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STRAWBERRY BOTRYTIS FRUIT ROT (GRAY MOLD) AND BLOSSOM BLIGHT

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Botrytis fruit rot (BFR), also called gray mold, is caused by the fungus *Botrytis cinerea* and is considered one of the most destructive annual diseases of strawberry worldwide. BFR is most commonly found on harvested strawberries but the disease may appear before harvest depending on weather conditions. Postharvest rot is often very rapid, and the infected berries are not marketable. In addition to fruit rot, this fungal pathogen can infect strawberry leaves, blossoms, and petioles.

Symptoms

Young flowers are very susceptible to infection. One or several flowers in a cluster may show a tan-brown discolouration or blighting and may eventually dry while still attached to the pedicel **(Figure 1A).** The infection may also extend down the pedicel. The flowers are susceptible to infection for the first 2-3 days after opening and the conidia (spores) of the fungus can infect petals, stamens, and pistils. Blossom blight develops under cool wet conditions and frost injury can aggravate the damage. In extreme cases, the entire inflorescence may become colonized and die **(Figure 1 B)**. However, most flower infections are less obvious, but are still very important. In fact, research has shown that most fruit infections occur during bloom, but symptoms do not appear until close to harvest. These flower infections allow the fungus to become established in the receptacle of the young fruit as 'latent' or 'quiescent' infections. As the fruit matures from the white to pink stages, the fungus becomes increasingly active and symptoms of rot intensify with berry development **(Figure 1)**. Initial rot symptoms of light to medium brown lesions may appear on any part of the fruit and any tissue in contact with the lesion **(Figure 1 C and D)**. The infected fruit loses its shape as it grows, and the rot expands rapidly near maturity until the entire fruit is affected. Soon, the whole rotted fruit becomes tough, dried, and mummified **(Figure 1 E and F)**.

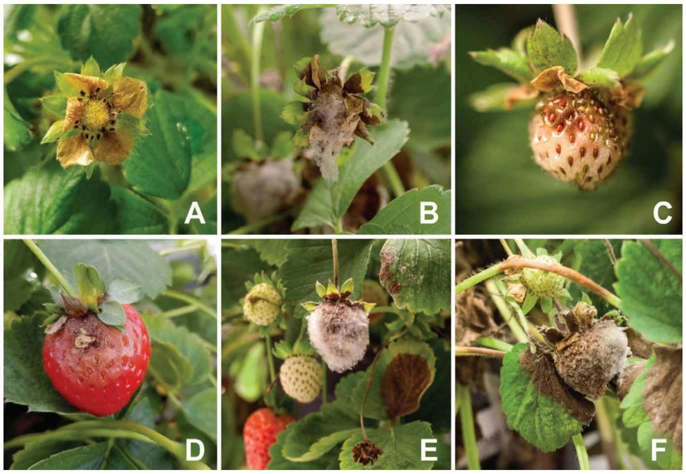

Figure 1. Symptoms of *Botrytis cinerea* infections in strawberry. (**A**) Senesced flower with *B. cinerea* mycelium growth. (**B**) An advanced floral infection with greyish mycelium of *B. cinerea*, (**C** and **D**) Infections of fruit at different stages. Infected petal can be seen as the source of fruit infection in Panel D. (**E** and **F**) Mummified strawberry and browning of leaves due to *B. cinerea* infection. (Source: *Petrasch et al. (2019). Molecular Plant Pathology 20(6), 877–892).*

The disease can be easily recognized by the presence of a grayish fuzz consisting of mycelium (fungal threads), conidiophores (spore bearing threads), and conidia of the fungus on surfaces of rotted tissues, especially on rotted fruit **(Figure 2)**. Harvested strawberry fruit can sometimes be infected with Rhizopus and Mucor decay fungi as well, but BFR can be distinguished from these in that Rhizopus and Mucor cause the berries to rapidly collapse and leak juices, whereas, BFR does not cause extensive leaking.

B. cinerea produces small black, irregular shaped sclerotia (~ 5 mm long) which are the long-term survival structures of this pathogen. The sclerotia are seldom produced on decayed fruit in the field but they can be observed on dead petioles, residues left from the previous year, straw used for mulching in the strawberry fields and on dead weeds.

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Disease Cycle

Botrytis cinerea overwinters as sclerotia and mycelium on dead tissue. In spring, the fungus becomes active and produces large numbers of conidia on the surfaces of the dead tissues. Spores are produced optimally at 15-22 ˚C with only a few spores produced at ≤ 5 and ≥ 25 ˚C. The spores are mainly wind-dispersed or by rain/irrigation and become deposited on flowers and developing fruit. They germinate in the presence of a moisture film from dew, rain or irrigation and can initiate new infection within a few hours depending upon the temperature of the wet period. For example, the incidence of flower infection by *B. cinerea* conidia increases from zero to 90% at temperatures of 15-25 ˚C as the duration of leaf wetness increases from 6 to 24 hours. Infection can occur at lower temperatures if wet periods are prolonged. The incidence of BFR is often highly correlated with the amount of rainfall 11-30 days prior to the first harvest, which corresponds with the early bloom through green fruit stage of development. Thus, the most critical period for applying fungicides for disease control is during flowering. However, direct infection of ripening fruit by conidia is also possible once disease becomes established in a field with susceptibility increasing from green to ripe fruit. Over ripe fruit is highly susceptible to infection, rapid colonization, and subsequent production of conidia **(Figure 2)**.

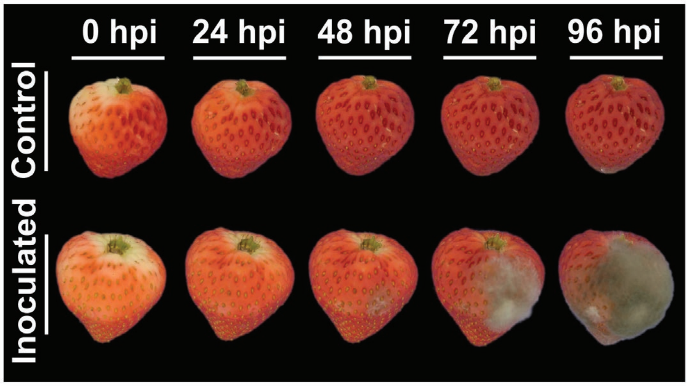

Figure 2. Ripe strawberry infection by *Botrytis cinerea* under experimental conditions. After 48 hours of post infection, mycelium can be observed and by 96 hours post infection the entire ripe strawberry is covered by *B. cinerea*. It can be a huge problem if strawberries are not stored properly.(Source: *Petrasch et al.* (2019). *Molecular Plant Pathology* 20(6), 877–892).

Disease Management

Prevention is the most important management strategy as symptomless transplants are an important source of *B. cinerea* in new fields. Transplants should be purchased from a reputable nursery.

- Cultivar resistance to BFR is lacking, but partial resistance offered by some cultivars in combination with an effective fungicide spray program can control this disease.
- Since most infections occur during the flowering period, an effective fungicide spray program during this period can significantly reduce the disease threat. Different classes of labelled fungicides should be used in rotation as Botrytis has developed resistance to many fungicide groups.
- Chlorothalonil can effectively prevent spore production by Botrytis on over wintered dead debris. One application in the fall and two applications before flowering can reduce the need for additional treatment during post flowering and fruit development. Pre-flowering treatment also helps to reduce pesticide residue on the fruit.
- Careful harvesting to minimize fruit injury reduces direct infections by conidia of *B. cinerea* and subsequent colonization. Overripe and diseased fruit should be avoided at harvest. Only firm and ripe fruit should be picked and if possible promptly cooled to near 0 ˚C to suppress fruit respiration and to slow the growth of *B. cinerea* and other pathogens **(Figure 2)**.
- Scout strawberry fields for browning on blossoms and calyces of developing fruit. Look in the center of rows where plant canopies are the most dense and relative humidity is the highest. As the fruit ripens, check for signs of rot. Older plantings where crop debris has built up over time are more at risk.
- Maintaining proper nitrogen levels is important since high nitrogen levels promote BFR development as it can increase BFR incidence from 60-80% under favorable environmental conditions.
- Close mowing during renovation combined with the removal of cut foliage can suppress BFR by 50% in the next cropping season. Without the removal of crop debris, mowing will not suppress the BFR. However, removal of debris may be economical only in organic operations. Where fungicides are used, debris removal is not considered to be cost effective.
- Infected fields should be worked last in a work schedule to reduce disease spread to healthy fields on machinery and workers.

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