ORGANIC PEST AND DISEASE MANAGEMENT OF SELECTED CROPS ON CALIFORNIA'S CENTRAL COAST:

A Guide for Beginning Specialty Crop Growers

This brief guide to organic pest and disease management reviews general management strategies, then describes options for reducing the occurrence and impacts of the most common pests and diseases affecting dry-farmed tomatoes, potatoes, winter squash, peppers, and bush beans on California's Central Coast. Much of the information provided here is based on the UC IPM website (ucipm.edu).

General Management Strategies

Effective ecological arthropod and disease management begins with design and management of a farming system that avoids or suppresses pests and diseases. Such a system requires few external inputs. Knowing which pests and diseases are prevalent in your area allows you to implement strategies to manage them before they occur. By anticipating likely pest and disease species for crops you intend to grow, you can identify them correctly when they do appear.

Before you select varieties and plant your crop, look up common pests that affect the crop in your area. Learn about pest and disease life cycles, preventive practices, and possible treatments using resources such as the UC IPM website (ucipm.edu), your county Cooperative Extension offices, ATTRA's Biorationals: Ecological Pest Management Database (ncat.org/attra-pub/biorationals), local growers, and other knowledgeable professionals. The information in this guide is not intended to take the place of advice provided by professional pest and disease management experts or organic certification personnel.

Note that if using material inputs, include all materials you plan to use in your organic system plan (OSP); apply only after the material is approved for your intended use by your certifier. If you decide during the season to use a material that was not included in your OSP, check with your certifier first. Use material inputs only when preventive practices, including natural enemies, are insufficient to prevent economic damage. Select pesticide materials for minimal toxicity to beneficial insects (see ATTRA's Biorationals: Ecological Pest Management Database).

Arthropods

- Use resistant varieties when available.
- Exclude pests. Use certified seed and pest-free planting materials; certified seed means the planting stock is certified to be free of certain pests and diseases. Seed certification is distinct from, but complimentary to organic certification. Organic producers should seek both, as well as varieties that are well adapted to local growing conditions.

- Create habitat for biological control organisms (e.g., insect predators and parasites, birds, bats, soil and foliar microorganisms). This usually involves increasing in- and around-field plant diversity to enhance biological control organisms:
  - Insectary plants as rows within the crop (normally 1 bed/12 beds of crop), or as individual plants (one plant every 50 sq. ft.): e.g., white alyssum, regular cilantro, and green and white dill. Insectary plant species vary with crop and time of year to match insectary flowering with crop life cycle.
  - Hedgerows: native woody perennial shrubs and small trees planted along roads, pruned as necessary to discourage vertebrate pests.
  - Summer and winter cover crops.
- Control host vegetation, manage weeds. Mow field margins to reduce alternate hosts for pest arthropods.
- Reduce tillage to destroy fewer soil-dwelling biological control organisms.
- Practice temporal crop rotation (timing). Avoid growing crops during times of the season when pests may be unmanageable.
- Practice spatial crop rotation/isolation. Put serial plantings upwind (especially for weak fliers such as aphids). Isolate serial plantings from each other as much as possible (for strong fliers, such as cucumber beetles).
- Use row covers.
- Use insect vacuums (bug vacuums). Four bed and larger are most effective. Fields should always be vacuumed at least twice during each treatment. Vacuums are a little dangerous if used early in the season because natural enemies of pests may also be removed before they can control the infestation. Begin vacuuming a few weeks before harvest when it is clear that natural enemies won't provide control and there won't be time for another pest to build up.
- Scout fields regularly and use farm-developed action thresholds for insecticide applications. Effective field scouting is 1–3 times per week. Frequency should increase with temperature. As you gain experience, you will learn what level of uncontrolled infestation leads to crop loss and therefore triggers insecticides application(s).
- Use insecticides only when necessary and choose materials with little to no impact on biological control organisms when possible. Cooperative Extension, other farmers, and ucipm.edu are the best sources for information on specific materials. Be sure that registrations and inclusion on lists of products allowed for use in organic production are current. Always follow the label.
- Rogue (remove) affected plants.

Diseases

- Exclude pathogens. Use certified seed and disease-free planting materials (see page 1). Compost using disease-destructive methods. Sanitize equipment.
- Use resistant varieties when available.
- Design fields and rows with aspect and airflow in mind. South slopes get more sun and dry more quickly. Orienting rows N-S prevents rows in multi-row beds from getting less sun and more humidity than others. N-S rows also improve airflow, reducing pockets of high humidity.
- Build your soil, e.g., by adding compost, growing cover crops, and reducing tillage. Manage nutrients, balance cations, and match nitrogen with crop need. These practices increase soil organic matter and augment biological activity with microorganisms that suppress damping-off diseases, while reducing excessive growth that makes some crops more susceptible to some diseases.
- Practice temporal crop rotation (timing). Avoid growing crop during times of the season when diseases may be unmanageable.
- Practice spatial crop rotation/isolation. Put serial plantings of the same crop upwind. Isolate serial plantings from each other as much as possible to minimize foliar diseases that spread with wind and/or rain.
- Practice genetic crop rotation. Rotate crops such that those that share the same important soilborne diseases (or foliar diseases that overwinter in soil) are grown on the same ground as infrequently as possible (never sequentially; sometimes separated by several years' time). Best rotations include pasture, livestock, trees, broad-leaved species after or before grass family species, and different plant families.
- Irrigate to minimize foliar/fruit wetting (for non-powdery mildew foliar diseases) and to minimize periods of soil saturation (for soilborne diseases).
- Supplement drip irrigation with sprinkler irrigations (for some powdery mildews).
- Reduce crop residue (for damping-off diseases and other diseases that survive on crop residue). Time, tillage, and irrigation facilitate breakdown of crop residue.
- Maximize airflow (for foliar diseases). Generous plant spacing, staking, and pruning can reduce the canopy's relative humidity.
- Reduce soil/fruit contact by using drip irrigation, staking, mulch (for fruitrot; soilborne diseases that affect fruit).
- Provide covered growing areas, such as high tunnels or plastic covered hoops (for foliar diseases that spread with abundant free moisture and/or water splashing).
- Scout fields regularly, and use farm-developed action thresholds for disease-suppressive materials applications. Effective field scouting is 1–3 times per week. Frequency should increase with temperature.
- Apply disease-suppressive materials before disease is seen. E.g., apply dusting sulfur to prevent powdery mildew in late season cucurbit crops. Disease pressure varies widely with crop and time of year. Most crops receive no supplemental pesticides for diseases, others require regular protection. Your goal is to anticipate disease and apply materials before disease starts: pesticides are less effective after diseases start.
- Rogue (remove) affected plants.

Dry-farmed Tomatoes: Pests and Diseases, Prevention, and Management Options

Main dry-farmed tomato arthropod pests

Aphids and viruses: Green peach aphid, *Myzus persicae* **and Potato aphid,** *Macrosiphum euphorbiae*

Aphids can spread many tomato viruses that severely affect tomato plants. High aphid populations can cause necrosis, distort foliar growth, and stunt plants. The honeydew secreted by aphid feeding promotes secondary infections of sooty mold on foliage and fruit. Aphid feeding reduces yields most when aphid populations are high, 6–8 weeks before tomato harvest. Yield losses are less significant closer to harvest. However, sunburn of fruit may result if heavy aphid feeding reduces leaf area. Although green peach aphid feeding is less significant, they can transmit viruses such as Alfalfa mosaic virus (calico).

- **Exclusion:** Plant virus-free seed.
- **Beneficial habitat:** Maintain alternate food sources for beneficial insects, such as extrafloral nectaries on fava and bellbeans, and hedgerows with year-round flowers. Generalist predators are natural enemies that can significantly reduce aphid populations.
- **Weed management:** Control weeds in non-crop areas to minimize nearby sources of early season aphid infestation of tomato crops. Important overwintering hosts include tumble mustard (*Sisymbrium altissimum*), penny cress (*Thlaspi arvense*), and other mustards (*Brassica* spp.).
- **Crop rotation/isolation:** Avoid planting next to, or downwind of, other crops commonly infested by green peach aphid, such as lettuce.
- **Scouting and pesticides:** Allowed pesticide materials can be useful when preventive management strategies are insufficient to control an unusual outbreak. Use high volumes of water (100–200 gal/acre if possible) and get good coverage. Apply two sprays 5–7 days apart.
- **Roguing:** Remove plants with virus symptoms as soon as you see them.

Tomato russet mite, *Aculops lycopersici*

Tomato russet mites are tiny, wedge-shaped acarids. Seeing them requires a hand lens. Adults lay clear round eggs on the underside of leaves, usually in dusty areas, low on the plant. Nymphs suck the liquid out of plant cells, causing leaves and stems to bronze, dry up, and die.

- **Weed management:** Control weeds, especially alternate hosts such as nightshades and bind weed that can sustain a population of mites to reinfest a subsequent year.
- **Crop rotation/isolation:** Separate tomato plantings. Situate successional crops upwind of earlier plantings.
- **Scouting and pesticides:** Check for mites above any greasy-looking or bronzed lower leaves and stems every 2–3 days at the stage of crop development when green fruit reaches 1" in diameter. Mark the boundaries of infested areas. Treat immediately if damage symptoms spread. Apply micronized sulfur 7–14 days apart.

Stink bugs: Consperse stink bug, *Euschistus conspersus*. **Redshouldered stink bug,** *Thyanta pallidovirens* **(=** *T. accerra*). **Say stink bug complex,** *Chlorochroa sayi* **and** *Chlorochroa uhleri*. **Southern green stink bug,** *Nezara viridula*

Several stink bugs feed on and damage tomatoes. All have the characteristic shield shape of true bugs, with similar life histories and damage. Adults are brown or green, some with distinct markings. Adults overwinter on the ground under leaves of legume crops, blackberries, or certain weeds such as Russian thistle, malva, and mustards. Adults lay drum-shaped eggs in clusters on leaves in March or April. Nymphs resemble adults, but without wings. On green tomato fruit, feeding damage looks like pinpricks, and their piercing mouthparts can insert yeast or other pathogens that can cause fruit to grow soft and rot.

- **Habitat to foster natural biological control organisms:** Generalist predators and parasites both attack stink bug egg masses. Native parasites can parasitize a majority of eggs. If parasitized egg masses are found, monitor newly hatched nymphs. Treatment may be unnecessary.
- **Weed management:** Control overwintering hosts such as legumes, blackberries, Russian thistle, mustards, and malva around fields that are to be planted to tomatoes in spring.
- **Scouting and pesticides:** Examine stink bug eggs to determine levels of parasitization. Parasitized eggs are dark, and emergence holes are irregular, unlike the round holes stink bugs leave when they emerge. Monitor for stink bugs by shaking the vines and checking the ground. Stink bugs leave brown liquid frass that dries into minute spots on leaves and fruit.
- **Treatment with kaolin clay or insecticidal soap can deter feeding or kill the bugs, respectively:** Apply with high water volume and slow speed to get canopy penetration and coverage of bugs on the ground.

Main dry-farmed tomato diseases

Late Blight, *Phytophthora infestans*

Late blight is a serious disease that develops rapidly and can destroy an entire tomato field in a few weeks' time. The disease is common in coastal areas because it develops in humid conditions (foggy, dewy, rainy), and moderate temperatures (50–80°F). The disease survives only in living tissue. To prevent its spread to new plantings, avoid

introduction into the fields or proximity of infected living hosts, including solanaceaous weeds, and volunteer potatoes and tomatoes.

Learn to recognize the disease! See photos of the disease on tomato leaves, stems, and fruit (Figure 1; see also *Late blight on tomatoes* in **Additional Resources**, page 12). Lesions start as small, dark brown, oily-looking lesions on leaves and stems. These quickly develop white fungal growth that produces thousands of spores, which can be spread by the wind in a matter of hours.

The "Scouting" section of the article *Organic management of late blight of potato and tomato* (see reference in **Additional Resources**) describes the importance of acting quickly to salvage what can be harvested of a current crop affected by late blight, and/or destroying foliage to minimize late blight survival and spread to crops in future years and neighboring fields.

Although certain copper-based products are allowed with restrictions in organic production, their use must be limited (to avoid copper build-up in the soil), and used preventively (see reference in **Additional Resources**). Use of a copper-based fungicide, at best, delays the demise of a susceptible host crop where the inoculum is present and conditions are favorable to development of the disease.

- **Field sanitation/Pathogen exclusion:** Use clean planting stock. Eliminate volunteer tomatoes and solanaceous weeds.
- **Resistant varieties:** Plant tomato cultivars with late blight resistance. Organic Seed Alliance trials identified some late blight resistance in tomato cultivars 'Stupice' and 'Juliet'.
- **Crop rotation/isolation:** Isolate successive tomato plantings, and plant as far as possible from other susceptible crops such as potatoes.
- **Air and humidity management:** Stake and prune tomatoes to facilitate air circulation and allow leaves to dry. Consider growing under cover in hoophouses.

FIGURE 1. Late blight *(Phytopthera infestans)* **on tomato leaves.**

Powdery Mildew caused by *Leveillula taurica (Oidiopsis taurica)*

Leaves of tomato plants infected by powdery mildew develop irregular, bright yellow blotches, where spots of dead tissue eventually develop; when severely affected, leaves die but usually remain on the plant. Stems and fruit do not develop lesions. You may see patches of white spores on the upper or lower surface of affected leaves. Loss of leaf cover may lead to sunburn damage, fruit cracking, and weakened plants.

- **Pathogen exclusion:** A small infestation in an early crop can provide inoculum for a more serious infestation in later blocks: remove above-ground growth as soon as harvest is over.
- **Crop rotation/isolation:** Tomato powdery mildew also infects peppers and some weeds such as annual sow thistle and groundcherry. Planting tomatoes away from, and upwind of, peppers may be somewhat helpful.
- **Pesticides:** Under favorable conditions and climates, powdery mildew spreads too rapidly to be controlled after first symptoms appear. Preventive sprays of micronized sulfur 7–14 days apart may be necessary, beginning just after the first flowers open, and continuing until two weeks before the end of harvest.

Tomato spotted wilt virus (TSWV) in the tospovirus group

Plants infected with TSWV do not usually produce marketable fruit. This virus is not seedborne or spread by physical contact. It is only transmitted from one plant to another by western flower thrips (see *Tomato spotted wilt virus* in **Additional Resources**).

Susceptible hosts include crops, ornamentals, and weeds, though the thrip can only complete its entire life cycle on certain plants. In California, key crop hosts include tomato, pepper, radicchio, and lettuce. Weed hosts include *Malva parviflora*, sowthistle (*Sonchus oleraceus*), and prickly lettuce (*Lactuca serriola*).

In areas where it is known to occur, effective management of tomato spotted wilt includes use of resistant plant varieties, and an integrated (challenging) approach to managing western flower thrips and onion thrips, vectors of the virus.

- **Pathogen exclusion:** Use virus- and thrips-free transplants (sources that monitor for thrips and inspect for disease).
- **TSWV-resistant cultivars:** Select varieties with the Sw-5 gene, when practical.
- **Vector management:** Manage thrips on transplants.
- **Crop rotation/isolation/weed management:** Isolate new plantings from older fields (especially those confirmed to have TSWV infection) with key crop hosts and weeds. Control weeds and volunteers near fields where tomato crops will be planted.
- **Roguing:** Destroy plants infected at the seedling stage to prevent spread of the disease.

Potatoes: Pests and Diseases, Prevention and Management Options

Main potato insect pests

Cucumber beetle: Western spotted cucumber beetle, *Diabrotica undecimpunctata undecimpunctata* **and Western striped cucumber beetle,** *Acalymma trivittatum*

The spotted cucumber beetle is more common on the Central Coast than the striped cucumber beetle. However, both may be present, and potatoes can tolerate a number of either beetle. Significant damage generally occurs only in warmer inland areas, surrounded by rangeland, and usually later in the year. Cucumber beetles do not have effective natural enemies in California (although bats can eat large numbers of them). Insecticides allowed for use in organic production are mostly ineffective.

- **Crop rotation/isolation:** Cucumber beetles are strong fliers. Isolate potatoes and other highly susceptible crops, such as cucurbits and corn. Separate sequential plantings of the same crop; plant new blocks upwind and away from older blocks. In areas where pressure is high, consider planting after a recent cash crop instead of a cover crop, as cucumber beetle larvae infest cover crop roots, and adults emerge to feed on crops.
- **Row covers:** Exclude new entry of cucumber beetles by securing row cover over the crop when it is young. Effective prevention of entry must be weighed against risk of enclosing beetles already infesting the field, as well as the cost of the fabric and the labor to keep it in place (more difficult in windy areas). Another downside is that row cover may protect early aphid and mite infestations from the natural enemies that could otherwise reduce their populations. However, mites and aphids are easier to control than cucumber beetles, using cultural practices such as sprinkler irrigation, biological control with insect releases, or pesticides approved for use in organic crop production.
- **Bug vacuum:** Vacuum several times per week during the warmest time of the day when the beetles are most active.
- **Scouting:** Scout by inspecting the undersides of plants. Depending on the stage of the crop, one beetle per plant may be an action threshold. Younger plants are most vulnerable.

Tuber moth, *Phthorimaea operculella*

Tuber moth larvae, or tuberworms, cause economic damage when they tunnel into potato tubers, both in the field and in storage. This pest is most problematic in warmer climates where temperatures do not drop below 50°F, such that all stages—eggs, larvae, pupae, and adults, can overwinter in potatoes either in the soil or after harvest. Tubers that are exposed to the air or close to the soil surface are most vulnerable to infestation. Prevention is key, since currently available insecticides allowed for use in organic production are ineffective against this pest.

FIGURE 2. Spotted cucumber beetle (at left) and assassin bug eating beetle. *Photo: Doug O'Brien*

The adult moth is brown with black markings, with a wingspan of about half an inch, and rests with its wings folded next to its body. Moths lay pale oval eggs on potato leaves or directly on tubers that are exposed or accessible through cracks in the soil. Caterpillar larvae have brown heads and pale bodies up to half an inch long. When eggs hatch, larvae may feed on stems or leaves, then drop to the soil and burrow into the tubers. Webbing and frass (excrement) may be visible where a larvae has entered the potato and begun to tunnel. Larvae feed mostly just below the potato surface, but occasionally go deeper. They leave a dark tunnel ("dirty" because it is filled with frass, unlike "clean" tunnels of wireworms).

- **Field sanitation/exclusion:** Prevent introduction of pests by using certified seed. Certified seed means the planting stock is certified to be free of certain pests and diseases. Seed certification is distinct from, but complimentary to organic certification. Organic producers should seek both, as well as varieties that are well adapted to local growing conditions, and resistant to common pests and diseases. Eliminate pest reservoirs by managing weeds and eliminating volunteer potatoes, both of which can increase populations and be a source of early season infestation.
- **Temporal crop rotation:** Plant early, especially in warmer inland areas; late plantings are more susceptible to tuberworm.
- **Monitoring:** Sample potatoes directly. If you find one tuberworm feeding hole in 10 tubers, harvest potatoes as soon as possible. Pheromone traps also detect tuber moth activity.
- **Minimize exposure of tubers:** Plant potatoes deep in the soil. Maintain hilling so that tubers are always covered with at least 2" of soil. If soil is prone to cracking, use sprinkler irrigation to help close cracks in the soil, and prevent potato tuber moths from access to potatoes on which to lay their eggs.

- **Prompt, thorough harvest:** Harvest potatoes a few days after vine kill or dieback. Do not leave harvested potatoes in the field overnight; moths can lay eggs on them. Clean bins and storage areas before storing potatoes. Destroy culls by burying them deeply or feeding them to livestock. Avoid piles of cull potatoes that provide a year-round tuber moth breeding site.

Aphids and viruses: Green peach aphid, *Myzus persicae* and Potato aphid, *Macrosiphum euphorbiae*

Aphid feeding on potatoes is a problem mainly because they are vectors that transmit plant viruses. Potato Leaf Roll Virus (PLRV), cucumber mosaic and alfalfa mosaic (calico) viruses are spread by both green peach and potato aphids, the former being the more effective vector. Early season PLRV infection stunts plants. Infected russet and yellow-skinned potatoes develop phloem net necrosis, a brown discoloration that diminishes market quality. Other viruses spread by aphids include cucumber mosaic and alfalfa mosaic (calico).

- **Sanitation:** Purchase clean, certified seed. Plants grown from infected seed potatoes will not produce marketable potatoes.
- **Habitat enhancement and biological control:** Manage habitat to foster natural biological control by beneficial insects (generalist predators), or release beneficial insects.
- **Weed management:** Control weeds, especially malva and brassicas, in non-crop areas that host overwintering aphids and facilitate early season aphid infestation.
- **Crop rotation/isolation:** Plant upwind of other potato plantings or other crops that are commonly infested by green peach aphid, such as lettuce.
- **Allowed pesticides:** Use high water volume (100–200 gal/acre) to maximize coverage. Two sprays 5–7 days apart are most effective (preferable to additional sprays or a longer interval between sprays).
- **Roguing:** Remove plants with virus symptoms as soon as you see them.

Tuber Flea Beetles, *Epitrix tuberis*

Sporadic outbreaks of flea beetles occur in potatoes on the Central Coast, mostly in warmer inland areas, after dry winters, and late in the season. The adults are small (1/16") and jump like fleas. Several species of shiny flea beetles cause economic damage to leafy crops such as brassicas when the adults eat many tiny holes "shot-holes" in the foliage.

It is the Tuber Flea Beetle whose larvae feed on tubers that causes economic damage to potatoes. Preventive strategies, such as crop rotation and weed host management, are key to organic flea beetle management. Allowed pesticides are not very effective against flea beetle, which tends to hide in the soil.

Flea beetles overwinter as adults in weeds and field borders, emerging when temperatures reach about 50°F. Adult flea beetle feeding on potato foliage is of concern only because it indicates a future risk of economic damage by larval feeding on the tubers. After feeding for several days, adults lay eggs in the soil at the base of plants. Slender white larvae hatch and feed on roots, underground stems, and tubers. Damage appears as a pimply surface and small brown tunnels in the tubers.

- **Crop rotation:** Plant potatoes in a field previously planted to a non-susceptible plant family such as legumes or grasses, not solanums or brassicas. Avoid planting potatoes soon after potatoes or other susceptible crops, such as brassicas.
- **Weed management:** Manage weeds (especially those in the brassica family) in and around potato fields.
- **Row cover:** Exclude flea beetles by covering crops immediately after planting, provided that the field is not already infested. Seal the edges of row cover well to keep these very small and persistent insects out.
- **Bug vacuum:** Vacuum beetles into fine mesh nets because flea beetles are small and resistant to dying.

Wireworms. Common local species of wireworms include: Pacific coast wireworm, *Limonius canus*. Sugarbeet wireworm, *Limonius californicus*. Dryland wireworm, *Ctenicera pruinina*

Wireworms are click beetle larvae that live in the soil. They cause economic damage by eating potato seed pieces or roots of young plants, or burrowing into developing tubers. Adult click beetles mate in early summer and lay eggs just below the soil surface in grassy or weedy areas. Wireworms begin as small white larvae, feed on many different crops, and mature over 3–5 years into hard (wiry) cylindrical orange-brown worms. Feeding damage is worst in years 2–3.

Wireworms are more prevalent in sandy soils previously in pasture or apple orchard. To assess their presence, monitor by direct observation during normal tillage operations, or by baiting with carrot or potato pieces placed 4–6" deep when soil temperatures warm up above 50°F. Small, localized infestations may be reduced by manually killing wireworms eating this bait. Using this as a damage predictor for the current season is relatively impractical, since it needs to be done when soils are warm. Early planting of potatoes is preferable.

- **Crop rotation/location:** Avoid planting potatoes after sod or in fields where populations are high.
- **Biological control:** The fungus *Metarhizium anisopliae* holds promise as a biocontrol, but commercial products may not yet be available.

Many other management options have downsides. E.g., tillage, disking, cultivation, and summer fallow reduce wireworm populations, but some of these practices also diminish soil structure and organic matter. Flooding for one week during warm weather will kill all stages in the soil, yet this may not be practical given the value of water on the Central Coast.

Main potato diseases

Late Blight, *Phytophthora infestans*

Late blight caused the Irish Potato famine in the mid-1800s. The disease is common in coastal areas because it develops in humid conditions (foggy, dewy, rainy), and moderate temperatures (50°–80°F). Late blight develops rapidly, and can defoliate a crop within a few weeks. The disease survives only in living tissue. To prevent its spread to new plantings, avoid introduction/proximity of infected living hosts, including volunteer potatoes and tomatoes, and solanaceous weeds.

Although certain copper-based products are allowed with restrictions in organic production, their use must be limited (to avoid copper build-up in the soil), well timed, and preventive (see *Organic management of late blight of potato and tomato with copper products* in Additional Resources). At best, use of copper-based fungicides delays the demise of a crop where the inoculum is present and conditions are favorable to development of the disease on a susceptible host plant.

Lesions on infected leaves start as small, irregular, water-soaked spots, but expand quickly to dark, dead tissue. Infected tubers show a firm, brown decay on the outside. See photos of the disease on potatoes at *Late blight on potatoes* in Additional Resources.

- **Field sanitation/pathogen exclusion:** Plant certified disease-free seed. Eliminate volunteer potatoes and solanaceous weeds. Destroy potato culls by burying or feeding to livestock.
- **Resistant varieties:** Plant potato cultivars with late blight resistance, such as 'Defender,' (russet type), 'Jacqueline Lee' (round yellow), 'Ozette' (white fingerling) or other emerging varieties resistant to late blight that may become available (see www.ospud.org).
- **Crop rotation/isolation:** Isolate successive potato plantings, and plant as far as possible from other susceptible crops such as tomatoes.
- **Timing:** Plant only in April–May near the coast; later and earlier plantings are more likely to be damaged by blight.

Verticillium Wilt, *Verticillium dahliae*

Verticillium wilt infestation appears as yellowing (chlorosis) and death (necrosis) of lower leaves. These wilt symptoms progress up the plant, causing plants to senesce and die early, resulting in very low yields. The fungus can persists in soil for years, and infects many broad-leaved crops, including strawberries. Infection occurs most in cool weather, but high temperatures favors disease development, such that this disease is more of a problem on potatoes grown inland. The disease interferes with the plant water transport (vascular) system, so the impact becomes visible quickly in hot weather.

- **Pest and disease avoidance:** Do not plant potatoes in fields known to be infested with problematic potato pests, including Verticillium, but also wireworm or tuberworm (discussed on page 6).
- **Resistant varieties:** Choose Verticillium-tolerant cultivars. Yellow Finn is susceptible.
- **Crop rotation:** Use a 2–3 year rotation grasses and legumes before planting potatoes and other susceptible crops.
- **Timing:** Avoid late plantings, when temperatures favor the disease.

Scab, *Streptomyces* spp.

Scab causes potato tubers to be unmarketable. Common scab may look similar to tuber lesions caused by *Spongospora subterranea* or russetting caused by *Rhizoctonia solani*. Scab inoculum, or fungal spores, may persist in soil on decaying organic matter, or be brought into the field on infected seed tubers. New young tubers may be infected as soon as they begin growing; mature tubers are not susceptible. Implement long crop rotation to break this disease cycle.

- **Sanitation/Pathogen exclusion:** Plant certified seed potatoes free from common scab.
- **Soil amendment:** More alkaline soils favor scab development. Acidify with soil amendments such as sulfur and gypsum to decrease soil pH and reduce favorability to disease development.
- **Resistance:** Plant resistant varieties
- **Crop rotation:** Choose cover crops such as rye and oats. Avoid rotations with carrots, beets, spinach, turnips, or radishes.
- **Irrigation management:** Maintain high soil moisture (80–90% of available water storage) during tuber initiation and the following 6–8 weeks.

Winter Squash: Pests and Diseases, Prevention and Management Options

Main winter squash insect pests

Cucumber beetle: Western spotted cucumber beetle, *Diabrotica undecimpunctata undecimpunctata* and Western striped cucumber beetle, *Acalymma trivittatum*

The spotted cucumber beetle is most common and does more damage to squash foliage, but the smaller striped cucumber beetle may feed on the fruits, making them unmarketable. Expect more damage during warm weather, in warmer climates, in areas surrounded by rangeland, and later in the year. Cucumber beetles do not have effective natural enemies in California (though bats can eat large numbers). Currently, organically-approved insecticides are mostly ineffective against this beetle.

- **Crop rotation/timing:** Avoid planting squash where infestations of cucumber beetle have been heavy or common. Plant early. Rotate crops. Cucumber beetles are strong fliers—plant upwind and separated from older sequential blocks, and other highly susceptible crops, such as potatoes, cucurbits, beans, and corn.

- **Row covers:** Consider excluding new entry of cucumber beetles by covering young crops with row cover. Weigh potential benefits against the costs of material and labor to secure the fabric in place, and the risks of enclosing beetles already in the field and excluding natural enemies of pests. Row covers must be removed when the plants flower to allow pollination, and thus do not help with a late season infestation. Note that cucumber beetles can completely kill young seedlings; if heavy cucumber beetle populations are likely, apply row covers before seedlings emerge and remove them when plants are at the 4-true leaf stage.
- **Bug vacuum:** While bug vacuuming may be used to manage beetles in other crops, it may not be practical or cost-effective in squash.
- **Scouting:** Monitor for beetles at growing points and undersides of young plants.

Melon Aphid, *Aphis gossypii* and other aphids

The melon or cotton aphid may be yellow, green, or black, winged or wingless (see *Melon aphid or cotton aphid* in Additional Resources). A pest with many host plants, they are problematic with high temperatures later in the season (September and October), feeding on the underside of older leaves. The plants may lose vigor, become stunted, or die. Fruits coated with sticky honeydew can develop secondary infections of sooty mold and become unmarketable. Aphids can also transmit plant viruses.

- **Weed and residue management:** Manage common weeds that harbor aphids. Incorporate crop residues as soon as harvest is finished.
- **Crop rotation/isolation:** Rotate crops. Locate new sequential plantings upwind of older squash plantings, or other crops that are frequently infested by melon aphids such as chard, beets, and other cucurbits.
- **Scouting:** Scout for pests, taking note of beneficial insects and mummified aphids. Very often, natural enemies will control aphids.
- **Pesticides:** Pesticides allowed for use in organic production can be useful when cultural practices and natural enemies are insufficient. Apply two sprays 5–7 days apart, using high volumes of water (100–200 gal/acre if possible) to get good coverage.
- **Roguing:** Rogue out plants with virus symptoms as soon as you see them.

Main winter squash diseases

Powdery mildew: *Sphaerotheca fuliginea* (=*Podosphaera xanthii*) and *Erysiphe cichoracearum* (=*Golovinomyces cichoracearum*)

Powdery mildew is caused by several different organisms, and affects leaves and stems of older, fruit-bearing plants. It is most common in the fall, when humidity is high (50–90%), days are warm (60–80°F), and nights are cool. Spores overwinter on weeds, and carry long distances on the wind. Powdery mildew is especially damaging to highly susceptible squash such as spaghetti, acorn, and kabocha varieties. Some other varieties (e.g., butternut) are more resistant.

Powdery mildew begins as pale yellow spots, then its mycelium spreads quickly over plant surfaces, producing spores that have a powdery appearance (Figure 3). Infected leaves lose vigor, and eventually die and turn papery brown. When leaves no longer shade the fruit, it will not mature properly, and dark-skinned squashes can be badly sunburned.

- **Resistance:** Plant resistant cultivars.
- **Manage weeds and residue:** Eliminate sources of above-ground inoculum that can readily infect a crop. Incorporate crop residue as soon as harvest is complete.
- **Crop rotation:** Plant squash where the crop will have full sun exposure and good air circulation. Rotate crops.
- **Sprinkler irrigation:** Sprinkler water inhibits germination and kills spores of powdery mildew, but can only provide early season control; it must stop when fruits form or they will rot on the damp ground. Early season control with sprinkler water sometimes delays the epidemic long enough for fruit to mature. Late season prevention with sulfur may be needed if the weather is favorable for powdery mildew; growers usually do one sulfur spray after the sprinklers are turned off, compared with 2–3 sprays for fields that start on drip irrigation. Where weeds are problematic, growers often prefer drip irrigation combined with multiple sulfur sprays for powdery mildew, rather than fewer sprays and more hand labor to control weeds in fields with sprinklers.
- **Pesticides:** When conditions are favorable for powdery mildew, the disease spreads too fast to be controlled after symptoms appear. Pesticides may be effective as preventive or suppressive, not curative. Apply a biorational material, such as micronized sulfur, bicarbonate, or biological materials beginning just after the first flowers open until three weeks before the end of harvest. Backpack spraying may be necessary for vining varieties.

Verticillium Wilt, *Verticillium dahliae*

Verticillium wilt affects all cucurbits, but varieties vary in their susceptibility. Symptoms begin as chlorosis (yellowing) on the

FIGURE 3. Powdery mildew on winter squash.

edges of leaves and progress into wilting and necrosis (dying) out to the ends of runners. The disease grows in the vascular system (xylem), where it interferes with water transport; symptoms show up as brown streaks. The progression of the disease depends on the host's susceptibility. It may kill the plant in a matter of weeks, or, in more resistant hard squashes, merely reduce yield and quality.

Verticillium dahliae can survive dormant in the soil for years, and affects a wide host range. Infection happens in cool weather, but symptoms show up when temperatures are high and the plant is stressed, often after fruit set. It is more of a problem in inland areas.

- **Resistance:** Plant resistant crop varieties.
- **Crop rotation/location:** Use long rotations (2–3 years or more) out of susceptible crops such as cucurbits, solanums, and strawberries to non-susceptible crops, such as grasses and legumes. Microsclerocia persist in the soil. Do not plant where soils are heavily infested and therefore unsuitable to susceptible crops.
- **Timing:** Plant early in the season; avoid late plantings when high temperatures favor the disease.
- **Fertility/irrigation:** Manage fertility and irrigation to avoid excess of nitrogen or moisture. Where weather warm enough for it to be effective, consider soil solarization.

Peppers: Pests and Diseases, Prevention and Management Options

Main pepper insect pests

Thrips. Western flower thrips, *Frankliniella occidentalis***. Onion thrips,** *Thrips tabaci***. Chili thrips,** *Scirtothrips dorsalis* **and other species.**

Thrips can be vectors of Tomato Spotted Wilt Virus (TSWV; see disease section, page 10). Scout early by looking for the tiny insects on growing tips with a hand lens. Apart from virus transmission, thrips cause the most damage to peppers before first fruits form, and as temperatures warm up. They feed on young growing tips, causing young leaves to distort, discolor, and stunt. Tolerance is low: one thrips per growing tip. A heavy infestation can stunt plants and lower yields. Natural enemies can be helpful, but may not control populations early enough to prevent economic damage.

- **Site management**: Mow field borders to reduce thrips habitat and prevent their migration to young peppers.
- **Pesticides:** Apply pesticides if scouting shows more than one insect per plant tip.

Aphids: Green peach aphid, *Myzus persicae*

Peppers can tolerate a small population of aphids, particularly if natural enemies are abundant nearby. However, heavy infestations will coat fruit with sticky aphid exudates that are difficult to remove.

- **Plant in-field insectaries:** Cilantro and dill are good insectary plants for slow maturing peppers. Natural enemies, nourished by the insectaries, will often control aphids in peppers.
- **Crop rotation/isolation:** Avoid planting peppers next to, or downwind of, other crops such as lettuce that are frequently infested by green peach aphid.
- **Row covers:** Row covers may be used to exclude aphids, but they also exclude natural enemies that may otherwise control aphids.
- **Scouting and pesticides:** Scout early and frequently. Apply two sprays, 5–7 days apart, of a minimally toxic pesticide to prevent harm to beneficial insects. Use high volumes of water (100–200 gal/acre if possible) and get good coverage.

Cucumber beetle: Western spotted cucumber beetle, *Diabrotica undecimpunctata undecimpunctata* **and Western striped cucumber beetle,** *Acalymma trivittatum*

The spotted cucumber beetle is more common and does more damage to foliage, but the smaller striped cucumber beetle may feed on fruit calyxes, making fruit unmarketable. Scout early. Expect more damage during warm weather, in warmer climates, in areas surrounded by rangeland, and later in the year. Cucumber beetles do not have effective natural enemies in California. Currently, organically-approved insecticides are mostly ineffective.

- **Location/timing:** Avoid planting peppers where infestations of cucumber beetle have been heavy or common. Plant early. Rotate crops. Cucumber beetles are strong fliers—plant upwind and separated from older sequential blocks, and other highly susceptible crops, such as potatoes, cucurbits, beans, and corn.
- **Monitoring:** Scout by inspecting the undersides of plants. Depending on the stage of the crop, one beetle per plant may be an action threshold. Younger plants are most vulnerable.
- **Row covers:** Exclude new entry of cucumber beetles by securing row cover over the crop when it is young. Benefits of excluding the pest must be weighed against risk of enclosing beetles already infesting the field, as well as the cost of the fabric and the labor to keep it in place (more difficult in windy areas). Another downside is that row cover may protect early aphid and mite infestations from the natural enemies that could otherwise reduce their populations. However, mites and aphids are easier to control than cucumber beetles, using cultural practices such as sprinkler irrigation, biological control with insect releases, or pesticides approve for use in organic crop production.
- **Bug vacuum:** Vacuum removal of cucumber beetle can be effective if done frequently during the warmest time of the day when the beetles are most active. The lack of natural enemies makes vacuuming one of the best strategies.

Main pepper diseases

Powdery mildew caused by *Leveillula taurica* (*Oidiopsis taurica*)

Powdery mildew can be a serious disease of peppers, especially in warm climates, in late season plantings, in high tunnels, and with drip irrigation. The diseases affects older leaves most, showing up as patchy white spots that can spread rapidly under favorable conditions. Infected leaves curl up and leave fruit vulnerable to sunburn.

Prevention and management options:

- **Field sanitation/pathogen exclusion:** Even small infestations early in the crop cycle can be sources of inoculum and cause a serious infestation. Incorporate all crop residue as soon as harvest is over.
- **Crop rotation:** Rotate peppers with crops not susceptible to powdery mildew. Avoid planting in close proximity to susceptible crops.
- **Irrigation:** Sprinkler irrigating can delay the development of powdery mildew long enough to harvest the crop, or to avoid one or more prevention sprays. Although they grow best in high humidity, unlike most fungal diseases, powdery mildews are suppressed by overhead irrigation. Time irrigation carefully—start later in the season, after the canopy shades the ground, to minimize weed growth. Discontinue use of sprinkler irrigation when fruit is mature enough to touch the ground and rot.
- **Pesticides:** If other management methods are insufficient to control powdery mildew, apply micronized sulfur when mildew is anticipated just after flowers open, and continue until two weeks before the end of harvest. If sprinkler irrigation is used, at least one of the early sprays can be eliminated.

Tomato spotted wilt virus (TSWV) in the tospovirus group

This disease is sporadic, but serious, since plants infected with TSWV usually do not produce marketable fruit. Symptoms in peppers vary with the stage of growth infected, the cultivar, other viruses, and environmental conditions, but typically include spotting, bronzing, dying leaves, and ringspots on fruit. In areas where it is known to occur, effective management of tomato spotted wilt includes use of resistant plant varieties, and an integrated (challenging) approach to managing western flower thrips and onion thrips, which are key vectors of the virus (see Tomato spotted wilt virus in Additional Resources).

- **TSWV-resistant cultivars:** Select varieties with the Sw-5 gene, when practical.
- **Pathogen exclusion:** Use virus- and thrips-free transplants (from sources that monitor for thrips and inspect for disease).
- **Vector management:** Manage thrips on transplants.
- **Site selection/Spatial crop rotation:** Isolate new plantings from older fields (especially those confirmed to have TSWV infection) with key crop hosts and weeds. Control weeds and volunteers near fields where peppers will be planted.
- **Monitoring:** TSWV can be identified in 5–10 minutes using dipsticks smeared with prepared plant sap samples (ELISA, immunostrip tests that recognize TSWV proteins; PCR tests detect the virus's genetic material). TSWV immunostrip supplies are from companies such as AgDia (www.agdia.com) and EnviroLogix (www.envirologix.com).
- **Roguing:** To prevent spread of the disease, destroy plants infected at the seedling stage.

Beans: Pests and Diseases, Prevention and Management Options

Main bean insect pests

Aphids: Cowpea aphid, *Aphis craccivora*. Black bean aphid, *Aphis fabae*. Pea aphid, *Acyrthosiphon pisum*. Green peach aphid, *Myzus persicae*

Aphids suck plant juices, weakening and distorting crops, and feed on many different host plants. Their piercing mouthparts transmit viruses. Presence of aphids makes some crops unmarketable.

The black bean aphid is the most common and problematic of the aphid pests of beans. These, and other aphids, can proliferate rapidly.

- **Encourage beneficials:** Prevent outbreaks by planting and maintaining in-field insectaries to sustain beneficial insects. Generalist predators such as ladybeetles, green lacewing larvae, and syrphid fly larvae eat many aphids. Plant white alyssum for fast-maturing bush beans, and a mix of alyssum and cilantro for pole beans.
- **Timing/isolation:** Plant early in the season, as late plantings may suffer more damage. Avoid planting near, or downwind from other susceptible crops such as fava bean, chard, and cucurbits.
- **Scouting:** Scout early and frequently by looking on the undersides of leaves. Look also for hollow brown aphid "mummies". Parasitoide wasps, *Lysiphlebus testaceipes*, lay their eggs in aphids. Their developing larvae eat out their insides, leaving an empty brown shell (see photo http://ipm.ucanr.edu/PMG/A/I-HO-AGOS-LT.015.html). Their activity may be sufficient to prevent a serious outbreak.
- **Irrigation/pesticides:** If you do not see mummified aphids, take action quickly to control infestations. Water spray or sprinkler irrigation can help dislodge aphids and also favors beneficial fungus as biological control to kill aphids. Pesticides can be useful to treat early infestations on small plants. Choose least toxic materials (see Biorationals: Ecological Pest Management Database) to prevent harming natural enemies that can help control aphids. Apply two sprays 5–7 days apart, using high volumes of water (100–200 gal/acre if possible) to get good coverage.

Cucumber beetle: Western spotted cucumber beetle, *Diabrotica undecimpunctata undecimpunctata* and Western striped cucumber beetle, *Acalymma trivittatum*

The spotted cucumber beetle is more common on the Central Coast and most serious. Tolerance for this pest in beans is low; even one bite can render a bean pod unmarketable. Damage is worst in warmer inland areas, near rangeland, and later in the year. Cucumber beetles do not have effective natural enemies in California (although bats can eat large numbers of them), and insecticides allowed for use in organic production are mostly ineffective against this beetle.

- **Timing/isolation/crop rotation:** Plant early. Avoid planting beans where infestations of cucumber beetle have been heavy or common. Rotate crops. Cucumber beetles are strong fliers—plant upwind and separated from older sequential blocks, and other highly susceptible crops, such as potatoes, cucurbits, beans, and corn.
- **Row covers:** Exclude new entry of cucumber beetles by securing row cover over the crop when it is young. Benefits of excluding the pest must be weighed against risk of enclosing beetles already infesting the field, as well as the cost of the fabric and the labor to keep it in place (more difficult in windy areas). Another downside is that row covers may protect early aphid and mite infestations from the natural enemies that could otherwise reduce their populations. However, mites and aphids are easier to control than cucumber beetles, using cultural practices such as sprinkler irrigation, biological control with insect releases, or pesticides approved for use in organic crop production.
- **Bug vacuum:** Vacuum removal of cucumber beetle can be effective if done 4–5 times per week during the warmest time of the day when the beetles are most active, starting 3 weeks before harvest.

Main bean diseases

Damping off caused by *Pythium spp.*, *Fusarium spp.*, *Rhizoctonia solani*, and *Thielaviopsis basicola*

Damping off is the most serious disease of beans in the Monterey Bay area, resulting in pre-emergent rot of the whole seed, emerging plant, or the first true leaves. Although symptoms are somewhat different depending on the organism, exact diagnosis is not usually important because all damping-off fungi are managed the same way. Cool soil is the most common reason for damping off, followed by oxygen deprivation caused by too much water.

- **Timing/location:** Plant after soil has warmed sufficiently. Design fields and rows with aspect in mind, using south-facing slopes for spring planting.
- **Irrigation:** Manage irrigation—for best results, follow the instructions for planting beans to moisture (see Organic Fresh Market and Dry Bean Production in this **Grower Guide** series).

Powdery mildew caused by *Erysiphe polygoni*

Powdery mildew can be a problem in dry beans, pole beans, late season plantings, warm areas, and with drip irrigation. It affects all above-ground parts of bean plants. Initial symptoms are small, white spots on the upper surface of leaves. Spots grow and run together in a whitish growth that gradually spreads over a large area of the leaves. Severe infestation reduces yields and shortens the productive life of plants.

- **Exclude pathogens:** A small infestation in an early crop can provide inoculum for a more serious infestation in later blocks: incorporate above-ground growth as soon as harvest is over.
- **Irrigation:** Sprinkle irrigate once, just before flowering, to delay powdery mildew long enough to harvest the crop. Unlike most fungal diseases of plants, powdery mildews are damaged by overhead irrigation. Time/apply this sprinkler irrigation carefully. If too early in the crop cycle, it promotes weed growth; if too much, it may favor growth of *Botrytis* mold.
- **Pesticides:** If other management methods are insufficient, apply micronized sulfur once as soon as symptoms are anticipated or first seen. Symptoms usually appear just before flowering. Application of sulfur after beans are half formed may not improve harvest, and may result in undesirable residue on the pods.

ADDITIONAL RESOURCES

Biorationals: Ecological pest management database, by Rex Dufour. https://attra.ncat.org/attra-pub/biorationals/

Use database to search for individual pests and diseases, e.g., powdery mildew, Verticillium wilt.

Bug vacuums for organic crop protection, by George Kuepper and Raeven Thomas. NCAT IP194, 2002. https://attra.ncat.org/attra-pub/summaries/summary.php?pub=128

Farmscaping to enhance biological control, by Rex Dufour. NAT CT065, 2000. https://attra.ncat.org/attra-pub/summaries/summary.php?pub=145

Hedgerows for California agriculture: A resource guide, by Sam Earnshaw. Community Alliance with Family Farmers (CAFF), 2004. http://caff.org/wp-content/uploads/2010/07/Hedgerow_manual.pdf

Late blight management in tomato with resistant varieties, by Margaret Tuttle McGrath. eOrganic, 2015. http://articles.extension.org/pages/72678/late-blight-management-in-tomato-with-resistant-varieties#.VRNfGkZwfsM

Late blight management on organic farms: 2010 Webinar. eOrganic, 2014. http://articles.extension.org/pages/28346/late-blight-management-on-organic-farms:-2010-webinar

Late blight on potatoes. College of Agriculture and Life Sciences, Cornell University. http://livegpath.cals.cornell.edu/gallery/potatoes/late-blight/

Photos of late blight at various stages on potatoes.

Late blight on tomatoes. College of Agriculture and Life Sciences, Cornell University. http://livegpath.cals.cornell.edu/gallery/tomato/tomato-late-blight/

Photos of late blight at various stages on tomatoes.

Melon aphid or cotton aphid. Featured Creatures, Entomology and Nematology. University of Florida. http://entnemdept.ufl.edu/creatures/veg/aphid/melon_aphid.htm

Organic IPM field guide, by Ann Baier et al. 2006. NCAT. https://attra.ncat.org/attra-pub/summaries/summary.php?pub=148

Useful photos to identify symptoms of many different diseases and pests.

Organic management of late blight of potato and tomato with copper products, by Alex Stone and Brian Baker. eOrganic, 2010. http://articles.extension.org/pages/18351/organic-management-of-late-blight-of-potato-and-tomato-with-copper-products

Organic management of late blight of potato and tomato *(Phytophthora infestans),* by Alex Stone. eOrganic, 2015. http://articles.extension.org/pages/18361/organic-management-of-late-blight-of-potato-and-tomato-phytophthora-infestans

Pest management strategic plan for organic potato production in the west. Summary of workshops held on February 16, 2006, Buhl, Idaho and January 9, 2008, Portland, Oregon. Jennifer Miller, Ronda Hirnyck, Lisa Downey-Blecker. Issue Date, December 19, 2008. http://www.ipmcenters.org/pmsp/pdf/CA-CO-ID-OR-WAOrganicPotatoPMSP.pdf; see pages 7–9

Pesticide Safety Information Series (PSIS), California Department of Food and Agriculture. http://www.cdpr.ca.gov/docs/whs/psisenglish.htm (En Español: http://www.cdpr.ca.gov/docs/whs/psisspanish.htm)

Potato scab, by Rosemary Loria. Vegetable MD Online, Cornell University, 1991. http://vegetablemdonline.ppath.cornell.edu/factsheets/Potato_Scab.htm

Thrips *in* Pests in gardens and landscapes, UC IPM, Statewide Integrated Pest Management Program. http://ipm.ucanr.edu/PMG/PESTNOTES/pn7429.html

Tipsheet: Organic pest management, by Rex Dufour. NCAT IP404, 2015. https://attra.ncat.org/attra-pub/summaries/summary.php?pub=518

For general pest management strategies that are compliant with USDA organic regulations.

Tomato russet mite *in* Florida tomato scouting guide. University of Florida, 2008. http://erec.ifas.ufl.edu/tomato-scouting-guide/bugs/tomato-russet-mite.shtml

Tomato spotted wilt virus, by T.A. Zitter, M. L. Daughtrey, and J. P. Sanderson. Vegetable MD Online, Cornell University, 1989. http://vegetablemdonline.ppath.cornell.edu/factsheets/Virus_SpottedWilt.htm

Verticillium wilt. UC IPM, 2012. http://ipm.ucanr.edu/PMG/r116100111.html

Organic Pest and Disease Management of Selected Crops on California's Central Coast: A Guide for Beginning Specialty Crop Growers by Doug O'Brien and Ann Baier.

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