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Authors

Insects: D. R. Haviland, UCCE Kern Co.

About this publication

Produced and edited by:

UC Statewide IPM Program
University of California Agriculture and Natural Resources
Guidelines Coordinator: R. DeBiase
Production: F. Rosa

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

Note to readers: These guidelines represent the best information currently available by the authors and are intended to help you make the best choices for an IPM program. Not all formulations or registered pesticides 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.

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## General Information

*Section reviewed 12/18*

### RELATIVE TOXICITIES OF INSECTICIDES AND MITICIDES USED IN BLUEBERRY TO NATURAL ENEMIES AND HONEY BEES (12/18)

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Mode of action</th>
<th>Selectivity (affected groups)</th>
<th>Predatory mites</th>
<th>General predators</th>
<th>Parasites</th>
<th>Honey bees</th>
<th>Duration of impact to natural enemies</th>
</tr>
</thead>
<tbody>
<tr>
<td>acetamiprid (Assail)</td>
<td>4A</td>
<td>moderate (sucking insects, larvae)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>II</td>
<td>moderate</td>
</tr>
<tr>
<td>azadirachtin (Aza-Direct)</td>
<td>un</td>
<td>broad (insects, mites)</td>
<td>M</td>
<td>L/M</td>
<td>L/M</td>
<td>II</td>
<td>short</td>
</tr>
<tr>
<td>Bacillus thuringiensis ssp. kurstaki</td>
<td>11A</td>
<td>narrow (caterpillars)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>III</td>
<td>none</td>
</tr>
<tr>
<td>bifenthrin (Brigade)</td>
<td>3A</td>
<td>broad (insects, mites)</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>long</td>
</tr>
<tr>
<td>cyantraniliprole (Exirel)</td>
<td>28</td>
<td>narrow (sucking insects, caterpillars)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>—</td>
<td>short</td>
</tr>
<tr>
<td>fenpropathrin (Danitol)</td>
<td>3A</td>
<td>broad (insects, mites)</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>—</td>
</tr>
<tr>
<td>imidaclorpid, systemic (Admire Pro)</td>
<td>4A</td>
<td>narrow (sucking insects)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>II</td>
<td>short to moderate</td>
</tr>
<tr>
<td>malathion</td>
<td>1B</td>
<td>broad (insects, mites)</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>moderate</td>
</tr>
<tr>
<td>methomyl (Lannate)</td>
<td>1A</td>
<td>broad (insects, mites)</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>I</td>
<td>moderate</td>
</tr>
<tr>
<td>methoxyfenozide (Intrepid)</td>
<td>18</td>
<td>narrow (caterpillars)</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>II</td>
<td>short</td>
</tr>
<tr>
<td>pyrethrin (Evergreen, PyGanic)</td>
<td>3A</td>
<td>broad (insects)</td>
<td>—</td>
<td>M</td>
<td>M</td>
<td>I</td>
<td>short</td>
</tr>
<tr>
<td>spinetoram (Delegate)</td>
<td>5</td>
<td>broad (caterpillars, aphids, scales)</td>
<td>L/M</td>
<td>M</td>
<td>M/H</td>
<td>II</td>
<td>moderate</td>
</tr>
<tr>
<td>spinosad (Entrust)</td>
<td>5</td>
<td>narrow (caterpillars, aphids, scales)</td>
<td>L</td>
<td>M</td>
<td>L/M</td>
<td>II</td>
<td>short</td>
</tr>
</tbody>
</table>

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

1 Rotate pesticides 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; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. Mode-of-action group numbers for insecticides and miticides (un=unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://www.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 Toxicities are generally to western predatory mite, Galendromus occidentalis. Where differences have been measured in toxicity of the pesticide-resistant strain versus the native strain, these are listed as pesticide-resistant strain/native strain.

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

5 Ratings are as follows: I—Do not apply or allow to drift to plants that are flowering; II—Do not apply or allow to drift to plants that are flowering, except when the application is made between sunset and midnight if allowed by the pesticide label and regulations; III—No bee precaution, except when required by the pesticide label or regulations. For more information about pesticide synergistic effects, see Bee Precaution Pesticide Ratings.

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

7 May cause increase in spider mites numbers.

8 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.
Insects
(Section reviewed 4/14)

CITRUS THRIPS (12/18)
Scientific Name: Scirtothrips citri

DESCRIPTION OF THE PEST
Adult citrus thrips are 1/25 inch (1 mm) long, orange-yellow insects with fringed wings. Citrus thrips move actively on new blueberry foliage during the spring and summer. The first and second generation are usually found near the tips of new sucker growth at the base of the plant; subsequent generations are found on new growth at the top of the canopy during the last few weeks of harvest through fall.

Female thrips lay about 25 eggs in new leaf tissue or green shoots. Eggs laid during the spring and summer hatch within a few days; eggs laid during October and November overwinter and hatch the following April.

First-instar larvae are very small, whereas second-instar larvae are about the size of adults, spindle-shaped, and wingless. Third- and fourth-instar (propupa and pupa) thrips do not feed and complete development on the ground.

Citrus thrips do not develop below 58°F (14°C). They can produce up to eight generations during the year if the weather is favorable.

Do not confuse citrus thrips with western flower thrips, Frankliniella occidentalis. Western flower thrips are very common in blueberry fields during bloom and migrate out of blueberry fields shortly after the end of petal fall. Western flower thrips damage to blueberries is very rare, even when thrips numbers are very high, and usually only consists of a few random berries with oviposition scars.

DAMAGE
Citrus thrips are primarily a pest of blueberries grown in the San Joaquin Valley; damage in coastal blueberry production areas is rare. Citrus thrips feed at the growth tip of developing shoots and leaves, causing stunting and scarring of new shoots coupled with curling and discoloration of new leaves. In severe cases feeding can cause terminal growth to die causing new lateral shoot growth.

Damage to new growth is most common after harvest, from late June through early October. Stunting of fruiting wood during the previous summer and fall can cause a reduction in yield the following spring. Citrus thrips do not cause any reductions in fruit quality.

MANAGEMENT
In areas where citrus thrips are a problem, carefully monitor numbers. If monitoring indicates insecticide control is needed, apply an insecticide shortly after harvest. In areas with high pest pressure or more vigorous plants, one or more additional applications may be necessary.

Cultural Control
All varieties of blueberries can be damaged by citrus thrips. However, the variety Star is especially attractive to citrus thrips. Avoid planting this variety in areas close to established citrus production orchards or otherwise prone to citrus thrips problems. Some research suggests that the use of overhead sprinklers can reduce thrips populations.

Biological Control
While a number of natural enemies attack citrus thrips in citrus, natural enemies are rarely found in blueberries and do not provide economic control.

Organically Acceptable Methods
Application of the Entrust formulation of spinosad is the only reliable organic option to reduce citrus thrips numbers. Other organically-acceptable methods have not proven successful in field studies. These include lacewing larvae releases, twice per week applications of water at high pressure, and use of entomopathogenic pathogens (such as Beauveria bassiana).
Resistance
Citrus thrips has a history of rapidly developing resistance to chemicals that are used repeatedly and frequently for its control. For example, resistance to beta-cyfluthrin (Baythroid) and fenpropathrin (Danitol) have been documented in several citrus groves in Kern County. With the limited number of pesticides available for citrus thrips now and in the foreseeable future, monitor citrus thrips levels carefully, and limit treatments only to populations that are causing economic damage.

Monitoring
Monitor for citrus thrips weekly from the last 2 weeks of harvest through September using beat samples. Sample 10 shoots to get a general idea of pest density in any particular area of a field. Initially, sample all varieties to determine which variety has the highest thrips density. From then on, sample only the variety with the most thrips. There is no need to sample fruit.

1. Sample in the morning when it is cool; in the afternoon adults quickly fly away when disturbed.
2. Observe the quality of new growth by noting the prevalence of scarring to new leaves and shoots.
3. Tap the terminal 6 inches of new growth onto a clipboard or other flat surface (preferably black).
4. Count the thrips.
5. Repeat this process on 10 shoots per each region of the field to be sampled.
6. Calculate the average number of thrips per beat sample.

Treatment Decisions
Apply insecticides after harvest when there are an average of 25 to 30 thrips per beat sample in the variety with the highest thrips numbers. At this pest density, scarring of the stems and curling of leaves will begin to be present. If this threshold is reached or exceeded before the end of harvest, wait and treat after harvest because

- Citrus thrips cause no direct damage to fruit.
- There is still time for plants to recover prior to the development of fruiting buds.
- A treatment may affect logistics related to picking crews, preharvest intervals, and residues on fruit.

The exception to this rule is when SPOTTED WING DROSOPHILA is present. In this case preharvest treatments of spinosad, spinetoram, or fenpropathrin will control citrus thrips.

Re-treatments may be needed in some areas of high citrus thrips pressure. In these cases, re-treat if new scarring becomes evident and thrips numbers have returned to 25 to 30 thrips per beat sample. When re-treating, rotate the insecticide mode of action to avoid the development of resistance.

Do not apply insecticides after late September. At this time eggs stop hatching until the following spring, and adult thrips die off during the winter. Also, by early October blueberry plants have already produced fruiting wood, and fruiting bud differentiation has already occurred, such that fall thrips populations have little to no impact on the next year’s crop.

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Not all registered pesticides are listed. 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. Always read the label of the product being used.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A. **SPINETORAM**
   (Delegate WG)
   MODE-OF-ACTION GROUP NUMBER: 5
   COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging. To reduce the risk of resistance, use 5 to 6 oz per application in Kern, Tulare, and Fresno counties.
   3–6 oz 4 See label

B. **SPINOSAD**
   (Entrust)#
   MODE-OF-ACTION GROUP NUMBER: 5
   COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.
   1.25–2 oz 4 3

C. **CYANTRANILIPROLE**
### Citrus Thrips

**Common name** (Example trade name) | Amount per acre | REI‡ (hours) | PHI‡ (days)
--- | --- | --- | ---
(Exirel) | 13.5–20.5 fl oz | 12 | 3
**MODE-OF-ACTION GROUP NUMBER**: 28  
**COMMENTS**: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

D. **ACETAMIPRID**  
(Assail 70WP) | 1.9–2.3 oz | 12 | 1
**MODE-OF-ACTION GROUP NUMBER**: 4A  
**COMMENTS**: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

E. **FENPROPATHRIN**  
(Danitol 2.4EC) | 10.667–16 fl oz | 24 | 3
**MODE-OF-ACTION GROUP NUMBER**: 3A  
**COMMENTS**: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

F. **METHOMYL**  
(Lannate LV) | 1.5 pts | 48 | 3
**MODE-OF-ACTION GROUP NUMBER**: 1A  
**COMMENTS**: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

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

1 Rotate pesticides 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; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. Mode-of-action group numbers for insecticides and miticides (un=unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at [http://www.irac-online.org/](http://www.irac-online.org/).

# Acceptable for use on organically grown produce.

* Permit required from county agricultural commissioner for purchase or use.
KATYDIDS (4/14)
Scientific Names:  Forktailed bush katydid: *Scudderia furcata*
                 Angularwinged katydid: *Microcentrum retinerve*

DESCRIPTION OF THE PESTS
Katydids are an occasional pest of blueberry in the San Joaquin Valley. There are two species of katydids found in California blueberries, the angularwinged katydid and forktailed bush katydid. The forktailed bush katydid occurs most frequently in blueberries.

<table>
<thead>
<tr>
<th>Forktailed bush katydid</th>
<th>Angularwinged katydid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smaller and not humpbacked</td>
<td>Distinct humpbacked appearance</td>
</tr>
<tr>
<td>Long, banded black and white antennae</td>
<td>Long, uniformly green antennae</td>
</tr>
<tr>
<td>Flat bean-shaped eggs 0.125 inch long (3 mm) inserted into the edges of leaves in fall</td>
<td>Flat elliptical eggs 0.125 to 0.15 inch long (3–6 mm), gray, and laid in two overlapping rows that form a long “tent” on the surface of twigs and branches in fall</td>
</tr>
<tr>
<td>Nymphs emerge late March through May; adult katydids appear 2 to 3 months later</td>
<td>Nymphs emerge in May; adult katydids appear 2 to 3 months later</td>
</tr>
<tr>
<td>Oviposition begins in June and July, and continues through summer and fall</td>
<td>Oviposition begins midsummer, and continues through the fall</td>
</tr>
<tr>
<td>Some eggs hatch in July and August, the rest overwinter</td>
<td>Eggs overwinter</td>
</tr>
<tr>
<td>1 or 2 generations per year</td>
<td>1 generation per year</td>
</tr>
</tbody>
</table>

DAMAGE
Katydids occasionally become damaging pests in fields that have not been treated with broad-spectrum pesticides or where tillage is not used. High numbers of these pests occur sporadically, and they may cause damage one year and not the next.

Both nymphs and adults feed on leaves or fruit, but the adults are the most damaging. Katydids tend to feed on a small section of a fruit before moving on to another feeding site. Hence, a few katydids may damage a large number of fruit in a short time. Katydids will feed on any size fruit. Feeding wounds heal over and enlarge into corky patches as the fruit expands. Damage to a young fruit can cause it to become distorted as it develops. Nymphs and adults also chew holes in foliage. Smaller nymphs feed in the middle of the leaf, creating small holes, whereas larger nymphs and adults feed on the leaf edge.

MANAGEMENT
In most years katydid management in blueberries is only needed in a few fields in the San Joaquin Valley. These sites are often near alternate hosts such as stone fruits or citrus. In these areas, monitor for katydid migrations from April through May using sweep nets or beat sheets on cover crops and weeds near the perimeter of the fields. Monitor blueberries by looking for feeding holes on leaves and feeding scars on fruit. If significant amounts of fruit are damaged, consider a treatment; damage to foliage is not of economic importance.

Biological and Cultural Control
To date very little is known about cultural controls for katydids in blueberries. Egg parasites can reduce katydid numbers throughout the year. However, they provide minimal to no control of katydids that mature in overwintering hosts and then migrate to blueberries as adults.
Not all registered pesticides are listed. 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. Always read the label of the product being used.

A. SPINETORAM  
(Delgate WG)  
MODE-OF-ACTION GROUP NUMBER: 5  
COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.  
3–6 oz  
4  
See label

B. AZADIRACHTIN  
(Aza-Direct)#  
MODE-OF-ACTION GROUP NUMBER: un  
COMMENTS: Moderately effective on immature katydids. Must be contacted by spray so good coverage is essential.  
1–2 pts  
4  
0

C. PYRETHRIN  
(Pyganic EC1.4II)#  
(Evergreen EC60-6)  
MODE-OF-ACTION GROUP NUMBER: 3A  
COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.  
16–64 oz  
12  
Until dry

2–16 oz  
12  
Until dry

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

# Acceptable for use on organically grown produce.

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LIGHT BROWN APPLE MOTH (12/18)

Scientific Name:  Epiphyas postvittana

DESCRIPTION OF THE PEST

Light brown apple moth (LBAM) is an exotic pest native to Australia that has been detected in coastal California from Los Angeles to Sonoma counties. It is a quarantined pest with special requirements regarding movement, inspection and treatment of regulated plant materials. Consult the CDFA website (http://www.cdfa.ca.gov/plant/lbam/regulation.html) or a county agricultural commissioner’s office for local compliance information. Take suspect larvae, preferably alive, or tortricid moths found in light brown apple moth pheromone traps, to the county agricultural commissioner’s office for proper identification.

In both appearance and behavior, the light brown apple moth is similar to other leafroller species in the tortricid family. The mature larvae are pale to medium green with a light yellow-tan head. The first segment behind the head (prothoracic shield) is greenish with no dark markings. Full-grown larvae are about 1/2 to 3/4 inch (10 to 18 mm) long. However, larvae cannot be reliably identified using morphological characters.

There are many native tortricids that can be confused with this pest. Tortricid moths hold their wings over their abdomens in a bell shape when at rest, and have protruding mouthparts that resemble a snout. Many moths have oblique markings on the wings.

Depending on the climate, light brown apple moth may have 2 to 4 generations a year. In its native range it does not survive well at high temperatures, but it does thrive in cooler areas with mild summers, moderate rainfall, and moderate to high humidity. Overwintering larvae do not have a winter resting stage (diapause). They pass the winter as second- to fourth-stage larvae on vegetation surrounding field. Larvae may survive for up to 2 months in the winter without feeding.

Adult moths emerge after 1 to 3 weeks of pupation and mate soon after emergence. They stay sheltered in the foliage during the day, resting on leaf undersides. Females begin to lay eggs 2 to 3 days after emerging. The eggs are laid on leaves in masses of 20 to 50 (but may contain up to 170 eggs), slightly overlapping each other like fish scales. Egg masses are covered with a greenish transparent coating when newly laid, but the eggs become darker as the embryo develops. Larvae emerge after 1 to 2 weeks and disperse widely on the plant. In spring the first stage larvae move to shoot tips and form nests by webbing together developing leaves. The larvae feed within these shelters. Later in the season, larvae may enter fruit.

For more information on scouting and field identification, see the video: Scouting and Field Identification of Light Brown Apple Moth in California Nurseries, available online at: http://stream.ucanr.org/relay/nbpmurray/Scouting_and_Field_Identification_of_Light_Brown_A---_20140709_154356_7.html.

DAMAGE

Overwintering larvae feed on buds; injured buds may fail to develop. During bloom, larvae feed on flower and fruit clusters. Feeding can also cause direct damage to berries.

MANAGEMENT

Research on management of light brown apple moth in California has been limited, due to the quarantines imposed wherever it is found. As a result, most recommendations for California are based on work in grapes from other countries such as Australia and New Zealand, where overwintering sanitation, biological control, and selective insecticides are the primary means of control.

Biological Control

General insect predators and several species of spiders can reduce leafroller numbers by feeding on eggs or larvae. High mortality has been reported during the initial dispersal of the newly hatched larvae. Several parasitic wasps, Meteorus sp. in particular, have been recorded parasitizing light brown apple moth in California.

Cultural Control

In grapes, sanitation of mummy clusters in the dormant season can help reduce the number of overwintering leafrollers. However, the value of sanitation in blueberries is unknown.
Organically Acceptable Methods
Cultural control and sprays of *Bacillus thuringiensis* and the Entrust formulation of spinosad are acceptable for use on organically certified crops.

Monitoring and Treatment Decisions
The most efficient and reliable method for monitoring the presence of moths is with the use of light brown apple moth pheromone traps, using commercially available lures.

In early spring, monitor shoots for webbing of leaves and larvae inside their nests. Look for rolled leaves that appear glued to shoots. Beginning at bloom, monitor fruit for webbing and larvae. Treatment thresholds are not yet established.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
</table>
| **A. METHOXYFENOZIDE**  
(Intrepid 2F) | 10–16 fl oz | 4 | 7 |
| **B. BACILLUS THURINGIENSI S ssp. KURSTAKI#**  
(various products) | Label rates | 4 | 0 |
| **C. SPINOSAD**  
(Entrust)# | 1.25–2 oz | 4 | 3 |
| **D. SPINETORAM**  
(Delegate WG) | 3–6 oz | 4 | 3 |

Not all registered pesticides are listed. 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. Always read the label of the product being used.

A. METHOXYFENOZIDE  
(Intrepid 2F)  
MODE-OF-ACTION GROUP NUMBER: 18

B. BACILLUS THURINGIENSI S ssp. KURSTAKI#  
(various products)  
MODE-OF-ACTION GROUP NUMBER: 11A  
COMMENTS: Most effective on young larvae. Check with certifier to determine which products are organically acceptable.

C. SPINOSAD  
(Entrust)#  
MODE-OF-ACTION GROUP NUMBER: 5  
COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

D. SPINETORAM  
(Delegate WG)  
MODE-OF-ACTION GROUP NUMBER: 5  
COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.

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

# Acceptable for use on organically grown produce.

1 Rotate pesticides 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; insecticides with a 1B group number should be alternated with insecticides that have a group number other than 1B. Mode-of-action group numbers for insecticides and miticides (un=unknown or uncertain mode of action) are assigned by IRAC (Insecticide Resistance Action Committee). For additional information, see their website at http://www.irac-online.org/.
MASKED CHAFER (White Grub) (4/14)

Scientific Names: *Cyclocephala longula*

DESCRIPTION OF THE PESTS

Masked chafer larvae (grubs) are found in the soil from August through June.

- C-shaped beetle larvae
- Large, up to 1 inch (2.5 cm) long
- White with dark translucent dorsal stripes
- Brown head capsules and legs
- Bristles on the posterior end of the abdomen (raster)

Adult beetles:

- About 1/2 inch (1.25 cm) long
- Golden brown
- Hairy on the underside of the thorax
- Dark brown head with distinctive antennae, shaped like a club composed of several plates (lamellae)

Masked chafers complete one generation per year, overwintering as mature larvae. The larvae form earthen cells in the soil where they pupate in April. Adults emerge from mid-June to mid-July in the San Joaquin Valley.

Adult beetles hide in the soil during the day and fly around in search of mates during the first 2 hours after dusk. Adults of both sexes are highly attracted to black-light traps.

Masked chafers are in the insect family Scarabaeidae, and like others in this family, are commonly called scarab beetles.

DAMAGE

Masked chafer grubs are found throughout California but are most likely to reach damaging levels in the San Joaquin Valley. They feed on roots, resulting in plants that have the appearance of drought stress, even where there is sufficient irrigation. For mature plants it may take several years for grub numbers to build up to a damaging level. However, root feeding on one-year-old plants can cause plants to desiccate and die within a few months of being planted.

Most damage usually takes place in late summer or early fall when second- and third-instar larvae are actively feeding and summer temperatures are at their peak.

Severe stunting or desiccation and death of new plants can occur any time new blueberry fields are being planted next to existing fields. Older fields can have large numbers of grubs, but tolerate grub feeding, and so show relatively little or no damage. Adult beetles from these existing fields are very attracted to fresh organic matter that is commonly incorporated into new fields prior to planting. Adult beetles fly to this fresh compost and lay eggs in it even before blueberries are planted. Then, as larvae grow, they find the new plants, feed on the new roots, and can cause extensive plant damage or death, particularly if plants lack vigor due to inappropriate cultural practices.

MANAGEMENT

In most California locations, masked chafers do not reach levels requiring an insecticide treatment. Where damage does occur, control grubs with imidacloprid or entomopathogenic nematodes through the drip irrigation system.

**Biological Control**

Naturally-occurring biological control in blueberry has not been documented. However, applications of a commercially available entomopathogenic nematode, *Heterorhabditis bacteriophora*, can effectively control masked chafers. *Steinernema carpocapsae* nematodes are not effective.

**Cultural Control**

Maintain overall plant health with optimum soil and water pH management and pruning practices.
**Monitoring and Treatment Decisions**

Monitoring is based on the time of year and stage of the pest. Because treatment thresholds do not exist, monitor to determine if grubs are present and to evaluate the effectiveness of management programs.

1. **From August to May** monitor for grubs or pupae by digging in the root zone.
2. **In the spring**, apply entomopathogenic nematodes through the drip irrigation system. Apply when soil temperatures are at least 60°F to ensure that the nematodes are active and allow as much time as possible for them to infect the larvae before adult beetles emerge in June and July.
3. **During June and July** monitor for adults using a black light or by looking for adult emergence holes from pupal cells on the side of the berm.
4. **In early August**, apply imidacloprid or entomopathogenic nematodes when grubs are small.

Irrigate before and after applying nematodes or imidacloprid to ensure good soil moisture. Store nematodes properly before use as directed, and apply during the coolest time of day in hot areas.

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. IMIDACLOPRID (Admire Pro)</td>
<td>7–14 fl oz</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 4A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Apply as a soil treatment through drip irrigation; foliar applications are not effective. Typically applied in the fall.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. HETERORHABDITIS BACTERIOPHORA</th>
<th>500 million infectious juveniles per treated acre</th>
<th>NA</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMMENTS: Can be applied in the spring or fall. Make treatment calculations based on the use of 500 million infectious juveniles per treated acre. A mature field with treatments to a 3-foot band in a field with 11-foot spacing means that 500 million infectious juveniles is sufficient to treat approximately 3.7 acres.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

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NA Not applicable.

* Permit required from county agricultural commissioner for purchase or use.
PACIFIC FLATHEADED BORER (4/14)
Scientific Name: Chrysobothris mali

DESCRIPTION OF THE PEST
Pacific flatheaded borer is an occasional pest in the San Joaquin Valley. The adult beetle is about 0.4 inch long with a dark bronze body and coppery spots on the wing covers. A fully grown larva is light colored, with a prominent, flat enlargement just behind the head and a pair of triangular dark brown mandibles at the tip of the head. There is one generation each year.

Adult pacific flatheaded borers are generally present in May and June. When spring months are warm, they may be seen as early as late March or early April.

DAMAGE
Feeding by Pacific flatheaded borer larvae weakens the cane, resulting in stunted growth or death of the cane. Adult beetles are attracted to stressed or damaged blueberry canes, particularly areas with pruning scars or sunburn. Adult female beetles lay eggs on the injured area, and larvae excavate tunnels just beneath the bark and bore through the cane. Excavations are usually filled with tightly packed, finely powdered sawdust. Later, these areas may crack and expose the mines.

MANAGEMENT
Pacific flatheaded borers are managed by pruning and maintaining healthy bushes. Applying pesticides for this insect is not recommended.
• Each year, remove old canes that exhibit borer damage and train new canes to take their place.
• Prune at a time of year and in a manner that prevents sunburn of canes to reduce borer damage.
• After pruning, chip or remove prunings from the field before immature stages of the borer can complete their development.
SPOTTED-WING DROSOPHILA  (12/18)

Scientific Name:  *Drosophila suzukii*

DESCRIPTION OF THE PEST
(View male/female identification card) , available online at: http://ipm.ucanr.edu/PDF/PMG/SWD_IDCard.pdf

Spotted-wing drosophila is established in all California counties where blueberries are grown but is of greatest concern in areas along the coast. Adults and larvae (maggots) closely resemble the common vinegar fly, *Drosophila melanogaster*, and other *Drosophila* species that primarily attack rotting or fermenting fruit. Spotted-wing drosophila, however, attacks undamaged fruit prior to harvest.

Adults are small (2–3 mm) flies with red eyes, a pale brown thorax, and abdomen with black stripes. The most distinguishable trait of the adult is that the males have a black spot near the tip of each wing. The female ovipositor is very large and serrated, so it is able to penetrate the skin of soft-skinned fruit and lay one to three eggs in each. The female will lay eggs in many fruit.

Eggs are laid within the fruit skin and can be recognized with a hand lens by two white breathing tubes that extend out of the surface of the fruit.

Larvae are tiny (up to 3.5 mm), white, cylindrical maggots that are found feeding in fruit. One or more larvae may be found feeding within a single fruit. After maturing, the larvae partially or completely exit the fruit to pupate.

Spotted-wing drosophila prefers mild, humid weather that usually occurs throughout the year in coastal areas of California and during the spring and fall in inland valleys. Peak activity occurs when temperatures are in the 60s and 70s (°F), which is typical during harvest seasons across all production regions of the state.

Spotted-wing drosophila has a life cycle that varies from one to several weeks depending on temperature and may have as many as ten generations per year. This rapid developmental rate allows it to quickly reach high numbers and inflict severe damage to a crop.

DAMAGE
Unlike other vinegar flies that occur in California, spotted-wing drosophila is a significant pest that attacks healthy fruit prior to harvest. As fruit integrity is compromised by oviposition and larval feeding, common vinegar flies (i.e., *Drosophila melanogaster*) may also oviposit in the damaged fruit. Damage can also provide entry for infection by secondary fungal and bacterial pathogens, but this is not always the case. Often damage is not seen until the fruit is at the market; fruit is soft and has a reduced shelf-life.

Oviposition creates a small depression ("sting") on the fruit surface. Many larvae are possible within a single fruit because females can lay more than one egg in each fruit and multiple females will oviposit on the same fruit. Maggots develop and feed inside the fruit, causing the flesh to turn brown and soft. When infested fruit are gently squeezed, fluid exudes out of the hole in the fruit surface where the egg was laid.

MANAGEMENT
Management of spotted-wing drosophila is required any time susceptible fruit and flies are present at the same time. Apply insecticides based on field history and trap catches, with the goal of preventing oviposition; insecticides do not control larvae within the fruit.

Biological Control
Spotted-wing drosophila natural enemies have not been observed.

Organically Acceptable Methods
Application of the Entrust formulation of spinosad is the only control method available to organic blueberry growers.

Resistance Management
When applying pesticides, it is extremely important to consider resistance management. Drosophila flies have a history of rapidly developing resistance to insecticides that are used repeatedly and frequently. Additionally, insecticides such as spinosad and fenpropathrin are also two of the key insecticides used for citrus thrips control.
later in the season. If control of both pests within a season is needed, carefully plan the insecticide treatments in a way that reduces the risk of resistance development for both pests.

**Monitoring**

Monitor spotted-wing drosophila using homemade traps.

- Make a trap capable of holding liquid.
- Traps should be able to hang from a wire within the blueberry canopy.
- Traps need holes or other openings in them to release the scent of the bait, and for spotted-wing drosophila to enter the trap. Holes should not be too big or larger nontarget insects can enter.

The two most common versions of these traps are various sized bottles with 3/16-inch holes drilled in them or containers with mesh on top.

1. Bait traps with 1/2 to 1 cup of apple cider vinegar (depending on the size of the trap).
2. Add 1 teaspoon of a dishwashing detergent per gallon of apple cider vinegar to increase the number of flies that fall into the liquid bait and drown.
3. Place traps low in the blueberry canopy.
4. Check weekly.
5. Count the number of male flies (the ones with spots on the wings).

Counting male flies should be adequate for determining whether or not spotted-wing drosophila is present, and for observing if numbers are going up, down, or remaining the same.

**Treatment Decisions**

If trapping programs indicate the presence of adult spotted-wing drosophila, apply an insecticide when the first berries begin to turn pink, with a second application just prior to harvest. Green fruit are very poor hosts and there is no indication that management after harvest has any benefit for the following season. These treatments target adults before oviposition occurs because effective larvicides are not available.

After treatments, if traps indicate that adult flies are still present, especially if flies are migrating into the field from other crops such as cherries or caneberrries, additional treatments may be warranted at 7- to 14-day intervals until harvest is over.

<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. SPINETORAM</strong> (Delegate WG)</td>
<td>3–6 oz</td>
<td>4</td>
<td>See label</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. SPINOSAD</strong> (Entrust)#</td>
<td>1.25–2 oz</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C. FENPROPATHRIN</strong> (Danitol 2.4EC)</td>
<td>16 fl oz</td>
<td>24</td>
<td>3</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D. BIFENTHRIN</strong> (Brigade WSB)</td>
<td>16 oz</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>MODE-OF-ACTION GROUP NUMBER: 3A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS: Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>E. MALATHION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Not all registered pesticides are listed. 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. Always read the label of the product being used.*

Online with photos at http://ipm.ucanr.edu/PMG/selectnewpest.blueberry.html
<table>
<thead>
<tr>
<th>Common name (Example trade name)</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malathion 57%</td>
<td>2 pt</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td><strong>MODE-OF-ACTION GROUP NUMBER:</strong> 1B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>COMMENTS:</strong> Do not spray directly or allow to drift onto blooming crops or weeds where bees are foraging.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F. PYRETHRIN

<table>
<thead>
<tr>
<th>Product</th>
<th>Amount per acre</th>
<th>REI‡ (hours)</th>
<th>PHI‡ (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyganic EC1.4I#</td>
<td>16–64 oz</td>
<td>12</td>
<td>Until dry</td>
</tr>
<tr>
<td>Evergreen EC60-6</td>
<td>2–16 oz</td>
<td>12</td>
<td>Until dry</td>
</tr>
<tr>
<td><strong>MODE-OF-ACTION GROUP NUMBER:</strong> 3A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
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# Acceptable for use on organically grown produce.
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, unauthorized persons, pets, or livestock. DO NOT store pesticides with foods, feed, fertilizers, or other materials that may become contaminated by the pesticides.

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 exposure to pesticides and from contamination due to drift, runoff, or residues. Certain rodenticides may pose a special hazard to animals that eat poisoned rodents.

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

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

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

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

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

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

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