Small Fruit Crops

Blueberry Pests

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INCLUDES MANAGEMENT OPTIONS FOR COMMERCIAL AND HOME USE

In all cases, follow the instructions on the pesticide label. The *PNW Insect Management Handbook* has no legal status, whereas the pesticide label is a legal document. Read the product label carefully before making any pesticide applications.

Protect pollinators: See How to Reduce Bee Poisoning from Pesticides.

Note: Products are listed in alphabetical order and *not* in order of preference or superiority of pest control.

Blueberry—Aphid

Includes
Ericaphis fimbriata (no common name)
Green peach aphid *(Myzus persicae)*

Pest description and crop damage Green peach aphids are medium to large aphids, 2-3 mm in length when fully grown. Wingless adults are green to pale yellow or pink. Ericaphis is a small (1-2 mm in length), spindle-shaped light-colored (yellow-green) wingless aphid; winged adults are dark colored. They secrete honeydew, and their feeding can deform leaves and devitalize plants. Both are also known to transmit blueberry scorch virus (BlSV).

Biology and life history Most species of aphid have similar life cycles. Aphid females give birth to live offspring all year without mating. When other hosts are not available, aphid live on a wide variety of weeds. Aphids are usually found in colonies on new growth, the undersides of leaves, and near flower and fruit clusters. In summer and fall, aphids may produce winged females and, later, winged males. They mate and produce eggs for overwintering, especially in colder climates. Otherwise, adult aphids overwinter on crops, weeds, or trees. There may be as few as two generations or as many as 16 generations each year, depending on the species and climate.

Scouting and thresholds Check plants frequently after new growth begins. Aphids are often concentrated in "hot spots." Be sure to look for evidence of biological control; i.e., the presence of predators, parasites (aphid mummies), and disease. Aphid flights are most common during periods of moderate temperatures (60° to 80°F).

Management—biological control

Many parasites and predators attack aphids. Monitor the proportion of aphid mummies to unparasitized adults, and the number of predators such as lady beetles. If the biocontrol agents appear to be gaining control, avoid sprays which would disrupt this system. Most products available for aphid control are highly disruptive of natural enemy populations.

Management—cultural control

Controlling weeds late in the season may help reduce overwintering populations. Aphid populations tend to be higher in plants that are fertilized liberally with nitrogen. Prune out suckers and other excess growth that might encourage colonization.

Home gardeners: Control ants, which "farm" the aphids and protect them from predators. A narrow band of "stickem" at the base of the stem should exclude ants.

Management—chemical control: HOME USE

Apply when aphids appear, and repeat if necessary. Direct spray to undersides of leaves and growing tips. Avoid making applications of insecticides to plants in bloom to avoid bee injury. Follow all label directions.

- acetamiprid
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- carbaryl
- esfenvalerate
- imidacloprid
- insecticidal soap—May require several applications. Some formulations are OMRI-listed for organic use.
- kaolin—Applied as a spray to leaves, stems and fruit it acts as a repellant to some insect pests. Some formulations are OMRI-listed for organic use.
- malathion
- permethrin
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- spinosad
- zeta-cypermethrin—Toxic to bees; do not apply when bees are foraging.

Management—chemical control: COMMERCIAL USE

- acetamiprid (Assail) at 0.044 to 0.1 lb ai/a. PHI 1 day. Do not exceed 0.5 lb ai/a per season.
- azadirachtin (Neemix and other brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use.
- cyantraniliprole (Exirel) at 0.088 to 0.133 lb ai/a. PHI 3 days. Do not apply when bees are foraging. Note "Bee Advisory Box" and restrictions on the label.
- diazinon (several brands) at 0.5 lb ai/a. PHI 7 days. Do not apply during bloom. One application per season allowed; as such, consider other pests that may need to be managed with diazinon.
- flupyridifurone (Sivanto) at 0.09 to 0.14 lb ai/a. PHI 3 days. Toxic to adult bees in laboratory studies via oral exposure, however, not toxic to bees through contact exposure, and field studies conducted with this product have shown no effects on honeybee colony development. Two applications, 7 days apart, and no more than 0.365 lb ai/a allowed per season. Avoid rotation with neonicotinoid products, if possible.
- imidacloprid (Admire Pro and other brands) at 0.036 to 0.05 lb ai/a for foliar applications, and 0.25 to 0.5 lb ai/a for soil applications. (Check label of other brands for correct rate). PHI 3 days (foliar) or 7 days (soil). Do not apply pre-bloom, during bloom or when bees are foraging. Note "Bee Advisory Box" and restrictions on the label.
- insecticidal soap (M-Pede and other brands)—Consult label for rate and use directions. PHI 0 days. Some formulations are OMRI-listed for organic use.
- malathion (several brands) at 1.25 lb ai/a. PHI 1 day. During bloom, apply only in late evening.

- methomyl (Lannate) at 0.45 lb ai/a. PHI 3 days. Do not apply during bloom.
- pyrethrin (several brands)—Consult label for rate and use directions. PHI 0 days. Direct contact is essential for effective results. PyGanic brand is OMRI-listed for organic use.
- thiamethoxam (Actara) at 0.047 to 0.062 lb ai/a. PHI 3 days. Foliar applied. Actara and Platinum have the same active ingredient; for resistance management, do not follow one with the other. Do not apply when bees are foraging. Note "Bee Advisory Box" and restrictions on the label.
- thiamethoxam (Platinum) at 0.078 to 0.188 lb ai/a. PHI 75 days. Apply to soil and incorporate with irrigation. Platinum and Actara have the same active ingredient; for resistance management, do not follow one with the other. Wait at least 5 days after application before placing beehives in the treated field. Note "Bee Advisory Box" and restrictions on the label.

Blueberry—Blueberry gall midge

Dasineura oxycoccana

Pest description and crop damage The adult is a very small fly, about 1-3 mm long, and reddish. Larvae are white to orange, very small and difficult to see with the naked eye. The larvae feed on developing shoot tips, causing distorted growth. Damage may be confused with boron deficiency or even with normal black tip stage of development. Terminal growth feeding releases apical dominance and will often cause branching and a witches-broom appearance. Bud damage at an economic level has not been observed in the PNW.

Biology and life history This insect overwinters in the pupal stage in the soil. In the spring, the female emerges and lays eggs in either floral or vegetative buds just after bud swell, when bud scales begin to separate. Eggs hatch into larvae within a few days and begin feeding within the blueberry bud. After about a week of feeding, these larvae drop to the soil and form puparia. There may be up to four generations per year.

More information is available in the OSU Extension publication EM 8889, *Blueberry Gall Midge-A Possible New Pest in the Northwest* (https://extension.oregonstate.edu/catalog).

Management—chemical control: HOME USE

- carbaryl
- pyrethrins—Some formulations are OMRI-listed for organic use.
- spinosad—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin—Toxic to bees; do not apply when bees are foraging.

Management—chemical control: COMMERCIAL USE

Note: The following recommendations are legal pesticide uses even though blueberry gall midge may not be listed on the pesticide label.

- cyantraniliprole (Exirel) at 0.088 to 0.133 lb ai/a. PHI 3 days. Note "Bee Advisory Box" and restrictions on the label.
- diazinon (several brands) at 0.5 lb ai/a. PHI 7 days. One application per season allowed; as such, consider other pests that may need to be managed with diazinon.
- malathion (several brands) at 1.25 lb ai/a. PHI 1 day.
- methomyl (Lannate) at 0.45 lb ai/a. PHI 3 days.
- novaluron (Rimon 0.83EC) at 0.13 to 0.19 lb ai/a. PHI 8 days. Apply when larvae are young and small.
- spinetoram (Delegate WG) at 0.05 to 0.09 lb ai/a. PHI 3 days. Provides suppression only. SLN 24c OR-170016 for Delegate allows a 1-day PHI in Oregon only; read label carefully for restrictions on number of applications allowed.
- spinosad (Success or Entrust) at 0.062 to 0.09 lb ai/a. PHI 3 days. SLN 24c OR-160013 and WA-140014 for Entrust SC formulation allow a 1-day PHI in Washington and Oregon only. Entrust is OMRI-listed for organic use.

Blueberry—Brown marmorated stink bug

Halyomorpha halys

This pest is not currently of commercial concern. It is present in the Pacific Northwest but has not been reported for causing damage to blueberry crops. It may pose a significant risk to fruit if populations increase.

See
EMERGING PEST: Brown Marmorated Stink Bug—A Pending Threat to Pacific Northwest Agriculture

Blueberry—Cherry fruitworm

Grapholitha packardi

Pest description and crop damage In the PNW, cherry fruitworm has been found infesting blueberries only in parts of western Washington. Adults are small, dark gray/brownish moths with a wingspan of about 9-10 mm. They are active mostly at night and so are rarely seen. Larvae have pink-red bodies with brown or black heads. Newly hatched larvae tunnel into fruit. One larva can easily destroy an entire cluster of berries.

Biology and life history The fruitworm overwinters as a mature larva, hibernating in cavities in dead wood on the bush, or in pruning stubs. As temperatures warm, the larva changes into a pupa, and, about 2 weeks later, the adult emerges in late spring. A few days after emergence, mating and egg deposition occur. Females lay opaque, green-white flattened eggs on the underside of leaves at the time of blossom drop, as well as on developing small green fruit. After eggs hatch, larvae penetrate the berry and begin feeding on the fruit pulp. There is only one generation per year.

Scouting Visual inspection for eggs should begin at petal fall/early fruit set and when adult flight has started. Eggs are opaque and difficult to see; look carefully on the underside of leaves and on small green berries. Larval infestations may be difficult to detect early in the season because there is little external evidence of the insect's presence. Look for a pin-sized entry hole near the stem of any small, shrunken berries that have turned prematurely blue, and then open adjacent berries to find the larvae.

Management—cultural control

Remove overwintering environments for larvae, such as weeds, prunings, and trash around the plants. Also, if possible, manage alternate hosts (e.g. cherry, apple, rose) on field borders.

Home gardeners: Larvae and eggs can be hand-picked if found.

Management—chemical control: HOME USE

Because this is a fruit pest, and because egg laying and hatch occur at bloom and petal fall, great care must be taken if applying pesticides to avoid bee injury with any of the following products. Apply after petal fall, or at night.

- carbaryl
- esfenvalerate
- pyrethrins—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

Apply insecticides when larvae are small, usually at petal fall.

- acetamiprid (Assail) at 0.085 to 0.1 lb ai/a. PHI 1 day. Do not exceed 0.5 lb ai/a per season.

- *Bacillus thuringiensis (Bt)* (several brands)—Consult label for rate. PHI 0 days. A spreader-sticker increases efficacy. OMRI-listed for organic use.
- carbaryl (Sevin and other brands) at 1.5 lb ai/a. PHI 7 days. Latex-based formulations such as Sevin XLR Plus are less hazardous to bees. Do not apply to bloom.
- cyantraniliprole (Exirel) at 0.065 to 0.088 lb ai/a. PHI 3 days. Do not apply when bees are foraging. Note "Bee Advisory Box" and restrictions on the label.
- diazinon (several brands) at 0.5 lb ai/a. PHI 7 days. Do not apply to bloom. One application per season allowed; as such, consider other pests that may need to be managed with diazinon.
- esfenvalerate (Asana XL) at 0.025 to 0.05 lb ai/a. PHI 14 days. Aids in control. Apply prebloom or postbloom only. Esfenvalerate can act like a bee repellent; do not apply within 7 days of pollination.
- fenpropathrin (Danitol) at 0.2 to 0.3 lb ai/a. PHI 3 days. Do not exceed two applications per season.
- indoxacarb (Avaunt) at 0.065 to 0.11 lb ai/a. PHI 7 days.
- malathion (several brands) at 1 lb ai/a. PHI 1 day. Apply only during late evening to avoid bee poisoning.
- methomyl (Lannate) at 0.45 to 0.9 lb ai/a. PHI 3 days. Do not apply during bloom. Apply as spray in 100 gal water/a at blossom drop and again two weeks later. Cover foliage thoroughly.
- methoxyfenozide (Intrepid 2F) at 0.25 lb ai/a. PHI 7 days. Apply when egg laying begins and again at 100% petal fall (usually 7 to 14 days after first application). Additional applications at 10- to 14-day intervals may be required under high population pressure or sustained moth flights.
- spinetoram (Delegate WG) at 0.05 to 0.09 lb ai/a. PHI 3 days. SLN 24c OR-170016 for Delegate allows a 1-day PHI in Oregon only; read label carefully for restrictions on number of applications allowed. Toxic to bees for three hours following treatment. Do not apply when bees are foraging.
- spinosad (Success or Entrust) at 0.062 to 0.09 lb ai/a. PHI 3 days. SLN 24c OR-160013 and WA-140014 for Entrust SC formulation allow a 1-day PHI in Washington and Oregon only. Target eggs at hatch or small larvae. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. Entrust is OMRI-listed for organic use.
- tebufenozide (Confirm 2F) at 0.25 lb ai/a. PHI 14 days. Apply when egg laying begins and again at 100% petal fall (usually 7 to 14 days after first application). Additional applications at 10- to 14-day intervals may be required under high population pressure or sustained moth flights. Do not exceed 64 fl oz/a product per crop season.

Blueberry—Leafroller

Includes
Obliquebanded leafroller *(Choristoneura rosaceana)*
Orange tortrix *(Argyrotaenia franciscana = A. citrana)*

Pest description and crop damage Both species are found in blueberries. Depending on the region, one species may be more dominant than the other. Adults of these two species are buff-colored moths with a wing span of 12-20 mm, and bell-shaped at rest. As the name indicates, the obliquebanded leafroller moth has a dark band across its wings. The larvae of the orange tortrix are light cream to green with light brown heads, and are up to 12 mm long at maturity. Obliquebanded larvae can be 12-25 mm long and have darker green bodies with dark brown to black heads. The larvae roll and tie leaves together with silk for shelter and feeding; they wriggle and thrash about violently when disturbed. Eggs are green and laid on leaves in clusters of up to 200 eggs. They hatch in about 10 to 14 days. The larvae feed on leaves, which causes relatively minor damage. Feeding on growing points on young plants can promote undesirable branching. Loss of fruit quality can occur from binding of leaves to developing fruit, and if the larvae contaminate the fruit in mechanically harvested fields. Larval feeding on blossoms is thought to spread *Botrytis* fruit disease.

Biology and life history Both species overwinter as larvae on a variety of host plants. Larvae may feed during warm periods in winter but become active in spring with onset of new growth. Pupation occurs within the larval leaf roll. Depending on species, adult moths emerge from April to July. These adults lay eggs for the next generation. There are two to three generations per year.

Scouting Observe early spring growth for rolled leaves and feeding damage on new growth. Larvae move from plant to plant, and between fields, on silken threads; this silk can be easily seen upon close inspection or if viewed in the slanting sunlight. Pheromone traps are available for monitoring adult male flight. These can help to determine the timing of adult emergence and timing of larvae presence. Pheromone traps should be placed in fields beginning in late April or May and checked weekly. Starting one week after peak flight, leaves can be examined for larval infestation.

Management—biological control

Very low temperatures in winter significantly reduce overwintering populations. Spiders and parasitic/predatory insects greatly reduce leafroller populations throughout the year.

Management—cultural control

Removal of overwintering sites, such as rolled leaves on the ground or plastered to canes, can reduce next year's population. Avoid use of broad-spectrum insecticides which can disrupt natural enemies.

Management—chemical control: HOME USE

Dormant-season spray

- superior-type oil—Some formulations are OMRI-listed for organic use.

Growing-season spray

Avoid making applications of insecticides to plants in bloom to avoid bee injury. Follow all label directions.

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- *Bacillus thuringiensis* var. *kurstaki*—Some formulations are OMRI-listed for organic use.
- carbaryl—In severe infestations of leafrollers, three applications may be necessary: first, May 15; second, June 1; third, June 15. The extent of infestation should determine the number of applications. Do not apply carbaryl during blossoming—extremely toxic to bees.
- esfenvalerate
- kaolin—Applied as a spray to leaves, stems and fruit it acts as a repellant to some insect pests.
- permethrin
- pyrethrins—Some formulations are OMRI-listed for organic use.
- spinosad—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin—Toxic to bees; do not apply when bees are foraging.

Management—chemical control: COMMERCIAL USE

- azadirachtin (Neemix and other brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use.
- *Bacillus thuringiensis (Bt)* (several brands)—Consult label for rate. PHI 0 days. A spreader-sticker increases efficacy. OMRI-listed for organic use.

- bifenthrin (Brigade and other brands) at 0.033 to 0.1 lb ai/a. PHI 1 day.
- carbaryl (Sevin and other brands) at 1.5 lb ai/a. PHI 7 days. Use postbloom only. Latex-based formulations such as Sevin XLR Plus are less hazardous to bees.
- chlorantraniliprole (Altacor) at 0.066 to 0.099 lb ai/a. PHI 1 day.
- esfenvalerate (Asana XL) at 0.025 to 0.05 lb ai/a. PHI 14 days. Washington and Oregon only. Apply prebloom or postbloom only. Acts like a bee repellent; do not apply within 7 days of pollination.
- fenpropathrin (Danitol) at 0.2 to 0.3 lb ai/a. PHI 3 days. Do not exceed two applications per season.
- indoxacarb (Avaunt) at 0.11 lb ai/a. PHI 7 days.
- methomyl (Lannate) at 0.45 to 0.9 lb ai/a. PHI 3 days. Do not apply during bloom.
- methoxyfenozide (Intrepid 2F) at 0.25 lb ai/a. PHI 7 days. For overwintering populations, make one to two applications between budbreak and petal fall, when young larvae are active. For the summer generation, begin applications at peak moth flight. Additional applications at 10- to 14-day intervals may be required under high pest pressure. Do not exceed three applications per season.
- novaluron (0.83EC) at 0.13 to 0.19 lb ai/a. PHI 8 days. Apply when larvae are young and small.
- phosmet (Imidan 70W) at 0.93 lb ai/a. PHI 3 days. Do not exceed five applications per season. Do not apply to bloom.
- pyriproxyfen (Esteem) at 0.1 lb ai/a. PHI 7 days. Apply when egg-laying begins and again at petal fall.
- spinetoram (Delegate WG) at 0.05 to 0.09 lb ai/a. PHI 3 days. SLN 24c OR-170016 for Delegate allows a 1-day PHI in Oregon only; read label carefully for restrictions on number of applications allowed. Toxic to bees for three hours following treatment. Do not apply when bees are foraging.
- spinosad (Success or Entrust) at 0.062 to 0.09 lb ai/a. PHI 3 days. SLN 24c OR-160013 and WA-140014 for Entrust SC formulation allow a 1-day PHI in Washington and Oregon only. Target application to small larvae or eggs at hatch. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. Entrust is OMRI-listed for organic use.
- tebufenozide (Confirm 2F) at 0.25 lb ai/a. PHI 14 days. For overwintering populations, make one to two applications between budbreak and petal fall, when young larvae are active. For the summer generation, begin applications at peak moth flight. Additional applications at 10- to 14-day intervals may be required under high pest pressure. Do not exceed 64 fl oz product/a per season
- zeta-cypermethrin (Mustang) at 0.05 lb ai/a. PHI 1 day.

Blueberry—Obscure root weevil

Sciopithes obscurus

Pest description and crop damage Adults are predominantly gray with a wavy brown line across the wing covers. They are about 6-8 mm long. Larvae resemble strawberry root weevil larvae in appearance and life cycle and also feed on roots. Adults feed on foliage; they cause little damage to leaves but may contaminate fruit in mechanically harvested fields.

Biology and life history Weevils overwinter as larvae in the soil. Feeding may occur throughout mild winters. From April to June, larvae pupate, and adult emergence occurs. Unlike other weevil species found in blueberries, the obscure root weevil is known to stay in the plant foliage during the day and remain inactive, becoming active and feeding at night. However, some obscure root weevils do migrate to the soil during the day and climb up to feed on foliage at night. Adult weevils cannot fly, but walk or are carried from one location to another by equipment. All adults are females capable of laying hundreds of eggs.

Eggs are laid in clusters in or on the soil from June to September. The eggs hatch and the larvae immediately wriggle through the soil to begin feeding on roots. There is one generation per year.

Scouting and thresholds Observe leaves for notching from adult feeding in early summer. Controls should be undertaken soon after adult feeding is observed, but before egg laying occurs, generally about four weeks. Presence of adults can be confirmed by night inspection of foliage on warm, still evenings. Or, look for adults during the day in the foliage or by looking through debris at the base of the plant for those weevils that have migrated. Wrapping the trunks of the plant with cardboard will provide a refuge that can be checked easily in the early morning.

Management—biological control

- beneficial nematodes—*Heterorhabditis* spp. and *Steinernema* spp., have shown some effectiveness in controlling larvae when applied as label directs, as a drench in the fall. Nematodes must be placed in the root zone where weevil larvae are.

See also:
Entomopathogenic Nematodes

Management—cultural control

Cultivating soil in April–May can eliminate overwintering larvae before planting. Use a cereal cover crop, as small grains are not a host for root weevils.

Management—chemical control: HOME USE

- pyrethrins—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

- esfenvalerate (Asana XL) at 0.05 lb ai/a. PHI 14 days. Apply pre-bloom or post-bloom only. Asana can act like a bee repellent; do not apply within 7 days of pollination. Label allows use for weevil control in Washington and Oregon only.
- malathion (several brands) at 1.25 lb ai/a. PHI 1 day. EC formulations may leave an oily film on fruit when used near or during harvest. Apply at night, usually between dusk and midnight, on warm, calm evenings. Control is poor when applied by day or on cold, windy nights. Toxic to bees; do not apply when bees are foraging.

Blueberry—Root weevil

Includes
Black vine weevil *(Otiorhynchus sulcatus)*
Rough strawberry root weevil *(O. rugosostriatus)*
Strawberry root weevil *(O. ovatus)*

Pest description and crop damage Black vine weevil (BVW) is probably the most common weevil to infest blueberries, but the strawberry root weevil (SRW) and rough strawberry root weevil (RSRW) are also pests. Adult weevils are from 8-12 mm long, depending on the species. Adults are reddish brown to black; the BVW is larger and darker than the other species. Larvae of all species are quite similar in appearance and habits: they are C-shaped, legless, and white with tan heads, up to 12 mm long. Adult weevil feeding causes a characteristic notching in the leaves of blueberries and other host plants. This feeding damage is relatively minor and causes little damage to the plants, but adults may contaminate fruit in mechanically harvested fields. Larvae feeding on roots can cause stunting and poor yields in young plants. With severe infestations, young plants may die.

Biology and life history Weevils overwinter as larvae in the soil. Feeding may occur throughout mild winters. In April–June, larvae

pupate, and adult emergence occurs. Adults are night feeders that remain in the soil or in debris at the base of the plant during the day, then climb up to feed on leaves at night. Adult weevils cannot fly, but walk or are carried from one location to another on plant material or by equipment. All adults are females capable of laying hundreds of eggs. Adults are slow moving and should not be confused with swifter predacious ground beetles.

Eggs are laid in clusters in or on the soil from June to September. The eggs hatch and the larvae immediately wriggle through the soil to begin feeding on roots. There is one generation per year.

Scouting and thresholds Inspect leaves for notching from adult feeding in early summer. Controls should be undertaken soon after adult feeding is observed, but before egg laying occurs, generally about four weeks. Presence of adults can be confirmed by night inspection of foliage on warm, still evenings. Or, look for adults during the day by looking through debris at the base of the plant. Wrapping the trunks of the plant with cardboard will provide a refuge that can be checked easily in the early morning.

Management—biological control

- beneficial nematodes—*Heterorhabditis* spp. and *Steinernema* spp., have shown some effectiveness in controlling larvae when applied as label directs, as a drench in the fall. Nematodes must be placed in the root zone where weevil larvae are.

See also:
Entomopathogenic Nematodes

Management—cultural control

Cultivating the soil in April–May before planting can eliminate overwintering larvae. Use a cereal cover crop, as small grains are not a host for root weevils.

Home gardeners: hand-pick and destroy adults when found.

Management—chemical control: HOME USE

Avoid making applications of insecticides to plants in bloom to avoid bee injury. Follow all label directions.

- carbaryl
- pyrethrins—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin—Toxic to bees; do not apply when bees are foraging.

Management—chemical control: COMMERCIAL USE

Apply foliar sprays at night, usually between dusk and midnight, on warm, calm evenings when adult weevils are on foliage and feeding. Control is usually poor when applied by day or on cold or windy nights.

- azadirachtin (Neemix and other brands)—Consult label for rate. Some formulations are OMRI-listed for organic use.
- *Beauveria bassiana* (Mycotrol and other brands)—Consult label for rate. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade and other brands) at 0.05 to 0.1 lb ai/a. This is a legal pesticide use even though root weevils may not be listed on the label. Toxic to bees; do not apply when bees are foraging.
- cryolite bait at 4 to 8 lb ai/a. PHI 3 days. For adult weevil control, apply to the soil surface in the plant row. Washington and Oregon 24c labels (WA-980001 and OR-980006).
- esfenvalerate (Asana XL) at 0.05 lb ai/a. PHI 14 days. Do not apply when bees are foraging. Label allows use for weevil control in Washington and Oregon only.
- malathion (several brands) at 1.25 lb ai/a. PHI 1 day. Do not apply when bees are foraging.
- phosmet (Imidan 70W) at 0.93 lb ai/a. PHI 3 days. Do not exceed five applications per season. Do not apply to bloom.
- thiamethoxam (Actara) at 0.062 lb ai/a. PHI 3 days. Foliar application for adult root weevils. Actara and Platium have the same active ingredient; for resistance management, do not follow one with the other. Do not apply when bees are foraging. Note "Bee Advisory Box" and restrictions on the label.
- thiamethoxam (Platinum) at 0.078 to 0.188 lb ai/a. PHI 75 days. Although root weevil larvae are not on the label, application made to the soil, and incorporated with irrigation, may provide some control of larvae in the soil via contact. Platinum and Actara have the same active ingredient; for resistance management, do not follow one with the other. Wait at least 5 days after application before placing beehives in the treated field. Note "Bee Advisory Box" and restrictions on the label.
- zeta-cypermethrin (Mustang) at 0.05 lb ai/a. PHI 1 day. Toxic to bees; do not apply when bees are foraging.

Blueberry—Scale insects

Includes
Azalea bark scale *(Eriococcus azaleae)*
Lecanium scale *(Lecanium* spp.*)*

Pest description and crop damage Lecanium scales overwinter on twigs and branches under a hard, helmet-like, reddish-brown covering, which is about 6-8 mm in diameter. Azalea bark scales overwinter on older twigs and branches, under a white, felt-like egg sac about 6-12 mm in diameter. In the spring, the eggs under the winter covering hatch and young nymphs (crawlers) actively move about the plant and begin feeding on leaves and stems. Azalea bark scale nymphs are distinguished by their red color. Nymph feeding of both species can reduce photosynthetic capability of the plant and cause weak growth and, possibly, a reduced crop the following year. A more direct damaging affect is the sooty mold (a black fungus) that grows on the honeydew secreted by the scale, rendering fruit unmarketable or of a lower value. Control requires thorough coverage with a drenching spray.

Scouting and thresholds Inspect twigs during the dormant season for scale. Pay particular attention to weak plants. The crawlers are best observed during May–July with a 10X magnifying glass. In spring, when weather warms up, placing a sticky substance, such as double-stick tape, Tanglefoot, or a similar adhesive, around a branch above and below infestations of adult scale can easily "catch" crawlers as they migrate from their winter enclosures and indicate when crawlers are on the move and a good time to target control.

Management—biological control

Larvae of green lacewings are aggressive predators of scale.

Management—cultural control

Avoid excessive nitrogen fertilizer, as this favors increases in scale populations.

Home gardeners: scale can be rubbed off plants by hand with a glove or toothbrush. Major infestations can be pruned off.

Management—chemical control: HOME USE

Chemical controls are timed to achieve control of either the overwintering scale or the crawlers.

Dormant-season spray

- dormant oil (98%)—Apply oil sprays while plants are dormant and when temperatures are above freezing. Some formulations are OMRI-listed for organic use.

Growing-season spray

- acetamiprid
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- carbaryl
- insecticidal soap—Some formulations are OMRI-listed for organic use.
- malathion
- permethrin
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- spinosad—Some formulations are OMRI-listed for organic use.
- sulfur
- zeta-cypermethrin—Toxic to bees; do not apply when bees are foraging.

Management—chemical control: COMMERCIAL USE

- azadirachtin (Neemix and other brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade and other brands) at 0.033 to 0.1 lb ai/a. PHI 1 day. Make a cover spray application when crawlers first emerge.
- horticultural oil (several brands)—Consult label for rate. Apply oil while plants are dormant and when temperatures are above freezing. Some formulations are OMRI-listed for organic use.
- insecticidal soap (M-Pede and other brands)—Consult label for rate and use directions. PHI 0 days. Apply when crawlers first emerge. Some formulations are OMRI-listed for organic use.
- malathion (several brands) at 1.25 lb ai/a. PHI 1 day. Apply when crawlers appear, as a spray in 100 gal water/a. After June, use 150 to 200 gal water/a.
- pyriproxyfen (Esteem) at 0.1 lb ai/a. PHI 7 days. Apply either at dormant or delayed-dormant for the overwintering stage, or as an in-season cover spray for control of the crawlers. At dormant or delayed-dormant, use with a horticultural oil. Make cover spray applications when scale crawlers first emerge.

Blueberry—Spotted wing drosophila (SWD)

Drosophila suzukii

For pest description, crop damage, biology, life history, sampling and cultural management

See:
EMERGING PEST: Spotted Wing Drosophila—A Berry and Stone Fruit Pest

Management—chemical control: HOME USE

- acetamiprid—In field tests, this product has provided inconsistent control of SWD.
- azadirachtin (neem oil)—This product has been shown to provide about 25% control of SWD. Some formulations are OMRI-listed for organic use.
- pyrethrins—These products provide about 80% control of SWD but have no residual activity.
- spinosad—This product generally provides 90-100% control and 5-7 days residual activity. Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin—Toxic to bees; do not apply while bees are foraging.

Management—chemical control: COMMERCIAL USE

Laboratory tests and field experiments indicate that many of the pesticides registered for use in blueberries are effective in controlling the adult SWD. Although SWD may not be listed on a label, it is legal to use for SWD management. The products listed below target the adult stage of SWD.

- azadirachtin (Neemix and other brands)—Consult label for rate. PHI 0 days. Achieves only about 25% control of SWD. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade and other brands) at 0.1 lb ai/a. PHI 1 day. Toxic to bees and should not be used when bees are foraging. Toxic to fish and other aquatic invertebrates. Synthetic pyrethroids achieved 100% mortality of SWD and provide about 10 to 14 days residual control in the field.
- carbaryl (Sevin and other brands) at 1.5 lb ai/a. PHI 7 days. Use postbloom only. Latex-based formulations such as Sevin XLR Plus are less hazardous to bees. May provide 100% control of SWD. Toxic to bees; do not apply when bees are foraging. Toxic to aquatic invertebrates. Carbamate insecticide.
- cyantraniliprole (Exirel) at 0.088 to 0.133 lb ai/a. PHI 3 days. Do not apply when bees are foraging. Note "Bee Advisory Box" and restrictions on the label. Provides from 75-100% control, and 7 to 10 days residual control in the field.
- diazinon (several brands) at 0.5 lb ai/a. PHI 7 days. One application per season allowed; as such, consider other pests that may need to be managed with diazinon. Toxic to bees and most aquatic invertebrates, and carries the risk of mammalian toxicity. Do not apply when bees are foraging. May achieve 100% mortality of SWD and provide about 7 to 10 days residual control in the field. Organophosphate insecticide.
- esfenvalerate (Asana XL) at 0.05 lb ai/a. PHI 14 days. Toxic to fish and other aquatic invertebrates. Esfenvalerate can also act like a bee repellent; do not apply within 7 days of pollination. Synthetic pyrethroids achieved 100% mortality of SWD and provide about 10 to 14 days residual control in the field.
- fenpropathrin (Danitol) at 0.2 to 0.3 lb ai/a. PHI 3 days. Do not exceed two applications per season. Toxic to bees and should not be used when bees are foraging. Toxic to fish and other aquatic invertebrates. Synthetic pyrethroids achieved 100% mortality of SWD and provide about 10 to 14 days residual control in the field.
- horticultural oil (several brands)—Consult label for rate. Provides some control of SWD but has no residual activity. May cause spotting on fruit. Some formulations are OMRI-listed for organic use.
- malathion (several brands) at 1.25 lb ai/a. PHI 1 day. Toxic to bees and most aquatic invertebrates, and carry the risk of mammalian toxicity. Do not apply when bees are foraging. May achieve 100% mortality of SWD and provide about 7 to 10 days residual control in the field. Of the organophosphates tested, malathion had the longest residual activity (10 days). For SWD control, SLNs OR-130013 and WA-130010 for Malathion 8 Aquamul, and OR-130010 and WA-130004 for Malathion 8 Flowable; allow up to 2.5 lb ai/a, with a maximum of two applications, per season. The Washington SLN labels have a 2-day PHI restriction.
- methomyl (Lannate) at 0.9 lb ai/a. PHI 3 days. Do not use during bloom.
- phosmet (Imidan 70W) at 0.93 lb ai/a. PHI 3 days. Toxic to bees and most aquatic invertebrates, and carries the risk of mammalian toxicity. Do not apply when bees are foraging. May achieve 100% mortality of SWD and provide about 7 to 10 days residual control in the field. Organophosphate insecticide.
- pyrethrin (several)—Consult label for rate and use directions. Toxic to bees; do not apply when bees are foraging. Highly toxic to fish. Provides about 80% control of SWD but has no residual activity. Some formulations are OMRI-listed for organic use.

- spinetoram (Delegate WG) at 0.09 lb ai/a. SLN 24c OR-170016 for Delegate allows a 1-day PHI in Oregon only; read label carefully for restrictions on number of applications allowed. PHI 3 days. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. May achieve 100% mortality of SWD and provide about 5 to 7 days residual control in the field. Spinosyn insecticide.
- spinosad (Success or Entrust) at 0.062 to 0.09 lb ai/a. PHI 3 days. SLN 24c OR-160013 and WA-140014 for Entrust SC formulation allow a 1-day PHI in Washington and Oregon only. Entrust is OMRI-listed for organic use. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. May achieve 100% mortality of SWD and provide about 5 to 7 days residual control in the field. The bait formulation of spinosad (GF-120) is not effective against SWD. Spinosyn insecticide.
- zeta-cypermethrin (Mustang) at 0.05 lb ai/a. PHI 1 day. Toxic to bees and should not be used when bees are foraging. Toxic to fish and other aquatic invertebrates. Synthetic pyrethroids achieved 100% mortality of SWD and provide about 10 to 14 days residual control in the field.

Blueberry—Winter moth

Operophthera brumata

Pest description and crop damage Four species of inchworms may injure blueberries, three of which are native to North America. The fourth, and potentially most serious, is the European winter moth, *Operophthera brumata*, which was introduced to the PNW in 1958. Adult males are small moths with light brown to tan colored wings which have a hairy appearance. Female moths have reduced wing size and are flightless. The larvae are pale green with a light stripe down their sides, up to 12 mm long. Larvae damage the buds, blooms, leaves, and fruit from March to midsummer. Symptoms of leaf feeding are distinct from leafroller larvae: leaves are tied together with silken threads, but not rolled like a leafroller.

Biology and life history This insect pupates in the soil in summer and fall; adults emerge in late fall and early winter (hence the name "winter moth"). After emergence, the flightless female mates, crawls up the canes, and deposits eggs in bud or cane crevices. Larvae hatch in early spring and immediately begin feeding on developing buds. After feeding for several weeks, larvae drop to the soil on silken threads and pupate until fall. Adults emerge after the first frost. There is one generation per year.

Sampling and thresholds Monitor fields in early spring for larvae, larval webbing, and feeding on buds. Also, in early morning and early evening, silken webs may be seen in the slanting sunlight (young larvae climb out to an open branch and send out a fine, silken web for dispersion by wind to find new food sources). A treatment application may be necessary if there are more than eight larvae per plant.

Management—biological control

General predators such as lacewings, assassin bugs, and spiders feed on the larvae, but populations are not well regulated by these predators. Cold winter temperature may play a bigger role in controlling populations.

Management—cultural control

Home gardeners: Pick larvae when you find them, and prune out infested growth.

Management—chemical control: HOME USE

No products are registered for control of this pest in the home garden.

Management—chemical control: COMMERCIAL USE

- acetamiprid (Assail) at 0.085 to 0.1 lb ai/a. PHI 1 day. Do not exceed 0.5 lb ai/a per season.
- *Bacillus thuringiensis (Bt)* (several brands)—Consult label for rate. PHI 0 days. OMRI-listed for organic use.
- bifenthrin (Brigade and other brands) at 0.033 to 0.1 lb ai/a. PHI 1 day.
- chlorantraniliprole (Altacor) at 0.066 to 0.099 lb ai/a. PHI 1 day.
- diazinon (several brands) at 0.5 lb ai/a. PHI 7 days. One application per season allowed; as such, consider other pests that may need to be managed with diazinon.
- esfenvalerate (Asana XL) at 0.025 to 0.05 lb ai/a. PHI 14 days.
- horticultural oil (several brands)—Consult label for rate. When oil is used for lecanium scale suppression in the dormant season, winter moth eggs on the plants may also be controlled. Some formulations are OMRI-listed for organic use.
- indoxacarb (Avaunt) at 0.11 lb ai/a. PHI 7 days.
- methomyl (Lannate) at 0.9 lb ai/a. PHI 3 days. Do not use during bloom.
- methoxyfenozide (Intrepid 2F) at 0.25 lb ai/a. PHI 7 days. Begin applications when first signs of feeding damage appear, usually on buds in late winter or early spring. Do not exceed three applications per season.
- novaluron (Rimon 0.83EC) at 0.13 to 0.19 lb ai/a. PHI 8 days. Apply when larvae are young and small, just after egg hatch.
- spinetoram (Delegate WG) at 0.05 to 0.09 lb ai/a. PHI 3 days.
- spinosad (Success or Entrust) at 0.062 to 0.09 lb ai/a. PHI 3 days. Apply at egg hatch or to small larvae. Entrust is approved for organic production. SLN 24(c) OR-160013 and WA-140014 for Entrust SC formulation allow a 1-day PHI in Washington and Oregon only.
- tebufenozide (Confirm 2F) at 0.25 lb ai/a. PHI 14 days. Begin applications when first signs of feeding damage appear, usually on buds in late winter or early spring. Do not exceed 64 fl oz product/a per season.
- zeta-cypermethrin (Mustang) at 0.05 lb ai/a. PHI 1 day.

Blueberry—Yellowjacket

Includes:
Aerial yellowjacket *(Dolichovespula arenaria)*
Common yellowjacket *(Vespula vulgaris)*
German yellowjacket *(V. germanica)*
Western yellowjacket *(V. pensylvanica)*

Pest description and crop damage Yellowjackets are about 12 mm long, have black bodies with yellow bands and, as compared to paper wasps, are rather stocky and have all-black antennae. Yellowjackets are not direct pests of blueberries, however some years their numbers reach levels high enough that they pose a risk to workers, making harvesting and cultural operations difficult. Yellowjackets are more typically a problem with later-ripening cultivars of blueberry.

Biology and life history All the yellowjacket species listed here build paper nests, enclosing tiers of combs. These can be found either aboveground in wall voids, under roof overhangs, abandoned structures, etc., or in paper nests underground. The western yellowjacket is the most common species in the PNW. They, along with the common yellowjacket, almost always build papery nests underground. The aerial yellowjacket builds papery nests both underground and aboveground. The German yellowjacket, an introduced species, builds papery nests either above or below ground. When nests are built in protected areas, like wall voids and attics, unlike other yellowjackets the German yellowjacket may overwinter.

Yellowjackets survive the winter as mated females (queens) in protected areas such as in woodpiles, under bark, or in areas of accumulated organic debris; they also attempt to come indoors at this time. In the spring, the females become active, and begin to build nests and lay eggs. As these initial eggs hatch, the queen feeds them with soft-bodied insects that she has killed. Once these mature, they take over nest-building activities and the queen's sole function is egg-laying. During the spring and early summer, yellowjackets feed primarily on soft-bodied insects, such as caterpillars, grubs and flies or on spiders. As prey become more scarce, yellowjackets seek out protein- and sugar-rich foods, including fruit. Honeydew produced by aphids, scale or other insects is also favored. In late summer to early fall, males and new queens are produced; they leave the nest and mate. The first freezes of the season kills all workers in the nest. Only the newly mated queens survive the winter. Nests from one season are never re-used.

Management—biological control

Spring weather has an important effect on yellowjacket populations: cool, wet weather in April and May reduces the ability of overwintering queens to build a nest and feed her young.

Management—cultural control

- heptyl butyrate traps—These traps mimic the odor produced by some ripening fruits and are effective against western yellowjackets, less so the common or German yellowjacket. They are not effective, even if used in large numbers, at eliminating worker wasp activity in a given area.

Other traps involve the use of meat or fish as an attractant to yellowjackets. If meat or fish is attached to a string suspended just above a bucket of water with detergent added, the yellowjackets tend to take too big of a bite and fall into the water where they drown. As with other traps, their efficacy is improved if placed out before midsummer before their numbers build up.

Management—chemical control: HOME and COMMERCIAL USE

- aerosol sprays (various brands)—Spot-treat nests when discovered.

See also:
Public health pests—Wasp and bee

Cane Fruit Pests

Joe DeFrancesco, Brooke Edmunds, and Neil Bell

Latest revision—March 2018

INCLUDES MANAGEMENT OPTIONS FOR COMMERCIAL AND HOME USE

In all cases, follow the instructions on the pesticide label. The *PNW Insect Management Handbook* has no legal status, whereas the pesticide label is a legal document. Read the product label before making any pesticide applications.

Protect pollinators: See How to Reduce Bee Poisoning from Pesticides

Note: Products are listed in alphabetical order and *not* in order of preference or superiority of pest control.

Cane fruit—Aphid

Includes larger raspberry aphid *(Amphorophora agathonica)*

Pest description and crop damage Several different aphids can be found in caneberries but the major aphid pest of caneberries is the larger raspberry aphid. This aphid is large, up to 3 mm long, when compared to other species; they are dark green to yellow.

Large populations of aphids weaken and stunt new growth. Aphid feeding causes yellowing of foliage, deformed leaves, and can devitalize plants. They also exude sticky honeydew which results in sooty mold. The honeydew and mold can reduce the quality of fruit, and also attracts ants and yellow jackets. The major problem, though, is virus diseases, which the aphid can transmit readily.

Biology and life history The larger raspberry aphid overwinters as eggs on the canes. The eggs are light yellowish-white when laid in November, but later turn black. Eggs begin hatching by late February or March. The population increases slowly after that, with several overlapping generations per year. Winged forms, which lay the overwintering eggs, are produced in fall.

Scouting and thresholds Check plants frequently after new growth begins. Aphids often are concentrated in "hot spots." Be sure to look for evidence of biological control; i.e., the presence of predators, parasites (aphid mummies), and disease. Aphid flights are most common during periods of moderate temperatures (60° to 80°F).

Management—biological control

Many parasites and predators attack aphids. Monitor the proportion of aphid mummies to unparasitized adults and the number of predators such as lady beetles. If the biocontrol agents appear to be gaining control, avoid sprays which would disrupt this system. Most products available for aphid control are highly disruptive of natural enemies.

Management—cultural control

Aphid populations tend to be higher in plants that are fertilized liberally with nitrogen. Prune out suckers and other excess growth that might encourage colonization of the aphids.

Home gardeners: Wash aphids from plants with a strong stream of water. Control ants, which "farm" the aphids that protect them from predators.

Management—chemical control: HOME USE

Dormant-season spray

- superior-type oil—Some formulations are OMRI-listed for organic use.

Growing-season spray

Avoid making applications of insecticides to plants in bloom to avoid bee injury. Follow all label directions.

- acetamiprid
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- bifenthrin
- carbaryl
- esfenvalerate
- imidacloprid
- insecticidal soap—Some formulations are OMRI-listed for organic use.
- kaolin—Applied as a spray to leaves, stems and fruit it acts as a repellent to some insect pests. Some formulations are OMRI-listed for organic use.
- malathion
- permethrin (for use on raspberries only)
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- acetamiprid (Assail) at 0.044 to 0.1 lb ai/a. PHI 1 day. Do not exceed 0.5 lb ai/a per season.
- esfenvalerate (Asana XL) at 0.025 to 0.05 lb ai/a. PHI 7 days. Asana can act as a bee repellent; do not apply within 7 days of pollination. Apply pre-bloom or post-bloom only. Remove bees before applying. For maximum bee safety, apply in the evening after sunset. Because of pollinator hazard, WSU entomologists do not recommend its use on red raspberries.
- flupyridifurone (Sivanto) at 0.09 to 0.18 lb ai/a. PHI 0 days. Toxic to adult bees in laboratory studies via oral exposure, however, not toxic to bees through contact exposure, and field studies conducted with this product have shown no effects on honeybee colony development. Two applications, 7 days apart, and no more than 0.365 lb ai/a allowed per season. Avoid rotation with neonicotinoid products, if possible.
- imidacloprid (Admire Pro and other brands) at 0.1 lb ai/a for foliar applications, and 0.25 to 0.5 lb ai/a for soil applications. (Check label of other brands for correct foliar rate). PHI 3 days (foliar) or 7 days (soil). Do not apply pre-bloom, during bloom or when bees are foraging. Note "Bee Advisory Box" and restrictions on the label.
- insecticidal soap (M-Pede and other brands)—Consult label for rate. Some formulations are OMRI-listed for organic use. PHI 0 days.
- malathion (several brands) at 1.5 to 2 lb ai/a. PHI 1 day. Do not use during bloom.
- pyrethrin (several brands)—Consult label for rate and use directions. PHI 0 days. PyGanic brand is OMRI-listed for organic use.
- thiamethoxam (Actara) at 0.031 to 0.047 lb ai/a. PHI 3 days. Do not apply during bloom or when bees are foraging in the area. Note "Bee Advisory Box" and restrictions on the label.

Cane fruit—Armyworm and cutworm

Includes
Bertha armyworm *(Mamestra configurata)*
Spotted cutworm *(Xestia c-nigrum)*

Pest description and crop damage Several species of armyworms and cutworms can attack caneberries. These are green, reddish, or black caterpillars up to 50 mm long. Armyworm caterpillars feed in colonies shortly after hatching; their feeding skeletonizes the leaves. Near harvest, bertha armyworms can cause significant defoliation. Spotted cutworm is an early-season pest. It feeds on primary buds and can affect yield significantly.

Biology and life history Armyworms and cutworms are the larvae (caterpillars) of noctuid moths. Armyworms typically feed during the day, while cutworms spend the day just beneath the soil surface or in plant debris, and feed at night. Weeds are the primary food source of cutworms.

Management—cultural control

Control weeds, grasses, and debris that provide cover. Encourage natural enemies of cutworms like birds and spiders.
Home gardeners: Hand-pick cutworm larvae, using a flashlight to find them, if practical. Scratch the soil at the base of plants to find larvae in the daytime.

Management—chemical control: HOME USE

Avoid making applications of insecticides to plants in bloom to avoid bee injury. Follow all label directions.

- acetamiprid
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- *Bacillus thuringiensis kurstaki (Bt)*—Some formulations are OMRI-listed for organic use.
- bifenthrin
- carbaryl
- esfenvalerate
- kaolin—Applied as a spray to leaves, stems and fruit it acts as a repellent to some insect pests. Some formulations are OMRI-listed for organic use.
- permethrin (for use on raspberries only)
- pyrethrins—Some formulations are OMRI-listed for organic use.
- spinosad—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- *Bacillus thuringiensis (Bt)* (several brands)—Consult label for rate. PHI 0 days. Do not use DiPel ES with captan fungicide: the mixture will bronze foliage. Some formulations are OMRI-listed for organic use.
- carbaryl (and other brands) at 2 lb ai/a. PHI 7 days. Latex-based formulations such as Sevin XLR Plus are less hazardous to bees. Do not use during bloom.
- diazinon (several brands) at 1 lb ai/a. PHI 7 days. Do not use on bloom. One application per season allowed; as such, consider other pests that may need to be managed with diazinon.
- methoxyfenozide (Intrepid 2F) at 0.25 lb ai/a. PHI 3 days. Apply when first signs of feeding damage appear.
- spinetoram (Delegate WG) at 0.05 to 0.09 lb ai/a. PHI 1 day. Yellowstriped and western yellowstriped armyworms are not controlled with spinetoram. Toxic to bees for three hours following treatment. Do not apply when bees are foraging.
- spinosad (Success or Entrust) at 0.062 to 0.1 lb ai/a. PHI 1 day. Use higher rate for larger larvae or severe infestations. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. Entrust is OMRI-listed for organic use.

Cane fruit—Brown marmorated stink bug

Halyomorpha halys

This pest is not currently of commercial concern. It is present in the Pacific Northwest but has not caused damage to berry crops. It may pose a significant risk to fruit if populations increase.

See:
EMERGING PEST: Brown Marmorated Stink Bug—A Pending Threat to Pacific Northwest Agriculture

Cane fruit—Cane maggot

Pegomya rubivora

Pest description and crop damage The cane maggot is the larva of a small fly. It feeds on the cambial tissues of red raspberry, blackcap, loganberry, and occasionally blackberry. The larvae are white and legless.

The larvae feed downward in new canes. Canes are usually 1 to 3 ft long when attacked. Young shoots wilt suddenly, and a purple discoloration appears where the maggot girdles the cane. This causes a distinct drooping condition. Canes also may show a characteristic swelling where feeding is occurring.

Biology and life history The insect overwinters as a pupa in the soil. The adult flies emerge in April. The female deposits eggs near the tops of the young canes. After hatching, the young maggots burrow into the pith of young shoots and tunnel downward. Later feeding involves girdling the cane just under the bark.

Scouting and thresholds Remove and burn wilted canes as soon as they are seen. Cut canes off near the base. Very little loss is caused by this pest even when 60% to 70% of new canes are infested.

Management—chemical control

No chemical control is advised. Parasites control this pest most years.

Cane fruit—Dryberry mite

Phyllocoptes gracilis

Pest description and crop damage Tiny, elongated, yellowish to brown eriophyid mites that feed on the undersides of leaves, causing yellow blotching and reduced leaf size in some varieties. Feeding on young developing fruit causes them to become brown shortly after petal fall. Loganberries are particularly susceptible. Mite feeding may cause red raspberry fruit to appear sun scalded, with whitish to tan areas of dead drupelets, especially at the stem end of the fruit. Early fruits are often the most affected, while later fruit often escapes injury. Note: the symptom of "dryberry" may have other causes, such as poor pollination or fungal disease.

Biology and life history Dryberry mites overwinter in colonies, partly concealed by the buds. Colonies often contain 50 to 60 mites. These mites live and feed on the outside of developing fruits.

Management—biological control

Predator mites are effective natural controls.

Management—chemical control: HOME USE

- lime sulfur—Spray canes in spring when vegetative buds are about 0.5 inch long. Repeat application in the fall. Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

- calcium polysulfide (lime sulfur, Sulforix, and other brands)—Consult label for rate and use directions. Apply at least 200 gal/a spray solution at bud swell and again as buds begin to break and show silver. Note: Calcium polysulfide is used at bud break to suppress spur blight, which should help control dryberry mite. Some formulations are OMRI-listed for organic use.
- diazinon (several brands) at 1 to 2 lb ai/a. PHI 7 days. Apply as a dormant spray in early spring and when buds are closed. Apply in sufficient water to achieve good coverage. One application per season allowed; as such, consider other pests that may need to be managed with diazinon.

Cane fruit—Insect contaminants at harvest

Pest description and crop damage Aphids, leafhoppers, gnats, and many other insects present a problem at harvest time, especially if berries are machine harvested. The machine harvester shakes insects from the plants, potentially contaminating berries going into the harvest trays.

Management—cultural control

Correct adjustment of air-blast or vacuum-suction cleaner systems during harvest can lessen insect contamination of machine-picked berries.

Management—chemical control: COMMERCIAL USE

Carefully timing sprays pre-bloom and before and during harvest helps diminish insect contamination.

- malathion (several brands) at 1.75 to 2 lb ai/a. PHI 1 day. Apply to machine-harvested berries only. Thorough coverage is important. EC formulations may leave an oily film on the fruit when used near or during harvest.
- pyrethrin (several brands)—Consult label for rate and use directions. PHI 0 days. PyGanic brand is OMRI-listed for organic use.

Cane fruit—Leafroller

Includes
Obliquebanded leafroller *(Choristoneura rosaceana)*
Orange tortrix *(Argyrotaenia franciscana = A.citrana)*

Pest description and crop damage The principal leafroller pest of caneberries is the orange tortrix, which tends to infest early ripening caneberries and some blackberries. The obliquebanded leafroller is another leafroller species found in caneberry fields. Adults of these two species are buff-color moths with wing spans of 12-20 mm, and bell-shaped at rest. The larvae of the orange tortrix are light cream to green with light brown heads, and are up to 12mm long at maturity. Obliquebanded leafroller larvae are similar in size but are darker green with dark brown to black heads. The larvae roll and tie leaves together with silk for shelter and feeding; they wriggle and thrash about violently when disturbed. Eggs are green and laid on leaves in clusters. They hatch in about 10 to 14 days.

The larvae feed on leaves, which causes relatively minor damage. Feeding on the growing points of young plants can promote undesirable branching. Fruit quality can decrease from binding of leaves to developing fruit or contamination during harvest. Larval feeding on blossoms is thought to spread Botrytis fruit rot disease.

Biology and life history Both species overwinter as larvae on a variety of host plants. Larvae may feed during warm periods in winter but become active in spring with onset of new growth. Pupation occurs within the larval leaf roll. Depending on species, adult moths emerge from April to July. These adults lay eggs for the next generation. There are two to three generations per year.

Scouting Observe early spring growth for rolled leaves and feeding damage on new growth. Larvae move from plant to plant, and between fields, on silken threads; this silk can be easily seen upon close inspection or if viewed in the slanting sunlight. Pheromone traps are available for monitoring adult male flight. Pheromone traps should be placed in fields beginning in late April or May and checked weekly. These can help to determine the timing of adult emergence and timing of larvae presence. Apply insecticides about 2 to 3 weeks after peak flight as determined by pheromone traps, or apply immediately when 75 or more moths per week have been caught in pheromone traps

Management—biological control

Very low temperatures in winter significantly reduce overwintering populations. Spiders and parasitic/predatory insects greatly reduce leafroller populations throughout the year.

Management—cultural control

Removal of overwintering sites, such as rolled leaves on the ground or plastered to canes, can reduce next year's population. Proper pruning and training of canes can reduce leafroller populations. Avoid use of broad-spectrum insecticides which can disrupt natural enemies.

Management—chemical control: HOME USE

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- *Bacillus thuringiensis kurstaki (Bt)*—Some formulations are OMRI-listed for organic use.
- bifenthrin
- carbaryl
- esfenvalerate
- kaolin—Applied as a spray to leaves, stems and fruit it acts as a repellent to some insect pests. Some formulations are OMRI-listed for organic use.
- permethrin (for use on raspberries only)
- pyrethrins—Some formulations are OMRI-listed for organic use.
- spinosad—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- *Bacillus thuringiensis (Bt)* (several brands)—Consult label for rate. PHI 0 days. Use according to individual manufacturer's directions. Do not use DiPel ES with captan fungicide; the mixture will bronze foliage. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade and other brands) at 0.05 to 0.1 lb ai/a. PHI 3 days. Do not exceed two applications per crop season. Only one pre-bloom application of bifenthrin is allowed: either soil-applied for crown borer control or foliar-applied for root weevil or leafroller control, but not both.
- carbaryl (Sevin and other brands) at 2 lb ai/a. PHI 7 days. Apply pre-bloom. Do not use during bloom; it is highly hazardous to bees. Examine fields in April and May to determine need for control. Latex-based formulations such as Sevin XLR Plus are less hazardous to bees. Carbaryl use may aggravate mite problems and cause increased populations later in the season.
- chlorantraniliprole (Altacor) at 0.066 to 0.099 lb ai/a. PHI 3 days. Do not exceed 0.2 lb ai/a per crop season.
- esfenvalerate (Asana XL) at 0.025 to 0.05 lb ai/a. PHI 7 days. Apply no earlier than 12 days before harvest. Asana can act as a bee repellent; do not apply within 7 days of pollination. Apply as a pre-bloom or post-bloom spray only. Remove bees prior to application. For maximum safety to bees, apply in the evening after sunset. Some caneberries, such as red raspberries, have substantial bloom remaining during the 5-day window for first application. Because of pollinator hazard, WSU entomologists do not recommend its use on red raspberries.
- fenpropathrin (Danitol) at 0.2 to 0.3 lb ai/a. PHI 3 days. Do not exceed two applications per season.
- malathion (several brands) at 1.5 to 2 lb ai/a. PHI 1 day. EC formulations may burn foliage. Do not use on bloom; it is highly hazardous to bees.
- methoxyfenozide (Intrepid 2F) at 0.25 lb ai/a. PHI 3 days. For overwintering populations, make one to two applications between budbreak and petal fall, when young larvae are active. For the summer generation, begin applications at peak moth flight. Additional applications at 10- to 14-day intervals may be required under high pest pressure.
- spinetoram (Delegate WG) at 0.05 to 0.09 lb ai/a. PHI 1 day. Toxic to bees for three hours following treatment. Do not apply when bees are foraging.
- spinosad (Success or Entrust) at 0.062 to 0.1 lb ai/a. PHI 1 day. Use higher rate for larger larvae or severe infestations. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. Entrust is OMRI-listed for organic use.
- zeta-cypermethrin (Mustang) at 0.05 lb ai/a. PHI 1 day.

Cane fruit—Looper

Primarily alfalfa looper *(Autographa californica)*

Pest description and crop damage The alfalfa looper is native to the PNW. The adult is a gray moth with a wingspan of about 38 mm. Mature larvae are about 25mm long and are dark olive-green with a lighter head. They move in a looping fashion. They are general feeders and, in addition to potentially causing damage to alfalfa fields, they feed on other forage crops, cereals, weeds, berry crops, vegetables, ornamental and woodland trees and shrubs. The larvae feed on leaves, causing ragged-edge holes in the leaf and on the leaf margins. More importantly, they may contaminate mechanically harvested berries.

Biology and life history Alfalfa loopers overwinter as pupae either in the soil or in organic debris near the base of host plants. Moths begin emerging in late spring and adults lay eggs singly on weed hosts (mostly brassicas). Eggs hatch in 3 to 5 days and larvae feed for about two weeks before pupating in cocoons on the host plant or in organic debris. Adults emerge in about seven days (total development time from egg to adult requires about 30 days). Once adults emerge, they mate, and females deposit eggs as before, about three days after emerging. Damage is most evident in June and July, and again in September and October. There are three or four generations each year.

Management—biological control

Many predators and parasites combine to substantially maintain looper populations at low levels. The eggs and small larvae are attacked by bigeyed bugs, minute pirate bugs, and other predators.

Management—cultural control

Larvae can be hand-picked if found.

Management—chemical control: HOME USE

- azadirachtin (neem oil)—Some formulations are OMRI-listed.
- *Bacillus thuringiensis kurstaki (Bt)*—Some formulations are OMRI-listed for organic use.
- esfenvalerate
- pyrethrins—Some formulations are OMRI-listed for organic use.
- spinosad—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- *Bacillus thuringiensis (Bt)* (several brands)—Consult label for rate. PHI 0 days. Do not use DiPel ES with captan fungicide; the mixture will bronze foliage. Some formulations are OMRI-listed for organic use.
- methoxyfenozide (Intrepid 2F) at 0.25 lb ai/a. PHI 3 days. Begin applications at first egg hatch or to young larvae when infestations are detected.
- spinetoram (Delegate WG) at 0.05 to 0.09 lb ai/a. PHI 1 day.
- spinosad (Success or Entrust) at 0.062 to 0.1 lb ai/a. PHI 1 day. Use higher rate for larger larvae or severe infestations. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. Entrust is OMRI-listed for organic use.

Cane fruit—Lygus bug

Lygus spp., includes tarnished plant bug *(Lygus lineolaris)*

Pest description and crop damage Adult lygus bugs are oval-shaped, about 4 mm long with a light yellow 'V' on the back. These bugs feed on developing leaves, flowers and fruit, which kills the tissue around the feeding site. Lygus bugs can be a contaminant in mechanically harvested berries.

Biology and life history The insect overwinters as an adult in protected areas such as organic debris piles, in bark cracks, etc. Adults become active in early spring, feeding on buds of trees and shrubs before moving to other plants. Eggs are laid in the stems and other tissues of host plants. After the nymphs hatch, they begin feeding on plant tissue. There may be several generations per year.

Management—cultural control

Eliminate weeds that serve as protection and early season food for the insect.

Management—chemical control: HOME USE

Adults display considerable resistance to pesticides; chemical sprays should be directed at controlling the nymphs.

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- bifenthrin
- carbaryl
- esfenvalerate
- kaolin—Applied as a spray to leaves, stems and fruit it acts as a repellent to some insect pests. Some formulations are OMRI-listed for organic use.
- permethrin (for use on raspberries only)
- pyrethrins—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- *Beauveria bassiana* (Mycotrol and other brands)—Consult label for rate. Some formulations are OMRI-listed for organic use.
- fenpropathrin (Danitol) at 0.2 to 0.3 lb ai/a. PHI 3 days. Do not exceed two applications per season.
- malathion (several brands) at 1.75 to 2 lb ai/a. PHI 1 day. Thorough coverage is important.
- thiamethoxam (Actara) at 0.047 lb ai/a. PHI 3 days. Do not apply during bloom or when bees are foraging in the area. Note "Bee Advisory Box" and restrictions on the label.

Cane fruit—Obscure root weevil

Sciopithes obscurus

Pest description and crop damage Adults are predominantly gray with a wavy brown line across the wing covers. They are about 6-8 mm long. Larvae resemble strawberry root weevil larvae in appearance and life cycle, and also feed on roots. Adults feed on foliage; they cause little damage to leaves but may contaminate fruit in mechanically harvested fields.

Biology and life history Weevils overwinter as larvae in the soil. Feeding may occur throughout mild winters. In April–June, larvae pupate, and adult emergence occurs. Unlike other weevil species found in caneberries, the obscure root weevil is known to stay in the plant foliage during the day and remain inactive, becoming active and feeding at night. However, some obscure root weevils do migrate to the soil during the day and climb up to feed on foliage at night. Adult weevils cannot fly, but walk or are carried from one location to another by equipment. All adults are females capable of laying hundreds of eggs.

Eggs are laid in clusters in or on the soil from June to September. The eggs hatch and the larvae immediately wriggle through the soil to begin feeding on roots. There is one generation per year.

Scouting and thresholds Observe leaves for notching from adult feeding in early summer. Controls should be undertaken soon after adult feeding is observed, but before egg laying occurs, generally about four weeks. Presence of adults can be confirmed by night inspection of foliage on warm, still evenings. Or, look for adults in the day in the foliage or by looking through debris at the base of the plant for those weevils that have migrated. Wrapping the trunks of the plant with cardboard will provide a refuge that can be checked easily in the early morning.

Management—biological control

- beneficial nematodes—Nematodes, such as *Heterorhabditis* spp. and *Steinernema* spp., have shown some effectiveness in controlling larvae when applied as label directs, as a drench in the fall. Nematodes must be placed in the root zone where weevil larvae are present.

See also:
Entomopathogenic Nematodes

Management—cultural control

- Cultivating soil in April–May can eliminate overwintering larvae before planting. Use a cereal cover crop, as small grains are not a host for root weevils.

Management—chemical control: HOME USE

- pyrethrins—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

Apply foliar sprays at night, usually between dusk and midnight, on warm, calm evenings when adult weevils are on foliage and feeding. Control is usually poor when applied by day or on cold or windy nights.

- *Beauveria bassiana* (Mycotrol and other brands)—Consult label for rate. Some formulations are OMRI-listed for organic use.
- esfenvalerate (Asana XL) at 0.05 lb ai/a. PHI 7 days. Apply as a pre-bloom or post-bloom spray only. Remove bees prior to application. Asana can act as a bee repellent; do not apply within 7 days of pollination. For maximum safety to bees, apply in the evening after sunset. Label allows use for weevil control in Washington and Oregon only. Because of pollinator hazard, WSU entomologists do not recommend its use on red raspberries.
- malathion (several brands) at 1.75 lb ai/a. PHI 1 day. EC formulations may leave an oily film on fruit when used near or during harvest. Toxic to bees; do not apply when bees are foraging.

Management—biological control

- beneficial nematodes—Nematodes such as *Heterorhabditis* spp. and *Steinernema* spp. have shown some effectiveness in controlling larvae when applied as label directs, as a drench in the fall. Nematodes must be placed in the root zone where weevil larvae are present.

See also:
Entomopathogenic Nematodes

Management—cultural control

Cultivating soil in April–May can eliminate overwintering larvae before planting. Use a cereal cover crop, as small grains are not a host for root weevils.

Cane fruit—Raspberry beetle (aka Western raspberry fruitworm)

Byturus bakeri

Pest description and crop damage The adult is a small yellowish brown beetle 4-5 mm long. The larvae are 8 mm long; white with brown areas on the back of each segment. Adults feed on fruit buds and unfolding leaves. This injury can be serious in the spring. After the flowers open, the beetle feeds on the stamens and pistils. Injured blossoms often turn into distorted berries. The larvae enter the young blossoms or fruit and feed on the receptacle. The larvae often remain in the fruit at harvest, and represent a significant contaminant in harvested fruit.

Biology and life history Adult beetles overwinter in the soil, emerging in late April or May to feed on new leaves, blossoms, and berries and to lay eggs. Eggs are fastened to the flower buds or stems of the plant. The emerging larvae work their way to the center of the fruit. They feed on the fruit for 30 days or more, and then drop to the ground to pupate in the top 3 inches of soil. There is one generation per year.

Scouting and thresholds Adults are difficult to see (a hand lens may help) but can be observed by careful inspection of new leaves in spring and young blossoms. The adults feeding on unfolding leaves make characteristic slits by eating the interveinal areas of the leaf.

Management—chemical control: HOME USE

- carbaryl
- pyrethrins—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- carbaryl (Sevin and other brands) at 1 to 2 lb ai/a. PHI 7 days.
- diazinon (several brands) at 1 lb ai/a. PHI 7 days. Apply prior to bloom. One application per season allowed; as such, consider other pests that may need to be managed with diazinon.
- spinetoram (Delegate WG) at 0.05 to 0.09 lb ai/a. PHI 1 day. Toxic to bees for three hours following treatment. Do not apply when bees are foraging.
- spinosad (Success or Entrust) at 0.062 to 0.1 lb ai/a. PHI 1 day. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. Entrust is OMRI-listed for organic use.

Cane fruit—Raspberry crown borer

Pennisetia marginata

Pest description and crop damage The larvae of this insect bores into and damages the lower canes and crowns of most commercial caneberry species, as well as wild Rubus species like thimbleberry and salmonberry. The adult is a clear-winged moth with a yellow and black striped body that looks like a yellow jacket. The larvae are white with a brown head; when mature, they can be up to 38 mm long. Boring into the canes by larvae reduces cane vigor, and canes may break off at ground level. Individual canes within a hill may be affected. Feeding within the canes weakens blackcaps, boysenberries, loganberries, and blackberries, and may kill raspberries, if populations are large.

Biology and life history The life cycle of this insect requires two years to complete. Adults can be seen flying from late July through October. Eggs are laid on the underside or edges of leaves, are brownish orange in color as they mature, and hatch in 30 to 60 days. Larvae crawl to the base of the cane and form overwintering cells. In spring, the larvae feed for a few weeks then bore into the cane, where their feeding causes galls or swelling at or below the soil surface. Larvae overwinter the second year in the canes. The fully grown larvae continue to feed within the cane until June or July, and then pupate. The adults emerge from exit holes in the canes beginning in July. Generations overlap, and small and large larvae can be found in canes in April and May.

Scouting and thresholds Galls caused by larval feeding are particularly noticeable in October near the base of the plant. Look for brittle, hollow canes when tying up canes in the spring. During the growing season, individual canes may wilt or flag, indicating an infestation. There is very little tolerance for this pest, as a minor infestation can quickly become major.

Management—cultural control

Dig out and burn infested canes and crowns in the fall. Remove other hosts, such as wild blackberries, from the area.

Management—chemical control: HOME USE

No products are registered for home use for this pest

Management—chemical control: COMMERCIAL USE

Apply one of the following products as a crown drench in late March or before bud break. Use 100 to 300 gal/a, directing spray toward crown and lower portion of canes. Rain should follow to move insecticide into the root zone where the young larvae are feeding.

- bifenthrin (Brigade 2EC) at 0.1 lb ai/a. PHI 3 days. Only one pre-bloom application of bifenthrin is allowed in caneberries: either soil-applied for crown borer control or foliar-applied for root weevil or leafroller control, but not both.
- chlorantraniliprole (Altacor) at 0.1 lb ai/a. PHI 3 days. Do not exceed 0.2 lb ai/a per crop season.
- diazinon (several brands) at 2 lb ai/a. One application per season allowed.

Cane fruit—Redberry mite

Acalitus essigi

Pest description and crop damage Evergreen blackberries are infested most often, but other caneberries are also susceptible. This four-legged mite is only about 4 mm long and feeds at the base of berry drupelets in spring and summer, which causes persistence of red color at harvest time; affected drupelets remain hard.

Biology and life history These very small mites overwinter as adults in bud scale and in other crevices on the plant.

Management—biological control

Predator mites are effective natural controls.

Management—chemical control: HOME USE

Delayed-dormant season spray

- superior-type oil—Spray when floricane lateral growth is 2 to 6 inches long. This application may be repeated in the fall. Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

Dormant spray

- calcium polysulfide (lime-sulfur, Sulforix and other brands)—Consult label for rate and use directions. Apply dormant spray in spring shortly after budbreak. Follow with one of the following delayed-dormant sprays. Some formulations are OMRI-listed for organic use.

Delayed-dormant spray (select one)

The following products, rates, and times of application are labeled for disease control but have provided redberry mite control also. Apply in spring after new floricane lateral growth is 2 to 6 inches long.

- calcium polysulfide (lime-sulfur, Sulforix, and other brands)—Consult label for rate and use directions. Apply at least 200 gal/a spray solution. Some formulations are OMRI-listed for organic use.
- superior-type oil—This application may be repeated in the fall. Some formulations are OMRI-listed for organic use.
- wettable sulfur (several brands)—Consult label for rate.

Cane fruit—Root weevil

Includes
Black vine weevil *(Otiorhynchus sulcatus)*
Rough strawberry root weevil *(O. rugosostriatus)*
Strawberry root weevil *(O. ovatus)*

Pest description and crop damage Black vine weevil (BVW) is probably the most common weevil to infest caneberries, but the strawberry root weevil (SRW) and rough strawberry root weevil (RSRW) are also pests. Adult weevils are 8-12 mm long depending on the species. Adults are reddish brown to black; the BVW is larger and darker than the other species. Larvae of all species are quite similar in appearance and habits: they are C-shaped, legless, and white with tan heads, up to 12 mm long. Adult weevil feeding causes a characteristic notching in the leaves of caneberries and other host plants. This feeding damage is relatively minor and causes little damage to the plants, but adults may contaminate fruit in mechanically harvested fields. The real damage is done by the larvae, which feed through the winter and spring on the root systems of host plants. Larvae feeding on roots can cause stunting and poor yields in young plants. With severe infestations, young plants may die.

Biology and life history Weevils overwinter as larvae in the soil. Feeding may occur throughout mild winters. In April–June, larvae pupate, and adult emergence occurs. Adults are night feeders that remain in the soil or in organic material at the base of the plant during the day, then climb up to feed on leaves at night. Adult weevils cannot fly, but walk or are carried from one location to another on plant material or equipment. Also, all adults are females capable of laying eggs. Adults are slow moving and should not be confused with swifter predacious ground beetles.

Eggs are laid in clusters in or on the soil from June to September. The eggs hatch and the larvae immediately wriggle through the soil to begin feeding. There is one generation per year.

Scouting and thresholds Inspect leaves for notching from adult feeding in early summer. Controls should be undertaken soon after adult feeding is observed, but before egg laying occurs, generally about four weeks. Presence of adults can be confirmed by night inspection of foliage on warm, still evenings. Or, look for adults in the day by looking through plant debris at the base of the plant. Wrapping the base of the plant with cardboard provides a refuge that can be checked easily in the early morning.

Management—biological control

- beneficial nematodes—Nematodes, such as *Heterorhabditis* spp. and *Steinernema* spp., have shown some effectiveness in controlling larvae when applied as label directs, as a drench in the fall. Nematodes must be placed in the root zone where weevil larvae are present.

See also:
Entomopathogenic Nematodes

Management—cultural control

Cultivating the soil in April–May before planting can eliminate overwintering larvae. Use a cereal cover crop, as small grains are not a host for root weevils.

Home gardeners: Hand-pick and destroy adults when found.

Management—chemical control: HOME USE

- carbaryl
- pyrethrins—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

Apply chemical sprays at night, usually between dusk and midnight, on warm, calm evenings when adult weevils are on foliage and feeding. Control is usually poor when applied by day or on cold or windy nights.

- azadirachtin (Neemix, Aza-Direct, and other brands)—Consult label for rate. Some formulations are OMRI-listed for organic use.
- *Beauveria bassiana* (Mycotrol and other brands)—Consult label for rate. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade and other brands) at 0.05 to 0.1 lb ai/a. PHI 3 days. Do not exceed two applications per crop season. Only one pre-bloom application of bifenthrin is allowed in caneberries: either soil-applied for raspberry crown borer control, or foliar-applied for root weevil or leafroller control, but not both.
- cryolite bait at 4 to 8 lb ai/a. PHI 3 days. Raspberry only. SLN 24c labels OR-980006 and WA-980001. Oregon and Washington only.
- esfenvalerate (Asana XL) at 0.05 lb ai/a. PHI 7 days. Label allows use for weevil control in Oregon and Washington only. Apply as a pre-bloom or post-bloom spray only. Remove bees prior to application. For maximum safety to bees, apply in the evening after sunset. Asana can act as a bee repellent; do not apply within 7 days of pollination. Because of pollinator hazard, WSU entomologists do not recommend its use on red raspberries.
- malathion (several brands) at 1.75 lb ai/a. PHI 1 day. EC formulations may cause phytotoxicity or leave an oily film on fruit if used during or near harvest.
- thiamethoxam (Actara) at 0.047 lb ai/a. PHI 3 days. Do not apply during bloom or when bees are foraging in the area.
- zeta-cypermethrin (Mustang) at 0.05 lb ai/a. PHI 1 day.

Cane fruit—Rose leafhopper

Edwardsiana rosae

Pest description and crop damage Most commercial caneberry species, and native *Rubus* species like thimbleberry, are attacked. Adult leafhoppers are slender, yellowish-white, and about 3 mm long with folded wings. The nymphs are small, pale white, have long antennae, pink to reddish eyes, and move quickly when disturbed. Superficially, they appear similar to whiteflies. Both nymphs and adults feed on the underside of the leaves, causing whitish spots on the upper leaf surface. Heavy infestations cause the leaves to become mottled and, in hot weather, to wither and curl. Large populations can delay or inhibit fruit ripening, and feeding directly on the fruit results in dead or undeveloped drupelets. Also, the insects may deposit honeydew on the fruit, which lowers quality.

Biology and life history This insect overwinters as eggs within caneberry or rose canes. The eggs hatch in spring, and the nymphs are found on lower leaf surfaces in April and May. After 3-4 weeks, they become winged adults. Adults can migrate and lay eggs from June through September. Second generation nymphs appear in late July, and adults from this generation lay the overwintering eggs on canes.

Scouting and thresholds Inspect plants in spring for nymphs or evidence of feeding damage on leaves.

Management—biological control

Parasitic wasps may attack eggs during the summer and fall and help control populations.

Management—chemical control: HOME USE

- malathion
- pyrethrins

Management—chemical control: COMMERCIAL USE

Leafhopper damage does not often reach a threshold that necessitates a pesticide application. If large populations are present, pesticides used for aphid control will also control leafhoppers.

Cane fruit—Rose stem girdler

Agrilus cuprescens

Rose stem girdler is a damaging, small coppery metallic beetle (family Buprestidae) pest of cane fruit, increasingly being reported by growers throughout the Willamette Valley region of western Oregon and in southwest Washington. Infestations can reduce yield or kill canes. Canes with feeding damage are more susceptible to winter injury. Economic loss, particularly in blackberry cultivars with softer stems, has been reported. In addition to raspberry and blackberry, its host range includes wild Rosa and Rubus species. Adult beetles emerge from canes in late April – June. Prior to egg-laying adults must feed on leaves, resulting in a tattered appearance. Once reproductively mature, females lay their eggs generally on the basal 1/3 of canes. Eggs hatch within two weeks and flat-headed larvae bore directly beneath their eggshells into the canes. Larvae are cream-colored and feed just below the bark of the primocanes. During June, first and second instar larvae feed within the vascular tissue resulting in a characteristic spiral gall-like swelling, particularly apparent on first year soft and tender canes. Other symptoms include presence of elliptical emergence holes, wilted top growth appearing in June and July, and weakened canes which easily snap, particularly canes weighted by ripening berries. By mid-July third instar larvae move into the cane pith, where they remain until the following year when they pupate late March to early April and adults bore out of the canes.

Management—chemical control: HOME and COMMERCIAL USE

Continuous pruning and destroying of infested canes can help reduce field populations but should be supplemented with chemical controls if infestations are heavy. There are no insecticides labeled for control but applications of insecticides that are registered for use on caneberries that are relatively safe for pollinators, may provide some measure of control. Chemical management is targeted at the adult beetles to prevent egg-laying. Weekly applications should be applied as full cover sprays, including the basal area of the canes, beginning in mid- to late-April and continued while adults are present. Follow all pollinator guidelines that may appear on the pesticide labels.

Cane fruit—Sawfly

Leaf-rolling sawfly *(Onycholyda sitkensis)*
Raspberry sawfly *(Monophadnoides rubi)*

Pest description and crop damage Two types of sawfly are pestiferous in caneberries and cause two distinct types of damage. *Onycholyda sitkensis* larvae roll leaves and feed within the rolled leaves, which is inconsequential; the main concern is that they can be a contaminant in harvested fruit especially in mechanically harvested fields. *Monophadnoides rubi* larvae do not roll leaves but feed on leaves, leaving holes on leaf edges or between the leaf veins. Extensive feeding by Monophanoides larvae may skeletonize the leaves and negatively impact plant vigor and berry yield. They also can be a contaminant in harvested fruit.

Biology and life history Adult *Onycholyda sitkensis* sawflies usually have a black body, 10-20 mm long, with yellow spots on the head and thorax. Legs are often yellow and the wings are clear. Adults can be found flying in spring and early-summer. Females lay eggs in or on leaves; larvae hatch out in late spring and early summer, and begin feeding. Larvae range in color from tan to green, have a dark head, and can be up to 20 mm long. They may be solitary or form a colony as they feed; they spin cocoons and roll leaves when fully grown.

Adult *Monophadnoides rubi* sawflies are stout-bodied, about 6-12 mm long, and are usually entirely black with clear wings and with legs more pale than the body. They can be found flying in spring and early-summer. Females lay eggs on or in leaves which hatch in about 10 days. The larvae are 6-18 mm long, pale green with white tufts of spines arranged in rings around the body which gives them a hairy, bristly, or spiny appearance. They are solitary feeders and tend to feed at the tops of plants on the underside of young, tender primocane leaves. They feed for about two to three weeks before they drop to the soil and form cocoons in which they overwinter. There is one generation per year.

Scouting and thresholds Inspect plants in late spring for larvae, rolled leaves, or evidence of feeding damage between leaf veins.

Management—chemical control: HOME USE

- acetamiprid
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- bifenthrin
- carbaryl
- insecticidal soap—Some formulations are OMRI-listed for organic use.
- pyrethrins—Some formulations are OMRI-listed for organic use
- spinosad—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

Larval feeding is not usually a problem but larvae are sometimes a contaminant in mechanically harvested berries.

- diazinon (several brands) at 1 lb ai/a. PHI 7 days. One application per season allowed; as such, consider other pests that may need to be managed with diazinon.
- spinetoram (Delegate WG) at 0.05 to 0.09 lb ai/a. PHI 1 day. Toxic to bees for three hours following treatment. Do not apply when bees are foraging.
- spinosad (Success or Entrust) at 0.062 to 0.1 lb ai/a. PHI 1 day. Use higher rate for larger larvae or severe infestations. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. Entrust is OMRI-listed for organic use.

Cane fruit—Slug

Arion spp.*, Deroceras* spp.*, Limax* spp.

Pest description and crop damage Slow-moving, slimy animals without legs. They may climb canes and move onto berries, and become a contaminant at harvest time. They are most likely to be a problem in cool, wet summers. Slugs migrate into and under crates taken into the field before harvest; keep crates and pallets away from damp soil and grass.

For best slug control, bait after the first extensive late-summer rains, which activate the slugs. Baiting at this time kills egg-laying adults that would produce slugs next spring. Apply bait on the soil surface around plants. Do not contaminate berries or foliage with slug bait.

Management—chemical control: HOME USE

- iron phosphate
- metaldehyde

Management—chemical control: COMMERCIAL USE

- iron phosphate bait (Sluggo) at 20 to 44 lb/a product. OMRI-listed for organic use.
- metaldehyde bait (several brands)—Consult label for rate.

See also:
Slug Control

Cane fruit—Snowy tree cricket

Oecanthus fultoni

Pest description and crop damage These insects are frail, light green to whitish crickets 12-20 mm long. The snowy tree cricket is a generalist and feeds on foliage of many different plant species. They cause damage to canes primarily through its ovipositional activities of drilling small holes in the cane for depositing eggs. Canes may break at the ovipositional punctures sites and additional injury may take place if disease organisms enter the cane through the egg punctures. Large numbers of punctures can girdle and kill canes above the punctures site. However, the snowy tree cricket is not a common pest in caneberries and extensive damage is generally not attributed to this pest.

Biology and life history Adults mate and the female cricket punctures and lays eggs in canes in early fall. Eggs hatch in spring and young crickets feed and grow throughout the summer, reaching adulthood by early fall. There is one generation per year.

Scouting and thresholds The nymphs and adults have a very regular, melodious chirping sound. Inspect canes for puncture holes, often arranged in parallel straight lines up and down the cane.

Management—cultural control:

Caneberry fields most likely to be infested are those with large amounts of weeds, neglected fence rows, or surrounded by natural areas, which all provide food and shelter for the crickets. Good weed management helps mitigate a potential cricket problem.

Management—chemical control: HOME USE

- carbaryl

Management—chemical control: COMMERCIAL USE

- carbaryl (Sevin and other brands) at 2 lb ai/a. PHI 7 days. Latex-based formulations such as Sevin XLR Plus are less hazardous to bees. Do not use on bloom.

Cane fruit—Spider mite

Twospotted spider mite *(Tetranychus urticae)*
Yellow spider mite *(Eotetranychus carpini borealis)*

Pest description and crop damage Several species may occur on raspberries. Mite infestations are less common on blackberries. Adult twospotted spider mites are about 2-3 mm long, have eight legs, and are light tan or greenish with a dark spot on each side of the back. Mite feeding reduces plant vigor and may cause leaves to turn brown and drop prematurely, reducing yield. Spider mite feeding is accompanied by webbing on the undersides of the leaves.

Biology and life history Spider mites have four stages of development: egg, larva, nymph, and adult. Adults overwinter on canes or in plant debris. Warm temperatures significantly increase spider mite activity, and the entire life cycle may be completed in as little as 5 to 7 days under warm summer conditions. Therefore, there are many overlapping generations per year. Yellow spider mites are common early in the season in cooler temperatures. Mites do not fly but are blown from plant to plant, or are carried on plant material or equipment. On individual plants, they can walk from infested areas to new parts of the plant.

Scouting and thresholds Infestations usually begin on lower leaves of plants, then progress upwards. Inspect oldest leaves first for stippling; webbing and the mites themselves can be found on the underside of leaves.

Management—biological control

Various natural enemies, such as ladybeetles, green lacewings, pirate and big-eyed bugs, help reduce spider mite populations. Beneficial predator mites are also naturally present in caneberry fields and are effective in controlling spider mites. Introducing commercially available beneficial arthropods (especially predator mites) has been shown to be effective. Follow supplier's recommendations.

Management—cultural control

Spider mite populations are held down in cool conditions early in the season. Avoid early season applications of insecticides, which reduce populations of beneficial insects. Spider mite infestations are favored by dry, dusty conditions, so avoid creating these problems. Plant stress increases likelihood of infestations, so keep plants healthy and well watered. Excessive nitrogen fertilization may cause population buildup.

Home gardeners: Mites can be hosed from plants with a strong stream of water.

Management—chemical control: HOME USE

If treatment is necessary, use selective materials, preferably insecticidal soap or insecticidal oil. Both petroleum-based horticultural oils and plant-based oils are acceptable. Don't use soaps or oils on water-stressed plants or when temperatures exceed 90°F. These materials may injure some plants, so check labels and/or test them out on a portion of the foliage several days before

applying a full treatment. Oils and soaps must contact mites to kill them, so excellent coverage, especially on the undersides of leaves, is essential; repeat applications may be required.

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- bifenthrin
- horticultural oil—Some formulations are OMRI-listed for organic use.
- insecticidal soap—May require several applications. Infestations that develop after September 1 are probably not worth controlling. Some formulations are OMRI-listed for organic use.
- permethrin (for use on raspberry only)
- pyrethrins
- sulfur—Will suppress mite populations. Do not use sulfur above 90°F or within a month of an oil spray. Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- abamectin (Agri-Mek) at 0.01 to 0.02 lb ai/a. PHI 7 days. Controls adults, nymphs, larvae, and eggs. Application is not permitted from onset of flowering until petal fall is complete. Do not exceed 0.056 lb ai/a per season.
- acequinocyl (Kanemite) at 0.3 lb ai/a. PHI 1 day. Controls adults, nymphs, larvae, and eggs.
- bifenazate (Acramite 50WS) at 0.375 to 0.5 lb ai/a. PHI 1 day. Controls adults, nymphs, larvae, and eggs.
- etoxazole (Zeal) at 0.09 to 0.135 lb ai/a. PHI 1 day. Controls primarily larvae and eggs; not very effective against nymphs and adults.
- fenbutatin-oxide (Vendex 50WP) at 1 lb ai/a. PHI 3 days. Raspberries only. Controls larvae, nymphs and adults. Do not exceed one application per year. Label allows use in Washington and Oregon only.
- hexythiazox (Savey) at 0.125 to 0.1875 lb ai/a. PHI 3 days. Controls eggs, larvae and nymphs only; does not control adult mites. Do not exceed one application per crop season.
- insecticidal (M-Pede and other brands)—Consult label for rate. Controls adults, nymphs, larvae, and eggs. Some formulations are OMRI-listed for organic use. PHI 0 days.

Cane fruit—Spotted wing drosophila

Drosophila suzukii

For pest description, crop damage, biology, life history, sampling and cultural management

See:
EMERGING PEST: Spotted Wing Drosophila—A Berry and Stone Fruit Pest

Management—chemical control: HOME USE

- acetamiprid—In field tests, this product has provided inconsistent control of SWD.
- azadirachtin (neem oil)—This product has been shown to provide about 25% control of SWD. Some formulations are OMRI-listed for organic use.
- pyrethrins—These products provide about 80% control of SWD but have no residual activity. Some formulations are OMRI-listed for organic use.
- spinosad—This product generally provides 100% control and 5-7 days residual activity. Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

Laboratory tests and field experiments indicate that many of the pesticides registered for use in caneberries are effective in controlling the adult SWD. Although SWD may not be listed on a label, it is legal to use for SWD management. The products listed below target the adult stage of SWD.

- azadirachtin (Neemix and other brands)—Consult label for rate. PHI 0 days. Achieves only about 25% control of SWD. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade and other brands) at 0.1 lb ai/a. PHI 3 days. Toxic to bees and should not be used when bees are foraging. Toxic to fish and other aquatic invertebrates. Synthetic pyrethroids achieved 100% mortality of SWD and provide about 10 to 14 days residual control in the field.
- carbaryl (Sevin and other brands) at 1.5 lb ai/a. PHI 7 days. Use postbloom only. Latex-based formulations such as Sevin XLR Plus are less hazardous to bees. May provide 100% control of SWD. Toxic to bees; do not apply when bees are foraging. Toxic to aquatic invertebrates. Carbamate insecticide.
- diazinon (several brands) at 1.0 lb ai/a. PHI 7 days. One application per season allowed; as such, consider other pests that may need to be managed with diazinon. Toxic to bees and most aquatic invertebrates, and carries the risk of mammalian toxicity. Do not apply when bees are foraging. May achieve 100% mortality of SWD and provide about 7 to 10 days residual control in the field. Organophosphate insecticide.
- esfenvalerate (Asana XL) at 0.05 lb ai/a. PHI 7 days. Toxic to fish and other aquatic invertebrates. Asana can act as a bee repellent; do not apply within 7 days of pollination. Apply as a pre-bloom or post-bloom spray only. Remove bees prior to application. For maximum safety to bees, apply in the evening after sunset. Synthetic pyrethroids achieved 100% mortality of SWD and provide about 10 to 14 days residual control in the field. Because of pollinator hazard, WSU entomologists do not recommend its use on red raspberries.
- fenpropathrin (Danitol) at 0.2 to 0.3 lb ai/a. PHI 3 days. Do not exceed two applications per season. Toxic to bees and should not be used when bees are foraging. Toxic to fish and other aquatic invertebrates. Synthetic pyrethroids achieved 100% mortality of SWD and provide about 10 to 14 days residual control in the field.
- horticultural oil (several brands)—Consult label for rate. Provides some control of SWD but has no residual activity. May cause spotting on fruit. Some formulations are OMRI-listed for organic use.
- malathion (several brands) at 2.0 lb ai/a. PHI 1 day. Toxic to bees and most aquatic invertebrates, and carry the risk of mammalian toxicity. Do not apply when bees are foraging. May achieve 100% mortality of SWD and provide about 7 to 10 days residual control in the field. Of the organophosphates tested, malathion had the longest residual activity (10 days). For SWD control, SLNs OR-130013 for Malathion 8 Aquamul and OR-130011 for Malathion 8 Flowable, allow four applications per season.
- pyrethrin (several brands)—Consult label for rate and use directions. Toxic to bees; do not apply when bees are foraging. Highly toxic to fish. Provides about 80% control of SWD but has no residual activity. PyGanic brand is OMRI-listed for organic use.
- spinetoram (Delegate WG) 0.09 lb ai/a. PHI 1 day. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. May achieve 100% mortality of SWD and provide about 5 to 7 days residual control in the field. Spinosyn insecticide.
- spinosad (Success or Entrust) at 0.1 lb ai/a. PHI 1 day. Entrust is OMRI-listed for organic use. Toxic to bees for 3 hr following treatment. Do not apply when bees are foraging. May achieve 100% mortality of SWD and provide about 5 to 7 days residual control in the field. The bait formulation of spinosad (GF-120) is not effective against SWD. Spinosyn insecticide.

- zeta-cypermethrin (Mustang) at 0.05 lb ai/a. PHI 1 day. Toxic to bees and should not be used when bees are foraging. Toxic to fish and other aquatic invertebrates. Synthetic pyrethroids achieved 100% mortality of SWD and provide about 10 to 14 days residual control in the field.

Cane fruit—Stink bug

Includes consperse stink bug *(Euschistus conspersus)*

Pest description and crop damage Large, bright-green bugs, shield-shaped and flattened. They have a foul odor and may contaminate berries at harvest. The machine harvester can shake insects from the plants, potentially contaminating berries going into the harvest trays.

Management—cultural controls

Correct adjustment of air-blast or vacuum-suction cleaner systems on mechanical harvesters can lessen insect contamination of machine-picked berries.

Management—chemical control: HOME USE

- acetamiprid
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- bifenthrin
- carbaryl
- esfenvalerate
- insecticidal soap—Some formulations are OMRI-listed for organic use.
- kaolin—Applied as a spray to leaves, stems and fruit it acts as a repellent to some insect pests. Some formulations are OMRI-listed for organic use.
- permethrin (for use on raspberry only)
- pyrethrins—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

No insecticides are registered specifically for this pest. Products applied for leafroller control before harvest (such as: bifenthrin, esfenvalerate, fenpropathrin, malathion, and zeta-cypermethrin) may provide some control of stink bugs.

Cane fruit—Strawberry crown moth

Synanthedon bibionipennis

Pest description and crop damage The adult strawberry crown moth is a clear-winged moth about a 12 mm long that, like the raspberry crown borer, is black and yellow and resembles a yellowjacket wasp. Unlike raspberry crown borer larvae, strawberry crown moth larvae don't bore into canes but are found and feed on the outside of crowns and upper roots. Young larvae are all white. As they mature, they are white with a brown head; during the growing season, when they are actively feeding, they can take on a pinkish color. Mature larvae are up to 25 mm long. Larval feeding weakens the caneberry plant and can reduce vigor, especially in young plantings. Individual canes within a hill may be affected.

Biology and life history This insect completes its life cycle in one year. The larva overwinters in a silken cocoon covered with frass on the crown or upper roots of the plant. The larva leaves the cocoon and resumes feeding in spring. Pupation occurs from May to July; adults emerge and can be seen flying in June and July. Mating occurs shortly after emergence and females begin laying eggs singly on the leaf margins of lower leaves. Eggs are brown, oval-shaped, and have a lateral concave depression. Newly hatched larvae emerge in about two weeks, drop or crawl to the crown of the plant, and feed until the fall; they are nearly mature as they form a silken cocoon in which to overwinter.

Scouting and thresholds Pheromone traps are used to monitor adult male emergence and flight. This moth flies low so traps should be placed in several places throughout the planting at about 1.5 to 2 feet above the ground beginning in early May. When two or three adults are caught in traps in two or more consecutive days, treatment application may be necessary and are made about two weeks after a consistent trap count is achieved.

Management—chemical control: HOME USE

There are no products registered for control of this pest.

Management—chemical control: COMMERCIAL USE

- diazinon (several brands) at 2 lb ai/a. Apply as a crown drench in late March or before budbreak. Use 100 to 300 gal/a drench, directing spray toward crown and lower portion of canes. Rain should follow to move insecticide into the root zone where the larvae feed. One application per season allowed.

Note: Soil-applied bifenthrin (Brigade) and chlorantraniliprole (Altacor) in the spring for control of raspberry crown borer larvae may help control strawberry crown moth larvae.

Cane fruit—Thrips

Frankliniella spp.

Pest description and crop damage Adult thrips are small (about 1-2 mm long at maturity), slender insects with fringed wings. They are generally white when young but brown or black when mature. Larvae are very tiny and difficult to distinguish without magnification. They feed by puncturing plant material, often blossoms, and sucking out the cell contents. Injured blossoms often turn into distorted fruit. When feeding on flowers, affected petals appear stippled or are scarred with brown streaks or spots. When unusually abundant in spring, thrips have been reported to cause blossom blasting. Fruit may be misshapen or distorted. Controls are most effective when applied at flowering; field control is not practical in eliminating thrips present at harvest.

Management—chemical control: HOME USE

- acetamiprid
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- bifenthrin
- carbaryl
- imidacloprid
- insecticidal soap—Some formulations are OMRI-listed for organic use.
- malathion
- permethrin (for use on raspberries only)
- pyrethrins—Some formulations are OMRI-listed for organic use.
- spinosad—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- acetamiprid (Assail) at 0.085 to 0.1 lb ai/a. PHI 1 day. Do not exceed 0.5 lb ai/a per season.
- diazinon (several brands) at 1 lb ai/a. PHI 7 days. Use prebloom to prevent bee kill. One application per season allowed; as such, consider other pests that may need to be managed with diazinon.
- imidacloprid (Admire) at 0.25 to 0.5 lb ai/a. PHI 7 days. Soil applied. Admire and Provado have the same active ingredient; for resistance management, do not follow one with the other. Note "Bee Advisory Box" and restrictions on the label.

- imidacloprid (Provado 1.6F or Admire Pro) at 0.1 lb ai/a. PHI 3 days. Foliar applied. Provado and Admire have the same active ingredient; for resistance management, do not follow one with the other. Do not apply during bloom or when bees are actively foraging. Note "Bee Advisory Box" and restrictions on the label.
- spinetoram (Delegate WG) at 0.05 to 0.09 lb ai/a. PHI 1 day. Toxic to bees for three hours following treatment. Do not apply when bees are foraging.
- spinosad (Success or Entrust) at 0.062 to 0.1 lb ai/a. PHI 1 day. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. Entrust is OMRI-listed for organic use.

Cane fruit—Winter moth

Operophthera brumata

Pest description and crop damage Adults are small gray, tan, or off-white moths that have a hairy appearance. Female moths have a much reduced wing size and are flightless. Larvae, up to 12 mm long, are pale green with white, longitudinal stripes along the abdomen. The larvae move by "inching" along, hence the nickname "inchworm." Larvae damage buds, blooms, leaves, and fruit from March to mid-summer. Symptoms of leaf feeding are distinct from leafroller larvae: leaves are tied together with silken threads, but not rolled like a leafroller.

Biology and life history This insect pupates in the soil in summer and fall; adults emerge in late fall and early winter (hence the name "winter moth"). After emergence, the flightless female mates, crawls up the canes, and deposits eggs in bud or cane crevices. Larvae hatch in early spring and immediately begin feeding on developing buds. After feeding for several weeks, larvae drop to the soil on silken threads and pupate until fall. Adults emerge after the first frost. There is one generation per year.

Sampling and thresholds Monitor fields in early spring for larvae, larval webbing, and feeding on buds. Also, in early morning and early evening, silken webs may be seen in the slanting sunlight (young larvae climb out to an open branch and send out a fine, silken web for dispersion by wind to find new food sources). A treatment application may be necessary if there are more than eight larvae per plant.

Management—chemical control: HOME USE

There are no products registered for control of this pest.

Management—chemical control: COMMERCIAL USE

- *Bacillus thuringiensis (Bt)* (several brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use.
- chlorantraniliprole (Altacor) at 0.066 to 0.1 lb ai/a. PHI 3 days. Do not exceed 0.2 lb ai/a per crop season.
- diazinon (several brands) at 0.5 to 1 lb ai/a. PHI 7 days. One application per season allowed; as such, consider other pests that may need to be managed with diazinon.
- methoxyfenozide (Intrepid 2F) at 0.25 lb ai/a. PHI 3 days. Begin applications at first egg hatch or to young larvae when infestations are detected.
- spinetoram (Delegate WG) at 0.05 to 0.09 lb ai/a. PHI 1 day.
- spinosad (Success or Entrust) at 0.062 to 0.1 lb ai/a. PHI 1 day. Apply at egg hatching or to small larvae. Entrust is OMRI-listed for organic use.
- zeta-cypermethrin (Mustang) at 0.05 lb ai/a. PHI 1 day.

Cane fruit—Woods weevil

Nemocestes incomptus

Pest description and crop damage The woods weevil is a native insect and is also known as the raspberry bud weevil. The adults are sooty dark brown, covered with small hairs and with gray spots or patches on posterior end; about 6 mm long. The larvae are stout, legless grubs with pale brownish markings on their posterior ends. Unlike most root weevil larvae, which assume a "C" shape, woods weevil larvae are often straight. Adults feed on the buds of raspberries while larvae feed on the root system.

Biology and life history All life stages of this weevil may be present throughout the year. However, a flush of adults appears in late summer, often following fall rains. They may continue to feed throughout the winter as temperatures allow.

Management—biological control

- beneficial nematodes—Nematodes, such as *Heterorhabditis* spp. and *Steinernema* spp., have shown some effectiveness in controlling larvae when applied as label directs, as a drench in the fall. Nematodes must be placed in the root zone where weevil larvae are.

See also:
Entomopathogenic Nematodes

Management—chemical control: HOME USE

There are no products registered for control of this pest.

Management— chemical control: COMMERCIAL USE

Apply foliar sprays at night, usually between dusk and midnight, on warm, calm evenings when adult weevils are on foliage and feeding. Control is usually poor when applied by day or on cold or windy nights.

- *Beauveria bassiana* (Mycotrol and other brands)—Consult label for rate. Some formulations are OMRI-listed for organic use.
- esfenvalerate (Asana XL) at 0.05 lb ai/a. PHI 7 days. Label allows use for weevil control in Oregon and Washington only. Asana can act as a bee repellent; do not apply within 7 days of pollination. Apply as a pre-bloom or post-bloom spray only. Remove bees prior to application. For maximum safety to bees, apply in the evening after sunset. Because of pollinator hazard, WSU entomologists do not recommend its use on red raspberries.
- malathion (several brands) at 1.75 lb ai/a foliar spray. PHI 1 day. EC formulations may leave an oil film on fruit when used near or during harvest. Apply only in late evening to protect bees at bloom.

Cane fruit—Yellowjacket

Including
Aerial yellowjacket *(Dolichovespula arenaria)*
Common yellowjacket *(V. vulgaris)*
German yellowjacket *(V. germanica)*
Western yellowjacket *(Vespula pensylvanica)*

Pest description and crop damage Yellowjackets are about 12 mm long, have black bodies with yellow bands and, as compared to paper wasps, are rather stocky and have all-black antennae. Yellowjackets are not direct pests of caneberries, however some years their numbers reach levels high enough that they pose a risk to workers, making harvesting and cultural operations difficult. Yellowjackets are more typically a problem with later-ripening caneberry cultivars.

Biology and life history All the yellowjacket species listed here build paper nests, which enclose tiers of combs, that can be found either aboveground in wall voids, under roof overhangs, abandoned structures, etc, or in paper nests underground. The western yellowjacket is the most common species in the PNW. They, along with the common yellowjacket, almost always build papery nests underground. The aerial yellowjacket builds papery nests both underground and aboveground. The German yellowjacket, an introduced species, builds papery nests either above- or belowground. When nests are built in protected areas, like wall voids and attics, unlike other yellowjackets the German yellowjacket may overwinter.

Yellowjackets survive the winter as mated females (queens) in protected areas such as in woodpiles, under bark, or in areas of accumulated organic debris; they also attempt to come indoors at this time. In the spring, the females become active, and begin to build nests and lay eggs. As these initial eggs hatch, the queen feeds them with soft-bodied insects that she has killed. Once these mature, they take over nest-building activities and the queen's sole function is egg-laying. Unlike honey bees, yellowjackets do not produce honey. During the spring and early summer, yellowjackets feed primarily on soft-bodied insects, such as caterpillars, grubs and flies or on spiders. As prey become more scarce, they begin seeking out protein- and sugar-rich foods. Any type of meat product or sugar-containing substance is attractive to yellowjackets. Honeydew produced by aphids, scale or other insects is also favored. In late summer to early fall, males and new queens are produced; they leave the nest and mate. The first freezes of the season kills all workers in the nest. Only the newly mated queens survive the winter. Nests from one season are never re-used.

Management—biological control

Spring weather has an important effect on yellowjacket populations: cool, wet weather in April and May reduces the ability of overwintering queens to build a nest and feed her young.

Management—cultural control

- heptyl butyrate traps—These traps mimic the odor produced by some ripening fruits and are effective against western yellowjackets, less so the common or German yellowjacket. They are not effective, even if used in large numbers, at eliminating worker activity in a given area.

Other traps involve the use of meat or fish as an attractant to yellowjackets. If meat or fish is attached to a string suspended just above a bucket of water with detergent added, the yellowjackets tend to take too big of a bite and fall into the water where they drown. As with other traps, their efficacy is improved if placed out before midsummer before their numbers build up.

Management—chemical control: HOME and COMMERCIAL USE

- aerosol sprays (various)—Spot-treat nests when discovered.

See also:
Public health pests—Wasp and bee

Cranberry Pests

Kim Patten, Cassie Bouska, and Joe DeFrancesco

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INCLUDES MANAGEMENT OPTIONS FOR COMMERCIAL USE ONLY

In all cases, follow the instructions on the pesticide label. The *PNW Insect Management Handbook* has no legal status, whereas the pesticide label is a legal document. Read the product label carefully before making any pesticide applications.

Protect pollinators: See How to Reduce Bee Poisoning from Pesticides and check with WSDA, ODA, or ISDA for new federal requirements relating to the application of certain insecticides during bloom.

Maximum Residue Levels: Due to concerns about export qualifications of fruit treated with certain labeled pesticides, contact your processor before making any pesticide applications.

Note: Products are listed in alphabetical order and *not* in order of preference or superiority of pest control.

Cranberry—Blackheaded fireworm

Rhopobota naevana

Pest description and crop damage This insect overwinters in the egg stage on undersides of cranberry leaves. Larvae are greenish yellow with a shiny black head, and are 0.25 inch long at maturity. First-brood larvae web and feed on new tip growth in late April or early May. Second-brood larvae web runner ends and damage berries and fruit buds for next year's crop. When injury is severe, vine tips look brown, as if scorched by fire, and berries shrivel. A third generation of moths may emerge in August and September. Moths of the second and third broods lay overwintering eggs.

Sampling and thresholds In late April, begin to monitor for larvae that have hatched from overwintering eggs by using a sweep net or by doing a visual sweep. A visual sweep consists of 10 visual inspections of two square feet per acre. Treatment is recommended if one larva per sweep net or visual sweep is found. Control of the first larval hatch helps reduce likelihood of large subsequent hatches. Pheromone traps are available to monitor flight activity of the moth stage.

Management—chemical control: COMMERCIAL USE

- acephate (Orthene 97 and Acephate 97UP) at 1.0 lb ai/a. PHI 75 days. Washington SLN for Orthene WSP (WA-050002) also allows a 75-day PHI. Do not apply during bloom; material is hazardous to bees. Do not exceed one application per crop season. Do not tank mix with other organophosphate insecticides.
- *Bacillus thuringiensis (Bt)* (several brands)—Consult label for rate. PHI 0 days. Not effective for second generation larvae. Some formulations are OMRI-listed for organic use.
- carbaryl (several brands) at 1.5 to 2 lb ai/a. PHI 7 days. Do not apply during bloom; carbaryl is hazardous to bees. Latex-based formulations such as Sevin XLR Plus are less hazardous to bees.
- chlorantraniliprole (Altacor) at 0.066 to 0.099 lb ai/a. PHI 1 day. Apply just prior to egg hatch or to small larvae. Repeat application

14 to 20 days later. Do not exceed 2 consecutive applications of chlorantraniliprole (Group 28 insecticides) or > 0.198 lb ai per crop season.

- chlorpyrifos (Lorsban) at 1.41 lb ai/a. PHI 60 days. Do not apply to bloom; material is hazardous to bees. Do not exceed two applications per season. Restricted use material in the Grayland cranberry-growing area of Washington.
- *Chromobacterium subtsugae* (Grandevo) at 2 to 3 lb/a. PHI 0 days. Two applications are required to achieve adequate suppression. Temporarily repels honey bees for up to 4 to 6 days after spraying. OMRI-listed for organic use.
- diazinon (several brands) at 2 lb ai/a. PHI 7 days. Do not apply to bloom; material is hazardous to bees. Restricted use material in the Grayland cranberry-growing area of Washington.
- indoxacarb (Avaunt) at 0.11 lb ai/a. PHI 30 days. Material is hazardous to bees.
- methoxyfenozide (Intrepid) at 0.16 to 0.25 lb ai/a. PHI 14 days. Apply to small larvae. Repeat application 10 to 14 days later. Do not exceed 2 consecutive applications of methoxyfenozide (Group 18A insecticides) or four applications per crop season.
- phosmet (Imidan) at 0.9 to 2.8 lb ai/a. PHI 14 days. Allow at least 10 days between applications. Do not exceed 11 lb ai/a per crop season. Do not apply to bloom; material is hazardous to bees.
- pyrethrin (several brands)—Consult label for rate and use directions. PHI 0 days. Apply to small larvae. PyGanic brand is OMRI-listed for organic use. Do not apply to bloom; material is hazardous to bees.
- spinetoram (Delegate) at 0.05 to 0.09 lb ai/a. PHI 21 days. Apply at egg hatch or to small larvae. Repeat applications should not be made less than 7 days apart. Do not exceed 6 applications per season. Do not exceed 2 consecutive applications of spinetoram and spinosad (Group 5 insecticides). Do not apply to bloom; material is hazardous to bees for three hours following treatment.
- spinosad (Success or Entrust) at 0.062 to 0.15 lb ai/a. PHI 21 days. Apply at egg hatch or to small larvae. Entrust is OMRI-listed for organic use. Do not exceed 2 consecutive applications of spinosad and spinetoram (Group 5 insecticides). Do not apply to bloom; material is hazardous to bees for three hours following treatment.
- tebufenozide (Confirm) at 0.25 lb ai/a. PHI 30 days. Apply at first sign of larval infestation during first generation of the season; repeat application 7 to 10 days later. For second generation, apply at 10 to 20% egg hatch; repeat application 7 to 10 days later. Do not exceed 64 fl oz/a product per crop season.

Management—cultural control:

Short-term (24 to 48 hours) spring flooding just prior to or during egg-hatch can reduce populations of the first generation fireworm larvae. Water level must be maintained above vine tips.

Cranberry—Cranberry girdler

Chrysoteuchia topiaria

Pest description and crop damage Larvae overwinter in cocoons in plant duff. Adult moths appear in May, June, and July. Larvae reach 0.5 inch long and are dirty white with a brown head. They feed on stems and runners beneath plant duff. Feeding may kill all or part of the plant. In Oregon, damage from larval feeding is first observed in late August and September. If beds are weedy, especially grassy, girdlers will be able to establish themselves before they move to cranberries. Newly hatched larvae like to burrow into the crowns of grass plants and feed.

Sampling and thresholds Pheromone traps are available to monitor flight activity of the moth stage. Scout for larvae in weedy areas or areas of weak vine growth during early to midsummer. In late summer, look for frass in the duff next to cranberry stems.

Management—cultural control

Re-sanding the cranberry bed reduces populations of the cranberry girdler (they prefer plant duff) and also enhances insecticidal control. Apply 0.5 to 0.75 inch of sand in fall or winter when cold weather has firmed the bed. Short floods (1 or 2 days) in August after egg hatch have controlled small larvae; flooding more than 2 days may damage vines. A long flood (1+ month) during the dormant season may also help control girdler.

Management—chemical and biological control

- clothianidin (Belay) at 0.2 lb ai/a. PHI 21 days. Apply after fruit set. Incorporate into soil with several hours of irrigation. Do not apply during bloom or when bees are foraging. Wait at least 5 days after application before placing beehives in the treated field. Note "Bee Advisory Box" and restrictions on the label.
- parasitic nematodes—Apply to soil 2 to 4 weeks after pheromone traps indicate peak moth flight. See label for rate (generally 2 to 3 billion/a), timing, and irrigation requirements. Cranberry bed may be spot-treated with nematodes if areas of larval infestations are properly identified; if spot treating, apply a buffer area of about 20 ft around each infested area of the bed.

Cranberry—Cutworm

Numerous species

Pest description and crop damage There are a number of moth species with larvae (cutworms) that have a wide range of colors, markings, and patterns. The foliage-feeding larvae generally feed at night, and clip off tips of uprights and runners.

Management—cultural control

Light traps placed on or near beds can be used to reduce problematic populations of cutworms over time.

Management—chemical control: COMMERCIAL USE

- azadirachtin (Aza-Direct, Neemix and other brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use.
- *Bacillus thuringiensis (Bt)* (several brands)—Consult label for rate. PHI 0 days. A spreader-sticker increases efficacy. Some formulations are OMRI-listed for organic use.
- carbaryl (Sevin and other brands) at 1.5 to 2 lb ai/a. PHI 7 days. Do not apply during bloom; hazardous to bees.
- chlorpyrifos (Lorsban and other brands) at 1.41 lb ai/a. PHI 60 days. Do not apply during bloom; hazardous to bees.
- indoxacarb (Avaunt) at 0.11 lb ai/a. PHI 30 days. The effectiveness of Avaunt for controlling cutworms has not been determined, but as it controls other lepidopteran larvae, it might be effective for controlling cutworms. Hazardous to bees.
- phosmet (Imidan) at 0.9 to 2.8 lb ai/a. PHI 14 days. Allow at least 10 days between applications. Do not exceed 11 lb ai/a per crop season. Do not apply to bloom; material is hazardous to bees.
- spinetoram (Delegate) at 0.05 to 0.09 lb ai/a. PHI 21 days. Apply to small larvae; may provide some suppression. Do not apply to bloom; material is hazardous to bees for three hours following treatment.
- spinosad (Success or Entrust) at 0.062 to 0.15 lb ai/a. PHI 21 days. Apply to small larvae; may provide some suppression. Entrust is OMRI-listed for organic use. Do not apply to bloom; material is hazardous to bees for three hours following treatment.

Cranberry—Cranberry fruitworm

Acrobasus vaccinii

Pest description and crop damage This pest overwinters as larvae encased in a hibernaculum. Moth emergence occurs during late June and can be monitored with pheromone traps. Eggs are laid singly on the fruit and oviposition may be withheld until berries are of appropriate size and color (e.g., "BB to pea sized"). Larvae enter the fruit immediately upon hatch and may consume five to six fruit during development. Best control is achieved with applications of long residual insecticides.

Management—chemical control: COMMERCIAL USE

- chlorantraniliprole (Altacor) at 0.066 to 0.099 lb ai/a. PHI 1 day. Apply when fruit are "BB to pea size" and repeat application 10 to 20 days later. Do not exceed two consecutive applications of chlorantraniliprole (Group 28 insecticides) or three applications per crop season.
- methoxyfenozide (Intrepid) at 0.16 to 0.25 lb ai/a. PHI 14 days. Apply when fruit are "BB to pea size"; repeat application 10 to 14 days later. Do not exceed two consecutive applications of methoxyfenozide (Group 18A insecticides) or four applications.

Cranberry—Cranberry tipworm

Dasineura oxycoccana

Pest description and crop damage The adult is a very small fly, about 1 to 3 mm long, and reddish. Larvae are white to orange, very small and difficult to see with the naked eye. They undergo three larval instars: initially clear, then milky-white, then finally an orange color. Pupae, enclosed in a white silken cocoon, are orange but darken as they get closer to adult emergence. The larvae feed on flower buds and shoot tips, causing distorted growth. If the terminal is attacked later in the season, the damage can be more important because the vine may not recover in time to develop a fruiting bud for the following year. Infestation from first generations does little crop damage, but subsequent generations can prevent the formation of mixed terminal buds required for next year's crop. Tipworm is not noted to be a serious pest in southern Oregon beds, but numerous Washington and northwest Oregon beds suffered substantial crop loss from tipworm in recent years.

Biology and life history The cranberry tipworm overwinters in the larval stage in leaf litter. They pupate for a short time at the end of winter and adults emerge from the pupal stage in spring. Mated females deposit eggs on the inner leaves of newly emerging cranberry shoots. Emerging larvae attack tender shoot tips, potentially killing the apical meristem. Multiple overlapping generations are commonplace by mid-season.

Sampling and thresholds Tipworm larvae and pupae are barely visible to the naked eye. Infested uprights can be most easily noted by the peculiar cupping of tips. Presence of visible damage, however, does not mean presence of active insects in the tips. To accurately monitor for infestation, collect random samples of 25 to 50 uprights during mid-May (first generation), and late-June to mid-July (subsequent generations). Tease apart the tips and examine with a magnifying lens or dissecting scope for larvae and pupae. Treatment is recommended if crop loss has been experienced in previous years and percentage of infested tips is greater than 10% for first generation. Treatment timing for insecticides is at peak egg hatch for first generation of tipworm. This is normally early- to mid-May. Of the chemicals currently listed for management, carbaryl provides the most consistent management, but repeat applications are required for control.

Management—cultural control:

Adequate nutrition following tipworm infestation will aid in the production of side shoots to replace the destroyed terminal bud, especially if damage occurs early in the season.

Management—chemical control: COMMERCIAL USE

- acephate (Orthene 97, 75S, and WSP) at 0.98 lb ai/a. PHI 90 days. Use only prebloom. Do not exceed one application per crop season. Do not tank mix with other organophosphate insecticides. Do not apply to bloom; material is hazardous to bees.
- carbaryl (several brands) at 1.5 to 2 lb ai/a. PHI 7 days. Target first generation tipworm (prebloom). Two to three applications (7 days apart) are recommend for best control. Do not apply during bloom; carbaryl is hazardous to bees. Latex-based formulations such as Sevin XLR Plus are less hazardous to bees.
- chlorantraniliprole (Altacor) at 0.066 to 0.099 lb ai/a. PHI 1 day. Apply at egg-laying stage. Repeat application 7 to 10 days later. Do not exceed 2 consecutive applications of chlorantraniliprole (Group 28 insecticides) or > 0.198 lb ai per crop season.
- chlorpyrifos (Lorsban) at 1.41 lb ai/a. PHI 60 days. Do not apply to bloom; material is hazardous to bees. Do not exceed two applications per season. Restricted use material in the Grayland growing area of Washington.
- diazinon (several brands) at 2 lb ai/a. PHI 7 days. Do not apply to bloom; material is hazardous to bees. Restricted use material in the Grayland growing area of Washington. Depending on pest population may be applied pre- or post-bloom. Populations of tipworm in British Columbia have been noted to be resistant to diazinon.

Cranberry—Root weevil

Includes
Black vine weevil *(Otiorhynchus sulcatus)*
Strawberry root weevil *(O. ovatus)*

Pest description and crop damage Larvae are white with tan heads and have no legs. Adults are black beetles 0.25 to 0.5 inch long. Larvae feed on small roots and later on the cambium of large roots. Damage from larval feeding is most apparent just before and during bloom. Weevil presence can be detected by looking for notching or scalloping of the leaves on uprights. Edges of the cranberry bed and drier areas are most susceptible to weevil injury.

Biology and life history Larvae overwinter 2 to 8 inches deep in soil. Most are embedded in the duff. Adults are present in cranberry beds along coastal areas during most of the year but late May to early July is when they can start to be seen in large numbers. They begin egg laying in mid-June to early July. All adults are capable of laying eggs. Eggs normally hatch in 7 to 10 days, but some may overwinter or are deposited in spring by overwintering adults. About 5% of adults overwinter.

Sampling and thresholds Monitor populations of newly emerged adults from late-May to late-June after dark with an insect sweep net. Threshold is one adult per 25 sweeps.

Management—cultural control

Where flooding practices are used during harvest, some weevil larvae often drown. A flood applied for 2 to 3 weeks immediately after harvest, when temperatures may still be warm, can drown large numbers of early-stage larvae.

Management—chemical and biological control

- acephate (Orthene 97 and Acephate 97UP) at 1.0 lb ai/a. PHI 75 days. Washington SLN for Orthene WSP (WA-050002) also allows a 75-day PHI. Apply at night. To suppress over-wintering adults, apply in early May, before they lay eggs. For newly

emerged adults, treat post-bloom when most weevils are in the adult stage and are active but before egg laying begins. Do not apply during bloom; material is hazardous to bees. Do not exceed one application per crop season. Do not tank mix with other organophosphate insecticides.

- azadirachtin (Aza-Direct, Neemix and other brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use. Efficacy in the Pacific Northwest is questionable.
- *Beauveria bassiana* (Mycotrol, BotaniGard and other brands)—Consult label for rate and use directions. OMRI-listed for organic use.
- clothianidin (Belay) at 0.2 lb ai/a. PHI 21 days. Apply after fruit set. Incorporate into soil with several hours of irrigation. Do not apply during bloom or when bees are foraging. Wait at least 5 days after application before placing beehives in the treated field. Note "Bee Advisory Box" and restrictions on the label.
- imidacloprid (Admire Pro) at 0.25 lb ai/a for black vine weevil control. PHI 30 days. Do not exceed two applications per crop year. Make first application post-harvest, when plants are dormant (Nov. 1 to Mar. 1); Oregon and Washington 24c labels (OR-050025 and WA-050013) allow postharvest and dormancy applications. A second application can be made post-bloom the following season. Follow each application with 0.1 to 0.3 inch of irrigation water. Do not apply during bloom or when bees are foraging. Note "Bee Advisory Box" and restrictions on the label. This treatment is only effective in sandy soils.
- indoxacarb (Avaunt) at 0.11 lb ai/a. PHI 30 days. For adult control apply Avaunt at night at the first indication of adult emergence, usually in early- to mid-June. Repeat the applications every 10- to 14-days until adults are no longer obtained by night sweeping. Material is hazardous to bees.
- parasitic nematodes—See label for rate, timing, soil temperature, and irrigation requirements. Consult Extension personnel or other crop advisers for commercial sources of nematodes.
- thiamethoxam (Actara) at 0.062 lb ai/a. PHI 30 days. Do not apply when bees are foraging. Note "Bee Advisory Box" and restrictions on the label.

Cranberry—Scale

Brown soft scale *(Coccus hesperidum)*
Cottony scale *(Pulvinaria spp.)*
Greedy scale *(Hemiberlesia rapax)*
Lecanium scale *(Lecanium* spp*.)*

Pest description and crop damage Scale are sucking insects that infest vines and leaves of cranberry plants causing stunted, delayed vine growth and/or dead patches in beds. Scale presence can cause reduced fruit set on infested uprights. Small areas of infestation can be found in any part of the cranberry bed. Scale insects are often difficult to detect because they are small and relatively immobile. These insects are divided into two categories: armored scale and soft scale. Soft scale insects excrete a sugary substance called "honeydew," which becomes the substrate upon which sooty mold grows. Sooty mold accumulates on vines and is a good visual indicator of soft scale presence. Several species of scale insects are found in Pacific Northwest cranberry beds:

Greedy scale are light gray in color, circular in shape and convex. As armored scale, greedy scale have a plate-like cover (the "armor") that can be peeled off. Underneath the armor is the actual scale insect. Greedy scale measure approximately 1/16 inch (1 to 1.5 mm) when fully grown. In Oregon, greedy scale have been observed covering the woody portion of cranberry vines and can be dense enough to create dead spots in a bed. As armored scale, greedy scale do not produce honeydew. Treatment timing must coincide with initial crawler (newly hatched eggs) release to be effective. Monitoring efforts have indicated that greedy scale crawlers begin to emerge shortly before bloom, but year-to-year variation occurs.

Brown soft scale are brown in color, and flattened and oblong in shape. As soft scale, they do not have a removable "armor;" instead, their cover is fused with the insect body so that it peels away in one piece. Brown soft scale overwinter on uprights and leaves of cranberry plants and are typically located either on the upper leaf surface near the mid-rib, or on the stem. They produce multiple generations each year. They produce large amounts of honeydew; as such, black patches of sooty mold in a bed are a good indication that brown soft scale are present. Late-dormant treatment with 2% solution of insectidal soap has shown to be effective against brown soft scale. Multiple treatments will likely be necessary. Boom spray only.

Lecanium scale are hemispherical and chestnut-brown, 1/8 to 5/16 inch (3 to 8 mm) in diameter. Like brown soft scale, lecanium scale produce honeydew. Lecanium scale are a pest in only some areas of Oregon. They have one generation per year, with the crawlers emerging in June.

Cottony scale are soft scale that lay their eggs in cottony masses, often on stems of uprights and undersides of leaves. They have one generation per year. Parasitoid wasps were present in samples from a bed in southern Oregon, indicating that some biological control is in effect.

Management—biological control

The population of scale insect is dynamic, reflecting control by natural predators, such as parasitic wasps. The use of broad-spectrum insecticides, however, can disrupt these populations, resulting in an increasing problem with scale.

Management—chemical control: COMMERCIAL USE

Lecanium scale are usually controlled with fireworm insecticide applications that can coincide with migration of young crawlers on vines. Greedy scale may be controlled with applications for other scale insects. Brown soft scale are seldom controlled with only one or two sprays. Continue to monitor closely in subsequent seasons. The crawler stage is the most susceptible to chemical control efforts. Use double-sided tape to monitor for crawler emergence during dormant or delayed-dormant stages of growth (late winter/early spring) when temperatures reach 60°F. Control efforts early in the season before generations begin to overlap will be most effective.

- azadirachtin (Aza-Direct, Neemix and other brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use.
- diazinon (several brands) at 2 lb ai/a. PHI 7 days. Do not apply to bloom; material is hazardous to bees.
- insecticidal soap (M-Pede and other brands)—Consult label for rate and use directions. PHI 0 days. Some formulations are OMRI-listed for organic use. Effective against brown soft scale either alone or in combination with an approved organophosphate, applied during dormant/delayed dormant season. Not effective against greedy scale. Use high label rate of soaps when used alone; use lower rate if used with an organophosphate. Spot-treat infestations in dormant/delayed dormant period at 1 to 2% v/v solution.
- horticulture oil (several brands)—Consult label for rate and use directions. Apply oil during delay-dormant stage. Time application to coincide with temperatures of 60°F, dry weather, and crawler emergence. A second application will likely be necessary 2 to 4 weeks later. Monitor vines for crawler emergence and apply oil accordingly.
- pyriproxifen (Knack) - Consult label for rate and use direction. PHI 7 days.

Currant and Gooseberry Pests

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INCLUDES MANAGEMENT OPTIONS FOR COMMERCIAL AND HOME USE

In all cases, follow the instructions on the pesticide label. The *PNW Insect Management Handbook* has no legal status, whereas the pesticide label is a legal document. Read the product label before making any pesticide applications.

Protect pollinators: See How to Reduce Bee Poisoning from Pesticides.

Note: Products are listed in alphabetical order and *not* in order of preference or superiority of pest control.

Currant and gooseberry—Cottony maple scale

Pulvinaria innumerabilis

Pest description and crop damage The cottony maple scale is one of the largest soft scales. Immature forms (crawlers) are flattened and brown to yellowish green in color; however, the conspicuous, cottony egg sac of the mature female is two to three times the length of the scale body, or up to 6 mm. The insects feed on foliage, reducing vigor of the plant and causing twig dieback. Large amounts of honeydew, on which sooty mold will readily grow, is produced and can be a fruit contaminant.

Biology and life history This insect prefers to feed on maples, but will infest a wide array of trees, shrubs, tree fruits and berries. They spend the winter as mated females on twigs and branches. They resume feeding in the spring and produce the large cottony egg sac. The eggs hatch in early summer and nymphs feed on the undersides of the leaves near the midrib. At the end of the growing season, winged males appear and mate with the females, which then return to twigs to overwinter.

Scouting and thresholds Inspect plants in spring for cottony egg sacs on twigs and leaves.

Management—chemical control: HOME USE

Dormant-season spray

- superior-type oil—Some formulations OMRI-listed for organic use.

Growing-season spray

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

- azadirachtin (Neemix and other brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade and other brands) at 0.033 to 0.1 lb ai/a. PHI 1 day. Make cover spray applications when scale crawlers first emerge. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- horticultural oil (several brands)—Consult label for rates. Apply as a dormant spray in early season before buds open. Some formulations are OMRI-listed for organic use.
- insecticidal soap (M-Pede and other brands)—Consult label for rate and use directions. PHI 0 days. Apply when crawlers first emerge. Some formulations are OMRI-listed for organic use.
- malathion (several brands) at 1.25 lb ai/a. PHI 1 day. Apply when crawlers appear, as a spray in 100 gal water/a. After June, use 150 to 200 gal water/a. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- pyriproxyfen (Esteem or Knack) at 0.1 lb ai/a. PHI 7 days. The effectiveness of Esteem for controlling this pest has not been determined; but, as it controls lecanium scale, it might be effective for controlling cottony maple scale. Apply at either dormant, delayed-dormant, or as an in-season cover spray. At dormant or delayed-dormant, use with a horticultural oil. Make cover spray applications when scale crawlers first emerge.
- spirotetramat (Movento) at 0.1 to 0.13 lb ai/a. PHI 7 days. Gooseberry only. Movento is known to suppress lecanium scale and may be helpful with suppression of cottony maple scale.

Currant and gooseberry—Currant aphid

Cryptomyzus ribis

Pest description and crop damage This aphid is commonly found on currants and occasionally found on gooseberries. Adult aphids are greenish yellow and about 2 mm long. Immature aphids are yellowish in color. Eggs are shiny black. Aphid feeding on leaves causes a cupping, distortion, and red color. Feed can cause some loss of plant vigor. Honeydew accumulation, and associated sooty mold, on foliage and fruit is unsightly and can reduce fruit quality.

Biology and life history The currant aphid overwinters in the egg stage on bark or new canes. Eggs hatch in early spring, about the time leaf buds begin to open. The young aphids begin to feed immediately on leaves and leaf buds. This generation feeds for about 12 to 14 days, reaches adulthood, then produces not eggs but living young. Several such wingless generations are produced each summer. As fall approaches, winged forms are produced that mate and lay eggs on the canes to overwinter.

Scouting and thresholds Check plants frequently after new growth begins. Aphids are often concentrated in "hot spots" in the field. Be sure to also look for evidence of biological control; i.e., the presence of predators, parasites (aphid mummies will be apparent), and disease. Aphid flights are most common during periods of moderate temperatures (60° to 80°F).

Management—biological control

Many naturally occurring parasites and predators attack aphids. Monitor the proportion of aphid mummies to unparasitized adults and the number of predators such as lady beetles. If the biocontrol agents appear to be gaining control, avoid sprays which would disrupt this system. Most products available for aphid control are highly disruptive of natural enemies.

Management—cultural control

Aphid populations tend to be higher in plants that are fertilized liberally with nitrogen. Prune out suckers and other excess growth that might encourage colonization.

Home gardeners: Wash aphids from plants with a strong stream of water. Control ants, which "farm" the aphids and protect them from predators. A narrow band of "stickem" at the base of the stem should exclude ants. Use a floating row cover where feasible.

Management—chemical control: HOME USE

Dormant-season spray

- superior-type oil—Some formulations OMRI-listed for organic use.

Growing-season spray

- acetamiprid
- azadirachtin (neem oil) —Some formulations are OMRI-listed for organic use.
- imidacloprid
- insecticidal soap—Some formulations are OMRI-listed for organic use.
- kaolin—When applied as a spray to leaves, stems and fruit, it acts as a repellent to some insect pests. Some formulations are OMRI-listed for organic use.
- pyrethrins
- spinosad
- sulfur
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- acetamiprid (Assail) at 0.044 to 0.1 lb ai/a. PHI 1 day. Do not exceed 0.5 lb ai/a per season.
- azadirachtin (Neemix and other brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use.
- cyantraniliprole (Exirel) at 0.088 to 0.133 lb ai/a. PHI 3 days. Toxic to bees; do not use when bees are foraging. Note "Bee Advisory Box" and restrictions on the label. Also toxic to fish and other aquatic invertebrates.
- flupyridifurone (Sivanto) at 0.9 to 0.14 lb ai/a. PHI 3 day. Toxic to adult bees in laboratory studies via oral exposure, however, not toxic to bees through contact exposure, and field studies conducted with this product have shown no effects on honeybee colony development. Two applications, 7 days apart, and no more than 0.28 lb ai/a allowed per season. Avoid rotation with neonicotinoid products, if possible.
- imidacloprid (Admire Pro and other brands) at 0.036 to 0.05 lb ai/a for foliar applications, and 0.25 to 0.5 lb ai/a for soil applications. (Check label of other brands for correct rate). PHI 3 days (foliar) or 7 days (soil). Do not apply pre-bloom, during bloom or when bees are foraging. Note "Bee Advisory Box" and restrictions on the label. Also toxic to fish and other aquatic invertebrates.
- insecticidal soap (M-Pede and other brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use.
- malathion (several brands) at 1.25 lb ai/a. PHI varies by label. Apply in at least 100 gal/a water. Apply when aphids appear on leaves and cupping begins. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- pyrethrin (several brands)—Consult label for rate and use directions. PHI 0 days. Direct contact is essential for effective results. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates. Many brands, such as Pyganic, are OMRI-listed for organic use.
- thiamethoxam (Actara) at 0.047 to 0.062 lb ai/a. PHI 3 days. Foliar applied. Actara and Platinum have the same active ingredient; for resistance management, do not follow one with the other. Toxic to bees; do not use when bees are foraging. Note "Bee Advisory Box" and restrictions on the label. Also toxic to fish and other aquatic invertebrates.
- thiamethoxam (Platinum) at 0.078 to 0.188 lb ai/a. PHI 75 days. Soil applied. Apply to the soil and incorporate with irrigation. Actara and Platinum have the same active ingredient; for resistance management, do not follow one with the other. Do not apply when bees are foraging. Wait at least 5 days after application before placing beehives in treated field. Note "Bee Advisory Box" and restrictions on the label.

Currant and gooseberry—Currant borer

Synanthedon tipuliformis

Pest description and crop damage The adult is a blue-black clear-wing moth with yellow markings. In both sexes there is a prominent, shield-like tuft of long scales at the posterior end of the abdomen; it is larger and more flattened in the male. Wings are transparent and normally spread out while the moth is at rest. They are mostly devoid of scales except on the veins, which generally are black with golden-purplish markings. A fringe of long, pale purplish scales borders the exposed posterior margin of the wings. Each forewing has an area of black scales about two-thirds from the body. Red currants are the most susceptible host.

Biology and life history The insect overwinters as an inactive, nearly mature larva just above the ground on the canes. These larvae feed for a short time in the spring, chew a hole in the side of the cane, then cover the hole with silk and pupate in the cane. Adult moths emerge from the canes in June and July; they are active on bright, warm days. Adults mate and the females deposit eggs singly near nodes, pruning scars, or under loose bark.

Scouting and thresholds Inspect canes at the base of the plants for larval populations when larvae are active in the spring.

Management—biological control

Little is known about the role natural enemies play in control. Overwintering larvae are often prey to a parasitic wasp and a fungal disease which helps reduce borer populations.

Management—cultural control

Home gardeners: Remove infested canes and destroy them.

Management—chemical control: HOME USE

No products are registered for control of this pest on home garden currants or gooseberries.

Management—chemical control: COMMERCIAL USE

The following insecticides are registered for use in gooseberries and currants and, although currant borer does not appear on the labels, these products are known to control other lepidopteran larvae and might be effective in controlling the currant borer. Targeting the young larvae when they are exposed and before they have entered woody stem tissue is critical for successful control.

- bifenthrin (Brigade and other brands) at 0.033 to 0.1 lb ai/a. PHI 1 day. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- chlorantraniliprole (Altacor) at 0.066 to 0.99 lb ai/a. PHI 1 day.
- fenpropathrin (Danitol) at 0.2 to 0.3 lb ai/a. PHI for gooseberries is 3 days; PHI for currants is 21 days. Do not exceed 0.6 lb ai/a for currants or 0.8 lb ai/a for gooseberries per season. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- flubendiamide (Belt SC) at 0.1 to 0.125 lb ai/a. PHI 7 days. Gooseberry only.
- indoxacarb (Avaunt) at 0.065 to 0.11 lb ai/a. PHI 7 days. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- methoxyfenozide (Intrepid) at 0.25 lb ai/a. PHI 7 days. Apply when egg laying begins and young larvae are present.
- novaluron (Rimon 0.83EC) at 0.13 to 0.19 lb ai/a. PHI 8 days. Apply when larvae are young and small.
- spinetoram (Delegate) at 0.05 to 0.09 lb ai/a. PHI 3 days. Toxic to bees exposed to treatment for 3 hours following treatment. Do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.

- spinosad (Success or Entrust) at 0.062 to 0.09 lb ai/a. PHI 3 days. Entrust is OMRI-listed for organic use. Apply at egg hatch or to small larvae. Toxic to bees exposed to treatment for 3 hours following treatment. Do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- tebufenozide (Confirm 2F) at 0.25 lb ai/a. PHI 14 days. Apply when egg laying begins and young larvae are present.
- zeta-cypermethrin (Mustang) at 0.05 lb ai/a. PHI 1 day. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.

Currant and gooseberry—Currant fruit fly (gooseberry maggot)

Euphranta canadensis

Pest description and crop damage The adult is a small yellowish fly, about 8 mm long, with bright green eyes and smoky bands across the wings. The maggots are white, cylindrical, and tapered at the head. The maggots develop inside and feed in the berry, making them inedible. Infested fruit often drop prematurely, but others remain on the bush. Infested berries show a discolored area where the egg was inserted. Infested fruits often turn red before they drop.

Biology and life history The insect overwinters as a brown pupa about the size of a wheat grain in organic debris, or 1 to 3 inches deep in the soil at the base of the plant. In the middle of April, the flies emerge over a period of 40 to 45 days. The female flies insert oblong eggs under the fruit skin. The eggs hatch and the larvae burrow under the fruit skin, then into the fruit pulp. They feed on the pulp and seeds until mature, then burrow out through the skin and drop to the soil. There is one generation per year. Adult flies frequently rest on fence rows, brush, and trees adjacent to currant and gooseberry plantings.

Scouting and thresholds Scout fields in early spring for fly activity. Inspect fruit as they mature for any discoloration, and remove them from the plant.

Management—cultural control

Home gardeners: Use floating row covers to protect plants during adult emergence. Do not use this technique on infested plantings! Remove infested fruit when it appears. Lay a tarp under the plants to prevent flies from pupating in the soil.

Management—chemical control: HOME USE

No products are registered for this pest in home gardens.

Management—chemical control: COMMERCIAL USE

Apply chemical sprays when adults are present and active.

- bifenthrin (Brigade and other brands) at 0.033 to 0.1 lb ai/a. PHI 1 day. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- fenpropathrin (Danitol) at 0.2 to 0.3 lb ai/a. PHI for gooseberries is 3 days; PHI for currants is 21 days. Do not exceed 0.6 lb ai/a for currants or 0.8 lb ai/a for gooseberries per season. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- carbaryl (Sevin and other brands) at 0.5 lb to 1.0 ai/a. PHI 7 days. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- pyrethrin (several brands)—Consult label for rate and use directions. PHI 0 days. Direct contact is essential for effective results. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates. Many brands, such as Pyganic, are OMRI-listed for organic use.
- spinetoram (Delegate WG) at 0.05 to 0.09 lb ai/a. PHI 3 days. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- spinosad (Success or Entrust) at 0.062 to 0.09 lb ai/a. PHI 3 days. Entrust is OMRI-listed for organic use. Toxic to bees exposed to treatment for 3 hours following treatment. Do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- zeta-cypermethrin (Mustang) at 0.05 lb ai/a. PHI 1 day. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.

Currant and gooseberry—Currant stem girdler

Janus integer

Pest description and crop damage A slender species of sawfly that is about 6 to 12 mm long; females are slightly larger than the males. Both sexes have a black head and thorax. The male has a brownish yellow abdomen. The female abdomen is reddish orange and the posterior half is black. Larvae are straw-yellow in color, with a slightly darker head. Sawflies are in the insect order Hymenoptera but their larvae resemble a lepidopteran caterpillar. Female stem girdlers cause substantial damage to new growth by their girdling habit when laying eggs (see below), severely reducing crop growth and fruit production. Larvae cause significant damage to plants when they bore into, and feed within, canes.

Biology and life history After feeding within canes throughout the summer, full-grown, dormant larvae overwinter in canes and pupate in early spring. After about two weeks as a pupa, the adult emerges, usually in early May. Females lay their eggs singly, inserting them into the pith of new shoots. After each egg is laid, the female walks up the shoot, about 0.5 to 1 inch, and girdles it with her saw-like ovipositor. Usually, a portion of the shoot remains uncut, and the almost severed, wilted tip may remain attached for some time. One female can lay up to 30 eggs and therefore girdle 30 shoots. Presumably, girdling is done to prevent shoot growth and possible damage to the egg or young larva.

Management—chemical control: HOME USE

No products are registered for control of this pest in home gardens.

Management—chemical control: COMMERCIAL USE

- fenpropathrin (Danitol) at 0.2 to 0.3 lb ai/a. PHI for gooseberries is 3 days; PHI for currants is 21 days. Do not exceed 0.6 lb ai/a for currants or 0.8 lb ai/a for gooseberries per season. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.

Currant and gooseberry—Gooseberry cambium miner

Opostegoides scioterma

Pest description and crop damage Adults are a gray moth, about 6 mm long, that can be seen flying in early summer. Larvae are slender and semi-transparent. They feed and mine under the cane cambium of both new canes and canes from the previous season's growth. Their mining can stunt or kill the tips of new canes.

Biology and life history Adults can be seen flying in early summer. Larvae mine is a slender, linear tunnel that normally curves at both the upper and lower ends to form a narrow ellipse. When the larva completes a circle, it normally reinvades the initial mine and continues feeding and enlarging it.

Scouting and thresholds Inspect the cambium of new shoots for characteristic larval feeding and mining pattern.

Management—cultural control

Cut out and burn infested canes.

Management—chemical control: HOME USE

No products are registered for control of this pest in home gardens.

Management—chemical control: COMMERCIAL USE

No insecticides are registered for this pest. However, other insecticides registered for use in currants and gooseberries that are known to control lepidopteran larvae (e.g. tent caterpillar) may provide some control for this pest.

Currant and gooseberry—Imported currant worm

Nematus ribesii

Pest description and crop damage Adults are black sawflies about 8 to 9 mm long with light yellow marks on the abdomen. Larvae initially are small and white, but full-grown larvae are about 12 mm long and greenish, often with dark body spots, especially when partially grown. Sawflies are in the insect order Hymenoptera but their larvae resemble a lepidopteran caterpillar. Larvae feed along leaf margins and, when numerous, may defoliate the entire plant within a few days.

Biology and life history The insect overwinters in a capsule-like cocoon on the soil surface or just below. The adult sawfly emerges in April to coincide with leaf emergence, and lays eggs on the underside of the leaves, often toward the center of the plant. The eggs hatch, and the young larvae feed on the leaves for 2 to 3 weeks, then drop to the soil and pupate. The second generation larvae are active beginning about harvest, usually sometime in July. These larvae drop to the ground to overwinter.

Scouting and thresholds In April, inspect plants daily for signs of larval feeding. This will appear as small holes in the center of leaves, often near the middle of the plant.

Management—cultural control

Home gardeners: Pick off infested leaves and destroy larvae. Remove and destroy badly infested canes.

Management—chemical control: HOME USE

No products are registered for control of this pest in home gardens.

Management—chemical control: COMMERCIAL USE

Note: The effectiveness of spinetoram and spinosad for controlling this pest has not been determined; but, as they control a wide range of insects, they may also be effective for controlling the imported currant worm.

- malathion (several brands) at 2 lb ai/a for gooseberry and 1.25 lb ai/a for currant. PHI varies by label. Apply in 100 gal/a water. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- novaluron (Rimon 0.83EC) at 0.13 to 0.19 lb ai/a. PHI 8 days. Apply when larvae are young and small.
- spinetoram (Delegate) at 0.05 to 0.09 lb ai/a. PHI 3 days. Toxic to bees exposed to treatment for 3 hours following treatment. Do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- spinosad (Success or Entrust) at 0.062 to 0.09 lb ai/a. PHI 3 days. Entrust is OMRI-listed for organic use. Apply at egg hatch or to small larvae. Toxic to bees exposed to treatment for 3 hours following treatment. Do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.

Currant and gooseberry—San Jose scale

Quadraspidiotus perniciosus

Pest description and crop damage San Jose scale can be differentiated from other scale insects by the scale (shell) that covers the adult females. The scale is hard, gray to black, and cone-shape. The scale has a tiny white knob in the center with a series of grooves or rings around it. Scale insects are closely related to aphid, mealybugs, and whiteflies. Like these insects, they also have piercing–sucking mouthparts. Large populations of scale can devitalize plants and stunt growth. Severe infestations can kill twigs. Scale insects produce large quantities of honeydew, which makes leaves and fruit shiny and sticky. Sooty mold fungus may grow on this, giving the plants a dirty, sooty appearance and reduce quality of the fruit.

Biology and life history San Jose scale overwinters in an immature state and is black in color. In spring, the tiny winged males emerge and mate with wingless females. Females give birth to live young about a month later (no eggs are seen). The young scale insects, called "crawlers," are very small, flattened, and yellow, and move around on bark and foliage before settling down to feed. Young scale also can be dispersed by wind, rain, irrigation, or by the movement of people and machinery. A few days later, they secrete a waxy coating over their body that protects them from pesticides. From this point, female scale insects do not move. Crawlers can be seen during June and July, and again in August and September; there are two generations per year.

Scouting and thresholds Inspect twigs during the dormant season. Pay particular attention to weak plants. Observe the young bark for purplish-red halos, which indicate infestation. The crawlers are best observed during June–July with a 10X magnifying glass. Crawlers can be monitored by wrapping a piece of double-stick tape around an infested branch.

Management—biological control

- Larvae of green lacewings are aggressive predators of scale.

Management—cultural control

Avoid excessive nitrogen fertilizer, as this favors increases in scale populations.

Home gardeners: Scale can be rubbed off plants by hand with a glove or toothbrush. Major infestations can be pruned off. Tanglefoot, "stickem," or a similar adhesive can be applied around infestations of adult scale to catch the crawler stage.

Management—chemical control: HOME USE

Dormant-season spray

- lime sulfur—Spray to cover shoots thoroughly while plants are dormant in early spring. Some formulations are OMRI-listed for organic use.
- superior-type oil—Some formulations are OMRI-listed for organic use.

Growing-season spray

- acetamiprid
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- esfenvalerate (for use on gooseberry only)

Management—chemical control: COMMERCIAL USE

- azadirachtin (Neemix and other brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade and other brands) at 0.033 to 0.1 lb ai/a. PHI 1 day. Make a cover spray application when crawlers first emerge. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.

- horticultural oil (several brands)—Consult label for rate. Apply oil while plants are dormant and when temperatures are above freezing. Some formulations are OMRI-listed for organic use.
- insecticidal soap (M-Pede and other brands)—Consult label for rate and use directions. PHI 0 days. Apply when crawlers first emerge. Some formulations are OMRI-listed for organic use.
- malathion (several brands) at 1.25 lb ai/a. PHI 1 day. Apply when crawlers appear, as a spray in 100 gal water/a. After June, use 150 to 200 gal water/a. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- pyriproxyfen (Esteem or Knack) at 0.1 lb ai/a. PHI 7 days. Apply at either dormant, delayed-dormant, or as an in-season cover spray targeted at the crawlers. For dormant or delayed-dormant applications, use with a horticultural oil.
- spirotetramat (Movento) at 0.1 to 0.13 lb ai/a. PHI 7 days. Gooseberry only. Movento is known to suppress lecanium scale and may be helpful with suppression of San Jose scale.

Currant and gooseberry—Spotted wing drosophila

Drosophila suzukii

For pest description, crop damage, biology, life history, sampling and cultural management

See:
EMERGING PEST: Spotted Wing Drosophila—A Berry and Stone Fruit Pest

Note: Do not assume a small white larva found in the fruit is SWD; it may be the commonly found gooseberry maggot (see currant fruit fly, above). Properly identify the insect pest before undertaking management practices.

Management—chemical control: HOME USE

- acetamiprid—In field tests, this product has provided inconsistent control of SWD.
- azadirachtin (neem oil)—This product has been shown to provide about 25% control of SWD. Some formulations are OMRI-listed for organic use.
- pyrethrins—These products provide about 80% control of SWD but have no residual activity. Some formulations are OMRI-listed for organic use.
- spinosad—This product generally provides 100% control and 5 to 7 days residual activity. Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

Laboratory tests and field experiments indicate that many of the pesticides registered for use in currants and gooseberries are effective in controlling the adult SWD. Although SWD may not be listed on a label, it is legal to use for SWD management. The products listed below target the adult stage of SWD.

- azadirachtin (Neemix and other brands)—Consult label for rate. PHI 0 days. Achieves only about 25% control of SWD. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade and other brands) at 0.1 lb ai/a. PHI 1 day. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates. Synthetic pyrethroids achieved 100% mortality of SWD and provide about 10 to 14 days residual control in the field.
- carbaryl (Sevin and other brands) at 1.5 lb ai/a. PHI 7 days. Use post-bloom only. May provide 100% control of SWD. Toxic to bees; do not apply when bees are foraging. Latex-based formulations such as Sevin XLR Plus are less hazardous to bees. Also toxic to fish and other aquatic invertebrates. Carbamate insecticide.
- cyantraniliprole (Exirel) at 0.088 to 0.133 lb ai/a. PHI 3 days. Toxic to bees; do not use when bees are foraging. Note "Bee Advisory Box" and restrictions on the label. Also toxic to fish and other aquatic invertebrates. Provides from 75-100% control, and 7 to 10 days residual control in the field.
- fenpropathrin (Danitol) at 0.2 to 0.3 lb ai/a. PHI 3 days for gooseberry; 21 days for currant. Do not exceed two applications per season. Toxic to bees; do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates. Synthetic pyrethroids achieved 100% mortality of SWD and provide about 10 to 14 days residual control in the field.
- horticultural oil (several brands)—Consult label for rate. Provides some control of SWD but has no residual activity. May cause spotting on fruit. Some formulations OMRI-listed for organic use.
- malathion (several brands) at 2.0 lb ai/a for gooseberry and 1.25 lb ai/a for currant. PHI 1 day. Toxic to bees and most aquatic invertebrates, and carry the risk of mammalian toxicity. Toxic to bees; do not apply when bees are foraging. Also toxic to fish and other aquatic invertebrates. May achieve 100% mortality of SWD and provide about 7 to 10 days residual control in the field. Of the organophosphates tested, malathion had the longest residual activity (10 days).
- pyrethrin (several brands)—Consult label for rate and use directions. Toxic to bees; do not apply when bees are foraging. Also toxic to fish and other aquatic invertebrates. Provides about 80% control of SWD but has no residual activity. Many brands, such as Pyganic, are OMRI-listed for organic use.
- spinetoram (Delegate WG) at 0.09 lb ai/a. PHI 3 days. Toxic to bees exposed to treatment for 3 hr following treatment. Do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates. May achieve 100% mortality of SWD and provide about 5 to 7 days residual control in the field. Spinosyn insecticide.
- spinosad (Success or Entrust) at 0.09 lb ai/a. PHI 3 days. Entrust is OMRI-listed for organic use. Toxic to bees exposed to treatment for 3 hours following treatment. Do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates. May achieve 100% mortality of SWD and provide about 5 to 7 days residual control in the field. The bait formulation of spinosad (GF-120) is not effective against SWD. Spinosyn insecticide.
- zeta-cypermethrin (Mustang) at 0.05 lb ai/a. PHI 1 day. Toxic to bees; do not apply when bees are foraging. Also toxic to fish and other aquatic invertebrates. Synthetic pyrethroids achieved 100% mortality of SWD and provide about 10 to 14 days residual control in the field.

Currant and gooseberry—Tent caterpillar

Including western tent caterpillar *(Malacosoma californicum)*

Pest description and crop damage The adult is large-bodied light- to dark-brown moth with a wingspan of 25 mm or more. The larvae of the western tent caterpillar are hairy, dull yellowish brown in color, with a row of blue spots along the side. They live in silken tents constructed in branch crotches and are often found together in large numbers. Larvae feed on leaves and their feeding can defoliate a plant.

Biology and life history Several species of tent caterpillars are found in the Pacific Northwest including the western tent caterpillar, Pacific tent caterpillar *(M. constrictum)* and forest tent caterpillar *(M. disstria)*. They overwinter as eggs and hatch in spring after bud break, and begin constructing their protective tent. The larvae feed on the foliage for several weeks, maturing in early June. They pupate in silken cocoons near the tent. Adult moths emerge in early summer, mate, and lay eggs in a frothy mass around twigs and small limbs. There is one generation per year.

Management—biological control

Several predatory insects are effective against tent caterpillars, but most years diseases keep their population under control.

Management—cultural control

Destruction of egg masses on limbs, and cutting out tents early in the growing season, will control the caterpillars.

Management—chemical control: HOME USE

Dormant-season spray

- superior-type oil—Some formulations are OMRI-listed for organic use.

Growing-season spray

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- *Bacillus thuringiensis kurstaki*—For use on currants only. Some formulations are OMRI-listed for organic use.
- esfenvalerate—For use on gooseberry only.
- kaolin—When applied as a spray to leaves, stems and fruit, it acts as a repellent to some insect pests. Some formulations are OMRI-listed for organic use.
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- spinosad—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin—Toxic to bees; do not apply when bees are foraging.

Management—chemical control: COMMERCIAL USE

- azadirachtin (Neemix and other brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use.
- *Bacillus thuringiensis (Bt)* (several brands)—Use according to label directions. PHI 0 days. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade and other brands) at 0.033 to 0.1 lb ai/a. PHI 1 day. Toxic to bees; do not apply when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- indoxacarb (Avaunt) at 0.065 to 0.11 lb ai/a. PHI 7 days. Toxic to bees; do not apply when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- methoxyfenozide (Intrepid) at 0.25 lb ai/a. PHI 7 days. Apply when egg laying begins and young larvae are present. The effectiveness of Intrepid for controlling this pest has not been determined; but, as it controls other lepidopteran larvae, it may also be effective in controlling tent caterpillars.
- spinetoram (Delegate) at 0.05 to 0.09 lb ai/a. PHI 3 days. Toxic to bees exposed to treatment for 3 hours following treatment. Do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates. The effectiveness of spinetoram for controlling this pest has not been determined; but, as it controls other lepidopteran larvae, it may also be effective for controlling tent caterpillars.
- spinosad (Success or Entrust) at 0.062 to 0.09 lb ai/a. PHI 3 days. Entrust is OMRI-listed for organic use. Apply at egg hatch or to small larvae. Toxic to bees exposed to treatment for 3 hours following treatment. Do not use when bees are foraging. Also toxic to fish and other aquatic invertebrates. The effectiveness of spinosad for controlling this pest has not been determined; but, as it controls other lepidopteran larvae, it may also be effective for controlling tent caterpillars.

Currant and gooseberry—Twospotted spider mite

Tetranychus urticae

Pest description and crop damage These mites are about 4 mm long, have eight legs, and are light tan or greenish with a dark spot on each side. Spider mites feed by sucking the contents out of leaf cells, causing a mottling and bronzing of the leaves. Their feeding reduces plant vigor and may cause leaves to turn brown and drop.

Biology and life history Mites overwinter as females under loose bark or organic debris at the base of host plants, and on weeds. In the spring, they emerge, disperse, and lay eggs on the leaves. Eggs hatch into larvae in a few days. There may be multiple generations per year. The twospotted spider mite is a warm-season mite, and the greatest activity occurs under warm conditions. Depending on temperature, a complete generation may require one to three weeks. In the fall, adults cease feeding and migrate to overwintering sites.

Scouting and thresholds Infestations usually begin on lower leaves of plants, then progress upwards. Inspect oldest leaves first for stippling; webbing and the mites themselves can be found on the underside of leaves.

Management—biological control

Rain and cool temperatures tend to suppress mite populations. Considerable natural control is provided by lady beetles and minute pirate bugs (*Orius* spp.). Predator mites such as *Typhlodromus* spp., *Stethorus* spp., or *Neoseiulus fallacis* (syn. *Amblyseius fallacis*) are also effective at managing populations of spider mites and may be purchased and released.

Management—cultural control

Avoid early season applications of insecticides, which reduce populations of beneficial insects. Spider mite infestations are favored by dry, dusty conditions, so avoid creating these problems and stressing the plants. Mites can be hosed from plants with a strong stream of water. Excessive nitrogen fertilization may cause population buildup.

Management—chemical control: HOME USE

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- insecticidal soap—Some formulations OMRI-listed for organic use.
- kaolin—Applied as a spray, it acts as a repellent to some insect pests. Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

- acequinocyl (Kanemite) at 0.2 to 0.3 lb ai/a. PHI 7 days. Gooseberry only. Controls adults, larvae, nymphs and eggs.
- azadirachtin (Neemix and other brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use.
- bifenazate (Acramite 50WS) at 0.5 lb ai/a. PHI 14 days. Gooseberry only. Also allowed in non-bearing currants (PHI 365 days). Controls adults, larvae and nymphs, and some activity on eggs.
- etoxazole (Zeal) at 0.09 to 0.135 lb ai/a. PHI 0 days. Gooseberry only. Controls eggs and young mites only; not adult mites.
- fenpyroximate (FujiMite) at 0.075 to 0.1 lb ai/a. PHI 14 days. Gooseberry only. Controls all motile stages. Do not exceed one application per crop season.
- hexythiazox (Savey) at 0.125 to 0.1875 lb ai/a. PHI 7 days. Gooseberry only. Controls eggs, larvae and nymphs only; does not control adult mites. Do not exceed one application per crop season.
- horticultural oil (several brands)—Consult label for rates. Apply as a dormant spray in early season before buds open. Some formulations are OMRI-listed for organic use.
- insecticidal soap (M-Pede and other brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use.
- pyridaben (Nexter) at 0.2 to 0.5 lb ai/a. PHI 1 day for dry formulation; 10 days for liquid formulation. Gooseberry only.

Grape Pests

Patty Skinkis, Vaughn Walton, Joe DeFrancesco, Brooke Edmunds, and Neil Bell

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INCLUDES MANAGEMENT OPTIONS FOR COMMERCIAL AND HOME USE

In all cases, follow the instructions on the pesticide label. The *PNW Insect Management Handbook* has no legal status, whereas the pesticide label is a legal document. Read the product label carefully before making any pesticide applications.

Protect pollinators: See How to Reduce Bee Poisoning from Pesticides.

Note: Products are listed in alphabetical order and *not* in order of preference or superiority of pest control efficacy.

Grape—Black vine weevil

Otiorhynchus sulcatus

Pest description and crop damage The flightless adult has a roughened hard-shelled appearance and is 0.5 inches long. Adult beetles are black with small patches of white scales on the forewings. The front of the head projects forward into a long, broad snout. Adults feed on foliage as well as any portion of the inflorescence or cluster rachis, especially just before unfertilized berries drop shortly after bloom. Berry and cluster stems (rachis) can be girdled, and primary buds and new shoots may be destroyed in early spring. Larvae or grubs feed in the soil on the roots of the vine but cause no apparent damage.

Biology and life history Black vine weevils overwinter in the larval stage. Larvae pupate during April and adult beetles emerge in May and June. All black vine weevils are female and lay their eggs in the soil. Egg laying begins 2 to 3 weeks after emergence and continues for 6 to 8 weeks. A single female may lay 500 eggs.

Sampling and thresholds Monitor adults with cardboard traps. Vine trunks should be stripped of loose bark and corrugated cardboard traps should be wrapped around it. During the day, adults hide between the wrap's corrugations and the smooth trunk. The cardboard traps can be removed and inspected to determine presence of the pest. No information is available on threshold levels.

Management—biological control

Little is known about biological controls, but it is estimated that many larvae fall prey to predatory beetles, entomopathogenic fungi, and nematodes.

Management—cultural control

Cultivation around the base of vines in spring (April) is destructive to pupae as they are developing.

Management—chemical control: HOME USE

- azadirachtin (neem oil)
- imidacloprid
- pyrethrins—Some formulations are OMRI-listed for organic use.
- spinosad

Management—chemical control: COMMERCIAL USE

- azadirachtin (Aza-Direct, Neemix and other brands)—Rate varies with specific product. Apply foliar sprays to control adult feeding, and soil drench for larval stage. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade and other products) at 0.10 lb ai/a. PHI 30 days. Group 3A insecticide. Restricted use pesticide.

Note: Black vine weevil can be a serious problem, especially in newly established vineyards, but damage by this pest is usually sporadic.

Grape—Borer

Includes
Branch and twig borer *(Melalgus confertus)*
Grape twig borer *(Psoa quadrisignata)*
Polycaon borer *(Polycaon* spp.*)*

Pest description and crop damage Cane or twig borers are problematic in vineyards situated in close proximity to riparian areas or woodlands. These insects have a wide host range but predominantly impact older vineyards where vines have large pruning cuts and old wood. Borers have, however, also been found in young vineyards (<10 years of age) in western Oregon, particularly when located near old orchards, abandoned vineyards and/or riparian areas. Both adults and larvae damage the vine. Larvae bore into older canes and pruning cuts where they live until they emerge as adults. Adults burrow into the base of new shoots in spring to feed. The burrowing into the tissues causes shoots to wilt and die. Severe infestation can result in crop losses and damage can be significant. Holes (0.16 inches) can be found at the base of newly grown fruiting shoots or the base of old canes with frass or wood filings surrounding the hole. Cane-pruned vineyards appear to be more effected than spur-pruned vines.

Biology and life history Adults are long, brownish black and are visible early in the season (spring). They are between 0.4 to 0.7 inches long. Females are slightly larger than males. Larvae live within the cane/shoot for nearly a year before they emerge the next spring.

Sampling and thresholds Monitor the vineyard using corrugated cardboard traps (see black vine weevil traps) placed at the base of the vine trunk in order to capture the pest at night. Scout vineyards for flagging or drooped shoots in spring and examine the shoot for holes and cut open the shoot to determine if there has been evidence of burrowing. No economic thresholds have been determined.

Management—biological control

An entomopathogenic nematode, *Steinernema carpocasae*, has been used for biocontrol of twig borers. A commercial preparation of the nematode must be applied to burrow holes before budbreak in order to be effective.

Management—cultural control

The best way to manage twig borers is through sanitation. Remove pruning brush from the vineyard and destroy before the borers emerge in spring (April). Remove and destroy any alternate hosts from fencelines or dead shrub/debris piles from the vineyard area. If the vineyard is near a poorly managed or abandoned orchard or vineyard, talking to the landowner about management may be necessary.

Management—chemical control: HOME USE

- acetamiprid
- carbaryl
- imidacloprid
- pyrethrins—Some formulations are OMRI-listed for organic use.

- spinosad—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

It is difficult to control twig borers with chemical insecticides due to their burrowing nature. There is only a small window of opportunity to apply insecticides, typically in spring, when adults are mobile and have not yet laid their eggs within the shoot or cane. Do not apply chemical controls if adults are no longer visible.

- carbaryl (Sevin 4F and other brands) at 1 to 2 lb ai/a. PHI 7 days. REI 6 days. Avoid using if mite outbreaks are a concern. Group 1A insecticide.

Grape—Brown marmorated stink bug

Halyomorpha halys

BMSB are found in most commercial winegrape growing regions. BMSB crawl into clusters near harvest. They may pose a risk to fruit quality as they produce an aromatic taint during processing for wine production. Monitor for BMSB using commercially available pheromone traps placed at the border of vineyards, close to surrounding vegetation. Alternate hosts include English holly, broadleaf maple, tree of heaven, and empress tree. BMSB populations tend to build up during late summer and move from surrounding vegetation into vineyards and target grape clusters for shelter. There is a threshold of four bugs per cluster in winegrapes due to taint that can occur during wine production.

See also, in this Handbook:
EMERGING PEST: Brown Marmorated Stink Bug—A Pending Threat to Pacific Northwest Agriculture

For more information

Brown Marmorated Stink Bug (https://catalog.extension.oregonstate.edu/em9054)

El Chinche Apestoso Marrón Marmolado (https://catalog.extension.oregonstate.edu/em9054s)

How to Monitor Brown Marmorated Stink Bug in Specialty Crops (https://catalog.extension.oregonstate.edu/em9138)

Samuri Wasp: Promising Egg Parasitoid for Management of Brown Marmorated Stink Bug (https://catalog.extension.oregonstate.edu/em9164)

Grape—Cottony grape scale

Pulvinaria vitis

Pest description and crop damage This scale overwinters on grape canes as an immature brownish to black scale of about 0.06 to 0.14 inches long and has a flat and oval outline. Scales attain a maximum length of about 0.25 inches during spring. The conspicuous, cottony egg sac of the mature form is two to three times the length of the scale body. The insect feeds on foliage, reduces the vigor of the plant, and causes twig dieback. Feeding scales produce honeydew, which becomes a food source for ants and a substrate for sooty mold. Scout for noticeable presence of ants, as this may be the first sign that the scale is present on a vine.

Biology and life history Each female lays about 3,000 eggs. The egg sac remains for some time after the female has died and crawlers have dispersed to the undersides of leaves. Scales reach maturity in June, and crawlers appear in July and August. This pest has not been common in Oregon vineyards. Caution is to be taken with scale insects as they may vector certain grapevine viruses, such as grapevine leafroll virus.

Management—biological control

Although biological controls of cottony maple scale have not been studied, scale insects generally are preyed upon heavily by parasitic wasps.

Management—cultural control

Since much of the vine is removed at pruning, it may be unnecessary to apply control measures unless the scale is infesting the main trunk or cordons.

Management—chemical control: HOME USE

Dormant-season spray

- horticultural oils—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

- buprofezin (Applaud) at 0.53 lb ai/a. PHI 7 days. Do not exceed 1.06 lb ai/a per season. Allow at least 14 days between applications. Apply by ground using 50 to 200 gal/a water, depending on the size of the grape plants. Use of a higher volume of water will ensure better coverage, especially under adverse conditions, such as hot, dry weather and/or a dense canopy. Do not exceed two applications per season. Although cottony grape scale insect is not specifically listed on the label for grapes, it is an effective and legal use. Group 16 insecticide.
- horticultural oil (several brands)—Consult label for rate. Apply oil at a spray volume of 200 to 300 gal/a. Apply in late March or early April while vines are still dormant; do not apply oil after budbreak. Some formulations are OMRI-listed for organic use.
- imidacloprid (Admire Pro and other brands)
  - ◊ Soil application at 0.25 to 0.5 lb ai/a. PHI 30 days. Apply in one or two drip irrigations between budbreak and pea size stage of berry development. Consult label for restrictions. Do not apply more than 0.5 lb ai/a per year. Group 4A insecticide.
  - ◊ Foliar application at 0.036 to 0.05 lb ai/a. PHI 0 days. Although scale insect is not listed under foliar applications for grape, it is a legal use and should be helpful in controlling scale crawlers. Do not exceed 0.1 lb ai/a per year. Allow 14 days between applications. Group 4A insecticide.

Grape—Cutworm

Includes
Climbing cutworm *(Abagrotis orbis* and *Agrotis vetusta)*
Redbacked cutworm *(Euxoa ochragaster)*
Spotted cutworm *(Xestia c-nigrum)*
Variegated cutworm *(Peridroma saucia)*
Winter cutworm (Noctua pronuba)

For more information about winter cutworm, and photos and descriptions of the other cutworms, please refer to the publication "Winter Cutworm: A New Pest Threat in Oregon" (https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/em9139_1.pdf)

Pest description and crop damage Only the surviving overwintering cutworm larval population causes damage to grapevines. Cutworm larvae injure grapes primarily in early spring at or shortly after budbreak. The larvae feed on developing buds and emerging young shoots. When primary buds/shoots are destroyed, secondary buds may emerge. Depending on variety, the fruitfulness of secondary shoots is often lower than primary shoots, leading to reduced yields. Adults are dark gray moths about 1 inch long, and wingspan is about 1.5 inches. Caterpillars of these moths (cutworms) grow to about 1.5 inches long and are generally a dull gray-brown. Spotted cutworms have a row of dark, elongated triangular markings on each side of the upper body surface.

Biology and life history The spotted cutworm overwinters in the soil or under debris as a partially grown second or third instar. Cutworms begin feeding on winter annual weeds during warm periods in February to March. By budbreak, they are nearly full-grown. They remain under cover during the day (in cracks in the soil, plant debris, or under rough bark on the trunk), and climb vines at night to feed on buds and shoots. Not all cutworm species in vineyards will climb grapevines. If broad-leaved weeds are available, many cutworm species will stay on the vineyard floor. Recent research indicates that most damage to grapevine buds is caused by the two climbing cutworm species, *Abagrotis orbis* and *Agrotis vetusta*. Mature larvae return to the soil to pupate. The pupal stage lasts 7 to 10 days. Moths emerge from the soil in May and June. There are one or more generations per year.

Sampling and thresholds Cutworm control decisions usually are based on levels of bud injury in early spring. Cutworm infestations usually are localized within vineyards and often occur in the same places each year. Monitoring should start during bud swell for the presence of bud feeding/injury by cutworms. Concentrate on areas with a history of cutworm damage. Randomly select 20 locations to sample. Check three vines within each location for buds damaged by cutworms (total of 60 vines). Treatment is justified when about 10 to 15% of buds in susceptible areas are damaged. Treatment of an entire vineyard is rarely needed as damage is often localized and limited in size.

Continue monitoring until average shoot growth has reached 6 inches. If the population is not causing damage before this growth stage, foliar development will be sufficient to ensure adequate grape production.

Management—biological control

Natural enemies of cutworms include predatory and parasitic insects, nematodes, pathogens, mammals, birds, and reptiles. Parasitic wasps are probably the most important group, but predatory beetles and parasitic flies are also important in biological control.

Management—cultural control

Retention of broadleaved weeds in spring may help reduce cutworm damage, while mowing or removing these weeds at this time can increase it.

Management—chemical control: HOME USE

- azadirachtin (neem oil)
- *Bacillus thuringiensis* (Bt)—For most effective control, apply when the first tiny worms appear. Apply weekly until threat subsides. Some formulations are OMRI-listed for organic use.
- carbaryl—To avoid harming bees, do not apply products containing carbaryl to plants in bloom.
- cyfluthrin
- imidacloprid
- permethrin
- pyrethrins—Some formulations are OMRI-listed for organic use.
- spinosad—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

Barrier sprays to grapevine trunks and to posts, with fenpropathin or bifenthrin, are the preferred control strategy for cutworms. Apply barrier insecticides to the trunks, wire, posts, and the ground immediately beneath the vines, avoiding foliage as much as possible.

Barrier sprays

- bifenthrin (Brigade 2 EC and other brands) at 0.05 to 0.1 lb ai/a. PHI 30 days. Apply to trunks and posts in early-mid March. Thorough coverage is essential to get control. Do not apply more than 0.1 lb ai/a per season. Group 3A insecticide. Restricted use pesticide.
- fenpropathrin (Danitol 2.4 EC) at 0.2 to 0.4 lb ai/a. PHI 21 days. Apply to trunks and posts prior to emergence of the soil to feed on buds prior to budbreak (early-mid March to April, depending on location). Do not use more than 0.8 lb ai/a, and no more than two times per season to avoid resistance. Group 3 insecticide. Restricted use pesticide.

Foliar sprays

- carbaryl (Sevin 4F and other brands) at 1 to 2 lb ai/a. PHI 7 days. REI 6 days. Do not apply more than 10 lb ai/a per year (no more than 5 applications). Group 1A insecticide.
- chlorpyrifos (Lorsban Advanced) at 0.94 lb ai/a as a banded application to the base of vines in at least 50 gal/a water using power-operated ground spray equipment. Use in Idaho and Washington only as 24c labels allow use in grapes (ID-010004 and WA-090002). PHI 35 days in Washington. Do not apply after bloom stage of growth. Do not exceed two applications per season. Do not apply this product through any type of irrigation system. Restricted use pesticide (organophosphate insecticide). Group 1B insecticide.
- phosmet (Imidan 70W) at 0.7 to 1.5 lb ai/a. PHI is dependent on rate – check label. REI 14 days. Do not apply more than 4.55 lb ai each year This is an organophosphate insecticide and use should be limited. Group 1B insecticide. Although cutworm is not listed on the label, it is an effective and legal use.
- spinetoram (Delegate WG) at 0.047 to 0.078 lb ai/a. PHI 7 days. Treatment interval with this pesticide is 4 days. Do make more than 5 applications per season (not to exceed 0.305 lb ai/a per year), and do not use more than 2 consecutive applications. Group 5 insecticide.
- spinosad (Success or Entrust) at 0.062 to 0.124 ai/a. PHI 7 days. Treat when pests appear. Heavy infestations may require repeat applications. Do not exceed 0.45 lb ai/a per season. Do not exceed 3 applications in any 30-day period, and allow at least 5 days between applications. Entrust is OMRI-listed for organic use. Success is not listed for organic production. Group 5 insecticide.

Note: Bifenthrin, carbaryl, chlorpyrifos, fenpropathrin, methomyl, and phosmet are broad-spectrum insecticides and their use on foliage may adversely affect beneficial insect and mite populations, resulting in secondary outbreaks of spider mites and other pests. Apply sprays late in the day to maximize contact toxicity to the nocturnal larvae.

Grape—European fruit lecanium scale

Parthenolecanium corni

Pest description and crop damage This scale assumes many sizes, shapes, and colors. The typical form is almost hemispherical, shiny brown, smooth, and approximately 0.12 to 0.19 inch long. Eggs are oval and pearly white. The young vary from yellow to pale brown.

Biology and life history Adult females may be found on leaves or bunches but mostly on shoots of current growth or on 1- to 3-year-old wood. Males have not been observed. Females lay eggs under their bodies. As the female dies, the body shrinks and an egg-filled pocket is formed. As more eggs are laid, the walls of the scale's body becomes hard and, after death, brittle. Young overwinter in a juvenile state on 1- to 3-year-old wood. They mature in late spring, when eggs are produced in great abundance. Hatching continues during early to midsummer. There is one brood per year.

Management—biological control

Although biological controls of European fruit lecanium scale have not been studied, parasitic wasps generally parasitize scale insects heavily. In the Yakima Valley, *Metaphycus* spp. is the dominant parasitoid.

Management—cultural control

Since much of the vine is removed at pruning, it may be unnecessary to apply control measures unless the scale is infesting the main framework of the vine (main canes, cordons and trunk).

Management—chemical control: HOME USE

Dormant-season spray

- horticultural oils—Some formulations OMRI-listed for organic use.

Growing-season spray

- carbaryl
- imidacloprid
- pyrethrins—Some formulations OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

- horticultural oil (several brands)—Consult label for rate. Scales are controlled best in the dormant season. Apply spray at 200 to 300 gal/a with a hand or air carrier machine. Sprays help control mealybugs. Do not apply dormant oil after buds start to open. Some formulations OMRI-listed for organic use.
- imidacloprid (Admire Pro and other brands
  - ◊ Soil application at 0.25 to 0.5 lb ai/a. PHI 30 days. Apply in one or two drip irrigations between budbreak and pea size stage of berry development. Consult label for restrictions. Do not apply more than 0.5 lb ai/a per year. Group 4A insecticide.
  - ◊ Foliar application at 0.036 to 0.05 lb ai/a. PHI 0 days. Although scale insect is not listed under foliar applications for grape, it is a legal use and should be helpful in controlling scale crawlers. Do not exceed 0.1 lb ai/a per year. Allow 14 days between applications. Group 4A insecticide.

Grape—Grape bud mite

Includes grape bud mite *(Colomerus vitis)*

Pest description and crop damage Grape bud mites are tiny (0.1 to 0.2 mm long), wormlike, and whitish yellow with two pairs of legs near the head. They can only be seen under magnification (45 X or higher on a microscope), and the damage they cause is usually the first indication of their presence. The grape bud mite resides within the bud and causes damage by feeding on the stem, leaf and flower primordia within the bud. In spring, damaged buds may be delayed and only weak shoots may grow, if any at all from damaged buds. Vines infested with bud mites may exhibit erratic budbreak, stunted shoots, malformed basal leaves, and have reduced number of flower clusters. Stunted shoots may have arrested development and fail to grow beyond a few inches. Damage is most visible on tissues rapidly growing during budbreak and until shoots are less than 6 inches in length. Symptoms observed from mite feeding should not be confused with symptoms of nutrient deficiency (boron or zinc), low reserve carbohydrates, herbicide damage, frost, or thrips damage. There are distinct differences between bud mite-related damage and other factors.

Biology and life history Grape bud mites overwinter as adults inside buds where they feed on bud tissues and may kill the tissues within the overwintering bud. When buds begin to swell in spring, mites migrate to newly developing tissues where they feed and lay eggs. Eggs hatch and develop into adults. Bud mites move to the newly forming buds in the axils of the leaf petiole where they reside until budbreak the following year. During the next growing season, once growth commences, mites within the inner scales are distributed along the shoot length as the shoot develops. Those mites in the outer scales remain at the base of the shoot.

Sampling and thresholds Eriophyid mites are difficult to identify in sampling because of their microscopic size and translucent color. Because they reside in the buds for the majority of the year, they can be difficult to find. Populations are assessed by examining buds on dormant canes in winter, using magnification of 45X or higher. A sample should consist of forty 1-year old shoots (canes) samples randomly from affected areas in the vineyard. Select only the basal portions of the cane with at least three nodes. Place canes in a plastic bag and keep refrigerated until inspection. To look for mites in buds, use a dissecting microscope, and gently pull the outer bud scales off and work from the outside in, searching for the mites. To date, there are no damage thresholds known. However, if high populations are present in dormant buds, damage may have already been done, and spring control will reduce populations of bud mites for future years. While bud mites are different from rust mites, they look similar under magnification.

Management—chemical control: HOME USE

Dormant-season oils used for other pests may control this pest.

- carbaryl
- pyrethrins

Management—chemical control: COMMERCIAL USE

The emergence of these mite species as pests of Pacific Northwest vineyards may be related to a general reduction in sulfur use to manage disease in some areas of Oregon and Washington. Sulfur continues to be used by organic growers and in many other Oregon vineyards as an economical way to control powdery mildew. Sulfur is effective to control pest populations of rust and erineum (blister) mites but may cause a decline in predatory mites when used. Chemical management of pest mites should be based on properly timed applications of sulfur. The current recommendations for control of bud mites come from research conducted in Australia.

High-volume wettable sulfur (Microthiol Disperss, Kumulus DF, other brands) Check specific label for rate; apply at 100 gal water per acre. Make application at the woolly bud stage or during budbreak when temperature is above 60°F. A second follow-up spray is recommended approximately 7 to 10 days after the first, depending on weather conditions and growth rate, in order to target mites that were protected in unopened buds during the first spray application. High spray volume and timing are critical for targeting mites during migration and before they start producing eggs. Most brands are OMRI-approved for organic production.

Use sulfur sprays in newly established vineyards. Typically young vines (years 1 and 2) are not sprayed as regularly as producing vineyards, allowing mite populations to build during the growing season. It is best to apply sulfur during the growing season in young vineyards to control pest mite populations and powdery mildew.

For more information:

See http://www.extension.org/pages/33107/grape-rust-mite.

Grape—Grape erineum mite

Colomerus vitis

Pest description and crop damage This mite is similar in morphology to bud mite. It is microscopic, wormlike, and white-yellow in color. It overwinters between outer bud scales and bud tissue and feeds on leaves during spring and summer. The upper leaf surface becomes blistered, and the lower leaf surface of the blister appears hairy and white, almost resembling fungal growth. The lower leaf surface turns from a white color early in the season and progresses to yellow or brown later in the season. In severe cases, these mites may infest clusters in early spring. Grapevine Pinot Gris virus (GPGV) is known to be vectored by this mite.

Biology and life history During summer, colonies of erineum mites live in blisters (erinea) formed by their feeding on lower leaf surfaces. The blisters are comprised of masses of enlarged leaf hairs. These blisters protect mites from natural enemies and direct contact of pesticide sprays. As the population increases, some move to new areas or other leaves and form new erinea. From mid-August until leaf drop, there is a movement from the erinea back to overwintering sites beneath the bud scales.

Sampling and thresholds It is common for erineum mites to be found sporadically throughout western Oregon vineyards in any given year. In recent years, there has been an increase in erineum mite presence in vineyards where there has been reduced sulfur use. However, this rarely leads to economic problems or crop losses. Currently, there are no damage or management thresholds.

Management—biological control

Predatory mites and beetles are important biological control agents of these mites.

Management—chemical control: HOME USE

Dormant-season oils and insecticides used for other pests and sulfur applications for powdery mildew usually control this pest. Directed controls specifically for erineum mite usually are not necessary.

Management—chemical control: COMMERCIAL USE

Dormant-season oils and insecticides used for other pests usually control this pest. Also, sulfur applications for grape powdery mildew usually keep mite populations under control. Wettable sulfur is more effective than flowable sulfur formulations. Chemical controls are usually ineffective due to mite protection within galls.

- spirodiclofen (Envidor 2SC) at 0.25 to 0.53 lb ai/a. PHI 14 days. Use at least 100 gal/a. Do not use more than once a season, and do not exceed 0.53 lb ai/a per season. Group 23 acaricide.
- spirotetramat (Movento) at 0.10 to 0.13 lb ai/a. PHI 7 days. Ensure that there is adequate foliage for absorption of the compound. Allow 30 days between applications. Do not exceed 0.2 lb ai/a per season. Use a high quality spreader to enhance penetration into foliage; see label for more details on which adjuvants to use or avoid. Group 23 insecticide. Use recommended only when significant infestation may be affecting crop productivity.

Grape—Grape mealybug

Pseudococcus maritimus

Pest description and crop damage The grape mealybug has a soft, oval, flattened, distinctly segmented body. The adult female is 0.25 to 0.5 inch long, pink to dark purple, and with a white, mealy, wax secretion. Long posterior filaments along the lateral margin of the body become progressively shorter toward the head. Eggs are yellow to orange and laid in cottony egg sacs. Crawlers that hatch from them are tiny (0.06 to 0.12 inch long), yellow to brown. Males and females are similar in early instar stages. Males pass through three nymphal instars, then form a cottony cocoon about 0.12 inch long in which the pupa is formed. All stages of the female are similar, varying in size only. The crawler stage of this pest is most mobile.

Statewide surveys show that mealybugs can be problematic in southern and western grape-growing regions of Oregon. In these regions, mealybugs may come into direct contact with grape clusters resulting in direct crop losses. Grapes grown in the Willamette Valley of Oregon don't seem to have this severe problem of cluster contamination. Grape mealybug contaminates fruit with cottony egg clusters, eggs, immature stages, adults, and honeydew. Sooty mold (a black fungus) may grow on the honeydew. Of most concern in all regions is that grape mealybugs are important vectors of the grapevine leafroll virus. This insect can therefore spread the virus within and across vineyards. The virus may reduce crop yields and fruit quality. For this reason, it is important that growers know the status of mealybug presence in their vineyards.

Biology and life history Grape mealybugs of all life stages overwinter on the cordon section of vines and under the loose bark. These are the preferred feeding sites, making them inconspicuous to growers. Increasing summer populations move to new tissue growth to feed. Eggs can be laid on all plant parts during the season. Generations may overlap during the latter part of the season making control more difficult. As populations build, migrating mealybug populations may move to clusters during July and August, causing direct crop damage. Some females maturing in mid- to late August lay their eggs on fruit and leaves. Most late summer populations return to old wood in the cordon section of vines and under the loose bark to overwinter.

Sampling and thresholds Control thresholds have not been defined. The number of late season migrating mealybugs increase the likelihood of contamination with vine leafroll virus and warrant control. Commercial pheromone traps are available to aid in effective monitoring for mealybugs. Vineyards with known virus infection should be monitored for the presence of mealybug populations using pheromone traps starting during the late dormant period.

Management—biological control

Little research has been done in Oregon on the effectiveness of natural enemies in keeping mealybug populations at levels below economic damage. Parasitic wasps, predatory bugs, predatory beetles, lacewings, and spiders can take a considerable toll of mealybugs in vineyards that use few broad-spectrum chemicals. A lady beetle, the "mealybug destroyer" *(Cryptolaemus montrouzieri)*, is considered an effective predator of mealybugs worldwide. It has been seen in recent seasons in some Washington vineyards and is available for release from some insectaries.

Management—cultural control

To prevent movement and spread of mealybugs and virus within and between vineyards, it is critical to restrict movement of fruit and manage winery pomace (grape waste) properly.

Management—chemical control: HOME USE

Dormant-season spray

- superior-type oil

Growing-season spray

- acetamiprid
- cyfluthrin
- pyrethrins (often used in a mix with other ingredients)—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

Dormant season

A dormant spray with horticultural oil and/or the use of buprofezin (Applaud) causes the least disruption to IPM. Control is most effective when mealybugs are in the crawler stage, and Applaud is the recommended treatment. Direct spray the trunk and main laterals using sufficient water to loosen bark and drive the pesticide into cracks. If infestations are patchy, use spot-treat only. Frequent use of imidacloprid or chlorpyrifos can result in spider mite outbreaks.

Early season

- buprofezin (Applaud) at 0.40 to 0.53 lb ai/a. PHI 7 days. Apply at early stages of crawler emergence by ground using 50 to 200 gal/a water, depending on the size of the grape plants. Use of a higher volume of water will ensure better coverage, especially under adverse conditions such as hot, dry weather and/or a dense canopy. Do not exceed 1.05 lb ai/a per season. Allow at least 14 days between applications. Group 16 insecticide.
- Chromobacterium subtsugae strain PRAA4 (Grandevo) at 2 to 3 lb product per acre. PHI 0 days. OMRI-listed for organic use.
- chlorpyrifos (Lorsban Advanced) at 0.94 to 1.88 lb ai/a in at least 50 gal/a water using ground equipment only. For use in Idaho and Washington only (24c labels: ID-010004 and WA-090002). PHI 35 days. Use 0.94 lb ai/a for normal infestations, prior to bloom stage of growth. Use 1.88 lb ai/a for high infestations only as a dormant or late dormant application. Do not exceed 1.88 lb ai/a or two applications per crop growing season. Do not apply this product through any type of irrigation system. This is a restricted use pesticide (organophosphate insecticide). Group 1B insecticide.
- horticultural oil (several brands)—Consult label for rate. Apply oil at 200 to 300 gal/a. Apply in late March or early April. Do not apply oil after budbreak. These compounds generally do not lead to good levels of control.
- imidacloprid (Admire Pro and other brands)
  - Soil application at 0.25 to 0.5 lb ai/a. PHI 30 days. Apply in one or two drip irrigations between budbreak and pea-size stage of berry development. Consult label for restrictions. Do not apply more than 0.5 lb ai/a per year. Group 4A insecticide.
  - Foliar application at 0.036 to 0.05 lb ai/a. PHI 0 days. Do not exceed 0.1 lb ai/a per year. Allow 14 days between applications. Group 4 A insecticide.
- phosmet (Imidan 70W) at 1.0 to 1.5 lb ai/a. PHI 7 days. Apply as a delayed dormant (pre-budbreak) spray with a spreader sticker. REI 14 days. Do not use more than 4.55 lb ai/a each year. Phosmet has not shown good control in Oregon. This is an organophosphate insecticide and use should be limited. Group 1B insecticide.
- spirotetramat (Movento) at 0.10 to 0.13 lb ai/a. PHI 7 days. Ensure that there is adequate foliage for absorption of the compound. Allow 30 days between applications. Do not exceed 0.2 lb ai/a per season. A high quality spreader should be used to enhance penetration into foliage; see label for more details on which adjuvants to use or avoid. Group 23 insecticide.

Summer

- azadirachtin (Aza-Direct, Neemix and other brands) at 0.01 to 0.04 lb ai/a. Some formulations are OMRI-listed for organic use. Efficacy in PNW vineyards has been determined to not be very effective.
- buprofezin (Applaud 70DF) at 0.39 to 0.53 lb ai/a. PHI 7 days. Do not exceed 1.05 lb ai/a per season. Allow at least 14 days between applications. Apply by ground applicator using 50 to 200 gal/a water, depending on grape size. Using a higher volume of water assures better coverage, especially under adverse conditions such as hot, dry weather and/or a dense canopy. Do not exceed two applications per crop cycle. Group 16 insecticide.
- Chromobacterium subtsugae strain PRAA4 (Grandevo) at 2 to 3 lb product per acre. PHI 0 days. OMRI-listed for organic use.
- imidacloprid (Admire Pro and other brands) at 0.036 to 0.05 lb ai/a. Foliar application. PHI 0 days. Do not exceed 0.1 lb ai/a per year. Allow 14 days between applications. Group 4 A insecticide.
- malathion (several brands) at 1 to 2.5 lb ai/a. PHI 3 days. Make summer application at first sign of honeydew on fruit (early to mid-July). Group 1B insecticide. This is an organophosphate insecticide. Malathion has not shown good control in Oregon.
- phosmet (Imidan 70-W) at 1.0 lb ai/a applied when fruit sizing and pest is present on fruit and/or leaves. Ensure adequate coverage of fruit and leaves for best result. PHI 7 days. REI 14 days. Do not apply more than 4.55 lb ai/a annually. Group 1B insecticide. This is an organophosphate insecticide and use should be limited. Phosmet has not shown good control in Oregon.
- spirotetramat (Movento) at 0.10 to 0.13 lb ai/a. PHI 7 days. Ensure that there is adequate foliage for absorption of the compound. Allow 30 days between applications. Do not exceed 0.2 lb ai/a per season. A quality spreader should be used to enhance penetration into foliage; see label for more details on which adjuvants to use or avoid. Do not exceed 0.2 lb ai/a per season. Group 23 insecticide.
- thiamethoxam + chlorantraniliprole (Voliam Flexi) at 0.155 lb ai/a. PHI 14 days. Allow 14 days between applications. Do not apply more than 0.109 lb ai/a of thiamethoxam or 0.2 lb ai/a of chlorantraniliprole per season (2 applications) per season. Groups 4A and 28 insecticides.

For more information:

Prevention and Management of Grapevine Leafroll Virus and Mealybugs in Oregon Vineyards (https://catalog.extension.oregonstate.edu/em8990)

Distribution and Monitoring of Grape Mealybug: A Key Vector of Grapevine Leafroll Disease in Oregon (https://catalog.extension.oregonstate.edu/em9092)

Field Monitoring for Grapevine Leafroll Virus and Mealybug in Pacific Northwest Vineyards (https://catalog.extension.oregonstate.edu/em8985)

Grape—Grape phylloxera

Daktulosphaira vitifoliae

Pest description and crop damage Phylloxera are small, aphid-like insects that feed on roots of grapevines causing stunted growth, reduced vigor, and vine death of own-rooted Vitis vinifera grape varieties. Depending on the vineyard location and climate, death can occur within as few as 3 to 10 years. Mortality of vines is quicker in drier climates where vines experience more nutrient and water stress. Vineyard decline has been a slower process in Oregon as compared to other warmer, more arid regions, particularly because vines are under limited soil moisture or nutrient stress. Phylloxera can be found in most winegrape-growing regions of Oregon with the exception of the Milton-Freewater area of eastern Oregon. Some regions of Washington and the Walla Walla Valley region of Oregon are free of phylloxera at this time. Preventing the entry of phylloxera is critical for vineyards known to be phylloxera-free. Sampling of declining vineyards is encouraged to determine presence of phylloxera in areas thought to be phylloxera-free, particularly to avoid further spread.

Biology and life history The wingless females are oval in shape; egg layers are pear-shaped. They vary from 0.03 to 0.04 inch long. Adults vary in color according to food supply: on fresh, vigorous roots they are yellow, yellowish green, olive green, or light brown; on weakened roots, they are brown or orange.

Sampling and thresholds Sampling for phylloxera should be conducted during late summer and early fall when populations are at their highest. Dig 12 to 18 inches below the soil surface about 12 inches away from the vine trunk. Sample both soil and roots. Use a stereoscope to view the roots and search for root swellings (nodosites and tuberosites), adults and eggs. If you do not have a stereoscope or dissecting microscope available with adequate magnification, contact your local Extension agent or crop consultant for assistance in identifying the insect. Only one phylloxera is needed to start an infestation within the vineyard, as populations can increase and spread over time and attack grapevine roots.

Management—cultural control

Prevention is the key to phylloxera management. However, because of the widespread nature of this pest, it is advised that vineyards be planted with vines grafted to phylloxera-resistant rootstock. Once an own-rooted *Vitis vinifera* vineyard is infested, there is no reversing the damage. Vines can be maintained for longer periods of time by reducing vine stress through managing nutrition and irrigation.

Management—chemical control: HOME USE

Insecticides effective at controlling root populations are not registered for home use. See cultural control information for management option.

Management—chemical control: COMMERCIAL USE

There are commercially available chemicals labeled for phylloxera control. However, applications have limited efficacy in reducing phylloxera populations or reversing the damage already done to infested vines. Soil applications of insecticides labeled for use on phylloxera are ineffective in reaching all roots that may be hosting phylloxera populations. Also some chemical controls are for foliar forms of phylloxera, but these are often not observed in *Vitis vinifera* vineyards in the PNW.

- fenpropathrin (Danitol 2.4 EC) at 0.2 to 0.4 lb ai/a. Foliar application for foliar-feeding phylloxera. PHI 21 days. Group 3 insecticide. Do not apply more than 2 times per season (max 0.8 lb ai/a per year). Restricted use pesticide.
- sodium tetrathiocarbonate (Enzone)—Fumigant; best if used pre-planting or prior to re-planting of a vineyard. Consult label for rate and application instructions. Multiple treatments per year may be required for good efficacy; be aware that all biota within the treatment zone will be killed. Cautionary statements are found detailed on product label. Registered for use in Washington and Oregon, only.
- spirotetramat (Movento) at 0.10 to 0.13 lb ai/a. Apply with a high-quality adjuvant. Ensure there is adequate foliage to enable absorption into tissues. PHI 7 days. Allow 30 days between applications. Do not exceed 0.2 lb ai/a per season. Group 23 insecticide acts as a systemic to control phylloxera adults and larvae.
- thiamethoxam + chlorantraniliprole (Voliam Flexi) at 0.155 la ai/a. PHI 14 days. Do not apply more than 2 applications per season (not to exceed 0.109 lb ai/a of thiamethoxam or 0.2 lb ai/a of chlorantraniliprole per season). Allow 14 days between applications. Groups 4A and 28 insecticides.

For more information, see: OSU Extension publication EC 1463, Grape Phylloxera: Biology and Management in the Pacific Northwest (https://catalog.extension.oregonstate.edu/ec1463).

Grape—Grape rust mite

Calepitrimerus vitis

Pest description and crop damage Grape rust mites are tiny (0.1 to 0.2 mm long) and a have a wormlike shape, much like the bud and erineum mite. They have two pair of legs near the head. These mites are hard to see without magnification (45X or higher under a microscope), and are difficult to distinguish from other eriophyid mite species. The damage they cause to small shoots or leaves is usually the first indication of their presence. Grape rust mites cause damage to newly growing tissues in spring. Shortly after budbreak, rust mite damaged shoots appear stunted and may have significant pubescence—a downy appearance with many plant hairs. Leaves are often crinkled, deformed and cuplike. Scarring may be found on the stem tissues. Rust mites are found mainly on leaves during late spring and early summer, where they cause stippling. Stippling is most often found on the youngest leaves at the shoot tips or on lateral shoots as the season advances. High populations of rust mites on leaf surfaces can occur in mid- to late-summer through early fall. Later season symptoms are visible as purplish or blackish green color which may transition to a bronze (red-brown) color toward harvest.

Biology and life history Grape rust mites overwinter as adult females under the bark, in crevices and between the outer bud scales, and they migrate from these areas to developing shoots in early spring. Mites may congregate and feed on young susceptible shoots, then move on to opening foliage where they continue feeding during summer. Unlike most other mite species, grape rust mites feed on the top and bottom surfaces of leaves. Feeding on epidermal tissue of leaf surfaces results in stippling of the leaf during spring and summer, and they may cause visual discoloration of leaves that begins as dark-green to black and become a bronze or brown color during later summer when leaf populations are high.

Sampling and thresholds Rust mites are difficult to identify on plant tissues because of their microscopic size and translucent color. Presence is determined by examining buds collected during the dormant season under a stereomicroscope with a minimum of 45X magnification. Stems or leaves can be collected and observed for rust mite presence in spring and summer. Scout for grape rust mite populations during summer. Often leaf "bronzing" may start out as a dark green-black or purplish hue on the leaf surface and progresses to a bronze-copper color later in the season. Under high magnification (greater than 45X) worm-like mites can be observed moving on upper leaf surfaces. Assess mite density by using a mite washing technique (http://www.extension.org/pages/33107/grape-rust-mite#). Make note of summer population densities and plan to sample again during the late dormant season, as the majority of mites do not survive

winter. Not all infested vineyards will exhibit the leaf discoloration or "bronzing," particularly in healthy, vigorous vineyards of western Oregon.

Scouting during the winter involves collecting dormant 1-year old canes to examine buds. Randomly select forty canes from across affected areas in the vineyard. Canes should be cut close to the base of the shoot and should consist of at least 3 buds. Also collect loose bark from the trunk of the vine, focusing on the head of the vine. Place tissues in separate plastic bags and keep refrigerated until inspection. Rust mite numbers pre-season can be determined by observing these buds under magnification, starting by removing the outer bud scales. Rust mites are often found at the base of the bud, directly under the outer bud scale and surrounding areas. To determine if rust mites are on bark tissues, observe under the dissecting scope or place in a plastic bag with a 35% isopropyl alcohol solution, seal and shake briskly for 30 seconds. Decant into a petri dish and observe under a dissecting scope. To learn more about the washing method, view this instructional video (http://youtu.be/9Qe4gJ3y_-s?list=UUBr5ACbEF_9UljHRaT-2iSQ). To read more about grape rust mite, see Grape Rust Mite on eViticulture.org (http://www.extension.org/pages/33107/grape-rust-mite). There are no damage thresholds established at this time.

Management—biological control

Grape rust mites are subject to predation by a number of natural enemy species, particularly predatory mites. Sparse populations on leaves during spring and summer can be regulated by predatory mites, when predator-friendly chemicals are used in pest and disease management. The presence of grape rust mites during summer, and consequent recruitment of predatory mites, may also enhance biological control of spider mites. For information of the impact of commonly used chemicals on predators, see: OSU Extension publication EM 9095, Evaluating Compatibility of Horticultural Oils and Sulfur with Vineyard IPM (https://catalog.extension.oregonstate.edu/em9095).

Management—chemical control: HOME USE

- Dormant-season oils and insecticides used for other pests may control this pest.

Management—chemical control: COMMERCIAL USE

Spring to early summer

Sulfur continues to be used by many Oregon growers as an economical way to prevent powdery mildew, and it also is an effective way to control rust mite populations. Rust mite presence and damage has been found mainly in young vineyards in western Oregon, in part due to the fact that these vineyards are generally not managed with a full fungicide program during early years of establishment, and this allows pest mite populations to develop. Since there is evidence that rust mites are present on nursery stock, it is important for new vineyards to apply sulfur mid-spring to summer during the first few years to prevent damaging populations from developing and causing tissue damage and delayed canopy development.

- insecticidal soap (M-Pede and other brands) at 1-2% solution; Consult label for rates. PHI 0 days. Do not mix with sulfur. Some formulations are OMRI-listed for organic use.
- neem oil (Trilogy and other brands)—Check label for rates. Some formulations are OMRI-listed for organic use.
- stylet oil at 1 to 2 gal of product per 100 gal water/a. Do not apply sulfur within 10 days of applying oil. Do not apply when temperatures are above 90°F or below 50°F. Stylet oil has limited efficacy in western Oregon in controlling rust mites and use has resulted in increased erineum mite problems in early season. Some formulations are OMRI-listed for organic use.
- sulfur (Microthiol Dispersss, Kumulus DF, or other brands of wettable sulfur) at 3.2 to 4.0 lb ai/a (4 to 5 lb product/100 gal water) applied just before budbreak (at woolly bud stage) or during budbreak. A second spray is recommended between 7-14 days after the first in order to target mites as they emerge on new buds and move on expanding shoots and leaves. High spray volume and timing are critical for targeting mites during migration. Watch grape phenology closely when making these applications and consider the temperatures during early season as Oregon can be cold and have limited efficacy of sulfur if temperatures are below 60ºF. Group M2 product, 7-14 day spray interval, 0 PHI. Most brands are OMRI-approved for organic production.

Late summer

Foliar applications of wettable sulfur have shown efficacy in reducing canopy populations of rust mite mid- to late-summer when populations are high. During late summer/early fall mites begin migrating to overwintering sites and may be protected from sprays. More research is needed in this area to determine the best timing of sprays to control this pest to prevent problems with damage the following spring.

Grape—Grasshopper

Various species

Pest description and crop damage May feed on foliage, flowers and developing green fruit, reducing fruit yield and quality. This is often not observed in vineyards and may cause very low levels of damage in sporadic areas of the vineyard.

Management—chemical control: HOME USE

- carbaryl
- cyfluthrin
- pyrethrins—Some formulations are OMRI-listed for organic use.
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- carbaryl (Sevin 4F and other brands) at 0.5 to 1.5 lb ai/a. Apply a rate of 0.5 to 0.75 lb ai/a for nymphs or on smaller canopies and 1.0 to 1.5 lb ai/a for mature grasshoppers or dense foliage. PHI 7 days. REI 6 days. Do not apply to fruit as it may cause residue spotting. Group 1A insecticide.

Grape—Leafhopper

Includes
Virginia creeper leafhopper *(Erythroneura ziczac)*
Western grape leafhopper *(Erythroneura elegantula)*

Pest description and crop damage Adult western grape leafhoppers (WGLH) and Virginia creeper leafhoppers (VCLH) are about 0.12 inch long and are pale yellow with reddish and dark brown markings. VCLH can be distinguished from WGLH by red spots on the back behind the eyes. The short life cycle of both leafhopper species enables them to increase populations rapidly.

The eggs of both species are bean-shaped, 0.03 inch long, and laid mostly on the undersides of leaves, just under the epidermis. The eggs of WGLH are laid singly, but eggs of VCLH more often are laid in rows of two to nine. Newly hatched nymphs of both species are white. After 1 day, red spots appear on the back of VCLH nymphs.

Leafhopper adults and nymphs pierce leaf cells and suck out the contents. Each feeding puncture leaves a white spot. As injury increases, photosynthetic activity declines; heavily damaged leaves turn yellow and brown and fall off the vine in severe cases.

Biology and life history Grape leafhoppers overwinter as non-breeding adults in plant debris and leaf litter in protected locations.

Adults emerge from overwintering sites in March and feed on annual weeds on the vineyard floor. They move on to grape foliage after budburst, and females begin laying eggs usually in late April. Egg-laying continues for about 6 weeks.

The first generation of nymphs feeds primarily on basal leaves from May to June and produces new generation adults in July. The second generation of nymphs appears later in the month (feeding on younger leaves, including leaves toward the shoot tip and leaves on laterals) and produces the second adult generation in the latter half of August and September. These adults form the overwintering population.

Sampling and thresholds The relationship between leafhopper populations and economic damage to wine and juice grapes is not well understood in the Pacific Northwest, but it is clear that vines can tolerate large populations before suffering economic loss. This is particularly true for spring populations of overwintered adults and first generation nymphs, which confine their feeding activity to the basal six to eight leaves.

The second generation of nymphs moves onto outer canopy leaves. Their numbers should be assessed using leaf counts. An average of more than 20 nymphs per leaf on outer canopy leaves, with no evidence of egg parasitism, is likely to require treatment.

Management—biological control

Several generalist insect and mite predators prey on leafhopper adults and nymphs of all stages. Among the most abundant are lacewings, predatory bugs, predatory beetles, and spiders. The most important natural enemies of grape leafhoppers are microscopic parasitic wasps, particularly several different species of Anagrus. *Anagrus* wasps parasitize leafhopper eggs and can cause up to 100% mortality in August to September. Anagrus wasps cannot overwinter in vineyards, as they require a leafhopper host that overwinters as an egg. Thus, they take some time to recolonize vineyards during spring to summer, particularly when insecticides are being used.

The presence or absence of Anagrus wasps should be assessed before making management decisions. Anagrus is detected easily by observing the eggs leafhoppers: parasitized eggs turn brick-red before the adult wasps emerge. Always regard the presence of Anagrus during the first generation of eggs as a significant mortality factor. Buprofezin (Applaud) is the only insecticide compatible with *Anagrus* and is recommended.

Management—cultural control

Increased vine vigor and dense canopies tend to promote leafhopper populations. Maximum vineyard productivity is obtained from moderate vigor vines with less canopy density, which are only moderately attractive to leafhoppers.

Disking or tilling soil to remove weeds and vineyard debris in late winter to early spring can reduce populations of overwintered leafhoppers. If maintaining a vegetative cover in the alleyway (grass, weeds, or cover crop), consider mowing early in the season to reduce adult populations. Waiting until after budbreak to mow or till can result in adults moving to the vine foliage.

Management—chemical control: HOME USE

- acetamiprid
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- carbaryl
- cyfluthrin
- horticultural oils (rates vary with product)—Ensure good coverage of leaf surfaces. Some formulations OMRI-listed for organic use.
- imidacloprid
- insecticidal soap—Some formulations OMRI-listed for organic use.
- kaolin—Applied as a spray to foliage, stems and fruit it acts as a repellent to some insect pests. Some formulations are OMRI-listed for organic use.
- malathion—Spray when nymphs are on undersides of leaves.
- permethrin
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

- acetamiprid (Assail 30SG) at 0.047 to 0.1 lb ai/a. PHI 3 days. Do not exceed two applications per season (0.2 lb ai/a), and allow at least 14 days between applications. Group 4A insecticide.
- abamectin (Agri-Mek 0.15 EC) at 0.009 to 0.019lb ai/a. Apply with a nonionic surfactant (NIS) for contact knockdown only. PHI 28 days. Do not exceed two sequential applications or 0.038 lb ai/a per season. Group 6 insecticide; restricted use.
- bifenthrin (Brigade and other brands) at 0.05 to 0.10 lb ai/a. Do not apply more than 0.10 lb ai/a per season. PHI 30 days. Group 3A insecticide. Restricted use pesticide.
- buprofezin (Applaud) at 0.40 to 0.53 lb ai/a. PHI 7 days. Use 50 to 200 gal/a water. Do not exceed 1.05 lb ai/a per season. Allow at least 14 days between applications. Group 16 insecticide.
- Chromobacterium subtsugae strain PRAA4 (Grandevo) at 2 to 3 lb product per acre. PHI 0 days. OMRI-listed for organic use.
- fenoproprathin (Danitol 2.4EC) at 0.1 to 0.2 lb ai/a. Do not apply more than 0.8 lb ai/a per season, and do not apply more than two times per season for resistance management. PHI 21 days. Group 3A insecticide. Restricted use pesticide.
- imidacloprid (Admire Pro and other brands)
  - ◊ Soil application at 0.25 to 0.5 lb ai/a. PHI 30 days. Apply in one or two drip irrigations between budbreak and pea size stage of berry development. Consult label for restrictions. Do not apply more than 0.5 lb ai/a per year. Group 4A insecticide.
  - ◊ Foliar application at 0.036 to 0.05 lb ai/a. PHI 0 days. Do not exceed 0.1 lb ai/a per year. Allow 14 days between applications. Group 4A insecticide.
- insecticidal soap (M-Pede and other brands) at 2% solution; Consult label for rates. PHI 0 days. Do not mix with sulfur. Some formulations are OMRI-listed for organic use.
- kaolin clay (Surround WP) at 25 to 50 lb product per acre. The preferred rate is 25 lb of product in 50 gal water/a. Suppression only; supplemental controls may be needed for complete control. Apply at least two to three applications at 7- to 14-day intervals. OMRI-listed for organic use.
- stylet oil at 1 to 2 gal of product per 100 gal water/a. Do not apply sulfur within 10 days of applying oil. Do not apply when temperatures are above 90°F (potential tissue burning) or below 50°F (reduced efficacy). Some formulations are OMRI-listed for organic use.
- thiamethoxam + chlorantraniliprole (Voliam Flexi) at 0.155 fl oz of product/a. PHI 14 days. Allow 14 days between applications. Do not apply more than two applications per season (maximum of 0.109 lb ai/a of thiamethoxam or 0.2 lb ai/a of chlorantraniliprole per season). Groups 4A and 28 insecticides.

Grape—Spider mite

McDaniel spider mite *(Tetranychus mcdaneli)*
Two-spotted spider mite *(Tetranychus urticae)*
Willamette spider mite *(Eotetranychus willametei)*
Yellow spider mite *(Eotetranychus carpini borealis)*

Pest description and crop damage Adults are about 0.02 inch long. They have eight legs and an oval body. Female two-spotted spider mites have large dark blotchs on each side of the body. McDaniel spider mites have conspicuous white spines. Yellow spider mites are smaller, pale yellow, and usually have small black dots along the sides of the body. In Washington vineyards, *McDaniel spider mites* are often predominant. Yellow spider mites rarely are seen on Washington grapes but may be found in Oregon. The Willamette spider mite has been a problem in some vineyards in Oregon's Willamette Valley, particularly in warm, dry seasons.

Eggs are spherical and translucent white when first laid. Newly hatched larvae are six-legged and go through two nymphal stages before reaching adulthood.

Spider mites damage grape leaves by puncturing cells and sucking out the contents. This produces small yellow-white spots on the upper leaf surface. In heavy infestations, the spots coalesce and the leaf turns yellow or red (in red cultivars). In general, spider mites are not consistently a major problem on Pacific Northwest grapes. However, when a problem occurs, it invariably can be traced to use of broad-spectrum insecticides, over use of sulfur in spray programs, or environmental conditions conducive to mite outbreaks (e.g., hot, dry, and dusty conditions).

Biology and life history Spider mites overwinter as fertilized females under bark or in soil debris. They move to young foliage when buds break in spring and produce many generations from spring to autumn. Females can lay up to 10 eggs per day and more than 200 during their lifetime. Egg-to-adult development can take 7 to 10 days during summer. They thrive under hot, dry conditions. Large colonies of mites produce webbing. Dispersal occurs mainly through wind transport.

Sampling and thresholds For Pacific Northwest grapes, thresholds have not been established, but economic damage is unlikely at levels below 15 to 20 per leaf. Treatment thresholds must always consider the presence of predatory mites, which are major biological control agents (see below).

Management—biological control

An extensive community of natural enemies successfully regulates spider mite populations when undisturbed by pesticides. Consequently, spider mite problems on grapes and many other crops are considered secondary pest problems resulting from the elimination or suppression of natural enemies. Spider mites are not often a problem in low chemical input vineyards or with the use of "soft chemicals." However, sulfur, which is often considered a "soft chemistry", can cause mite outbreaks when used extensively as in the case with organic vineyards.

Research at WSU is investigating the components and interactions of the natural enemy community affecting spider mites in Pacific Northwest vineyards so that it can be managed more effectively. Recent results show that multiple applications of sulfur for disease management (more than five per season) tend to increase incidence and severity of spider mite problems by inhibiting the function of predators, particularly predatory mites (Phytoseiidae). Many Oregon vineyards use multiple sulfur applications per season, particularly when producing organically. However, spider mites are not often a problem for western Oregon vineyards, but problems have arisen in dry years in vineyards with substantial sulfur use. This may be due to reduction in predatory mite populations and dusty conditions in those years.

Management—cultural control

Spider mite outbreaks frequently occur in more arid regions where vines are dusty and/or water-stressed. Using water or vineyard floor vegetation to control dust along vineyard roads and headlands assists in minimizing mite problems. Where competition and low soil moisture is a concern, there are short, shallow rooted grasses that are able to be used as a non-competitive cover crop (e.g. sheep fescue, 'Elf' perennial ryegrass, etc.). Excessive use of sulfur or use of certain pesticides (see notes therein) can precipitate spider mite outbreaks. Field evidence suggests that using more than four or five applications of sulfur per season greatly increases the chances of spider mite outbreaks in late summer/early autumn, particularly in warm, dry years.

For more information see EB2010 *Cover Crops as a Floor Management Strategy for Pacific Northwest Vineyards,* WSU Extension (http://cru.cahe.wsu.edu/CEPublications/eb2010/eb2010.pdf).

Management—chemical control: HOME USE

- azadirachtin (neem oil)
- insecticidal soap—Complete coverage, especially of the underside of leaves, is essential.
- malathion
- pyrethrins
- spinosad
- sulfur

Management—chemical control: COMMERCIAL USE

Acramite and Envidor are preferred miticides due to their efficacy and relatively high degree of safety to mite predators. All other products suppress predatory mite populations to a greater or lesser extent.

- abamectin (Agri-Mek and other brands) at 0.009 to 0.019 lb ai/a. Apply with a nonionic surfactant (NIS) for contact knockdown only. Do not exceed two applications or 0.019 lb ai/a per season. Harmful to predatory mites. Group 6 insecticide. Restricted use pesticide.
- bifenazate (Acramite 50WS) at 0.75 to 1.0 lb ai/a. PHI 14 days. Use at least 50 gal/a. Do not use more than once per season.
- Chromobacterium subtsugae strain PRAA4 (Grandevo) at 2 to 3 lb product per acre. PHI 0 days. OMRI-listed for organic use.
- fenbutatin-oxide (Vendex 50WP) at 0.5 to 1.25 lb ai/a. PHI 28 days. Do not use more than twice per season or apply more than once in 21 days. Do not use more than 2 lb ai/a per year, and do not use more than 250 gal/a water. Group 12B acaricide. Restricted use pesticide.
- hexythiozox (Onager) at 0.094 to 0.188 lb ai/a. PHI 7 days. Do not apply more than once per season, and do not exceed 0.188 lb ai/a per season. Controls eggs and immatures. Group 10A acaricide.
- insecticidal soap (M-Pede and other brands) at 1-2% solution; Consult label for rates. PHI 0 days. Do not mix with sulfur. Some formulations are OMRI-listed for organic use.
- pyridaben (Nexter and other brands) at 0.24 to 0.5 lb ai/a. PHI 7 days. Apply in 50 to 400 gal/a water. Use the higher rate to ensure adequate concentrations in mature vineyards with dense foliage. Do not apply more than twice a season. Harmful to predatory mites. Group 21A acaricide.
- spirodiclofen (Envidor 2SC) at 0.25 to 0.53 lb ai/a. PHI 14 days. Use at least 100 gal/a. Do not use more than once a season, and do not exceed 0.53 lb ai/a per season. Group 23 acaricide.

Grape—Spotted wing drosophila

Drosophila suzukii

For pest description, crop damage, biology, life history, sampling and cultural management

See:
EMERGING PEST: Spotted Wing Drosophila (SWD)—A Berry and Stone Fruit Pest

This insect has limited known commercial impact on wine grapes in Oregon and Washington to date. Adult SWD can be found feeding on grapes directly before harvest. Wine grapes in Western production regions are more susceptible to SWD impact, especially when the berry surface area is cracked due to insect damage, bird damage or Botrytis. Research has shown that drosophilid flies may vector spoilage bacteria under these conditions, thereby influencing fruit quality. Growers should take necessary steps to ensure minimal berry damage. Virtually no fully intact berries collected in vineyard studies have SWD eggs or larvae developing in them. A very small portion of damaged berries may contain eggs and an even smaller portion of eggs manages to develop to adulthood. However, research continues to determine seasonal differences.

Management—chemical control: HOME USE

- acetamiprid—In field tests, this product has provided inconsistent control of SWD. Group 4A insecticide.
- azadirachtin (neem oil)—This product has been shown to provide about 25% control of SWD. Some formulations are OMRI-listed for organic use.
- pyrethrins (often use in a mix with other ingredients)—These products provide about 80% control of SWD but have no residual activity. Group 3A insecticide. Some formulations are OMRI-listed for organic use.
- spinosad—This product generally provides a relatively high level of adult control, and 5-7 days residual activity, depending on conditions. Under rainy conditions, this residual period may be shorter. Some formulations are OMRI-listed for organic use. Group 5 insecticide.

Management—chemical control: COMMERCIAL USE

Note: Treatment with pesticides is generally not necessary for this pest. However, if infestations and damage are noticed, the following insecticides can be used to manage this pest.

Laboratory tests and field experiments indicate that many of the pesticides registered for use in grapes are effective in controlling the adult SWD. Although SWD may not be listed on a label, it is legal to use for SWD management. The products listed below target the adult stage of SWD. The relative level of control indicated for each pesticide was determined under both laboratory and field conditions.

- azadirachtin (Aza-Direct, Neemix and other brands)—Consult label for rate. PHI 0 days. Achieves approximately 25% control of SWD. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade and other brands) at 0.1 lb ai/a. PHI 30 day. Toxic to bees and should not be used when bees are foraging. Toxic to fish and other aquatic invertebrates. Synthetic pyrethroids, such as bifenthrin, provide 100% mortality of SWD, and 10 to 14 days residual control in the field. Under rainy conditions this residual period may be shorter. Although SWD is not listed on the label, it is an effective and legal use.
- Group 3A insecticide. Restricted use pesticide.
- carbaryl (Sevin and other brands) at 1.5 lb ai/a. PHI 7 days. Use postbloom only. Carbaryl is a carbamate chemistry that is broad-spectrum and provides 100% control of SWD. Toxic to bees; do not apply when bees are foraging. Toxic to aquatic invertebrates. Group 1A insecticide.
- fenpropathrin (Danitol) at 0.2 to 0.4 lb ai/a. PHI 21 days. Do not exceed two applications per season (0.8 lb ai/a/year). Toxic to bees and should not be used when bees are foraging. Toxic to fish and other aquatic invertebrates. Synthetic pyrethroids, such as fenpropathrin, provide 100% mortality of SWD, and 10 to 14 days residual control in the field. Under rainy conditions this residual period may be shorter. Group 3A insecticide. Restricted use pesticide.
- horticultural oil (several brands)—Consult label for rate. Provides some control of SWD but has no residual activity. May cause spotting on fruit. Some formulations are OMRI-listed for organic use.
- malathion (several brands) at 2.0 lb ai/a. PHI 3 day. Toxic to bees and most aquatic invertebrates, and carry the risk of mammalian toxicity. Do not apply when bees are foraging. They provide 100% mortality of SWD, and 7 to 10 days residual control in the field. Under rainy conditions this residual period may be shorter. Group 1B insecticide. This is an organophosphate insecticide.
- pyrethrin (Pyganic and other brands)—Consult label for rate and use directions. Toxic to bees; do not apply when bees are foraging. Highly toxic to fish. Provides 80% control of SWD but has no residual activity. Some formulations are OMRI-listed for organic use. Group 3A insecticide.
- spinetoram (Delegate WG) at 0.047 to 0.078 lb ai/a. PHI 7 days. Retreatment interval 4 days. Do make more than 5 applications per season (not to exceed 0.305 lb ai/a per year). Toxic to bees for three hours following treatment. Do not apply when bees are foraging. May provide 100% mortality of SWD, and 5 to 7 days residual control in the field. Under rainy conditions this residual period may be shorter. Group 5 insecticide.
- spinosad (Success or Entrust) at 0.062 to 0.124 lb ai/a. PHI 7 days. See label for use in grape for OR, WA and ID. Entrust is OMRI-listed for organic use. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. May achieve 100% mortality of SWD, and provide 5 to 7 days residual control in the field. Under rainy conditions this residual period may be shorter. The bait formulation of spinosad (GF-120) is not effective against SWD. Group 5 insecticide. Do not make more than 2 consecutive applications of Group 5 insecticides. Do not apply more than 0.45 lb ai/a per season.

Grape—Stink bug

Pest description and crop damage Variously colored shield-shaped bugs that feed on flowers and fruit, resulting in poor set or malformed fruit. Stink bugs are not currently known to be economic pests of grape in Oregon.

Management—chemical control: HOME USE

- acetamiprid
- carbaryl
- cyfluthrin
- permethrin
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- sulfur
- zeta-cypermethrin

See also, in this Handbook:
EMERGING PEST: Brown Marmorated Stink Bug—A Pending Threat to Pacific Northwest Agriculture

Grape—Thrips

Includes
Grape thrips *(Drepanothrips reuteri)*
Western flower thrips *(Frankliniella occidentalis)*

Pest description and crop damage Thrips commonly found on grapes are approximately 0.04 to 0.6 inch in size. Adult thrips have feather-shaped wings. Nymphs are wingless and usually yellow-orange. They usually appear at bloom as they feed on pollen and tender tissues. However, thrips have been found in early spring in Oregon vineyards, much earlier than bloom. Thrips may scar very young berries as early as fruit set. Later, the scars can restrict berry growth, producing oddly shaped or scarred berries. Occasionally, large populations of thrips may damage shoots and leaves in spring, particularly when cool conditions restrict plant growth. Damage caused by thrips during this period has been reported to be similar to that of rust and bud mites (leaf deformation and shoot scarring). High thrips populations have been observed in western Oregon vineyards and have led to strange growth patterns; however, economic damage was not reported. Damage is usually minor and cosmetic on wine and juice grapes in the Pacific Northwest. These are of cosmetic concern for table grape production. Extremely high populations that cause greater damage are usually found in vineyards located near alternative wild hosts.

Biology and life history Western flower thrips appear to be the most important species on grapes in the Pacific Northwest. This species has up to five or six generations per year. Populations usually peak during spring, which may be a result of migration into vineyards from surrounding host plants that are beginning to senesce. Thrips overwinter as adults or nymphs.

Reproduction may be sexual or asexual. The minute eggs are laid in soft tissue, particularly in flowers. Each female lays about 20 eggs that hatch in about 5 days. Nymphs feed on the host through two nymphal stages lasting 7 to 12 days. Pupation occurs in soil debris. Adult thrips feed on pollen as well as plant tissues. Scarring has been observed on stem, leaf and berry tissue in Oregon.

Grape thrips overwinter as virgin females in the soil; populations usually reach a peak in midsummer. This species may be mostly responsible for young leaf and new growth damage during summer.

Sampling and thresholds Thrips populations can be determined by counting nymphs and adults that have been knocked out of flowers or fruit clusters onto a board or into a container. Reliable thresholds have not been developed, although numbers in the range of 5 to 30 thrips per cluster are unlikely to be damaging. Populations on leaves can be identified using leaf washes in spring and summer using the alcohol wash as described for rust mites.

See also:
Grape—Grape rust mite

Management—biological control

Little is known about natural control of thrips in vineyards. Some predatory mites, predatory bugs, and spiders are known to feed on them.

Management—chemical control: HOME USE

- acetamiprid
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- carbaryl
- cyfluthrin
- imidacloprid
- insecticidal soap—Some formulations OMRI-listed for organic use.
- kaolin—Applied as a spray to foliage, flowers and fruit, it acts as a repellent to some insect pests. Some formulations are OMRI-listed for organic use.
- malathion
- permethrin
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- spinosad—Some formulations are OMRI-listed for organic use.
- sulfur
- zeta-cypermethrin

Management—chemical control: COMMERCIAL USE

- azadirachtin (Aza-Direct, Neemix and other brands)—Rate varies with specific product. PHI 0 days. Some formulations are OMRI-listed for organic use.
- Chromobacterium subtsugae strain PRAA4 (Grandevo) at 2 to 3 lb product per acre. PHI 0 days. OMRI-listed for organic use.
- kaolin clay (Surround WP) at 23.75 to 47.5 lb ai/a (25 to 50 lb/a product). The preferred rate is 25 lb of product in 50 gal/a water. For suppression only; supplemental controls may be needed for complete control. Make one to two applications 7 days apart, starting at budbreak. Product may not adhere well to berries early in development (best adherence at véraison and after). See label for specific instructions on use in table, raisin and wine grapes, including information on how harvest may be altered. OMRI-listed for organic use.
- insecticidal soap (M-Pede and other brands) at rates between 0.25 to 4% (see label). Higher rates are used for stand-alone application but 1-2% is used in tank mixes. This is a contact insecticide, and efficacy is related to the solution concentration and contact with the pest. Some formulations are OMRI-listed for organic use. Do not use on Calmeria or Italia grape varieties. Do not mix with sulfur. PHI 0 days.
- spinetoram (Delegate WG) at 0.047 to 0.078 lb ai/a. PHI 7 days. Retreatment interval 4 days. Do not make more than 5 applications per season or exceed 0.305 lb ai/a. Group 5 insecticide. Do not use Group 5 insecticides more than twice consecutively.
- spinosad (Entrust or Success) at 0.062 to 0.124 lb ai/a. PHI 7 days. Treat when pest first appears. Heavy infestations may require repeat applications. Do not exceed 0.45 lb ai/a of Entrust or Success per season. Do not exceed three applications in any 30-day period. Allow at least 5 days between applications. Entrust is OMRI-listed for organic use; Success is not approved for organic production. Group 5 insecticide. Do not use Group 5 insecticides more than twice consecutively.

Strawberry Pests

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INCLUDES MANAGEMENT OPTIONS FOR COMMERCIAL AND HOME USE

In all cases, follow the instructions on the pesticide label. The *PNW Insect Management Handbook* has no legal status, whereas the pesticide label is a legal document. Read the product label carefully before making any pesticide applications.

Protect pollinators: See How to Reduce Bee Poisoning from Pesticides.

Note: Products are listed in alphabetical order and *not* in order of preference or superiority of pest control.

Strawberry—Aphid

Includes
Shallot aphid *(Myzus ascalonicus)*
Strawberry aphid *(Chaetosiphon fragaefolii)*

Pest description and crop damage Shallot aphids are small and pale greenish-brown. Aphid feeding causes the plants to be stunted, with crinkled and curled leaves. Damage may spread from small, circular patches to entire plantings. The shallot aphid transmits strawberry mottle virus. It is seldom a pest in Oregon strawberry fields. Strawberry aphid adults are generally yellow and wingless with small, clubbed hairs on the dorsal surface. Winged forms are pale green with black markings on head, thorax and abdomen. They are about 2 mm long. This aphid generally does not directly injure the plants but may transmit virus diseases.

Biology and life history Shallot aphids overwinter as adults and nymphs deep in the plant crown or amongst weeds. They resume feeding in early spring and continue through early summer. Winged forms leave strawberries in June and return in the fall. Strawberry aphids overwinter as adults or nymphs in the crown, or as black eggs on the undersides of older leaves. Winged adults appear in May and begin dispersing within the field or between fields. Peak aphid numbers occur in June, but in some years another peak may occur in September or October. There are several overlapping generations produced each summer.

Scouting and thresholds Inspect plants, especially the underside of leaves and in the crowns, for aphids in early spring. When aphid populations average half to one aphid per leaf, treatment may be necessary. Continue to monitor for aphids, especially after harvest and in early fall.

Management—biological control

Many naturally occurring parasites and predators attack aphid. Monitor the proportion of aphid mummies to unparasitized adults and the number of predators such as lady beetles. If the biocontrol agents appear to be gaining control, avoid sprays which would disrupt this system. Most products available for aphid control are highly disruptive of natural enemy populations.

Management—cultural control

Aphid populations tend to be higher in plants that are fertilized liberally with nitrogen. Use a floating row cover where feasible—this will not be effective on currently infested plants! The use of virus-resistant plants is probably the most effective control. Among June-bearing varieties, 'Hood' is very susceptible to virus, 'Redcrest' is less so. Most other June-bearing varieties, including 'Totem,' are fairly resistant. Day-neutral varieties have not been tested for virus resistance.

Home gardeners: Wash aphid from plants with a strong stream of water.

Management—chemical control: HOME USE

Chemicals applied for aphid control have not prevented the spread of virus diseases in strawberries, and aphid damage has not warranted the use of control measures; therefore, no chemical control is suggested.

Management—chemical control: COMMERCIAL USE

Aphid control helps suppress viruses when supported by use of certified plants, field rogueing of abnormal plants, very thorough application of an insecticide, isolation from infested fields, and regional spray programs. To prevent aphid migration to new fields and spread of virus within a field, treat bearing fields when aphids appear.

- acetamiprid (Assail) at 0.035 to 0.075 lb ai/a. PHI 1 day. Do not exceed more than two applications per season.
- azadirachtin (Neemix and other brands)—Consult label for rate and use directions. Some formulations are OMRI-listed for organic use.
- *Beauveria bassiana* (Mycotrol and other brands)—Consult label for rate. Some formulations are OMRI-listed for organic use.
- flonicamid (Beleaf 50 SG) at 0.089 lb ai/a. PHI 0 days. Apply when aphids first appear. Limited to three applications per crop season.
- flupyridifurone (Sivanto) at 0.09 to 0.14 lb ai/a. PHI 0 days. Toxic to adult bees in laboratory studies via oral exposure, however, not toxic to bees through contact exposure, and field studies conducted with this product have shown no effects on honeybee colony development. Limited to two applications, 10 days apart, and no more than 0.365 lb ai/a allowed per season. Avoid rotation with neonicotinoid products, if possible.
- imidacloprid (Admire Pro and other brands) at 0.38 to 0.5 lb ai/a. PHI 14 days. Soil application. It must be incorporated with 0.25 inch irrigation or rainfall within 2 hours of application. Do not apply immediately prior to bud opening or during bloom or when bees are foraging. Note "Bee Advisory Box" and restrictions on the label.
- imidacloprid (Admire Pro and other brands) at 0.047 lb ai/a. PHI 7 days. Foliar application. Do not apply during bloom, within 10 days of bloom, or when bees are actively foraging. Note "Bee Advisory Box" and restrictions on the label.
- insecticidal soap (M-Pede and other brands)—Consult label for rate. PHI 0 days. Some formulations OMRI-listed for organic use.
- malathion at 1 to 2 lb ai/a. PHI 3 days.
- naled (Dibrom) at 0.9 lb ai/a. PHI 1 day.
- sulfoxaflor (Closer SC) at 0.043 lb ai/a. PHI 1 day. Do not apply when bees are actively foraging. Note: Strawberry registration was cancelled on 11/12/2015 but EPA ruled that all product still in the hands of growers is allowed to be used until exhausted.
- thiamethoxam (Actara) at 0.023 to 0.047 lb ai/a. PHI 3 days. Actara and Platinum have the same active ingredient; for resistance management, do not follow one with the other. Do not apply during bloom or when bees are foraging in the area. Note "Bee Advisory Box" and restrictions on the label.

- thiamethoxam (Platinum) at 0.078 to 0.188 lb ai/a. PHI 50 days. Apply to soil and incorporate with irrigation. Platinum and Actara have the same active ingredient; for resistance management, do not follow one with the other. Do not apply when bees are foraging. Wait at least 5 days before placing beehives in the treated field. Note "Bee Advisory Box" and restrictions on the label.

Strawberry—Cyclamen mite

Phytonemus pallidus

Pest description and crop damage The mature mite is flat, lens-shaped, and transparent. The female's hind legs are threadlike. The cyclamen mite is much smaller than the twospotted spider mite and can be seen only with the aid of a hand lens. This mite is found on young, folded leaves along the mid-vein. Mite feeding stunts plants and reduces fruit production. Symptoms are similar to virus symptoms and including stunting and twisting of leaves and buds. Fruit size and yield can be significantly reduced. 'Totem' strawberries are very susceptible to cyclamen mite damage. This mite is also a serious pest on cyclamen, African violet, and other greenhouse-grown plants.

Biology and life history Cyclamen mites overwinter as adult females in the crown of the strawberry plant. Under cold temperatures, it remains dormant. As the weather warms, it resumes activity in spring. Eggs are laid in the folds of young leaves and buds. Most feeding activity occurs in protected areas of the plant in the folds of young leaves or unopened flower buds. Populations can build rapidly in fields after they become infested.

Scouting and thresholds In early spring, with the aid of a hand lens, inspect strawberry crowns, folded leaves and unopened buds for evidence of cyclamen mites. Puckered or contorted leaves indicate cyclamen mite feeding.

Management—biological control

Insects, such as the minute pirate bug and six-spotted thrips, are known to feed on cyclamen mite, as does the western predatory mite (*Galendromus occidentalis*). Releases of other predatory mites such as Amblyseius californicus may be effective if done early enough before populations build.

Management—cultural control

Use only clean planting stock in new plantings. Remove infested plants as soon as they are seen. Mites are easily transferred from infested fields to new locations by pickers and machinery. Mites on planting stock may be completely killed by immersion in water at 120°F for 30 minutes.

Management—chemical control: HOME USE

- plant-based oils such as clove, cottonseed and garlic—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

Control is improved with high drenching insecticide spray (400 gal/a of water).

- abamectin (Agri-Mek) at 0.019 lb ai/a. PHI 3 days. Provides suppression of cyclamen mite populations. Make two applications 7 to 10 days apart when mites first appear. Repeat this sequence of applications, if necessary, to maintain control (wait at least 21 days before repeating sequence). Do not exceed 0.075 lb ai/a in one growing season. Do not use less than 100 gal water/a.
- diazinon (several brands) at 1 lb ai/a. PHI 5 days. Do not apply during bloom. One application per season allowed.
- fenpyroximate (FujiMite) at 0.1 lb ai/a. PHI 1 day. Two applications per crop cycle.

Strawberry—Garden symphylan

Scutigerella immaculata

Pest description and crop damage Garden symphylans are sometimes called garden centipedes. When fully grown, they are not more than 8 mm long, have 15 body segments, and 11 or 12 pair of legs. They are slender, white, with prominent antennae. They can be mistaken for springtails. Symphylan feeding on roots can damage plants. Their ability to do damage decreases as the plant ages, but their pitting can allow entry to plant pathogens. Surviving plants may be stunted with reduced yields. Damage shows up as weak spots in a field although similar damage may be the result of root lesion nematodes, root weevils or root rot.

Biology and life history Eggs, nymphs, and adults can be found in the soil in any month of the year, but most eggs are found in the early spring and fall. Eggs are laid in clusters of 4 to 25, and hatch in about 40 days. Nymphs and adults become active in the top 8 inches of soil. Nymphs feed on small roots. There are one or two generations per year.

Scouting and thresholds Presence of symphylans can be confirmed by taking a soil sample with a shovel down to a depth of 8 inches. Thresholds for action are not well-established although more than 5 per shovelful is an informal level for action. Symphylan populations may also be determined by baiting: put a longitudinally cut potato or carrot on the ground under a white bucket and check for symphylans after 24 hours.

Management—biological control

Many organisms feed on symphylans in the field, including true centipedes, predatory mites, ground beetles, and various fungi. Little is known about their effect on symphylan populations.

Management—cultural control

Symphylan damage generally is associated with soils that are high in organic matter content and have good structure. Symphylans do not thrive in compacted or sandy soils, as these soils do not provide tunnels for their movement. Symphylans cannot make their own burrows. Packing down the soil surface after planting may provide some control. Flooding for 2 to 3 weeks has provided some control in some cases but not in others.

Management—chemical control: HOME USE

No appropriate pesticides are available for strawberries in the home garden.

Management—chemical control: COMMERCIAL USE

- chlorpyrifos (Lorsban and other brands) at 2.0 lb ai/a. Apply as a pre-plant broadcast spray and incorporate 2 to 4 inches.

See also:
Biology and Control of the Garden Symphylan

Strawberry—Leafroller

Strawberry leafroller *(Ancylis comptana fragariae)*
Western strawberry leafroller *(Compsolechia fragariella)*

Pest description and crop damage The adult is a reddish brown moth with distinctive yellow markings on the forewings, and has a wingspan of about 11-14 mm. Eggs are laid on leaves in clusters; they are translucent to pale green at first but turn yellowish as they reach maturity. They hatch in about 10 to 14 days. The larvae are pale green at first but change to grayish brown as they feed and mature. Mature larvae are about 12 mm long. The larvae roll and tie leaves together with silk for shelter and feeding, and wriggle and thrash about violently when disturbed. Larval feeding on buds can damage developing flowers which results in deformed fruit.

Biology and life history Strawberry leafrollers overwinter as larvae on strawberry plants. The adult moths appear in May and lay eggs on the foliage. Adults can be seen throughout the growing season as there may be several generations per year.

Scouting and thresholds Inspect leaves for evidence of larvae; look for rolled leaves and silken tubes on the underside of leaves.

Management—chemical control: HOME USE

Leafrollers are seldom a pest on strawberries, and treatment is usually not necessary.

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- *Bacillus thuringiensis (Bt)*—Some formulations are OMRI-listed for organic use.
- bifenthrin
- carbaryl
- malathion
- permethrin
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- spinosad—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

Leafrollers are seldom a pest on strawberries, and treatment is usually not necessary.

- *Bacillus thuringiensis (Bt)* (several brands)—Consult label for rate. PHI 0 days. Use according to individual manufacturer's directions. Do not use DiPel ES with captan fungicide as the mixture will bronze foliage.
- chlorantraniliprole (Coragen) at 0.045 to 0.065 lb ai/a. PHI 1 day. Do not exceed 0.2 lb ai/a per crop season.
- flubendiamide (Belt) at 0.075 lb ai/a. PHI 8 days. Do not exceed 0.225 lb ai/a per crop season.
- methoxyfenozide (Intrepid 2F) at 0.09 to 0.19 lb ai/a. PHI 3 days. Begin applications at first egg hatch or to young larvae when infestations are detected. Do not exceed 64 fl oz product/a per crop season.

Strawberry—Lygus bug

Lygus spp., especially tarnished plant bug *(Lygus lineolaris)*

Pest description and crop damage Adult tarnished plant bugs are about 5-6 mm long and their color is variable: they may be pale green to dark brown with yellow, black and occasionally red markings. Their feeding on buds, bloom, and small fruit results in deformed berries. Lygus is generally not a problem pest except, possibly, later in the summer on day-neutral strawberries.

Biology and life history The lygus bug overwinters as an adult in groundcover. As temperatures increase above 46ºF, they emerge from cover to feed. They have a wide host range that includes many weeds, tree fruit and berries. They will move from host plant to host plant as the year progresses; as these plants finish flowering or dry up, lygus bugs will seek other host plants. There are about three generations per year.

Scouting and thresholds These insects are difficult to monitor as they are found on a wide range of hosts and fly away quickly if disturbed. Sweep nets may be used to monitor for the presence of the insects, though no thresholds exist.

Management—chemical control: HOME USE

- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- carbaryl
- kaolin—Applied as a spray to leaves, stems and fruit it acts as a repellent to some insect pests. Some formulations are OMRI-listed for organic use.
- malathion
- permethin
- pyrethrins—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

- *Beauveria bassiana* (Mycotrol and other brands)—Consult label for rate. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade WSB and other brands) at 0.04 to 0.2 lb ai/a. PHI 0 days. Do not apply more than 0.5 lb ai/a per season. Toxic to bees and should not be used when bees are foraging. Also toxic to fish and other aquatic invertebrates.
- etoxazole (Zeal) at 0.09 to 0.135 lb ai/a. PHI 1 day. Controls primarily larvae and eggs; not very effective against nymphs and adults.
- fenpropathrin (Danitol) at 0.2 lb ai/a. PHI 2 days. Do not exceed two applications.
- flonicamid (Beleaf 50 SG) at 0.089 lb ai/a. PHI 0 days. Apply when lygus bugs first appear.
- naled (Dibrom) at 0.9 lb ai/a. PHI 1 day. Use in evening after bee activity has ended.
- novaluron (Rimon 0.83EC) at 0.13 to 0.19 lb ai/a. PHI 1 day. Apply when adults are observed in the field and just prior to egg hatch.
- sulfoxaflor (Closer SC) at 0.043 to 0.07 lb ai/a. PHI 1 day. Do not apply when bees are actively foraging. Note: Strawberry registration was cancelled on 11/12/2015 but EPA ruled that all product still in the hands of growers is allowed to be used until exhausted.
- thiamethoxam (Actara) at 0.062 lb ai/a. PHI 3 days. Suppression only. Do not apply during bloom or when bees are foraging in the area. Note "Bee Advisory Box" and restrictions on the label.

Strawberry—Omnivorous leaftier

Strawberry fruitworm *(Cnephasia longana)*

Pest description and crop damage The adult insect is a grayish-yellow, slender moth with brown markings about 12 mm long. The larvae are up to 12 mm long, dirty white, with a brownish head. The larvae web leaves and flowers together and feed on and tunnel into ripe and unripe fruit. Injured berries also contain excrement left by the larvae in the tunnels. One larva can damage several berries. Damage often can be seen on green berries immediately after fruit is set.

Biology and life history The insect overwinters in silken cases as a young larva on the bark of trees and other rough surfaces, but not on strawberry plants. In spring, the larvae spin silken threads, and are carried by wind to host plants which, besides strawberries, include Dutch iris, hops, filberts, pears, clover, and plantain. On strawberries, the larvae web the leaves and flowers together beginning in late April, then feed on the developing fruit. The moths appear in June and July and lay eggs. There is one generation per year.

Scouting and thresholds Watch for signs of leaf webbing in late April.

Management—cultural control

Floating row covers placed over the plants after spring growth begins, and removed after bloom begins, will exclude larvae. Remove any webbed leaves or larvae that are found.

Management—chemical control: HOME USE

If you use sprays, time them to coincide with the appearance of the first blooms. Do not treat when blossoms are open, in order to avoid bee poisoning.

- carbaryl—Apply when there are more than two larvae per plant.
- malathion
- permethrin

Management—chemical control: COMMERCIAL USE

A repeat application may be necessary in 3 weeks.

- *Bacillus thuringiensis (Bt)* (several brands)—Consult label for rate. PHI 0 days. Do not tank mix DiPel ES with captan or other fungicides that are not compatible with spray oil; the mixture will bronze foliage. Some formulations OMRI-listed for organic use.
- carbaryl (Sevin and other brands) at 1 to 2 lb ai/a. PHI 7 days. Latex-based formulations such as Sevin XLR Plus are less hazardous to bees. Do not apply to blooming plants.
- chlorantraniliprole (Coragen) at 0.045 to 0.065 lb ai/a. PHI 1 day. Do not exceed 0.2 lb ai/a per crop season.
- flubendiamide (Belt) at 0.075 lb ai/a. PHI 8 days. Do not exceed 0.225 lb ai/a per crop season.
- naled (Dibrom) at 0.9 lb ai/a. PHI 1 day. Apply during late evening, night, or early morning to avoid bee poisoning.
- pyrethrin (several brands)—Consult label for rate and use directions. PHI 0 days. Pyganic brand is OMRI-listed for organic use.

Strawberry—Root weevil

Includes
Black vine weevil *(Otiorhynchus sulcatus)*
Rough strawberry root weevil *(O. rugosostriatus)*
Strawberry root weevil *(O. ovatus)*

Pest description and crop damage Black vine weevil (BVW) is probably the most common weevil to infest strawberries, but the strawberry root weevil (SRW) and rough strawberry root weevil (RSRW) are also pests. Adult weevils are 8-12 mm long, depending on the species. Adults are reddish brown to black; the BVW is larger and darker than the other species. Larvae of all species are quite similar in appearance and habits: they are C-shaped, legless, white with tan heads, and up to 12 mm long. Adult weevil feeding causes a characteristic notching in the leaves of strawberries and other host plants. This feeding damage is relatively minor and causes little damage to the plants. The real damage is done by the larvae, which feed through the winter and spring on the root systems of host plants. Larvae feeding on roots can cause stunting and poor yields. With severe infestations, plants may die.

Biology and life history Weevils overwinter as larvae in the soil. Feeding may occur throughout mild wintersneFrom April to June, larvae pupate, and adult emergence occurs during this time. Adults are night feeders that remain in the soil or in organic material at the base of the plant during the day, then climb up to feed on leaves at night. Adult weevils cannot fly, but walk or are carried from one location to another on plant material or equipment. Also, all adults are females capable of laying eggs. Adults are slow moving and should not be confused with swifter predacious ground beetles.

Eggs are laid in clusters in or on the soil from June to September. The eggs hatch and the larvae immediately wriggle through the soil to begin feeding. There is one generation per year.

Scouting and thresholds Inspect leaves for notching from adult feeding in early summer. Controls should be undertaken soon after adult feeding is observed, but before egg laying occurs, generally about four weeks. Presence of adults can be confirmed by night inspection of foliage on warm, still evenings. Or, look for adults in the day by looking through plant debris at the base of the plant. Laying a small piece of cardboard next to the strawberry plant will provide a refuge that can be checked easily in the early morning.

Management—biological control

Nematodes, such as *Heterorhabditis* spp. and *Steinernema* spp., have shown some effectiveness in controlling larvae when applied as the label directs, as a drench. Nematodes must be placed in the root zone where weevil larvae are present.

See also:
Entomopathogenic Nematodes

Management—cultural control

Cultivating the soil in April–May before planting can eliminate overwintering larvae. Use a cereal cover crop, as small grains are not a host for root weevils.

Home gardeners: Hand-pick adults when found.

Management—chemical control: HOME USE

Controls adults only. Maximum control is achieved only if applied at night, when weevils feed.

- carbaryl
- malathion
- pyrethrins—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

Apply chemical sprays at night, usually between dusk and midnight, on warm, calm evenings when adult weevils are on foliage and feeding. Control is usually poor when applied by day or on cold or windy nights.

- azadirachtin (Neemix and other brands)—Consult label for rate and use directions. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade WSB and other brands) at 0.05 to 0.2 lb ai/a. PHI 0 days. Do not apply more than 0.5 lb ai/a per season. Closely monitor spider mites the following season.
- cryolite bait at 4 to 8 lb ai/a. PHI 3 days. Washington and Oregon 24c labels (WA-980001 and OR-980006).
- malathion (several brands) at 2 lb ai/a. PHI 3 days. Apply at night for maximum effectiveness to control adult weevils when present.
- thiamethoxam (Actara) at 0.062 lb ai/a. PHI 3 days. Foliar applied. Do not apply during bloom or when bees are foraging in the area. Note “Bee Advisory Box” and restrictions on the label. Actara and Platinum have the same active ingredient; for resistance management, do not follow one with the other.
- thiamethoxam (Platinum) at 0.078 to 0.188 lb ai/a. PHI 50 days. Apply to soil and incorporate with irrigation. Platinum and Actara have the same active ingredient; for resistance management, do not follow one with the other. Do not apply when bees are foraging. Wait at least 5 days before placing beehives in the treated field. Note “Bee Advisory Box” and restrictions on the label.

Strawberry—Slug

Includes
Arion spp.
Black greenhouse slug *(Milax gagates)*
Gray field slug *(Derocerus reticulatum)*
Large spotted garden slug *(Limax maximus)*
Marsh slug *(Derocerus laeve)*
Reticulated slug *(Prophysaon andersoni)*

Pest description and crop damage Slugs are related closely to snails but have no shell. Slug damage can be distinguished easily from damage caused by other pests by the presence of slime trails. Feeding damage to foliage is removal of plant tissue between veins and on the edge of leaves. Slug damage tends to be heaviest along field margins. Weedy or grassy borders serve as excellent habitat for slugs. High populations build up in perennial legumes used for cover crops.

Biology and life history Slugs are active above ground primarily at night, and also during the day during mild, wet periods, at any time of year. Very little activity takes place in cold, freezing, or extremely hot weather. During the day, slugs usually are found in the soil or in crevices or cracks, to protect themselves from dehydration and predators.

Scouting and thresholds Inspect plants for feeding damage and slime trails. Look for slugs on plants during the day when weather is wet, or at nighttime when weather is not cool or windy.

For best slug control, bait after the first extensive late-summer rains, which activate the slugs. Baiting at this time kills egg-laying adults that would produce slugs next spring. Apply bait on the soil surface around plants. Do not contaminate berries or foliage with slug bait.

Management—biological control

Encourage predators such as birds, garter snakes, frogs, ducks, and predacious ground beetles. Avoid use of broad-spectrum insecticides which can kill beneficial insects.

Management—cultural control

Clean up weeds and plant debris which may provide shelter for the slugs. Cut tall weeds and grasses around the strawberry planting and clean up rocks, boards, and other shelters with the planting.

Home gardeners: Hand-pick and kill slugs when noticed. Trap slugs with cans of stale beer sunk into the ground. Use chemical baits with caution, as pets can be poisoned.

Management—chemical control: HOME USE
- iron phosphate bait—OMRI-listed for organic use.
- metaldehyde bait

Management—chemical control: COMMERCIAL USE
- iron phosphate bait (Sluggo)—20 to 44 lb product/a. OMRI-listed for organic use.
- metaldehyde bait (several brands)—Consult label for rate. Apply in a band between rows and/or directed towards base of the plants; do not apply broadcast over the top of the plants.

See also:
Slug Control

Strawberry—Spittlebug

Meadow spittlebug *(Philaenus spumarius)*

Pest description and crop damage Adult spittlebugs are wedge-shape, grayish brown insects about 3 mm long, and similar in appearance to leafhoppers but are larger and stockier. They jump and fly readily. The young spittlebug nymphs are white to lemon-yellow in color and look like fat aphids. They encase themselves in a frothy spittle. Nymph feeding causes twisting of leaves and thickening and shortening of stems of fruit spurs. When this occurs, the yield is likely to be reduced. Nymphs develop in masses of spittle on plants.

Biology and life history The insect overwinters as eggs on the plant or in plant debris. The eggs hatch in early spring, and the first spittle masses are found in April just before bloom. Spittle masses are abundant from then through harvest. The first adults appear in May and lay orange eggs on the plants during harvest and after. There is only one generation per year.

Scouting and thresholds Inspect plants prior to bloom for eggs and egg hatch. Just before or at bloom, inspect plants for spittle masses.

Management—cultural control

On June-bearing cultivars, cut all the old leaves off the plants after final harvest to renew the foliage and remove egg masses.

Home gardeners: Nymphs are easy to remove by hand-picking. Also, a strong spray of water will knock them off the plant, preventing more damage.

Management—chemical control: HOME USE

Controlling spittlebugs with chemicals is almost impossible once spittle masses form. Do not apply when blossoms are open, in order to avoid bee poisoning.
- acetamiprid
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- bifenthrin
- carbaryl
- imadicloprid
- malathion
- permethrin
- pyrethrins—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

Control with chemicals is almost impossible once spittle masses form. Make treatment applications before significant spittle masses are formed and before nymphs are more than half grown.
- acetamiprid (Assail) at 0.035 to 0.075 lb ai/a. PHI 1 day. Do not exceed more than two applications per season.
- carbaryl (Sevin and other brands) at 1 to 2 lb ai/a. PHI 7 days. Latex-based formulations such as Sevin XLR Plus are less hazardous to bees. Do not apply to bloom.
- chlorpyrifos (Lorsban and other brands) at 0.94 lb ai/a. Use pre-bloom only, not during bloom when bees are present, or when fruit is present.
- fenpropathrin (Danitol) at 0.2 lb ai/a. PHI 2 days. Do not exceed two applications.
- imidacloprid (Admire Pro and other brands) at 0.047 lb ai/a. PHI 7 days. Do not apply during bloom, within 10 days of bloom, or when bees are actively foraging. Note “Bee Advisory Box” and restrictions on the label.
- malathion (several brands) at 1 to 2 lb ai/a. PHI 3 days.
- naled (Dibrom) at 0.9 lb ai/a. PHI 1 day. Do not apply to bloom.

Strawberry—Spotted wing drosophila

Drosophila suzukii

For pest description, crop damage, biology, life history, and cultural management

See:
EMERGING PEST: Spotted Wing Drosophila—A Berry and Stone Fruit Pest

Management—chemical control: HOME USE

- acetamiprid—In field tests, this product has provided inconsistent control of SWD.
- azadirachtin (neem oil)—This product has been shown to provide about 25% control of SWD. Some formulations are OMRI-listed for organic use.
- pyrethrins—These products provide about 80% control of SWD but have no residual activity. Some formulations are OMRI-listed for organic use.
- spinosad—This product generally provides 100% control and 5-7 days residual activity. Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

Laboratory tests and field experiments indicate that many of the pesticides registered for use in strawberries are effective in controlling the adult SWD. Although SWD may not be listed on a label, it is legal to use for SWD management. The products listed below target the adult stage of SWD.

- azadirachtin (Neemix and other brands)—Consult label for rate. PHI 0 days. Achieves only about 25% control of SWD. Some formulations are OMRI-listed for organic use.
- bifenthrin (Brigade WSB and other brands) at 0.2 lb ai/a. PHI 0 days. Toxic to bees and should not be used when bees are foraging. Also toxic to fish and other aquatic invertebrates. Synthetic pyrethroids achieved 100% mortality of SWD and provide about 10 to 14 days residual control in the field.
- carbaryl (Sevin and other brands) at 2.0 lb ai/a. PHI 7 days. Latex-based formulations such as Sevin XLR Plus are less hazardous to bees. Carbaryl is broad-spectrum and provides 100% control of SWD. Toxic to bees; do not apply when bees are foraging. Toxic to aquatic invertebrates. Carbamate insecticide.
- cyantraniliprole (Exirel) at 0.088 to 0.133 lb ai/a. PHI 1 day. Do not apply when bees are foraging. Note "Bee Advisory Box" and restrictions on the label. Provides from 75-100% control, and 7 to 10 days residual control in the field.
- diazinon (several brands) at 0.5 lb ai/a. PHI 5 days. One application per season allowed; as such, consider other pests that may need to be managed with diazinon. Toxic to bees and most aquatic invertebrates, and carry the risk of mammalian toxicity. Do not apply when bees are foraging. May achieve 100% mortality of SWD and provide about 7 to 10 days residual control in the field. Organophosphate insecticide. Use not allowed in Idaho.
- fenpropathrin (Danitol) at 0.3 to 0.4 lb ai/a. PHI 2 days. Do not exceed two applications per season. Toxic to bees and should not be used when bees are foraging. Toxic to fish and other aquatic invertebrates. Synthetic pyrethroids achieved 100% mortality of SWD and provide about 10 to 14 days residual control in the field.
- horticultural oil (several brands)—Consult label for rate. Provides some control of SWD but has no residual activity. May cause spotting on fruit. Some formulations OMRI-listed for organic use.
- malathion (several brands) at 2.0 lb ai/a. PHI 3 days. Toxic to bees and most aquatic invertebrates, and carry the risk of mammalian toxicity. Do not apply when bees are foraging. May achieve 100% mortality of SWD and provide about 7 to 10 days residual control in the field. Of the organophosphates tested, malathion had the longest residual activity (10 days).
- pyrethrin (several brands)—Consult label for rate and use directions. Toxic to bees; do not apply when bees are foraging. Highly toxic to fish. Provides about 80% control of SWD but has no residual activity. Pyganic brand is OMRI-listed for organic use.
- spinetoram (Radiant SC) at 0.08 lb ai/a. PHI 1 day. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. May achieve 100% mortality of SWD and provide about 5 to 7 days residual control in the field. Spinosyn insecticide.
- spinosad (Success or Entrust) at 0.09 lb ai/a. PHI 1 day. Toxic to bees for three hours following treatment. Do not apply when bees are foraging. May achieve 100% mortality of SWD and provide about 5 to 7 days residual control in the field. The bait formulation of spinosad (GF-120) is not effective against SWD. Spinosyn insecticide. Entrust is OMRI-listed for organic use.

Strawberry—Strawberry crown moth

Synanthedon bibionipennis

Pest description and crop damage The strawberry crown moth is an insect native to the PNW and has caused damage to strawberries in the northern Willamette Valley. The adult strongly resembles a yellow jacket; it is about 12-15 mm long, black with yellow markings. The eggs are brown, oval, sculpted on the surface, and distinctly cupped on the sides. The larvae are white with a brown head, and 16-25 mm long at maturity. Larvae feed on the crown and root tissue of the strawberry plant. This feeding provides entry points for root pathogens. Injured plants are stunted, may produce reddish foliage, and yield poorly. Tops of damaged plants are easily separated from the root system if pulled on, which quickly distinguishes this damage from that caused by root weevils. Damage is sporadic and has been most severe in Washington County, Oregon.

Biology and life history The insect overwinters in the crown of the strawberry plant. They become active in April and May and feed for a short time before pupating. Adults emerge in late June and July, mate, and lay eggs on leaves near the base of plants. The young larvae feed on the outside of the crown before boring deeper into the crown to feed and overwinter. There is one generation per year.

Sampling and thresholds Pheromone traps are available to monitor the emergence and flight of the moths.

Management—cultural control

- No commercial strawberry varieties resistant to SCM are available.
- Untopped strawberry plants can serve as trap plants. If plants are topped before the moth's flight period, a few rows should be left untopped. Egg-laying females are attracted to and deposit a significant portion of their eggs on the untopped plants. These untopped plants are then disked under in the fall.
- Remove infested plants. Infestations usually begin near field borders and damaged plants occur in clumps. These plants are stunted and develop a reddish color earlier in fall than uninfested plants. Remove and destroy these plants. Replant to fill the gap.
- Do not place new plantings adjacent to infested fields. Grain planted between a new field and an infested field can serve as a barrier to the flight of the adult moths (they are low flyers), thereby preventing infestation of the new field.
- Plow out infested fields in August, September, or October. Thorough shredding of all roots and crowns followed by deep plowing is necessary to kill the strawberry crown moth larvae and pupae.
- In home gardens, on June-bearers, complete removal of the old leaves with hedge shears or similar equipment will remove any eggs and induce a flush of fresh leaves.

Management—chemical control: HOME USE

Chemical control of this pest has not proven effective and is not recommended.

Management—chemical control: COMMERCIAL USE

Crown moth larvae are well established in strawberry roots and crowns by mid-August; applying insecticides to control this pest is not recommended after the first week in August.

- chlorpyrifos (Lorsban) at 0.94 lb ai/a. Apply immediately after last harvest, after topping plants. Apply in at least 100 gal water/a as a high-pressure spray to saturate crowns. Do not exceed two applications per season.

Strawberry—Thrips

Frankliniella occidentalis

Pest description and crop damage Adult thrips are small (about 1-2 mm long at maturity), slender insects with fringed wings. They are generally white when young but pale yellow to brown when mature. Larvae are very tiny and difficult to distinguish without magnification. They feed by puncturing plant material, often blossoms, and sucking out the cell contents. Injured blossoms often turn into distorted fruit. When feeding on flowers, affected petals appear stippled or are scarred with brown streaks or spots. When unusually abundant in spring, thrips have been reported to cause blossom blasting. Fruit may be misshapen or distorted. Controls are most effective when applied at flowering; field control is not practical in eliminating thrips present at harvest.

Biology and life history Thrips overwinter as adults in ground duff. In the spring they seek out flowers where they feed on pollen and nectar and lay eggs into floral parts. The larvae feed on flowers, buds and leaves. When mature, the larvae drop to the ground and pupate. The adults that emerge may lay eggs on developing fruit. Under favorable conditions, a complete life cycle may be completed in two weeks. There are several overlapping generations per year. Seasonal migration occurs at various times of the year due to destruction or drying up of host plants; adjacent crops may be invaded by these insects. Thrips eat pollen and nectar on a wide range of plants (at least 244 species from 62 families).

Management—biological control

There are no significant natural controls early in the season when damage is occurring. Later in the year, predators such as lacewings and minute pirate bugs may reduce populations. Cold, wet weather during bloom much reduces thrips damage.

Management—cultural control

Fields adjacent to unmanaged or wild land that contains many flowering host plants are often subject to more damage because of the habitat such areas offer. If other flowering plants with desirable flowers (complex flowers, yellow, white or blue in color) are nearby and in bloom at the same time as strawberries, allowing these to flower may reduce activity in the strawberries.

Management—chemical control: HOME USE

Sprays should be applied before blooms open or after petal fall to avoid bee injury.

- acetamiprid
- azadirachtin (neem oil)—Some formulations are OMRI-listed for organic use.
- carbaryl
- imidacloprid
- malathion
- permethrin
- pyrethrins (often as a mix with other ingredients)—Some formulations are OMRI-listed for organic use.
- spinosad—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

- azadirachtin (Neemix and other brands)—Consult label for rate and use directions. Some formulations are OMRI-listed for organic use.
- *Beauveria bassiana* (Mycotrol and other brands)—Consult label for rate. Some formulations are OMRI-listed for organic use.
- malathion (several brands) at 1 to 2 lb ai/a. PHI 3 days.
- naled (Dibrom) at 0.9 lb ai/a. PHI 1 day. Use in evening after bee activity has ended.
- spinetoram (Radiant SC) at 0.05 to 0.08 lb ai/a. PHI 1 day. Suppression only; control may be improved with the addition of an adjuvant.
- spinosad (Success or Entrust) at 0.062 to 0.09 lb ai/a. PHI 1 day. Entrust is OMRI-listed for organic use.
- sulfoxaflor (Closer SC) at 0.07 lb ai/a. PHI 1 day. Apply when thrips first appear. Provides suppression only. Do not apply when bees are actively foraging. Note: Strawberry registration was cancelled on Nov. 12,11/12/2015 but EPA ruled that all product still in the hands of growers is allowed to be used until exhausted.

Strawberry—Twospotted spider mite

Tetranychus urticae

Pest description and crop damage Adults are about 2-3 mm long, have eight legs, and are light tan or greenish with a dark spot on each side of the back. Mite feeding reduces plant vigor and may cause leaves to curl, turn brown, and drop prematurely, reducing yield. Spider mite feeding is accompanied by webbing on the undersides of the leaves.

Biology and life history Adults overwinter around buds or in plant debris, not only on strawberries but also on a wide range of plants. Warm temperatures significantly increase spider mite activity, and the entire life cycle may be completed in as little as 5 to 7 days under warm summer conditions. Therefore, there are many overlapping generations per year. Mites do not fly but are blown from plant to plant or are carried on plant material or equipment. On individual plants, they can walk from infested to new parts of the plant.

Scouting and thresholds Inspect oldest leaves first for stippling; webbing and the mites themselves can be found on the underside of leaves. Infestations early in the year, April or May, cause the most injury. If the population reaches an average of 20 to 25 mites per leaf, treatment is advisable. If the population remains low and does not rise until near or after harvest, treatment is probably not necessary.

Management—biological control

Rain and cool temperatures tend to suppress mite populations. Considerable natural control is provided by lady beetles and Minute Pirate Bugs (*Orius* spp.). Predator mites such as *Typhlodromus* spp. or *Neoseiulus fallacis* (syn. *Amblyseius fallacis*) are also effective at managing populations of spider mites and may be purchased and released. Use according to supplier's directions.

Management—cultural control

Excessive nitrogen fertilization may cause population buildup. Avoid early season applications of insecticides, which reduce populations of beneficial insects. Spider mite infestations are favored by dry, dusty conditions, so avoid creating these situations and stressing the plants.

Home gardeners: Mites can be hosed from plants with a strong stream of water.

Management—chemical control: HOME USE

- azadirachtin (neem oil) —Some formulations are OMRI-listed for organic use.
- insecticidal soap—Some formulations are OMRI-listed for organic use.
- plant-based oils like clove or garlic oil—Some formulations are OMRI-listed for organic use.

Management—chemical control: COMMERCIAL USE

- abamectin (Agri-Mek and other brands) at 0.019 lb ai/a. PHI 3 days. Make two applications 7 to 10 days apart when mites first appear. Repeat this sequence of applications, if necessary, to maintain control (wait at least 21 days). Do not exceed 0.075 lb ai/a in one growing season. Do not use less than 100 gal water/a.
- acequinocyl (Kanemite) at 0.3 lb ai/a. PHI 1 day. Controls all stages of mites.
- azadirachtin (Neemix and other brands)—Consult label for rate and use directions. Some formulations are OMRI-listed for organic use.
- bifenazate (Acramite) at 0.38 to 0.5 lb ai/a. PHI 1 day. Make two applications at least 21 days apart. Do not exceed two applications per season. Controls all motile stages, not eggs.
- cyflumetofen (Nealta) at 0.18 lb ai/a. PHI 1 day. Do not apply more than twice per crop season. Controls all stages of mites. Good coverage is essential for effective mite control.
- etoxazole (Zeal) at 0.09 to 0.135 lb ai/a. PHI 1 day. Controls eggs and young mites only.
- fenbutatin-oxide (Vendex) at 0.75 to 1 lb ai/a. PHI 1 day. Apply in 150 to 200 gal/a. Apply when mites appear. Do not apply more than twice per year. Good coverage is essential for effective mite control. Adjust spray volume and nozzle placement to ensure coverage of top and underside of leaves.
- fenpyroximate (Fujimite) at 0.1 lb ai/a. PHI 1 day. Most active on mite nymphs. Do not exceed 0.2 lb ai/a per season.
- hexythiazox (Savey) at 0.09375 to 0.1875 lb ai/a. PHI 3 days. Controls eggs and young mites only; does not control adult mites. Do not apply more than once per crop season.
- insecticidal soap (M-Pede and other brands)—Consult label for rate. PHI 0 days. Some formulations are OMRI-listed for organic use.
- pyridaben (Nexter) at 0.2 to 0.5 lb ai/a. PHI 1 day for dry formulation; 10 days for liquid formulation.
- spiromesifen (Oberon) at 0.2 to 0.25 lb ai/a. PHI 3 days. Controls eggs and young mites only.