

2015 Florida Plant Disease Management Guide: Strawberry¹

Natalia A. Peres²

Alternaria Rot

Alternaria rot, caused by *Alternaria tenuissima*, occurs infrequently and is usually not important in most strawberry-growing regions.

This rot affects ripe fruit in the field as well as post-harvest. Lesions are irregular in shape and slightly sunken. Older lesions are circular, firm, sunken, and dark green to black due to sporulation of the fungus (Figure 1).



Figure 1. Alternaria Rot.

Management

CULTURAL

Do not leave over-ripe fruit in the field.

Angular Leaf Spot

Angular Leaf Spot (ALS), caused by *Xanthomonas fragariae*, is an important disease for winter strawberry production worldwide. The disease was reported first in Minnesota in 1960 and since then it has been found in almost all cultivated strawberry areas in the U.S.

Symptoms

The first symptoms of ALS begin as small, water-soaked lesions on the undersurface of the leaves (Figure 2). When moisture is high on the leaves, these lesions ooze sticky droplets of bacteria. As the disease develops, the lesions enlarge to form reddish-brown spots that later become necrotic. A practical way to recognize the disease is to place the leaves against a source of background light where the spots are seen as translucent. The tissue with older lesions eventually dies and dries up giving leaves a ragged appearance.

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2. N. A. Peres, associate professor, Plant Pathology Department, Gulf Coast Research and Education Center, Wimauma, FL; UF/IFAS Extension, Gainesville, FL 32611.

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Figure 2. Angular Leaf Spot (ALS).

Causal Organism

X. fragariae is a slow-growing, gram-negative, motile bacterium that is highly specific to wild and cultivated strawberry.

Disease Cycle and Epidemiology

The primary source of inoculum in a new field is contaminated transplants. Secondary inoculum comes from bacteria that exude from lesions under high moisture conditions. Bacteria can survive on dry infested leaves and tissue buried in the soil for up to 1 year. The pathogen is mainly dispersed by rain and overhead sprinkler irrigation. It also can spread easily by harvesting operations when wet and cool conditions favor the production of bacterial exudate. Little is known regarding the epidemiology of ALS; however, development of the disease is favored by cool days (20°C/68°F) and cold nights (2–4°C/36–39°F).

Management

CULTURAL

The best way to control ALS is to use pathogen-free transplants. Minimizing the use of overhead sprinklers during plant establishment and for freeze protection may also reduce the spread and severity of the disease. Harvesting and moving equipment through infected fields should be avoided when plants are wet.

CHEMICAL

See Table 10.4 in <http://edis.ifas.ufl.edu/cv134>

Anthracnose Fruit Rot

Anthracnose fruit rot, caused by *Colletotrichum acutatum*, is an important disease for strawberry production

worldwide. Although fruit rot is the most important symptom caused by *C. acutatum*, the fungus can also attack other parts of the plant including the crown, leaves, petioles, and roots.

Symptoms

Symptoms of anthracnose fruit rot appear as dark, sunken lesions on infected fruit. On green fruit, anthracnose lesions are small (1/16 to 1/8-inch across) hard, sunken, dark brown or black. Lesions on ripening fruit are larger (1/8 to 1/2 inch) hard, sunken, and tan to dark brown (Figure 3). During wet weather, the lesions become covered by sticky, light orange ooze composed of millions of spores (conidia) in a mucilaginous matrix. When conditions are favorable for infection, multiple lesions nearly cover the fruit and lesions may appear on petioles. Strawberry flowers are highly susceptible and blighted flowers turn brown and remain attached to the plant, a symptom also produced by the fungus *Botrytis cinerea*.



Figure 3. Anthracnose Fruit Rot.

Causal Organism

C. acutatum produces orange masses of conidia that are hyaline, straight and usually with pointed ends. Molecular analysis of *C. acutatum* revealed that the population on strawberry reproduces asexually and has limited diversity. Other species of *Colletotrichum*, such as *C. fragariae* and *C. gloeosporioides*, cause anthracnose diseases of strawberry but are less frequently involved in fruit rot.

Disease Cycle and Epidemiology

Infected transplants are a common source of inoculum for production fields. *C. acutatum* apparently spreads first on the foliage, often without causing visible symptoms. Some conidia are formed on green leaves and petioles, and more are produced as the tissue ages and dies. Conidia are moved

from the foliage to flowers and fruit by splashing water and harvesting operations. There, they germinate and infect tissues. As anthracnose lesions develop, abundant spores are formed that may be moved to other plants and new fields on equipment and harvesters. Warm wet weather favors infection and disease spread.

Management

CULTURAL

Transplants should be obtained from pathogen-free nurseries. Moving personnel and equipment from affected fields into disease-free fields should be avoided without proper cleaning and disinfestation. ‘Sweet Charlie’ is considered relatively resistant to anthracnose fruit rot whereas ‘Strawberry Festival’ is moderately susceptible. Newer cultivars ‘Florida Radiance’ and ‘Sensation’ (FL 127) are more resistant than ‘Strawberry Festival’.

CHEMICAL

See Table 10.4 in <http://edis.ifas.ufl.edu/cv134>

Botrytis Fruit Rot or Gray Mold

Botrytis fruit rot, also known as gray mold, caused by *Botrytis cinerea*, is one of the most important diseases of strawberry worldwide. *B. cinerea* is a cosmopolitan fungus that infects a wide range of fruit, vegetable, and weed species.

Symptoms

Botrytis fruit rot occurs in the field and after harvest. Infection occurs in the flowers and recently set fruitlets, but the symptoms are observed commonly on green and ripening fruit. Lesions begin as small, light brown spots that quickly enlarge and become covered with white fungal mycelia. Under moist conditions, gray-to-brown spores cover the lesions and the entire fruit may become mummified (Figure 4). When diseased fruit are disturbed, large numbers of spores are often released and are visible as gray puffs.

Causal Organism

The pathogen produces hyaline, septate hyphae. Single-celled, multinucleated, ellipsoid conidia are produced on conidiophores. Conidia are hyaline individually but appear gray in mass.

Disease Cycle and Epidemiology

B. cinerea is a common colonizer of strawberry foliage in the nursery and also is present on dying vegetation around strawberry fields. After runner transplants are planted,

spores produced on old dying leaves rapidly colonize new emerging leaves without causing visible symptoms. These spores (conidia) are dispersed by air, by water, and by harvesters to infect flowers during the main bloom period in January and February. Cool to mild temperatures and prolonged leaf wetness promote spore production, germination, and infection of stamens, petals, and other floral parts. Flower infections often progress slowly, with lesions becoming visible on green and ripening fruit 2 to 4 weeks after infection. Direct infection of fruit by spores is not considered important in the field or after harvest. However, the pathogen also spreads from diseased fruit to healthy fruit by direct contact. As the epidemic progresses, diseased fruit, mummified fruit, and decayed flowers and pedicels become important new sources of inoculum. Botrytis fruit rot is especially damaging in annual production systems with prolonged flowering and fruiting cycles. The disease is favored by cool and wet weather. In Florida, the second crop of fruit that ripens in February and March is more seriously affected than the first crop of fruit that ripens in December–January.



Figure 4. Botrytis Fruit Rot.

Management

CULTURAL

Removal of infected fruit and plant debris can be used to reduce inoculum, but is not practical for control of Botrytis fruit rot. ‘Sweet Charlie’, ‘Florida Radiance’, and ‘Sensation’ (FL 127) are equally susceptible to Botrytis and more susceptible than ‘Strawberry Festival’.

CHEMICAL

Fungicides should be applied at peak bloom.

See Table 10.4 in <http://edis.ifas.ufl.edu/cv134>

Colletotrichum Crown Rot

Colletotrichum crown rot, caused by *Colletotrichum gloeosporioides* or *C. fragariae*, is a serious disease in subtropical production regions. Although crown rot is observed in fields during the winter production season, it is most severe in nurseries in the southeastern United States and is one of the primary reasons that production of transplants for the Florida fruit production season has been moved to cooler regions.

Symptoms

Symptoms caused by *C. gloeosporioides* and *C. fragariae* are virtually indistinguishable in the field. Plants infected initially show signs of water stress and may collapse relatively rapidly (2–3 days) at high temperatures. At cool temperatures, it may take weeks before plants collapse. The internal crowns of infected plants show a reddish-brown and firm rot when cut (Figure 5). Typically there are no lesions on foliage or stolons and symptoms may be confused with those of Phytophthora crown rot.



Figure 5. Colletotrichum Crown Rot.

Causal Organisms

Conidia of *C. gloeosporioides* are barrel shaped with both ends rounded, whereas conidia of *C. fragariae* are narrower at one end and are slightly pointed. Setae of *C. fragariae* differ from those of *C. gloeosporioides* in that they function as phialides and conidia can often be observed at the tips.

Disease Cycle and Epidemiology

Propagation of plants in Canada and northern states for the Florida fruit production season has greatly reduced the incidence of crown rot. However, during the warm months

at the beginning and end of the production season crown rot incidences of up to 5 percent occur in Florida fields. Recent studies have shown that inoculum for crown rot infections in Florida may be coming from non-cultivated hosts. *Colletotrichum* sp. responsible for crown rot do not appear to survive between seasons on plant debris in subtropical production systems since plants are usually killed immediately after the season ends in the spring and the fungus disappears from crowns during the hot summer months.

Management

CULTURAL

Transplants from northern nurseries should be used to avoid crown rot. Reducing water on foliage by using drip irrigation will also limit dispersal of the pathogen. Treasure cultivar is considered highly resistant to crown rot. Cultivars FL Radiance and Sensation (FL 127) are more resistant than Strawberry Festival.

CHEMICAL

See Table 10.4 in <http://edis.ifas.ufl.edu/cv134>

Leaf Scorch

Leaf scorch, caused by *Diplocarpon earlianum*, is a common leaf disease of strawberries worldwide.

Symptoms

Symptoms on leaves are numerous, irregularly shaped, purplish blotches that are 1/16 to 3/16 inch in diameter. Clusters of the blotches turn brownish, but never white or gray as in the case of common leaf spot. Dark, glistening acervuli appear in the lesions on the upper surfaces of the leaves. In severe cases, the leaf margins curl upward and the leaves dry to a tan color, progressing from the margins to the midrib, giving the leaf a scorched appearance.

Causal Organism

The fungus is limited to species and cultivars of *Fragaria*.

Disease Cycle and Epidemiology

Leaf scorch is favored by long periods of leaf wetness (12 hours or more), frequent rain, and moderate temperatures (60–78°F). The severity of the disease usually is low in annual production systems.

Management

CULTURAL

Prolonged use of overhead irrigation should be avoided.

CHEMICAL

See Table 10.4 in <http://edis.ifas.ufl.edu/cv134>.

Leaf Spot

Leaf spot, caused by *Mycosphaerella fragariae*, is one of the most common diseases of strawberries worldwide.

Symptoms

Leaf lesions are initially small, purplish-red and less than 1/8 inch in diameter. The spots may enlarge to 1/4 inch depending on the cultivar. On some, the lesions remain very small and numerous and the leaflets appear “rusty.” On others, the lesions increase to 1/4 inch in diameter or larger and develop white or gray centers with reddish-purple to dark purple borders. Lesions may also form on fruit, calyces, petioles, and stolons. Severe infection can result in death of leaflets and defoliation of plants.

Causal Organism

The fungus is considered to be pathogenic only to species and cultivars of *Fragaria* and several races have been defined according to their effects on different cultivars.

Disease Cycle and Epidemiology

Older lesions provide inoculum to infect plants during the season. Conidia are produced during the entire season if weather conditions are favorable (50–86°F) and are splash disseminated.

Management

CULTURAL

Disease-free transplants should be used.

CHEMICAL

See Table 10.4 in <http://edis.ifas.ufl.edu/cv134>.

Charcoal Rot

Charcoal rot, caused by *Macrophomina phaseolina*, was first reported in Florida in 2005.

Symptoms

Infected plants wilt and eventually die. The disease affects the plant roots and crowns and it can be difficult to distinguish from other crown diseases such as *Colletotrichum* and *Phytophthora* crown rots. Laboratory isolations are necessary for proper identification.

Causal Organism

Macrophomina phaseolina produces numerous dark oblong sclerotia on isolation medium after 4 to 5 days incubation. Ostiolate pycnidia bearing relatively large, broadly ellipsoidal, hyaline conidia occasionally develop on host tissue after 8 to 10 days of incubation.

Management

CULTURAL

Planting should be avoided in fields with a history of *Macrophomina*.

Phomopsis Leaf Blight and Phomopsis Soft Rot (*Phomopsis obscurans*)

Phomopsis leaf blight and Phomopsis soft rot, caused by *Phomopsis obscurans*, can occasionally cause serious problems on strawberry, especially on plants propagated in nurseries from the southeastern United States.

Symptoms

Lesions on the foliage are small initially and form circular, reddish-purple spots. Older spots can coalesce and form large V-shaped lesions with the widest part of the lesions at the leaf margin and the narrow base centered on a vein (Figure 6). Black specks that are the pycnidia often develop within the central areas of the older lesions. Initial symptoms on fruit are round, light pink, and water-soaked lesions (Figure 7). Frequently, two or more lesions may coalesce into large soft brown lesions with dark fruiting structures (pycnidia) on the surface. On plants propagated in Florida and the southeastern United States over-summer, the disease also may produce dark, sunken, and elongated lesions on the stolons and petioles while fruit symptoms are similar in appearance to anthracnose.

Disease Cycle and Epidemiology

Conidia of *Phomopsis obscurans* are spread by splashing water, harvesting operations, and equipment. The disease is favored by warm, wet conditions and can be most severe during the summer on plants propagated in Florida and the southeastern United States. In fruit production fields in Florida, Phomopsis leaf blight will develop during the fall and early winter. The fruit rot phase of the disease typically develops in fields where leaf blight is present in the fall and winter as the weather gets colder and drier. Both the leaf blight and fruit rot caused by *P. obscurans* are rarely observed during late season.



Figure 6. Phomopsis Leaf Blight.



Figure 7. Phomopsis Soft Rot.

Management

CULTURAL

Transplants should be obtained from northern Canada or the western United States since leaf blight typically occurs on transplants propagated in the southeastern United States.

CHEMICAL

See Table 10.4 in <http://edis.ifas.ufl.edu/cv134>.

Phytophthora Crown Rot

Phytophthora crown rot, caused mainly by *Phytophthora cactorum*, can be a serious disease of annual production strawberry in Central Florida.

Symptoms

The disease is characterized by a sudden decline and wilt of plants. Reddish-brown coloration on the internal crown makes symptoms difficult to distinguish from those produced by *Colletotrichum gloeosporioides* or *C. fragariae*. Thus isolation and characterization of the pathogen are important for proper identification.

Causal Organism

In Florida, *Phytophthora cactorum* historically has been responsible for causing the disease, although *P. citricola* also has been reported.

Disease Cycle and Epidemiology

Infected transplants are the primary source of inoculum for epidemics in Florida. The pathogen produces zoospores that infect strawberry plants under wet conditions. *Phytophthora* species produce oospores and chlamydospores that may persist in infested soil and plant debris, although oospores have not been observed in Florida. *Phytophthora cactorum* also causes leather rot and the infected fruit may provide a source of inoculum. The disease is favored by warm temperatures and prolonged periods of wetness, conditions that are common during the plant establishment period (October) in Florida.

Management

CULTURAL

Use of disease-free transplants is the best way to control the disease.

CHEMICAL

See Table 10.4 in <http://edis.ifas.ufl.edu/cv134>.

Phytoplasma Diseases

Several diseases of strawberry are caused by phytoplasmas. Some of the most common are aster yellows, green petal, bronze leaf wilt, and multiplier.

Symptoms

Phytoplasma diseases can be recognized by one or more characteristic symptoms, such as phyllody (Figure 8), stunting, and yellowing. Molecular techniques are necessary for detection and identification of phytoplasmas.

The disease is transmitted by grafting and by leafhoppers.



Figure 8. Phytoplasma-green petal.

Management

CULTURAL

Use of disease-free transplants.

Powdery Mildew

Powdery mildew, caused by *Podosphaera aphanis* (syn. *Sphaerotheca macularis*), occurs in most areas of the world where strawberries are grown. The disease is particularly severe on strawberries grown in greenhouses or plastic tunnels. In open fields in Central Florida, the disease is typically most severe in November and December and it may reappear in late February and March.

Symptoms

Early symptoms appear as small, white patches of fungus growing on the lower leaf surface. These patches can expand and coalesce to cover the entire leaf surface under favorable conditions. On some cultivars, irregularly shaped yellow or reddish brown spots will develop on colonized areas on the lower surface of the leaf and eventually appear on the upper surfaces. The edges of heavily infected leaflets curl upward (Figure 9). The fungus can also infect fruit and may reduce fruit quality and marketable yields.

Causal Organism

Podosphaera aphanis is an obligate parasite that only infects living tissue of wild or cultivated strawberry. The fungus produces chains of dry, hyaline conidia and, occasionally, cleistothecia containing ascospores on infected leaves.

Disease Cycle and Epidemiology

The fungus readily infects living, green leaves in the nursery. Thus, infected transplants are normally the primary

source of inoculum for fruiting fields in Florida. When conditions are favorable, conidia produced on infected plants are wind-dispersed. Development and spread of powdery mildew is favored by moderate to high humidity and temperatures between 60° and 80°F. Rain, dew, and overhead irrigation inhibit the fungus. Because dry conditions and high humidity are common in greenhouses and plastic tunnels, powdery mildew typically is more severe in protected culture.



Figure 9. Powdery Mildew.

Management

CULTURAL

Disease-free transplants should be used for controlling powdery mildew, although fields can become infected by conidia blown in from neighboring fields. Cultivars differ widely in their resistance to powdery mildew. ‘Strawberry Festival’ and ‘FL Radiance’ are moderately susceptible and the new cultivar ‘Sensation’ (FL 127) is highly susceptible.

CHEMICAL

See Table 10.4 in <http://edis.ifas.ufl.edu/cv134>.

Rhizopus Rot or Leak

Rhizopus rot or leak, caused by *Rhizopus stolonifera*, affects fruit and is most serious after harvest or in storage but can also occur in the field.

Symptoms

Infected fruits collapse and rapidly leak juice (Figure 10). A loose, cottony growth of mycelium (whiskers) grows over the surface of the fruit. Fruiting bodies (sporangia) appear as black dots scattered throughout the mycelium.



Figure 10. Rhizopus rot or leak.

Causal Organism

Rhizopus spp. cause rots of various fruit and vegetable crops. The fungus can spread from other plants or plant debris.

Disease Cycle and Epidemiology

The fungus survives on crop debris and in the soil between seasons. *Rhizopus* can infect only through wounds. Under favorable conditions of high temperature and moisture, sporulation is rapid and abundant. Spores are disseminated by air and by insects.

Management

CULTURAL

Fruit should be handled carefully to avoid bruising. When possible, fruit should be picked during the morning, protected from the sun, and cooled rapidly before shipping.

Root Necrosis

Root necrosis, caused by *Colletotrichum acutatum*, has been observed in Florida since 2000. This fungus is widely known as a fruit rot pathogen, but also infects other strawberry tissues, including the roots.

Symptoms

Transplants with infected root systems often grow poorly or fail to become established after overhead irrigation is withdrawn. Few functional roots are found on infected plants even 1 to 2 weeks after transplanting. Old structural roots are brown or black with few feeder roots, whereas new roots develop brown lesions, die back from the tip, or fail to emerge from the crown. In severe cases, *C. acutatum* enters

the crown, causing a basal crown rot and eventually killing the plant. Plants in affected fields are stunted or irregular in size, flower late, and produce a poor early crop (Figure 11). Infected plants may recover during the cool winter months and produce normally in February and March if an outbreak of anthracnose fruit rot does not follow.



Figure 11. Root Necrosis.

Causal Organism

See anthracnose fruit rot.

Disease Cycle and Epidemiology

C. acutatum frequently colonizes leaves and petioles of runner plants in the nursery. Obvious symptoms may not be visible in the nursery environment, but if inoculum is allowed to build up and the weather is favorable, lesions may develop on the petioles. Little is known about how or when the pathogen spreads from colonized tissue above the ground to the root system below. However, *C. acutatum* grows freely in diseased tissues and has been isolated from the soil around diseased plants. Healthy plants are presumably contaminated by this inoculum during normal digging, trimming, and packing operations in the nursery. Cultivars that are highly susceptible to anthracnose fruit rot, e.g., Camarosa and Treasure, are susceptible to root necrosis disease as well. Early in the season, plant-to-plant disease spread is not thought to occur below ground as the root systems are relatively isolated. However, above-ground spread does occur and may be facilitated by overhead irrigation during establishment.

Management

CULTURAL

Disease-free transplants should be used.

CHEMICAL

A pre-plant fungicide dip may suppress disease development when the disease is confirmed or when susceptible cultivars are being grown.

Stem-End Rot and Leaf Blotch

Stem-end rot and leaf blotch, caused by *Gnomonia comari*, occur sporadically and may be found in association with *Phomopsis obscurans*.

Symptoms

Fruit can be affected at all stages. Characteristic symptoms on small fruit are irregular, brown areas on the surface and cessation of fruit development. On ripe fruit, the disease is characterized by a soft rot that is often invaded by secondary organisms. Leaf blotch lesions on young leaves are purple to brown and occasionally enlarge to form light-brown, necrotic spots on older leaves (Figure 12). The outer leaves may die resembling the symptoms of Verticillium wilt. Peduncles, petioles, and calyxes may also be affected.



Figure 12. Leaf Blotch.

Causal Organism

G. comari infects numerous rosaceous species worldwide. Perithecia are globose and beaked, and ascospores are hyaline, straight or slightly curved, and septate.

Disease Cycle and Epidemiology

Fruit is infected by conidia and ascospores produced on other parts of the plant or on other hosts. The disease is spread by frequent rains or overhead irrigation. The fungus generally penetrates through stomata or wounds when humidity is high.

Management

CULTURAL

Some strawberry cultivars may be resistant but there is no information regarding the susceptibility of cultivars grown in Florida.

CHEMICAL

See Table 10.4 in <http://edis.ifas.ufl.edu/cv134>.

Verticillium Wilt

Verticillium wilt, caused by *Verticillium albo-atrum* and *V. dahliae*, is an occasional problem in winter annual strawberry production. These pathogens have wide host ranges and isolates that are pathogenic on potato and tomato are also pathogenic on strawberry.

Symptoms

Initial symptoms are wilting of the plant and browning of the margins and interveins of older leaves. Younger leaves may remain green, but develop slowly and the plant becomes stunted, declines, and ultimately dies (Figure 13). The crown of diseased plants develops necrotic streaking that appears similar to other crown rots. It is necessary to isolate the fungus to confirm its identity.



Figure 13. Verticillium Wilt.

Disease Cycle and Epidemiology

Infected transplants appear to be the primary source of inoculum for outbreaks of Verticillium crown rot in Florida. Disease spread from plant to plant seems unlikely, but infection may occur through root contact. The pathogen is favored by sudden weather changes such as increases in temperatures or lack of moisture.

Management

CULTURAL

The best method to control *Verticillium* wilt is to use disease-free transplants. Strawberry nurseries should avoid areas that were previously used for potato or tomato production. This fungus is likely to be more severe at high pH, so care should be taken to not over lime the soil.