Botrytis Fruit Rot / Gray Mold on Strawberry

NC STATE EXTENSION

Disease

Botrytis rot, or gray mold as it is often called, is a serious disease in all strawberry production areas and is a disease of concern in most years. The disease is a problem not only in the field, but also during storage, transit, and marketing of strawberry fruit, due to onset of severe rot as the fruits begin to ripen. Other parts infected by the fungus include leaves, crown, petals, flower stalks, and fruit caps. Crown rot is discussed elsewhere. Disease is most severe during bloom and harvest in seasons with lengthy periods of cloud and rain complemented by cool temperatures.

Symptoms and Signs

Gray mold may be present during all stages of strawberry fruit development. The most diagnostic symptom is rotted fruit with velvety gray mold growth (Figure SS-1). Light brown lesions usually develop on the stem end of the fruit due to flower infections but may also occur on the sides of fruit where soil, standing water, or infected berries or flower petals are in contact (Figure SS-2, Figure SS-3). Infected berries may remain firm, yet become covered with gray spores and mycelium. High humidity favors the moldy growth formation that is visible as a white to gray cottony mass (Figure SS-1, Figure SS-2). On undeveloped fruit, lesions may develop slowly and fruit may become mis-shapened and die before maturity. Fruit that are completely rotted become dry, tough and mummified.

Figure SS-1: Botrytis gray mold symptoms on ripe strawberry.

Attribution: F.J. Louws

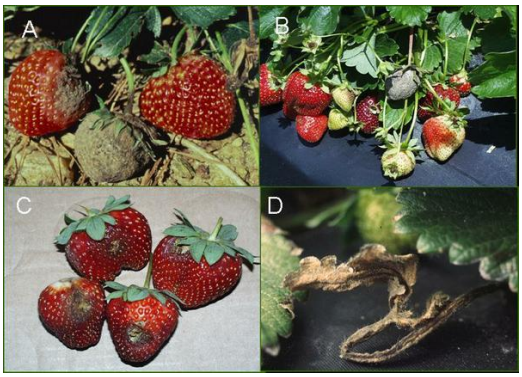

Figure SS-2: Gray mold symptoms: a) on fruit in a matted row system; b) on fruit in a plasticulture system; c) on fruit where flower petals fell allowing the pathogen to directly penetrate fruit; d) on dying leaf and petiole tissue.

Attribution: F.J. Louws

Disease Cycle

Botrytis can enter the field on transplant foliage. The fungus can live in the green tissue but be latent, or dormant, and not cause symptoms. Botrytis can affect many different crops and therefore weeds surrounding a field could be an important source of the pathogen. The pathogen can also produce dark hardened structures called sclerotia and these can persist in soils for years. Based on North Carolina research, it appears most infections occur from initial inoculum on leaf and crown tissue moving with transplants. In the case of symptomless leaf infections, as the infected strawberry leaf begins to die, the pathogen goes into an active stage, colonizing the leaf and obtaining its nutrients from the dead tissue (Figure SS-3a). Spores then form and, once environmental conditions are appropriate (between 65-75°F [18-24°C] and with damp or rainy weather), they are dispersed by water splash and/or wind onto newly emerging leaves or blossoms. Most fruit rots start with infections during the bloom stage; the pathogen grows into the flower and then will colonize the stem-end of the strawberry. Once the berries begin to ripen, the fungus and the weather conditions are favorable, the pathogen is able to colonize the fruit producing the stem-end brown rot (Figure SS-3c) and mold (Figure SS-1; Figure SS-2a,b) often seen in the field (this may be up to 24 or more days since bloom infection occurred). Some fruit infection occurs by direct growth from dropped flower petals (Figure SS-2c) or dead leaves (Figure SS-2d; Figure SS-3a).

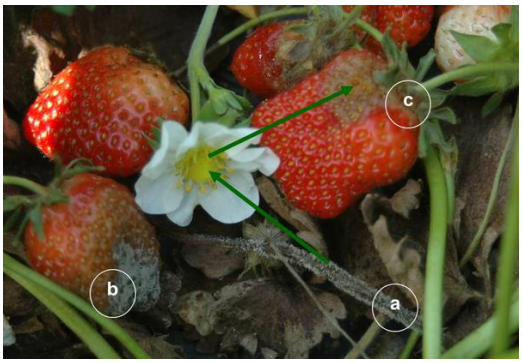

Figure SS-3: Infection cycle of B. cinerea in strawberry plantings. Gray mold on different parts of strawberry; a) Sporulation on dead petiole and leaf; b) fruit infection from colonized dead tissue; c) fruit infection that came through the flower.

Attribution: F.J. Louws

Management

Cultural

1. Plant Growth and Variety Selection:

B. cinerea is commonly associated with transplant leaves and two years of research has demonstrated that there are no differences due to plant source or variety. Currently, it is not possible to obtain disease-free plants and this should not be a burden on nursery growers. However, plug production practices may favor high populations of latent infections or crown rot problems (addressed elsewhere). Likewise, excess use of certain fungicides during the propagating phase results in resistant populations and poor control with these fungicides in fruit production fields. Plants with a more upright canopy (e.g. Sweet Charlie) or with dense growth tend to have higher levels of gray mold problems. Otherwise there is no host resistance against Botrytis gray mold.

2. Monitor

Excess nitrogen has been shown to increase fruit rot when weather conditions are favorable. To avoid over-fertilization, schedule fertilizer programs according to leaf tissue nutrient analysis reports. Research has demonstrated increasing nitrogen levels beyond an optimum level does not increase yield but does increase fruit rot problems.

Allow adequate spacing between plants to improve airflow in the canopy. However, manage plant spacing for optimum yields rather than to manage disease. Planting in raised beds improves drainage and also increases airflow, resulting in lower disease levels. Plastic mulch helps protect

against plant and soil-surface contact, weeds that may harbor *Botrytis* inoculum, and reduces moisture within the canopy. Drip irrigation provides a direct source of water and eliminates excess moisture on fruit and leaves.

SANITATION: Removal of dead and dying tissue from the field may be helpful in the fall, but is likely of most benefit in the early spring, just prior to bloom, to help lower inoculum levels. Sanitation involves the removal of dead and dying leaves from strawberry plants and costs about $300/A. The leaves can be dropped to the ground where they quickly rot and do not become a source of spores. An economic analysis has not been performed on the benefit of sanitation. In studies where sanitation was conducted, yields tended to be highest and growers experience the highest benefits if fungicides are not used (e.g. organic production systems). Where fungicides are used, the economic benefit of sanitation for gray mold control is doubtful. Sanitation should not be done if the anthracnose fruit rot pathogen is known to be present (*Colletotrichum acutatum*) since this spreads the anthracnose pathogen. Growers who perform leaf removal also pull emerging weeds from holes, lift plants parts from under the plastic and scout for other potential problems.

Harvested fruit should be monitored for disease, and infected berries removed where practical. Rapid removal of field heat and keeping fruit at around 34°F [1-2°C] and increasing carbon dioxide levels during shipping (12-15% concentration in gastight storage bags) when harvested will help keep *B. cinerea* problems down.

Chemical and Biological

Fungicides play a major role in the management of this disease. Fungicide applications are critical in problem fields during early and full bloom. These fungicides are targeted to limit flower infection that leads to fruit infection, and should limit the need for late season applications to the fruit. A few well-timed sprays starting at first bloom are less costly and more effective in controlling gray mold than frequent fungicide applications through harvest.

Growers must manage fungicides to avoid the development of resistant populations. A detailed fungicide schedule and resources to test the resistance profile of the field population are listed in our regional *Strawberry IPM Guide* updated yearly.

For organic growers, vigilantly manage plant growth as described above and incorporate plant sanitation by removing dead and dying leaves just prior to bloom. Some experience is available on the use of compost teas, biological control products, and other products (biological control products) and can be discussed further with a strawberry specialist. Harvest fruit in a timely manner and remove field heat ASAP to ensure fruit is cooled down prior to shipping or selling.

Antagonistic fungi such as *Trichoderma harzianium* Rifai and *Gliocladium roseum* Bainier have been used in Europe and Brazil as alternatives to fungicides. Efficacy trials in the USA provide limited information on effective biological controls for plasticulture production systems. In the northeastern matted row production region, bees have been used efficiently to deliver beneficial fungi to flowers resulting in reduced gray mold incidence.

Remember, *Botrytis* is in the field all season long. Don't wait until peak bloom or fruit set to begin control practices. Plan ahead and design your management program to inhibit disease progression at critical points in the season, especially during early bloom.

Pathogen

Botrytis cinerea is an unspecialized necrotrophic fungus that produces grayish masses of mycelium, conidiophores, and conidia on the surface of rotted tissues. Hyphae of the pathogen are branched, septate, and hyaline. *B. cinerea* produces asexual conidia on conidiophores that are formed directly from hyphae. Conidiophores usually have a swollen basal cell and are stout, tall (often 2-5 mm), dark brown, and irregularly branched near the apex. Conidia (8-14 x 6-9 µm) are one celled, multinucleate, ellipsoid to obovoid in shape, and have a smooth surface (Figure P-1). *B. cinerea* forms black, elliptical sclerotia that measure up to 5 mm in diameter (Figure P-2). Sclerotia are infrequent on strawberry plants in the field but occasionally appear on dead petioles (Sutton, 1998).

The teliomorph of *B. cinerea, Botryotinia fuckeliana*, has not been reported on strawberry plants during production.

Figure P-1. Multinucleate, ellipsoid to obovoid conidia of B. cinerea.

Attribution: Garrett Ridge

Figure P-2. Sclerotia formed by B. cinerea on a necrotic strawberry stem.

Attribution: Garrett Ridge

Diagnostic Procedures

A key diagnostic feature of Botrytis fruit rot is the grayish mass of mycelium, conidiophores, and conidia of *B. cinerea* on the surface of rotted tissues. When signs are absent, incubating symptomatic fruit or crowns for 24 to 48 hours in a moist chamber usually results in abundant sporulation of the fungus.

Exposure to daylight or UV radiation is needed for prolific sporulation on agar media. Pure cultures can be obtained by isolation of the hyphal tips from the growing margin of a colony on the nutrient

agar medium (Leyronas et al., 2012).

Symptoms and signs of Botrytis fruit rot could be confused with Rhizopus rot. In contrast to Rhizopus rot, little or no leak is associated with Botrytis fruit rot. Instead, rotted fruit become tough, dried, and mummified. Rhizopus rot growth is black and very fuzzy.

Figure DP-1. Sporulation of Botrytis cinerea on crown pieces of an infected strawberry plant after incubating for 3 days in a moist chamber.

Attribution: Garrett Ridge

References

Leyronas, C., Duffaud, M., and Nicot, P. C. 2012. Compared efficiency of the isolation methods for *Botrytis cinerea*. Mycology 3: 221–225.

Sutton, J. C. 1998. Botrytis Fruit Rot (Gray Mold) and Blossom Blight. Pp. 28-31 in: Compendium of Strawberry Diseases, 2nd edition, Maas, J. L. (ed.). APS Press. St. Paul, MN.

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