches and fencerows around buildings, within and bordering many agricultural crops, and on other uncultivated land. They tend to avoid flood irrigated areas, thick chaparral, dense woods, very moist areas, and lands that are under complete and frequent cultivation. They will travel 100 yards or more to feed in adjacent crops. When uncontrolled, they frequently move into perennial crops, such as orchards and vineyards, and dig burrows beneath the trees or vines.

The California ground squirrel can be active throughout the year in coastal areas of Southern California. Ground squirrels in the southern San Joaquin Valley become much less active during the winter, but seldom truly hibernate. Especially in hot locations, adult ground squirrels become temporarily dormant (estivate) when food is scarce or temperatures are extreme, primarily in late summer. Winter hibernation and summer estivation are more typical among ground squirrels in inland areas where temperature variations are more extreme. Regardless of location, young ground squirrels tend to be active all summer.

Ground squirrels that do hibernate generally emerge around January when weather begins to warm. In late winter and spring, they feed on green vegetation but switch to seeds and fruit in late spring and early summer as the vegetation dries up. Females have one litter, averaging 8 young, in spring. Young ground squirrels emerge from their burrow when about 6 weeks old; they do not estivate their first summer, and many may not hibernate during their first winter.

DAMAGE

California ground squirrels are responsible for major damage throughout the state. Their damage is most prevalent in crops adjacent to uncultivated areas where ground squirrels are not controlled.

- They easily climb trees and vines and feed on fruit and nuts from set to maturity and through harvest. Adult ground squirrels often cache seeds and nuts in their burrows, especially in the late summer and early fall. During this period, crop losses greatly exceed the amount the ground squirrels have consumed. Ground squirrels also consume vegetative crops (e.g., alfalfa, cole crops, and lettuce) and berries.
- Ground squirrels also gnaw fruit and bark, girdle trunks and scaffold limbs, and are capable of girdling and killing trees or vines in a relatively short time.
- In addition to above ground damage, they can damage roots, enabling fungal pathogens to infect trees.
- They often chew plastic irrigation lines, and their burrows can contribute to soil erosion.
- When digging burrows, ground squirrels bring soil and rock to the surface and deposit it in mounds near burrow openings. They enlarge burrow systems each year by constructing new tunnels and creating more entrances, so the longer the ground squirrels occupy the burrow, the more extensive it becomes. They create more entrances to serve a growing population. Large and numerous burrow openings and soil mounds are hard on equipment and can make mechanical harvesting especially difficult.
- The burrows of ground squirrels can divert irrigation water and have been known to cause severe damage to levees and other water retention systems.
- In some areas, ground squirrels can also pose a health risk to humans through the spread of sylvatic plague.

MANAGEMENT

The management action needed for ground squirrels depends on their activity pattern and feeding preferences during the time of year when action is taken. The choice of tactics is also influenced by the location of the infestation and number of ground squirrels present. For more detailed information on managing ground squirrels, see Ground Squirrel Best Management Practices (available online at <http://www.groundsquirrelbmp.com/management-cgs.html>).

Biological Control

Predators such as coyotes and hawks are usually not sufficient to effectively control ground squirrels. These predators consume a number of ground squirrels, but usually not enough to keep populations at sufficiently low numbers to eliminate the need for additional control measures.

Cultural Control

Habitat modification

Ground squirrels often burrow beneath long-standing piles of prunings, wood, or rock, or use them as harborage. Removing such piles may make the area somewhat less desirable to them, but the base of trees, fence lines, and ditch banks still offer burrowing sites. Peripheral cleanup may somewhat reduce the potential for ground squirrels. In addition, it makes burrow detection and monitoring easier and improves access to burrows during control operations. Ground squirrels are extremely adaptable so habitat modification has limited benefit in a management program. Squirrels may quickly invade abandoned burrow systems. Deep plowing (ripping) along field perimeters will destroy burrow entrances and will help slow the rate of invasion. Burrow fumigants, toxic baits, and traps currently are the most effective control methods.

Monitoring and Treatment Decisions

To make it easier to monitor and help reduce numbers, remove brush piles, debris, and stumps in and around the crop fields. Monitor for ground squirrels year-round, even in winter, especially during midmorning when they feed most actively. Monitor within the crop field during routine activities. Mid morning is usually the best time of day to observe squirrel activity.

To monitor:

1. Observe feeding grounds and watch for other signs of activity especially the appearance of burrows.
2. Check the perimeter of the crop fields at least once a month during the times of year when ground squirrels are active.
3. Periodically monitor areas from which ground squirrels are likely to invade, such as along ditch or road banks or in crops adjacent to your field.

Keep records and use them as the basis for future management decisions, noting:

- When ground squirrels emerge from hibernation
- When the first young are seen above ground
- Approximate number of ground squirrels you see and the location and number of burrows
- Changes in the general number of ground squirrels
- Management actions implemented, dates of use, and their effect

Treatment options

When even one or two ground squirrels are present in or immediately adjacent to the crop field, be prepared to take action. Treatment options for ground squirrels include the use of fumigants (e.g., gas cartridges, aluminum phosphide,* and carbon monoxide-producing devices) and baiting with multiple-dose anticoagulants (e.g., chlorphacinone* and diphacinone*) or zinc phosphide*. These are restricted-use pesticides that require a permit from the county agricultural commissioner for purchase or use.

Select the control method best suited for the time of year.

- The most effective time to control ground squirrels is in late winter or early spring when adults have emerged from their burrows but before they reproduce. For best control, use burrow fumigation about 2 to 3 weeks after the first ground squirrels emerge from hibernation.
- Because ground squirrels feed almost exclusively on green vegetation early in the season, poisoned grain baits are generally not effective until late spring or early summer.

- Trapping can be used year-round but is most effective when numbers are low.
- In late spring or summer, at locations where squirrels are moving from adjacent lands into the crop field to feed, baiting or trapping along the perimeter offers the most effective control if access to the neighboring property is not possible.

Fumigants

Fumigation can be very effective against ground squirrels. The best time to fumigate is late winter or early spring when the ground squirrels are active and soil is moist. Fumigation is also possible later in the year as long as sufficient soil moisture is present, although it is not effective when ground squirrels are hibernating or estivating; at those times, they seal themselves off from within their burrows. When the soil is dry, fumigation is much less effective because more of the toxic gas escapes from burrows through cracks in the soil.

When using a fumigant, make sure to treat all active burrow systems in and around the crop field. Recheck all areas a few days after fumigation and re-treat any that have been reopened. For safety's sake, do not fumigate burrow systems that are adjacent to buildings or may open under structures.

A relatively easy way to fumigate is with the use of gas cartridges. They are available commercially and from some county agricultural commissioners' offices. Use one or two cartridges for each burrow that shows signs of activity. A large burrow system may require more than two.

1. Quickly shove the ignited cartridge into the burrow using a shovel handle or stick and seal the burrow entrance with soil.
2. Watch nearby burrow entrances; treat and seal any that begin to leak smoke.
3. If smoke is observed escaping from other entrances, it means the burrows are connected. If the burrow is believed to be small, this additional entrance only needs to be sealed. If the burrow appears to be large, an additional cartridge may need to be inserted following the above-outlined protocol.

The larger and more complex the burrow system, the more smoke it takes to be effective.

Aluminum phosphide* is also a highly effective burrow fumigant. In fact, studies of this material for ground squirrel management indicate an efficacy of 95 to 100%. When aluminum phosphide* tablets come into contact with moist soil and air in the burrow they produce phosphine gas, which is highly toxic to any animal (never add water directly to the burrow to increase moisture as spontaneous combustion can occur if the product contacts water). When using aluminum phosphide*, treat every active burrow, fill the entrance with a wad of newspaper, and cover with soil. In addition to being somewhat more effective than gas cartridges, aluminum phosphide* is also much cheaper to apply. However, aluminum phosphide* is a highly restricted-use material, and these restrictions are frequently changing. Be sure to understand the current restrictions in place before using for ground squirrel control. Application personnel should be trained in the material's proper use and on its potential hazards.

As of 1 January 2012, pressurized exhaust machines can now be used to apply carbon monoxide to burrow systems. As of 2014, the author is aware of two commercial products available: the Pressurized Exhaust Rodent Controller (PERC®) machine and the Cheetah rodent control machine. Initial research into the efficacy of these devices has indicated that the PERC® is moderately effective for California ground squirrels, although results were highly variable. The Cheetah rodent control machine did not prove to be effective. Plans are in place to further test these devices in the future.

Baiting

Poison bait is usually the most cost-effective method for controlling ground squirrels, especially when numbers are high. Bait consists of grain or pellets treated with a poison registered for ground squirrel control. To be effective, bait must be used at a time of year when ground squirrels are feeding on seeds and will readily accept baits such as in late spring or early summer. In fall, ground squirrels store a lot of the seed instead of eating them, so it may require more bait to control the population.

Before you use baits, place a small amount of untreated grain, such as breakfast oats, near burrows in the morning and check in the late afternoon to see if the ground squirrels have taken it (this ensures that nocturnal animals have not eaten the grain). If the grain is taken during the day, proceed with baiting. If it is not taken, wait several days or a week and try again. Remember: bait is only effective if eaten by the target pest. If in a nut orchard, once squirrels begin feeding on nuts, they no longer show much interest in grain baits. Therefore, baiting programs must be initiated before this time to ensure effective control of ground squirrels. When using poison baits, make sure to follow label directions carefully to reduce hazards to nontarget species.

Multiple-dose anticoagulant baits (e.g., chlorophacinone* and diphacinone*) can be applied in bait stations, as spot treatments near burrows, or broadcast over larger infested areas. Check the label to make sure that the bait you plan to use is registered for the method you intend to use. For a multiple-dose bait to be effective, animals must feed on it over a period of 3 to 5 days so if spot or broadcast treatments are used, 2 or 3 applications may be necessary.

Zinc phosphide* is an acute toxicant that can also be used to control ground squirrels. It kills ground squirrels after a single feeding, so it can reduce numbers more quickly than anticoagulants. However, zinc phosphide* has a distinctive odor and taste that many ground squirrels seem to avoid. Likewise, ground squirrels will occasionally consume a sublethal dose of zinc phosphide* that will cause individuals to get sick but will not kill them. This leads to bait shyness in a ground squirrel population. These problems with bait acceptance and bait shyness sometimes result in greater control of ground squirrels when using anticoagulant baits. Pre-baiting the area with untreated grain 2 to 3 days prior to the application of zinc phosphide* may reduce the chances of bait shyness and improve the effectiveness of baiting programs. Control with zinc phosphide* is usually achieved within 48 hours of the bait application.

Baits applied as broadcast or spot treatments

When specified on the label, zinc phosphide* and anticoagulant baits* can be applied as spot-treatments, which are economical and effective for small populations. Reapply according to label directions to make sure there is no interruption in exposure to the bait. Scattering the bait takes advantage of the ground squirrels' natural foraging behavior and minimizes risks to nontarget species that are not as effective at foraging for seeds. Never pile the bait on the ground because piles increase the hazard to livestock and certain nontarget wildlife.

When ground squirrel populations are larger or cover a broader area, broadcast applications of zinc phosphide* or anticoagulants* may be used. This can be an effective and economical method for controlling this species over a large area. Usually squirrels retreat back to burrows when sick and will die there, although up to 20 to 30% of ground squirrels may die aboveground.

Baits applied in bait stations

Various kinds of bait stations are commonly used with diphacinone* and chlorophacinone* 0.005% baits; all are designed to let ground squirrels in but to exclude larger animals. Special types of stations must be used within the ranges of the San Joaquin kit fox or endangered kangaroo rats to ensure that these species are excluded. Consult your local agricultural commissioner or the California Department of Pesticide Regulation website (<http://www.cdpr.ca.gov/docs/endspec/>) for the latest recommendations on use of poison baits in areas that are within the range of endangered species.

1. Place bait stations near runways or burrows and secure them so they cannot easily be tipped over. If ground squirrels are moving into the crop field from adjacent areas, place bait stations along the perimeter of the field where ground squirrels are invading, one station every 100 feet. Use shorter intervals between stations when the number of ground squirrels is high.
2. Check bait stations daily at first, then as often as needed to keep the bait replenished. If bait feeding is interrupted, the bait's effectiveness will be greatly decreased. Make sure to pick up any bait that spills and to replace bait that is wet or moldy. Successful baiting usually requires 2 to 4 weeks. Continue to supply bait until feeding ceases and you observe no ground squirrels; then remove and properly dispose of unused bait if there is not a threat on continued reinvasion.
3. Zinc phosphide* cannot be used in bait stations.

After treatment, pick up and dispose of any carcasses whenever possible to prevent secondary poisoning of dogs or other scavengers. Burial is a good method for disposal as long as the carcasses are buried deep enough to discourage scavengers. Do not touch dead animals with bare hands.

Assess the potential hazard to humans, livestock, and nontarget wildlife before you use baits; if it is risky, use another method for ground squirrel control.

Trapping

Because trapping is time-consuming, it is most practical for small infestations any time of year when ground squirrels are active. Trapping is especially effective from mid-spring through fall. Ground squirrel traps include

Conibear traps and modified gopher box traps. As with all traps, take precautions to minimize trapping of non-target wildlife and pets.

Conibear traps

Conibear kill traps are usually placed unbaited in the burrow entrance, where ground squirrels are trapped as they pass through. Trap effectiveness can be increased by putting a tunnel of roofing paper (24 inches long) at the entrance of the burrow. The ground squirrel will mistake the light at the end of the tunnel for the burrow opening and run full speed through the trap. The tunnel also minimizes any sun reflection off the metal trap.

If you are using this type of trap within the range of the San Joaquin kit fox, you must place the trap in a covered box with an entrance no larger than 3 inches wide to exclude the fox, or you must spring the traps at dusk and reset them again in the morning.

Box traps

Modified wooden pocket gopher box traps consist of a pair of box traps that have been joined together by removing the backs, connecting the two traps with wire mesh, and then to a board. Another very effective trap is a single wooden box trap. The single wooden box trap (Critter Getter DK-3) is larger than the pocket gopher box trap (DK-2) and has a pull trigger rather than the push type for pocket gophers. The traps are baited with foods such as almonds, barley, melon rinds, oats, or walnuts. Place bait in traps well behind the trigger or tied to the trigger without setting the traps for several days, until the ground squirrels become used to taking the bait. Then put in fresh bait and set the traps. With the single pull trap, secure the bait to the trigger and wire the trap to a stake, fence, or other stationary object. Place traps so that nontarget animals are not likely to be caught. For example, place traps inside a larger box with openings no larger than 3 inches wide, just large enough to allow ground squirrels to enter.

Live traps

Live-traps, such as wire-cage and multiple-capture traps, can also be used to capture ground squirrels. The Black Fox repeating live trap has proven to be very effective in catching several individuals at one time. This 24" x 24" x 4" heavy gauge wire trap has doors that are wired open for several days for pre-baiting. When the self-closing doors are dropped down after pre baiting, the ground squirrel pushes to get in but cannot get out. As with box traps, pistachios, almonds, walnuts, oats, barley, and many fruits and vegetables are all effective baits. Because these traps keep ground squirrels alive after capture, they are useful in areas where nontarget captures are a concern (e.g., areas with pets, children, etc.). However, ground squirrels must be euthanized by the trapper upon capture as translocation of ground squirrels is illegal unless in possession of a permit issued by the California Department of Fish and Wildlife, unloads your problem on others, and can spread disease such as sylvatic plague. It is this extra step that limits the utility of live-trapping for some growers. Methods considered humane by the American Veterinary Medical Association include: gassing with carbon dioxide and shooting. Drowning is not an approved method of euthanasia and is illegal in California. Traps need to be checked once daily, and any animals found must be removed and should be euthanized.

Gas explosive device

The use of a gas explosive device that combines propane with oxygen has been used to kill ground squirrels through concussive force. This device has the added benefit of destroying part or all of the ground squirrel's burrow system, thereby potentially slowing reinvasion rates. This control method carries with it a substantial fire hazard. To date no scientific studies have shown this method to be overly effective at ground squirrel control.

Repellents

No repellents have proven effective at substantially reducing damage caused by ground squirrels.

Frightening devices

No frightening devices have proven effective at substantially reducing damage caused by ground squirrels.

* User must be a certified applicator or be under the supervision of someone who is. Some products also require a permit from the county agricultural commissioner for purchase or use.

DEER (7/16)

Scientific Name: *Odocoileus hemionus*

DESCRIPTION OF THE PEST

Deer are large mammals, typically around 3 to 3.5 feet at the shoulder. Deer are often not seen, in large part because they forage primarily during low-light hours (i.e., early morning and late evening). However, in residential and residential interface areas, deer often habituate to people, and are seen regularly during light hours.

When not visible, other forms of deer sign, such as hoof prints, must be observed to verify their presence. Deer hoof prints are split and about 2 to 3 inches in length. They are easily distinguished from pig and sheep prints in that deer prints are more pointed at the front and rounded at the back; the opposite is true for pigs and sheep. Deer droppings can also be used to verify deer presence. The appearance of droppings vary, but commonly each fecal pellet is oblong, somewhat pointed at one or both ends, and 0.25 to 0.5 inch long.

Deer occur in many foothill and coastal areas and sometimes in the Central Valley near riparian habitats.

DAMAGE

Mule deer, including the subspecies called black-tailed deer (*O. hemionus columbianus*), can be serious pests to tree and vine crops. They are also occasional pests to alfalfa and a variety of row crops.

Deer can completely defoliate young trees or vines. They can stunt, distort, or kill plants by repetitive browsing. Although relatively rare, buck deer can severely scar the bark when they rub their antlers on trunks and lower limbs. Deer may browse on older trees or vines, but the damage to them is usually less severe than that caused to young plants.

MANAGEMENT

Deer can cause significant damage in areas where adjacent habitat supports moderate to high deer populations. Foothill and coastal districts with brush or woodlands that provide cover for deer usually experience the most frequent damage. Some valley orchards or vineyards near stream bottoms may also suffer. State game management laws limit the control methods available to growers and make combating deer damage expensive. Primary control methods include exclusion, repellents, frightening devices, and shooting.

Cultural Control

Exclusion

Fencing is the most effective method for excluding deer from a field. Fencing also substantially reduces crop theft and vandalism from humans. Fencing is costly, but if you are planting where deer and uninvited people are likely to present continuing problems, it will likely pay for itself in the long run.

Check deer fences periodically to be sure they remain intact; damaged wire, broken gates, soil washout beneath fences, etc., permit access and must be repaired immediately. Deer that manage to circumvent the fence and get inside may have to be removed by shooting if they cannot be driven out.

Woven Wire Fences

A fence made of woven wire exclude deer if the fence is tall enough. Use a 6-foot (1.8 m) fence of woven wire with several strands of smooth or barbed wire along the top to extend the height to 7 or 8 feet. Be sure the fence is tight to the ground or deer will crawl under.

Wire mesh cylinders around individual trees may be effective where only a few new trees are being planted in a location subject to deer damage. Make the cylinders at least 6 feet tall and large enough in diameter to keep deer from reaching over them to eat the foliage. Secure the cylinders with stakes so they cannot be tipped over.

Electric Fences

Electric fencing is less expensive to install than woven mesh fencing but it costs more to maintain. High-tensile wire is the best choice, as it is more resilient than other types; it can absorb the impact of deer, falling limbs, and farm equipment without stretching or breaking. Use a high-voltage, low-impedance power source that provides sufficient voltage to repel deer while being less likely to short out when vegetation touches the wires. Control

vegetation around the base of the fence; in wet weather, contact with wet foliage can drain enough voltage from the fence to render it ineffective.

Habitat modification

Eliminating suitable cover for bedding and other survival needs rarely results in less crop damage. Deer are highly mobile and many travel 1/2 mile or more to reach a desired area, especially when they have become accustomed to feeding there.

Monitoring and Treatment Decisions

In brushy areas, deer usually stay out of sight during the daytime. They move into vineyards or orchards at night to browse, although in areas where hunting is not allowed, deer can habituate to humans; consequently, they are often seen in the daytime in these areas. Feeding evidence and hoof prints indicate their presence. In areas where deer are not visible, you may also use spotlights to check for deer at night.

Repellents

Growers can use chemical repellents for tree and vine crops over relatively small areas. Repellents are not always effective for a variety of reasons including:

1. lack of alternative food sources for deer
2. habituation to the field
3. need for frequent reapplication after rainfall or irrigation events
4. need to reapply to new vegetative growth

As such, repellents should not be relied upon to eliminate damage, but rather to reduce damage to acceptable levels.

Depending on the active ingredient, chemical repellents elicit a fear, pain, or discomfort response in deer. Those repellents that elicit a fear response (e.g., repellents based on rotten egg formulations, dried blood, etc.) are typically most effective. Repellents that elicit a pain response (e.g., those containing capsaicin) are also effective if applied at high concentrations. Efficacy from urine and fecal matter from predators tends to be highly variable; more effective options are available.

Frightening devices

Noise-making devices such as propane exploders and electronic distress calls are not often reported to be effective for more than a day or so because deer rapidly habituate to frightening devices. A relatively new electronic distress call (<http://www.birdgard.com/deer-shield/DeerShield/>; <http://www.birdgard.com/deer-shield/>) is effective for white-tailed deer (*Odocoileus virginianus*). This product has not been sufficiently tested on mule deer in California, but may work given its reported success on white-tailed deer.

If only a few deer are involved, having someone patrol newly planted areas at night with a spotlight to frighten deer away may prove effective, though expensive.

For small fields (less than 80 acres), dogs can be effectively used to frighten deer away. Dogs must be fenced in to keep them from roaming away from the target area. Options for fencing include a woven wire fence, electric fencing, or invisible fencing. Effective breeds will vary but could include retrievers and other medium-sized active dogs. The dogs do not require extensive training, but not all dogs are appropriate for field protection; they must be out in the elements at all times, and must show an interest in chasing offending animals away.

Shooting

In some circumstances depredation permits may be obtained from the California Department of Fish and Wildlife, but shooting is rarely a successful solution to a significant deer problem. Encouraging deer hunting in the area can lower the overall deer population and thus reduce damage from deer.

POCKET GOPHERS (7/16)

Scientific Name: *Thomomys* spp.

DESCRIPTION OF THE PEST

Pocket gophers are stout-bodied rodents with short legs. Adults:

- 6 to 8 inches long
- brown, gray, or yellowish
- large clawed front paws
- small ears and eyes
- a short, scantily haired tail

On each side of the mouth pocket gophers have external cheek pouches or “pockets” used extensively for carrying food.

Pocket gophers are rarely seen above ground. They live almost entirely underground spending most of their time in a tunnel system they construct 6 to 12 inches beneath the soil surface. A single burrow system can cover several hundred square feet and consists of main tunnels with lateral branches used for feeding or for pushing excavated soil to the surface. Because gophers are extremely territorial, you rarely find more than one gopher per burrow system, unless it is during the breeding season or females are tending their young.

The conspicuous, fan-shaped soil mounds over tunnel openings are the most obvious sign of a gopher infestation. These tunnel openings are almost always closed with a soil plug unless the gopher is actively excavating a tunnel.

Gophers feed primarily on the roots of herbaceous plants. They may also come aboveground to clip small plants within a few inches of the tunnel opening and pull vegetation into the burrow to eat.

Gophers breed throughout the year on irrigated land, with a peak in late winter or early spring. Females bear as many as three litters each year, although typically only one or two per year, each averaging five young. Once weaned, the young gophers travel to a favorable location to establish their own burrow system. Some take over previously vacated burrows. The buildup of gophers in crop fields is favored by extensive weed growth, including nutsedge, or the presence of many cover crops, especially perennial clovers and legumes.

DAMAGE

Pocket gophers can be serious pests. They are active throughout the year and if uncontrolled and food is plentiful, can increase to 30 to 40 gophers per acre. While herbaceous cover crops are their preferred food, pocket gophers also feed on the bark of tree crowns and roots, particularly when cover crops or weeds dry up. Bark consumption may be extensive enough to girdle and kill young vines or trees or reduce the vigor of older vines or trees. Usually gophers feed on trees from underground so the damage may not be evident until they show signs of stress. Pocket gophers also feed on the roots of vegetable and berry plants. Plants with more fibrous root systems often suffer minimal damage; plants with large taproots are most susceptible. Gophers sometimes gnaw on plastic irrigation lines. These holes lead to uneven water distribution, with some areas receiving too much water, and other parts not receiving any. Fixing pocket gopher punctures of subsurface drip tape can be time-consuming and quite expensive. Tunnel systems often lead to a loss or diversion of irrigation water and may lead to severe erosion.

MANAGEMENT

Persistent efforts can control pocket gophers and even eliminate them. Pocket gopher damage typically occurs belowground; therefore, it often goes undetected until individual plants or trees exhibit stress. By that time the tree or plant may be beyond saving. Gopher activity is readily detected, however; just look for fresh mounds of soil. Gophers make the greatest numbers of fresh mounds in the spring and fall, when the soil is amply moist.

Take action as soon as you see any sign of gopher activity. Common control methods include trapping, aluminum phosphide* fumigation, or hand-applied poison bait. Trapping and hand-baiting can be used at any time of year, but they are easier when the soil is moist and not dry and hard; aluminum phosphide* must be used when the soil is moist. Control of vegetative cover can reduce the attractiveness of fields to gophers by removing preferred food sources (e.g., nutsedge, clovers, and legumes). In addition, consider managing gophers in adjacent areas to reduce the potential for gopher reinvasion.

Gopher control is best done in late fall through late winter when mounding activity is high. Additionally, because numbers are usually lowest during early winter, management during this time of year can be more effective than after gophers have reproduced.

Biological Control

Snakes, owls, and hawks are usually not sufficient to effectively control gophers. These predators consume a number of gophers but usually not enough to keep populations at low enough numbers to eliminate the need for additional control measures.

Cultural Control

Flood irrigation

If flood irrigation is possible, it can help control gophers; they are not aquatic. This type of irrigation often drives gopher activity to the edges of the field where they are more easily located to control, if not killed by flooding. Growers and their dogs can also actively seek out voles at this time to further reduce population size.

Tilling

When taking a field out of production, deep tilling of soil will kill some gophers and destroy most or all burrow systems in a field. This can slow reinvasion rates and provides more time to get gopher populations under control.

Monitoring and Treatment Decisions

The best times to monitor for gopher activity are after irrigation and when mound building peaks in fall and spring.

- Monitor monthly.
- Pay close attention to field perimeters to determine whether gophers are invading the field from adjacent property.
- Monitor closely in weedy areas such as roadsides and in young orchards with extensive weed growth or ground cover. This type of vegetation is more likely to support gophers, and low-growing vegetation makes signs of burrowing activity more difficult to see.
- Look for darker-colored mounds, which indicate newly removed, moister soil.
- If you find mounds, trees or vines showing signs of stress, or both, look for girdling of roots or crowns at or below the soil.

Treatment options

The preferred control methods are baiting with multiple-dose anticoagulants, strychnine* or zinc phosphide*; trapping; and burrow fumigation. Neither chemical nor mechanical repellents have been found effective against pocket gophers. Remove vegetative cover and preferred food sources (e.g., clovers and legumes) to reduce the attractiveness of cover crops in orchards and vineyards to gophers. Often, a single approach is not sufficient to effectively control gophers. An integrated approach that uses more than one control option should provide greater control.

Strychnine*, zinc phosphide*, anticoagulants*, and aluminum phosphide* are currently restricted materials that require a permit from the county agricultural commissioner for purchase or use in agricultural fields. Be aware that restrictions for use of baits and fumigants around buildings may exist. However, restriction criteria of baits and fumigants often change, so it is best to consult your local agricultural commissioner before using any baits or fumigants to assure full compliance with current laws and regulations.

All treatment options require access to the main tunnel, located about 6 to 12 inches belowground. Finding the main tunnel takes practice, skill, and the use of a probing device. To find a main tunnel:

1. Locate a fresh gopher mound. The key is to look for mounds that contain moist dirt.
2. Start by finding the plug of the mound.
3. Begin probing anywhere from 4 to 12 inches behind this plug.
4. You will know you have found the tunnel when you feel a drop in the probe (i.e., less resistance) of a couple of inches. Tunnels typically run in only one or two directions. Occasionally you will have tunnels running in three or more directions.

Baiting

While multi-dose anticoagulants (e.g., chlorophacinone* and diphacinone*) are available for gopher control, single-dose acute baits (e.g., strychnine* and zinc phosphide*) have historically been the most effective.

Gophers often back-fill old tunnels with loose soil and these backfilled tunnels can feel like open tunnels to inexperienced bait applicators. Applying bait in these backfilled tunnels will greatly limit the efficacy of this management approach; gophers will not find bait placed here.

Before initiating a baiting program, train all bait applicators to identify backfilled tunnel systems. An effective way to conduct this training is to:

1. Have novice bait applicators probe for open (non-back-filled) tunnel systems.
2. Once they have found a tunnel, they dig down into these tunnel systems to verify whether they are open or backfilled.
3. Repeat until the bait applicator successfully identifies open tunnel systems with at least 90% accuracy.

Following these methods should result in consistently more efficacious control efforts when using baits and burrow fumigants.

Apply bait below ground. For small infestations or where the use of a mechanical burrow builder is not feasible, use a probe to find the main tunnel next to a fresh mound or between two fresh mounds. Once you find the main tunnel,

1. Enlarge the probe opening by rotating the probe back-and-forth
2. Place a small amount of grain or pelletized bait in the burrow; a funnel can also be used to pour the bait into the tunnel.
3. Place a dirt clod, stone, or another covering over the hole to keep out light and prevent soil from falling onto the bait.

Place bait in two or three places along the tunnel. This hand-application method can be used for single-dose or multiple-dose baits.

If gophers have infested a large area, reservoir-type hand probes designed to deposit single-dose baits are available. Bait application is faster with these devices because they eliminate the need to stop and place the bait by hand. Once you have located a tunnel using the probe, a trigger releases a measured amount of bait into the tunnel. It is important to check the probe periodically to make sure that it has not been clogged with soil. Generally, strychnine* or zinc phosphide* bait is used with such an applicator because it can dispense only a small quantity of bait at a time. Anticoagulant* baits are less toxic and require greater volumes of bait to be effective, thereby limiting the utility of bait probes for these baits.

A mechanical burrow builder can also be effective and economical for infestations that cover large areas. This device is pulled behind a tractor to construct artificial gopher tunnels into which it places bait. Artificial burrows either intercept some of the gopher's natural burrows, or the gopher will soon discover the artificial burrow and consume the bait. Prior to using this application device, it is important to know the average depth of active pocket gopher burrows before setting up the burrow builder. Use a probe to find burrows and a shovel to verify they are active (open). After starting the application, use a shovel to occasionally open a small section of the artificial burrow and inspect its depth and condition. It is also important that the compaction/drive wheels properly compact the soil over the burrow. Soil moisture is important, as tunnels created in dry soil will cave in, while tunnels created in wet soil may not form properly. Soil moisture must be intermediate to produce a well-formed, smooth, artificial burrow. Follow the manufacturer's manual to properly set the depth and calibration of bait application. All baits used in burrow builders are restricted-use materials. Use of a mechanical burrow builder may be feasible in situations such as unplanted borders or between widely spaced young trees when the terrain is relatively level and the soil is not too rocky or before planting a field. However, because the burrow builder creates an extensive network of burrows, only use it when gopher numbers are high as these new burrows will increase the speed with which gophers can invade new areas.

Trapping

Traps are effective against small numbers of gophers but are labor intensive. As such, they can be relatively expensive to use over large acreage. However, trapping often results in greater control of gophers than baiting, so the cost may be offset by effectiveness. Use either pincher traps (most common) or box-type kill traps. The smaller size and lower cost of pincher traps typically makes them a more practical choice in a field setting. Pincher traps

such as the Macabee, Cinch, or Gophinator have a vertical metal or wire pan which the gopher triggers by pushing against it. Studies have shown the Gophinator and Cinch traps to be more effective than other tested traps.

Pincher-type traps can be placed in the main tunnel of a gopher burrow system or in lateral tunnels. Setting traps in lateral tunnels is quicker and easier than trapping in the main tunnel. However, trapping in lateral tunnels may be less effective at certain times of the year (e.g., summer) and for more experienced gophers (e.g., adult males).

To place traps in the main tunnel find a fresh mound and probe as described in the Treatment Decisions section. When found, clear out the tunnel until the opening is just wide enough to insert the traps. Place traps in the main tunnel, one facing each direction the tunnel goes.

1. Set traps and place them entirely into the tunnels. The number of traps required will depend on the number of tunnels present.
2. Stake the traps by fastening wire, light cable, or twine to the trap and stake to prevent predators from carrying away traps with catches. Stakes also serve as markers to indicate trap location.
3. You can cover up the trap-hole with sod, plywood, canvas, or some other material to keep light from entering the tunnel system. However, a recent study has shown that covering trap-holes has only a minor effect on capture success. When trapping a large area, leave trap-holes uncovered to save substantial time; however covering trap-holes may keep children and pets out of traps, if this is a concern.
4. If there is no evidence that a gopher has visited the trap within 24 hours, move it to a new location.

To place traps in lateral tunnels, remove the plug from a fresh mound and place the trap entirely into the lateral tunnel. In many areas, the plugs in these lateral tunnels are quite extensive; in these situations, trapping laterals becomes counterproductive given the extensive period of time required to remove these plugs.

Fumigants

Most fumigants, such as gas cartridges, are not effective because gophers quickly seal off their tunnels when they detect the smoke or poison gases. However, aluminum phosphide* can be effective if applied underground into tunnels during a time of year when soil is moist enough to retain the toxic gas, typically in late winter to early spring, or year-round in irrigated crops. In fact, burrow fumigation with aluminum phosphide* is typically the most consistently efficacious option for gopher control as long as sufficient soil moisture is present.

Application of aluminum phosphide* is similar to hand-baiting.

1. Use a probe to locate the main tunnel.
2. Once the tunnel has been found, wiggle the probe to enlarge the hole large enough to dispense the aluminum phosphide* tablets into the tunnel.
3. Follow label instructions on the number of tablets to place into the tunnel.
4. Cover the probe hole with a rock or dirt clod, being careful not to bury the tablets under loose dirt.
5. Treat each tunnel system twice.

When using aluminum phosphide*, be sure to carefully follow all label directions and safety instructions.

As of 1 January 2012, the use of pressurized-exhaust machines that inject carbon monoxide into burrow systems has become a legal technique for controlling burrowing mammals in California. The California Department of Pesticide Regulation is now developing regulations for use of this method of control. This approach appears to be somewhat effective at controlling pocket gophers, although early studies have not shown it to be as effective as burrow fumigation with aluminum phosphide* or trapping.

Gas explosive device

The use of a gas explosive device that combines propane with oxygen has been used to kill gophers through a concussive force. This device has the added benefit of destroying part or all of the gopher's tunnel system, potentially slowing reinvasion rates. Exercise caution when using these devices because of the potential for unintended damage to property, injury to users and bystanders, potential for starting fires in dry environments, and destruction of turf. Additionally, these devices can be quite loud, making them unsuitable in residential areas. Studies on the efficacy of this device have not been positive. Alternative options such as burrow fumigation, trapping, and baiting appear to be more effective.

Repellents

No scientific data has been reported to show that chemical repellents effectively keep gophers from inhabiting fields, orchards, or vineyards. A new repellent for use in subsurface drip tape has been developed that may offer some promise although it has yet to be sufficiently tested to verify efficacy.

Frightening devices

Frightening gophers with sound or vibrations also does not appear to be effective.

- * User must be a certified applicator or be under the supervision of someone who is. Some products also require a permit from the county agricultural commissioner for purchase or use.

TREE SQUIRREL (7/16)

Common Name: eastern fox squirrel **Scientific Name:** *Sciurus niger*
Common Name: western gray squirrel **Scientific Name:** *Sciurus griseus*
Common Name: eastern gray squirrel **Scientific Name:** *Sciurus carolinensis*

DESCRIPTION OF THE PEST

Two introduced and one native tree squirrel species are occasional pests in tree fruit and nut orchards.

Eastern fox squirrels

Eastern fox squirrels are reddish brown in color and are the primary tree squirrel pest. They reproduce once or twice per year with litters occurring between January and April and between July and September.

Eastern gray squirrels

Eastern gray squirrels are somewhat smaller than fox squirrels and lack their reddish-brown coloration. Eastern gray squirrels can also bear two litters per year, one in late winter, and one in late summer.

Western gray squirrels

Western gray squirrels are large silver-gray squirrels with a peppered back and white stomach. As with the other tree squirrel species, they can have two litters per year.

Tree squirrels typically live in woody areas along creeks and river banks from where they can invade orchards. The western gray squirrel is found up to elevations greater than 5,000 feet except in desert areas. This species is fairly common where found, but is often out-competed by the eastern fox squirrel. The eastern fox squirrel is more numerous than the eastern gray squirrel. Regions with large numbers of eastern fox squirrels include agricultural and natural areas around Fresno and Sacramento, as well as coastal areas south of San Francisco as far as Los Angeles County. The eastern gray squirrel is found in localized pockets in the San Francisco Bay Area, the San Joaquin Valley, and Calaveras and San Joaquin counties.

DAMAGE

Tree squirrels can cause substantial nut loss due to their feeding and hoarding activities. They also occasionally damage fruit crops and are known to strip bark from trees sometimes causing severe damage. As with all rodents, they can gnaw on irrigation pipe, potentially causing water and monetary losses to growers.

MANAGEMENT

Relatively few options exist for controlling tree squirrels.

Monitoring and Treatment Decisions

Trapping

Trapping is often sufficient to control tree squirrels. Common traps used include tunnel or tube traps, as well as wooden box traps with nut meat placed behind the trigger.

Shooting

When possible, shooting can be effective at removing tree squirrels from orchards as well. A .22 caliber rifle or high-powered air rifle is the best option, although shotguns can be effective as well. Keep in mind that lead ammunition is no longer allowed in California condor range, and will be completely banned starting 2019. Non-lead ammunition is typically more expensive and may not be available depending on the caliber of gun used. Additional information on this lead ban can be found the California Department of Fish and Game website available online at <https://www.wildlife.ca.gov/Hunting/Nonlead-Ammunition>.

You must have a depredation permit from California Department of Fish and Wildlife to trap or shoot eastern and western gray squirrels; this permit is not required for the eastern fox squirrel. However, if shooting during the tree squirrel hunting season, no depredation permit is usually required as long as all hunting regulations are adhered to, although various regional laws may prohibit this as well. It is best to check with local authorities before shooting tree squirrels to ensure that all local regulations and ordinances are followed.

VOLES (MEADOW VOLE, MEADOW MICE) (7/16)

Scientific Name: *Microtus* spp.

DESCRIPTION OF THE PEST

Voles are also called meadow mice. Adults:

- Larger than house mice but smaller than rats
- Blunt-nosed stocky rodents
- Full grown length is 4 to 6 inches
- Small ears and eyes
- Short legs
- Short tails
- Coarse fur is usually dark gray or grayish brown

Compared to deer mice, voles have a more robust body, less obvious ears, and a relatively shorter tail. Vole ears are at least partly obscured by the hair in front of them and their tails are about one-half to one-quarter the length of their head and body combined. Deer mice have relatively large and prominent, fleshy ears, white belly and feet, and their tail is bi-colored and more than 70% the length of their head and body.

Voles live in colonies and are active both day and night, all year-round. Females bear 5 to 10 litters per year, with peaks of reproduction in spring and fall. Because voles mature rapidly and bear multiple litters yearly, numbers can increase quickly reaching as high as hundreds of voles per acre. In many areas, populations peak every 4 to 8 years, and then decline fairly rapidly. Voles live in areas such as irrigated pastures, fencerows, or weedy ditch-banks, where the soil is suitable for burrowing and where vegetation provides cover. Grasses and other dense ground cover provide food and shelter that favor the buildup of vole populations. They usually avoid sandy soils. The soil of the Tulelake Basin of Northern California is a location that is highly favorable for voles.

You can recognize vole activity by the narrow runways in grass or other ground cover, connecting numerous shallow burrows with openings about 1-1/2 inches in diameter. Voles seldom travel far from their burrows and runways, usually less than 10 feet (3 m) from the nest. Droppings are about 0.18 inch (4.5 mm) long and greenish when fresh, turning brown or gray with exposure to the environment. Sometimes fresh leaves or other cuttings are found in these trails.

Five species of voles, genus *Microtus*, occur in California. The most widespread species in the state is the California vole (*Microtus californicus*), which occurs in the Central Valley and throughout the length of the coast range. In potatoes, most damage occurs in the Klamath Basin, where the montane vole (*M. montanus*) is found.

DAMAGE

In orchards and vineyards

Voles can cause severe damage in orchards and vineyards by feeding on bark. Characteristic damage is complete or partial girdling of trunks from just below the soil line to usually no more than 5 inches high. In rare situations, voles climb higher on young trees or vines.

In addition to bark, voles also feed around the root crown, and sometimes chew holes in irrigation lines. Young trees or vines are more readily fed upon and most susceptible to being completely girdled and killed by voles. Large trees or vines can be damaged, but this is uncommon and rarely ends in death. For instance, after severe pruning, sufficient light penetrates the canopy for vegetation to grow near trunks, providing cover and food for voles. Voles live in areas where grass or other permanent vegetative cover remains year-round. Orchards or vineyards that have cover crops or those in which grass and herbaceous plants are left to grow next to trunks are most susceptible to damage.

MANAGEMENT

The best management programs for voles keep numbers at low levels; once vole numbers reach high levels, control becomes much more difficult and costly. Vegetation management and the proper use of exclusion keep damage to a minimum. Poisonous bait (either multiple-dose anticoagulants* or zinc phosphide*) can control voles that reach harmful numbers. All field-use rodenticides for voles are restricted use materials that require the applicator

to be a private or commercial certified applicator or to be under the supervision of a certified applicator. Some require a permit from the county agricultural commissioner for purchase or use.

Biological Control

Predators such as coyotes, foxes, badgers, weasels, owls, and hawks feed on meadow voles; however, predation is rarely, if ever, a major factor in controlling a rapidly increasing vole population.

Cultural Control

Habitat Management

Cultural practices can significantly affect meadow vole numbers. Because voles travel only a few feet from their burrows to obtain food, any destruction of vegetation will make the area less favorable to them and results in burrow abandonment and/or mortality. Physically removing vegetation, using herbicides or other methods to keep an area about 3 feet out from the trunks free of vegetation, has been proven to reduce damage. If you maintain ground cover or resident weeds in the row middles, keep it mowed fairly short (< 2 inches) to be less attractive to voles.

Maintaining weed-free fencerows, roadsides, and ditch banks is also an important preventive measure. A vegetation-free zone 30 to 40 feet wide between a field and adjacent areas helps reduce the potential for invasion by voles, but such a wide area is rarely practical; bare soil borders may be undesirable where off-site movement of contaminated soil and water must be prevented with a vegetative border to filter runoff.

Exclusion

Cylindrical wire or plastic trunk guards to protect young trees or vines from voles are widely used. An effective guard can be a 24-inch-tall cylinder made of ¼ - or ½ -inch mesh hardware cloth that is of sufficient diameter to allow several years' growth without crowding the tree or vine. Bury the guards' bottom edge at least 6 inches below the soil surface, but note that voles may dig beneath them.

Plastic, heavy cardboard, or other fiber materials, such as milk cartons, can also be used to make trunk guards. These materials are less expensive, also provide sunburn protection, and are more convenient to use; however, they provide less protection against vole damage since the voles can chew through them and sometimes use them as a harborage.

Regularly check beneath tree guards for evidence that voles are burrowing underneath them to gnaw on the tree trunk, looking also for the presence of other pests such as snails. If voles take up residence inside the cover, the damage is often greater than if the covers were not used. Good weed control around trunks improves the effectiveness of trunk guards.

Exclusionary fencing consisting of aluminum flashing can be used along field borders. The fencing should be buried at least 6 inches below ground and should extend 12 inches above ground. Drive rebar or wooden stakes into the ground every 15 feet to provide support for the fencing. The efficacy of such fencing is greatly increased if bare soil is present around the base of the fence. Be aware that equipment must frequently move in and out of fields, thereby limiting sites where fencing is practical. Fencing is expensive, so significant damage should be expected to justify the cost of installation.

Flood irrigation

Where still feasible, flood irrigation can help control vole populations. When a field is flooded, the voles must come to the surface or drown. When at the surface, they can be picked off by a number of predators; growers and their dogs can also actively seek out voles at this time to further reduce population size.

Monitoring and Treatment Decisions

It is important to monitor for voles carefully. Otherwise, you may not notice damage until it is too late to prevent significant injury.

Make sure to check ditch banks, fencerows, roadsides, and other areas where permanent vegetation favors the buildup of voles. Dense grass is their preferred habitat.

Starting in midwinter, monitor monthly in cover crops, weedy areas, and alfalfa fields looking for:

- Active runways: 1- to 2-inch wide surface paths that lead to silver dollar-sized burrow openings.

- Place snap traps in runways to detect pests. Scatter around the field to identify active areas needing baiting. Use expanded trigger traps to avoid having to use bait.
- Fresh vole droppings and short pieces of clipped vegetation, especially grass stems, in runways.
- Burrow openings around the bases of orchard trees or vines. Burrows frequently have numerous openings to the surface. They are relatively shallow and contain food and nesting chambers.

If you find burrows in orchard or vine crops, remove the soil from around the base of the tree or vine and look for bark damage. Voles usually start chewing on bark about 2 inches below the soil line and then move upward to about 5 inches aboveground.

Baiting

If you find damaging infestations or numbers increasing within orchard, vineyard, or vegetable crops, poison baits can be used during the dormant season to greatly reduce vole numbers. Baiting can also reduce voles in adjacent areas before they have a chance to invade. Single- and multiple-dose baits are available, but there may be baiting restrictions in some areas to protect endangered species. It is imperative that you understand and follow the label directions for use. In particular, please note that poison baits cannot be applied within orchard, vineyard, or vegetable crops from green up (spring) until after harvest occurs.

For small infestations, scatter the bait in or near active vole runways and burrows according to the label directions. For larger areas and where the label permits, you can make broadcast applications using a belly grinder-type seeder or a vehicle with a tailgate seeder. Broadcast application rates vary, depending upon estimated numbers of voles and type of toxicant. Both single-dose (e.g., zinc phosphide*) and multiple-dose (e.g., first-generation anticoagulants, chlorophacinone* and diphacinone*) poisons are used for meadow vole control in orchard, vineyard, and vegetable crops. These are restricted-use pesticides that require a permit from the county agricultural commissioner for purchase or use.

In ditchbanks and other non-cropland sites, bait should be applied in fall or spring before the voles' reproduction peaks to slow or prevent populations from expanding into the crop. However, application within an orchard, vineyard, or vegetable field is restricted to the nonbearing season, so timing is key to prevent a population explosion during the growing season. Bait acceptance will depend on the amount and kind of other food available. When baiting for voles with anticoagulants, you should remove all aboveground carcasses by burying them underground, or by bagging and disposing them in the trash. This will reduce potential secondary poisoning hazards.

Trapping

Trapping is not typically practical as voles often number in the thousands over even relatively small areas.

Fumigants

Fumigation is not typically effective because of the shallow, open nature of vole burrow systems and the large number of voles.

Repellents

Repellents are not effective in preventing damage.

* User must be a certified applicator or be under the supervision of someone who is. Some products also require a permit from the county agricultural commissioner for purchase or use.

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 <https://globalmrl.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.

ANR NONDISCRIMINATION AND AFFIRMATIVE ACTION POLICY STATEMENT FOR UNIVERSITY OF CALIFORNIA PUBLICATIONS REGARDING PROGRAM PRACTICES

The University of California, Division of Agriculture and Natural Resources (UC ANR) prohibits discrimination against or harassment of any person in any of its programs or activities on the basis of race, color, national origin, religion, sex, gender, gender expression, gender identity, pregnancy (which includes pregnancy, childbirth, and medical conditions related to pregnancy or childbirth), physical or mental disability, medical condition (cancer-related or genetic characteristics), genetic information (including family medical history), ancestry, marital status, age, sexual orientation, citizenship, status as a protected veteran or service in the uniformed services (as defined by the Uniformed Services Employment and Reemployment Rights Act of 1994 [USERRA]), as well as state military and naval service. UC ANR policy prohibits retaliation against any employee or person in any of its programs or activities for bringing a complaint of discrimination or harassment. UC ANR policy also prohibits retaliation against a person who assists someone with a complaint of discrimination or harassment, or participates in any manner in an investigation or resolution of a complaint of discrimination or harassment. Retaliation includes threats, intimidation, reprisals, and/or adverse actions related to any of its programs or activities. UC ANR is an Equal Opportunity/Affirmative Action Employer. All qualified applicants will receive consideration for employment and/or participation in any of its programs or activities without regard to race, color, religion, sex, national origin, disability, age or protected veteran status. University policy is intended to be consistent with the provisions of applicable State and Federal laws. Inquiries regarding the University's equal employment opportunity policies may be directed to: John I. Sims, Affirmative Action Compliance Officer and Title IX Officer, University of California, Agriculture and Natural Resources, 2801 Second Street, Davis, CA 95618, (530) 750-1397. Email: jsims@ucanr.edu. Website: http://ucanr.edu/sites/anrstaff/Diversity/Affirmative_Action/.