



Production Guideline

The California Strawberry Commission Production Guidelines are produced in cooperation with scientists who conduct research related to strawberry production. These guidelines are a tool for growers, providing critical scientific background information on diseases and pests common to strawberry production in California. For copies of this guideline or others in the series, visit www.CalStrawberry.com.

Anthracnose of Strawberry

Anthracnose is a disease that occurs wherever strawberries are produced. In California, the disease occurs sporadically and its importance can vary greatly. In some seasons the disease is very destructive, resulting in plants with reduced productivity, unmarketable fruit with lesions, and even plant death. In other years, anthracnose is a minor issue and may be hard to find in the field. Historically the disease is of little concern in California's central coast fruit production fields but may be more damaging to crops in the south coast region. The severity of anthracnose is dependent on the extent to which transplants are contaminated with the pathogen and the amount of overhead irrigation and rain that falls on the planted crop.

Symptoms

The pathogen can infect many different parts of the strawberry plant, though some infections are more common and important than others.

In This Issue

- Anthracnose incidence varies among California strawberry production regions and years and is dependent upon nursery stock cleanliness and environmental conditions.
- Moderate and warm temperatures and wet, humid conditions encourage pathogen spread and disease development.
- Sanitation during strawberry multiplication in the nurseries, pre-plant treatment of transplants, minimizing the use of sprinklers to establish transplants, and application of post-plant foliar fungicides can help manage anthracnose disease.

Root infections, though not commonly seen, result in rotted, non-functional roots that cause the plant to wilt. On occasion, the fungus can also infect the inner tissues of the crown, resulting in an internal red brown discoloration and again, plant wilting. Therefore, root and crown anthracnose disease (Table 1) may resemble symptoms caused by soilborne pathogens such as *Phytophthora*.

On strawberry leaf petioles, runner stolons, and flower peduncles, the anthracnose pathogen causes oval to elongated lesions that range in color from brown to gray to black (Table 1; Figure 1). If conditions are suitable for development of the fungus, the lesions will contain numerous tiny orange masses of spores (Figure 2). Infected leaves can form round, oval, or irregularly shaped brown spots which likewise may produce the orange spore masses.

Strawberry flowers can also become infected, turn brown, and bear the orange spore masses (Figure 3). In some cases, the flower may be killed. Green immature and red ripe fruit show perhaps the most readily identified symptoms. Such fruit develop round to oval shaped, sunken, brown lesions (Figure 4). Lesions are usually firm in texture and may be surrounded by a dark border. As disease develops, the orange spore masses form extensively in the fruit lesions (Table 1; Figure 5).

Pathogen

Anthracnose on strawberry in California is primarily caused by the fungus *Colletotrichum acutatum*, though strawberry is also host to additional species including *C. gloeosporoides* and *C. fragariae*. *Colletotrichum acutatum* is found worldwide on strawberry and many other crop and weed hosts. Some of these other hosts include almond, celery, delphinium, pepper, pine, tomato, walnut, zinnia, chickweed, fiddleneck, and vetch. It is unclear to what extent *C. acutatum* from non-strawberry hosts can infect and cause damage to strawberry.

Strawberry tissue	Symptoms	Orange spore masses?
root	discolored, rotted roots, causing leaves to wilt	no
crown	discolored internal crown, causing leaves to wilt	no
leaf petiole	dark brown, elongated lesions	yes
leaf blade	gray to brown circular spots	yes
runner	dark brown, elongated lesions	yes
flower peduncle (stem)	dark brown, elongated lesions	yes
flower	discolored tissue, causing flower to shrivel	yes
fruit	brown, oval to round, firm, dry sunken spots	yes

Table 1. Anthracnose can cause varying symptoms on different strawberry tissues. Orange spore masses may or may not be visible depending upon the tissue type.



Figure 1. Anthracnose causes oval, elongated lesions on petioles, runners, and other stem tissue.



Figure 2. Lesions often contain numerous tiny fungal bodies and orange masses of spores.

For example, researchers have found that strawberry isolates of *C. acutatum* are more aggressive and damaging to strawberry than isolates from other hosts. *Colletotrichum acutatum* populations from different hosts show genetic relatedness but are not identical groups, indicating that they are distinct from one another. Therefore, *C. acutatum* is likely composed of diverse strains or sub-types that have some degree of host specialization.

Disease Cycle

Colletotrichum acutatum is not a true soil inhabitant and does not survive for long periods of time in the soil. Studies show that this pathogen, under California conditions, can remain viable on bits of strawberry crop residue in the soil for about nine months. Based on limited survival capability and the pattern and sporadic distribution of disease when it does develop, disease occurrence in fumigated production fields is primarily due to infested or diseased strawberry transplants. Disease outbreaks in production fields occur when an infected transplant develops symptoms and the pathogen produces fungal fruiting bodies and spores on the infected tissues. Spores form in a sticky orange ooze and are almost exclusively spread by splashing water, so there must be rain or overhead sprinkler irrigation taking place for the spores to be splashed from the initially diseased plant to surrounding healthy ones. With continued favorable weather (moderate temperatures of 60 to 85 degrees F and wet, humid conditions) the spores germinate and infect the surrounding plants, resulting in disease outbreaks. Therefore, if there are no rains during the fruit production period, significant levels of anthracnose disease on strawberry fruit are rare. To a lesser extent, spores can also be spread through physical contact (such as from passing equipment that brushes against the wet, infected foliage). The anthracnose fungus is not spread via airborne spores, which is the case for powdery mildew and Botrytis gray mold.



Figure 3. Infected flowers can turn brown and bear orange spore masses.



Figure 4. Infected fruit develop round to oval, sunken brown lesions.

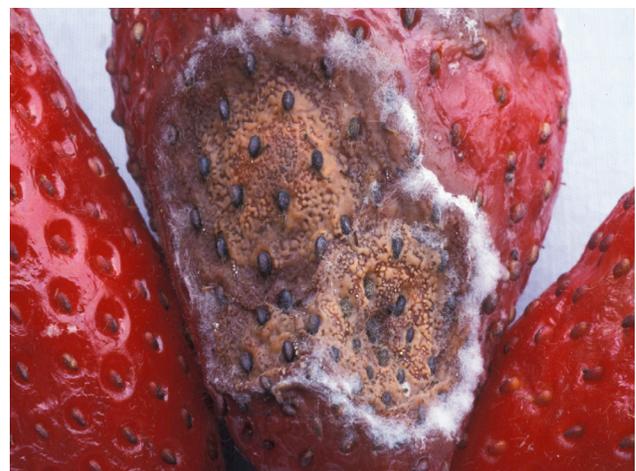


Figure 5. If weather conditions are suitable, fruit lesions will contain mycelium and orange spore masses.

Disease Management

Pre-plant control measures: Because anthracnose—resistant strawberry cultivars are not yet available, the most essential step in preventing this disease in production fields is the use of pathogen-free plants. Therefore, integrated disease management strategies in nurseries are critical. Mother plants should be maintained pathogen-free at every step of multiplication. Irrigating nursery plants using drip systems will decrease disease spread and development. Alternatively, using micro-sprinklers instead of high impact sprinklers could minimize conditions that favor anthracnose, though field research has not yet demonstrated this advantage of micro-sprinkler systems. The use of fungicides as plant dips or foliar sprays is an important tool for minimizing anthracnose. If symptoms develop on transplants, removing diseased plants may also help reduce disease spread to other parts of the transplant field. Transplants coming out of cold storage for planting into nursery fields (and not for fruit production purposes) can be treated with hot water to reduce, though not eradicate, *C. acutatum*. However, if not conducted properly, hot water treatments can damage the plants. See Integrated Pest Management for Strawberries (UC ANR Publication 3351) and other information sources for guidelines on hot water treatments.

Pre-plant soil fumigants likely can reduce *Colletotrichum* populations remaining in soil following disking and incorporating a previously diseased strawberry crop. However, the extent of pathogen survival following the application of materials like chloropicrin and 1,3-dichloropropene + chloropicrin (InLine) has not been well documented for California fruit production fields. Broadcast applications are likely to provide a greater level of control than bed-only fumigation or drip applied materials.

If a strawberry crop is planted into non-fumigated soils that had anthracnose-infected plants the previous season, the subsequent crop is subject to infection from soilborne inoculum. Therefore, crop rotation is recommended and back-to-back strawberry plantings should be avoided. Judicious crop rotation is especially important for organic strawberry since a fumigation step is not possible. Second-year strawberry fields, if infected with anthracnose in year one, will likely have higher levels of disease in year two.

For fruit production fields, treating transplants prior to planting can reduce the level of anthracnose. Thoroughly washing transplants in plain water to remove soil has demonstrated some reduction in anthracnose, likely due to the washing off of fungal inoculum present on the transplants. However, such a treatment could increase the incidence of other diseases, such as angular leaf spot caused by the bacterium *Xanthomonas fragariae*. Dipping transplants in the fungicides Abound (azoxystrobin) or Switch (cyprodinil + fludioxonil) can reduce the incidence and severity of anthracnose. Switch is an effective fungicide with no reports of resistance associated with its use for anthracnose control in California.



Current manufacture recommendations state that plants should be dipped in the fungicide solution for no longer than five minutes and then not stored longer than 12 hours before planting. Abound can also be effective, though there is evidence that some *Colletotrichum* isolates may be resistant to this fungicide. Care should be taken when treating transplants with fungicides, because failure to adhere to treatment recommendations could result in damaged transplants. Before implementing transplant treatments, check with your transplant supplier for guidelines and consult your local Agricultural Commissioner's office and product labels for current status of product registration, restrictions, and use information.

Post-plant control measures: If transplants are established with the use of overhead sprinklers, such irrigations should be ended as soon as possible. Spores produced on infected plants will spread by the splashing water from sprinkler irrigations.

The mechanical spread of spores by equipment passing through the field is of secondary importance. Nevertheless, growers should be aware of the potential of moving spores around on machinery and crews when there are symptomatic plants in the field and the foliage is wet.

A key part of the management strategy is to accurately detect anthracnose in the field. Fruit and stem infections may be readily identified due to the formation of the orange spore masses on lesions. However, if the orange masses are absent, symptoms may look like other diseases or appear to be physical damage. *Colletotrichum*-infected roots and crowns cannot be diagnosed without laboratory tests. Therefore, carefully investigate possible anthracnose cases and consult appropriate professionals and laboratories as needed.





Timely foliar application of the fungicides Captan (captan), Abound (azoxystrobin), and Switch (cyprodinil + fludioxonil) is warranted if wet conditions from rain or extensive fog are anticipated and especially if anthracnose symptoms have been observed and the disease is confirmed. These fungicides are protectants and should be applied prior to extensive disease development.

Currently, there are no organically acceptable fungicides that are effective against anthracnose. Because fungicides are used to manage this disease at both transplant and fruit production stages, it is advisable to develop a comprehensive integrated disease management system that takes into account the fungicide products used in all phases of the strawberry industry.

Production Guideline by:

Mark Bolda
UCCE
p. 831.763.8040
mpbolda@ucanr.edu

Oleg Daugovish
UCCE
p. 805.645.1454
odaugovish@ucanr.edu

Steve Koike
UCCE
p. 831.759.7356
stkoike@ucanr.edu

California Strawberry Commission
P. O. Box 269 | Watsonville, CA 95077
p. 831.724.1301 | f. 831.724.5973
www.CalStrawberry.com
©2017 California Strawberry Commission

