Susceptibility of Strawberry Cultivars and Related Species to *Colletotrichum fragariae*

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ABSTRACT

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The relative susceptibility of 19 strawberry cultivars (*Fragaria* × *ananassa*) to *Colletotrichum fragariae* was evaluated. *F. virginiana* and *Potentilla canadensis* were susceptible to *C. fragariae*; however, *Duchesnea indica* did not become infected after repeated inoculations. The fungus spread 450 m from an inoculum source to infect healthy strawberry plants.

Additional key words: anthracnose, dissemination, resistance

Strawberry anthracnose, caused by *Colletotrichum fragariae* A. N. Brooks, limits production of strawberry plants (*Fragaria* × *ananassa*) in Florida, Louisiana, and North Carolina in hot, moist growing seasons (1,6,10). The fungus causes dark, elongated lesions that girdle runners and petioles of infected plants (1). It also invades crowns at the soil line, causing a reddish discoloration of the inner tissue, wilting, and plant death (2,6).

Abundant spore masses are produced on infected tissue (1) and are disseminated in surface water by flooding of low areas, splashing water, windblown water droplets, and movements of animals or people (1,3,10). Horn and Carver (7) reported that the fungus does not overwinter in soil but survives in infected crowns of apparently healthy strawberry plants that can serve as a source of primary inoculum the following spring.

Other hosts are also a possible source of inoculum. *C. fragariae* has been reported to infect *Duchesnea indica* (Andr.) Focke (wild strawberry) (1) and *Cassia obtusifolia* L. (sickleweed, coffeeweed) (9). *Cassia obtusifolia* has woody stems that degrade slowly when plowed, which allows the fungus to survive until new seedlings emerge in about 7 days. These seedlings may become infected and serve as a new inoculum source (9). Isolates of *C. fragariae* from *Cassia obtusifolia* are pathogenic on strawberry plants, causing typical anthracnose symptoms.

Disease control measures include fungicide sprays, resistant cultivars, and sanitation practices (3,4,8,10). Information on cultivar susceptibility in North Carolina has not been available. Control by sanitation practices depends on how far the fungus is effectively disseminated from primary inoculum sources. We present information on the relative susceptibility of strawberry cultivars, other hosts, and dissemination distance of *C. fragariae*.

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MATERIALS AND METHODS

Isolates. *C. fragariae* isolates CF-7 and -14 were obtained from Florida, CF-1 from Louisiana, and CF-4, -9, -10, -11, -12, -15, and -16 from North Carolina. Horn et al (8) designated isolate CF-1 as race 2. To obtain the isolates from North Carolina, infected crowns were washed in running water for 30 min and split lengthwise with a sterile scalpel. A small piece of crown tissue was aseptically transferred from the healthy-necrotic interface to a petri plate containing potato-dextrose agar.

Plant material. All test plants except the two Louisiana selections and one Maryland selection were obtained from a registered planting at the Sandhills Research Station, Jackson Springs, NC, where anthracnose has not been observed. Strawberry selections L-2556 and L-6632 were obtained from P. L. Hawthorne, Louisiana State University, and the MD-4409 selection was supplied by G. J. Galletta, USDA Agricultural Research Center, Fruit Laboratory, Beltsville, Maryland.

Plants were set in 10-cm pots containing Metro-Mix 220 (W. R. Grace & Co., Cambridge, MA 02140) and soil treated with methyl bromide (1:2, v/v) and allowed to grow in the greenhouse for 6–8 wk to confirm that they were free of anthracnose. All old petioles were removed before inoculation, leaving three to five healthy petioles.

Inoculation. Inoculum was prepared from *C. fragariae* grown on oatmeal agar in petri plates for 10 days at 25 C. Plants were inoculated by spraying the petioles with a suspension of 3×10^6 conidia per milliliter obtained as previously described (5). After 48 hr in a moist chamber at 100% relative humidity and 28–30 C, plants were evaluated and assigned a disease index based on petiole reactions: 1 = lesions less than 3 mm long; 2 = lesions 3–10 mm long; 3 = lesions 10–20 mm long, girdling petioles; 4 = entire petiole necrotic; 5 = crown necrotic, plant dead (5). Plants with a disease index greater than 2.0 were considered susceptible.

Cultivar susceptibility. Plants of several strawberry cultivars were inoculated with 10 fungal isolates. Number of plants inoculated varied among cultivars, depending on plant availability. Disease was evaluated 7, 14, and 21 days after inoculation.

Other hosts. Plants of *F. virginiana* Duchesne from the Blue Ridge Mountains and Wake County, NC, *Duchesnea indica,* and *Potentilla canadensis* L. were supplied by J. R. Ballington, North Carolina State University. Six plants of each species were set in the field in soil fumigated with methyl bromide, allowed

Table 1. Mean infection produced by isolates of *Colletotrichum fragariae* on strawberry cultivars after 21 days

Cultivars[a]	Disease index[b] Isolate number 1	4	7	9	10	11	12	14	15	16	Mean
Resistant											
L-6632	1.0	1.2	1.0	1.0	1.1	1.0	2.0	1.3	1.0	1.0	1.1
L-2556	1.0	1.0	1.0	1.0	1.4	1.0	1.0	1.2	1.0	1.0	1.1
Dover	1.1	1.4	1.5	1.0	1.4	1.4	1.0	1.4	1.9	1.1	1.3
Sequoia	1.3	1.6	1.0	1.3	1.3	1.4	1.6	1.1	1.1	2.0	1.4
Intermediate											
MD-4409	1.0	2.8	2.4	1.7	1.2	2.7	3.3	1.0	1.0	1.3	1.8
Tennessee Beauty	2.7	3.2	1.6	1.0	1.9	2.4	2.4	1.7	1.8	2.8	2.1
Apollo	3.0	3.6	1.0	3.6	2.7	2.4	2.2	1.0	2.0	2.6	2.4
Titan	2.7	2.1	2.6	3.1	3.4	2.1	3.8	2.7	1.8	2.5	2.6
Florida-90	2.6	2.6	1.8	2.4	2.0	2.1	4.0	3.0	2.8	3.2	2.6
Earlibelle	1.0	4.2	4.0	3.6	2.0	3.2	3.4	1.7	1.0	3.4	2.9
Sentinel	4.4	3.1	3.0	3.7	1.2	2.8	...[c]	2.8	2.7	2.1	2.9
Roseanne	3.7	2.7	2.1	2.1	2.4	3.7	2.6	3.2	3.6	3.3	2.9
Susceptible											
Albritton	4.2	4.0	3.2	4.0	4.2	4.0	...[c]	4.0	4.0	1.2	3.3
Prelude	3.6	2.7	2.7	4.1	3.4	3.7	3.0	3.7	2.7	3.0	3.3
Earliglow	3.1	3.4	3.0	3.7	2.5	3.7	2.2	4.1	3.2	3.3	3.3
Sunrise	1.5	4.5	4.0	4.5	...[c]	3.5	3.2	3.0	1.5	4.2	3.4
Atlas	2.5	3.9	3.6	4.4	3.7	3.8	3.3	3.7	2.1	4.2	3.6
Sumner	4.1	3.0	3.3	4.3	3.1	3.8	3.0	3.0	4.1	4.1	3.6
Delight	3.7	4.8	3.8	4.2	2.5	2.4	3.7	3.8	4.5	4.3	3.8
Mean	2.5	2.8	2.4	2.8	2.3	2.6	2.5	2.4	2.3	2.6	

[a] Resistant = disease index less than or equal to 2.0 for all isolates; intermediate = disease index less than or equal to 2.0 for some isolates and greater than 2.0 for others, with a mean less than 3.0; susceptible = mean disease index greater than or equal to 3.0.
[b] 0 = no infection; 1 = petiole lesions less than 3 mm long; 2 = petiole lesions 3–10 mm long; 3 = lesions 10–20 mm long, girdling petiole; 4 = entire petiole necrotic; 5 = crown necrotic, plant dead.
[c] Not tested.

to grow for 12 wk, and then inoculated with all isolates of *C. fragariae*. Diseased plant parts were placed in petri plate moist chambers to induce sporulation. Microscopic examination of spores and setae confirmed the presence of *C. fragariae*.

In a second test, *P. canadensis* from Wake County, *D. indica* from Castle Hayne and Clinton, NC, and two selections of *F. virginiana* from a strawberry field with anthracnose, where one selection appeared healthy and the other was diseased, were evaluated. Plants were grown in 10-cm plastic pots in a greenhouse for 4 wk, then were inoculated with a suspension of the mixed isolates CF-1, -4, -7, -9, and -16. Disease incidence was assessed weekly. Plants that were not infected after 2 wk were reinoculated.

Dissemination. Plants of six strawberry cultivars ranging from anthracnose-susceptible to anthracnose-resistant (Surecrop, Sequoia, Sunrise, Earlibelle, Florida-90, and Apollo in 1978; Surecrop, Sequoia, and Apollo in 1979) were set in soil treated with methyl bromide 2, 25, and 450 m from a known source of *C. fragariae* inoculum (inoculated border row) (4). The areas surrounding the plots were inspected for possible wild hosts. All dissemination plots were inspected weekly for anthracnose, and diseased plants were removed. Petiole samples were placed in petri plate moist chambers to induce sporulation. Anthracnose incidence was determined by examination of spores and direct isolations from the petioles and crowns.

RESULTS

Cultivar susceptibility. The reactions of 19 strawberry cultivars and selections to 10 isolates of *C. fragariae* are presented in Table 1. Previous studies (5) demonstrated that 21 days were required for determining resistance and susceptibility. Cultivar reactions to the different isolates varied from small flecks on the petiole to plant death after 21 days. Dover, Sequoia, L-6632, and L-2556 were resistant to all isolates (disease indexes of 2.0 or less). Prelude, Earliglow, Atlas, Sumner, and Delight were susceptible to eight or more isolates (disease indexes greater than 3.0 after 21 days).

Although a disease index of 2.1–2.9 is included in the susceptible range, it could be considered intermediate. Titan, Florida-90, Apollo, and Tennessee Beauty were intermediate in their reaction to seven or more isolates of *C. fragariae*. Surecrop plants, included in most tests as a susceptible check, were killed by all isolates after 14 days.

Other hosts. *C. fragariae* infected both *F. virginiana* selections in the field test, causing girdling of the runners. The fungus caused fleck-type lesions on *P. canadensis*. Spores and setae produced on infected tissue were typical of *C. fragariae* in all cases. *D. indica* remained asymptomatic throughout the growing season.

Symptoms in the greenhouse study were more severe than those in the field. Both *F. virginiana* selections were heavily infected 5 days after inoculation. Petioles became black and necrotic after 7 days, and 75% of the plants were dead after 21 days. Crowns of dead plants exhibited a reddish brown discoloration of the inner tissue. *P. canadensis* plants developed light brown, papery leaf lesions after 7 days and dark brown, petiole-girdling lesions with sharply defined borders after 21 days. One plant was dead after 21 days. *D. indica* plants did not become infected after two inoculations.

Dissemination. Strawberry anthracnose was present at all test locations in 1978. It was first observed 2 m from the source of inoculum 4 wk after inoculation. Plants located 25 and 450 m from the inoculum source became infected 6 wk after inoculation. All cultivars were infected after 8 wk, and disease severity indicated heavy inoculum pressure, possibly from secondary infection, although all diseased material was removed weekly. In 1979, plants located 2 and 25 m from the inoculum source became infected 4 and 7 wk after inoculation, respectively. Anthracnose was not observed on plants 450 m from the source during this season.

DISCUSSION

Although high inoculum density, long wet periods, and high temperatures can lower the resistance of a plant to strawberry anthracnose, disease development is retarded on resistant cultivars compared with susceptible cultivars (5). Resistant cultivars reduce the rate of disease spread in a field.

Plant reactions to isolates of *C. fragariae* varied widely within and among most cultivars. Only those cultivars or selections listed as resistant reacted consistently to the 10 isolates. Sumner was the only cultivar tested that had a disease index of 3.0 or greater for all isolates. Attempts to break down isolates into pathogenic races were unsuccessful. Perhaps, under more controlled growth, inoculation, and incubation conditions (eg, in a phytotron), race determinations would be possible.

F. virginiana and *P. canadensis* were infected but not killed by *C. fragariae* in the field. Therefore, they could serve as a constant source of inoculum to reinfect their own new growth as well as commercial plantings of strawberries. Because these plants grow in uncultivated areas, they are not plowed under and may harbor the pathogen over the winter. The healthy selection of *F. virginiana* from the diseased field was apparently an escape rather than a resistant plant.

D. indica, reported to be a host for *C. fragariae* by Brooks (2), was not infected in our tests after repeated inoculations in the field and greenhouse. *D. indica* may

be susceptible to some isolates of *C. fragariae* under Florida conditions and may serve as an inoculum source in these areas; however, it is not a likely host in North Carolina.

C. fragariae produces masses of conidia on diseased plant tissue, and the spores are spread to nearby plants primarily in splashing water. The fact that the pathogen will spread at least 450 m suggests that it is also windborne. The conidia are produced in a sticky matrix and are probably picked up and carried in windblown water droplets. The erratic success of this mechanism over longer distances is evident from the rapid dissemination to 450 m in 1978 but not in 1979. Other hosts or infected strawberry plants need not grow directly beside a strawberry field to serve as an inoculum source. Therefore, isolating commercial plantings is only a partial means of disease control.

Setting anthracnose-free plants of a resistant cultivar in an area isolated from inoculum sources will delay or prevent development of strawberry anthracnose. Even with these precautions, however, it is often necessary to apply a fungicide spray to protect plants from infection. If a protective fungicide is not used, late-season infections may remain dormant in apparently healthy plants until they are set in a new field. Spraying is especially important in plant-production nurseries where plants will be sold as disease-free stock.

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