Fruit Decays of Peach and Apple Caused by *Phomopsis mali*

D. A. ROSENBERGER and T. J. BURR, Assistant Professors of Plant Pathology, New York State Agricultural Experiment Station, Geneva 14456

ABSTRACT

Rosenberger, D. A., and Burr, T. J. 1982. Fruit decays of peach and apple caused by *Phomopsis mali*. Plant Disease 66:1073-1075.

Cultures of *Phomopsis mali* were obtained from peach fruit with sunken, black lesions at harvest and from unwounded apple fruit that had developed a light brown, water-soaked core rot during controlled-atmosphere storage. Both the apple and peach isolates of *P. mali* caused extensive decay when inoculated into mature apple and peach fruit, but grape isolates of *P. viticola* did not. This is the first report of an apple core rot caused by *Phomopsis mali*.

Additional key words: *Diaporthe eres, D. perniciosa*, moldy core

Phomopsis mali Roberts was first reported as the cause of rough bark disease of Yellow Newtown apples in Virginia in 1913 (13) and was also identified as the cause of an apple (*Malus sylvestris* Mill.) leaf spot in Arkansas (7), a canker on young apple trees in New York (3,8), a stem-end rot of apples in California (5), and a postharvest disease of peaches in New Jersey (6). In Great Britain and Europe, *Diaporthe perniciosa* Marchal causes a dieback of stone fruit trees (2,8), a fruit decay of peaches (*Prunus persica* (L.) Batsch) (9), and a stem-end rot of apples during storage (4,8,9,11). (*D. perniciosa* has been given as the name for the perfect state of *P. mali* [2,4,7–9,11], but Wehmeyer [15] considered *D. perniciosa* synonymous with the older species *D. eres* Nitschke.) We report here on a core rot of stored apples and an orchard fruit decay of peach caused by *P. mali*.

Address of first author: Hudson Valley Laboratory, Box 727, Highland, NY 12528.

Accepted for publication 4 June 1982.

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be hereby marked "*advertisement*" in accordance with 18 U.S.C. § 1734 solely to indicate this fact.

0191-2917/82/11107303/$03.00/0

MATERIALS AND METHODS

Spartan and Golden Delicious apples with unusual decay symptoms were found in controlled-atmosphere storage facilities in eastern New York in March 1979 during a survey for benomyl-resistant apple decay fungi (14). McIntosh and Delicious apples with similar decay symptoms were found in several other facilities during February 1981. The exteriors of Golden Delicious and some Delicious fruit showed irregularly shaped, water-soaked areas beneath the skin, and the interiors had extensive decay extending from the carpels into the flesh. In some Delicious fruit, a light brown decay had developed around the calyx end. Approximately 5% of the stored Spartan apples from one orchard were affected, but less than 0.5% of the Delicious and Golden Delicious were decayed.

Brilliant and Blake peaches with sunken, black lesions 3–6 mm in diameter were observed in a Long Island, NY, peach orchard during 1979 and 1980. The grower indicated that he had noted similar infections during previous seasons. Ten to 20 lesions were present on each fruit, and although the fruits were not extensively decayed, they were not suitable for fresh market use. In 1979, the disease affected more than 50% of the fruit in the most severely affected area of the orchard. Few diseased fruit were found in the same orchard in 1980, and none was found in 1981.

To isolate the pathogen from decayed

apples and peaches, small pieces of decayed flesh were aseptically removed from the margins of decayed areas and placed on potato-dextrose agar (PDA) plates incubated at room temperature (22 C). Growth of three isolates recovered from peaches and five isolates from stored apples was compared with that of a known culture of *P. mali* (ATCC 24162) and of three isolates of *P. viticola* (isolated from grape and supplied to us by R. C. Pearson). Growth comparisons were made by removing 8-mm plugs from the margins of actively growing cultures and placing them at the center of fresh PDA plates. Pathogenicity of the same isolates was tested by wound-inoculating both peaches and apples with 4-mm-diameter plugs of mycelium from PDA.

To determine whether the apple decays developed from infections initiated during bloom, blossoms on three Spartan apple trees were inoculated with a suspension of 6.5×10^7 alpha spores per milliliter (fertile, *Phoma*-type pycnidiospores) from stored-apple isolates grown on PDA. The spore suspension was sprayed onto open blossoms on 13 May 1979 in the middle of a 60-hr wetting period with an average temperature of 8 C. Fruit developing from inoculated and from uninoculated blossoms on the same tree were harvested 10 September and held at 10–12 C for 120 days before they were cut to check for decay. McIntosh and Golden Delicious blossoms were inoculated on 8 May 1980. Spore suspensions from both apple (5.0×10^7 alpha spores per milliliter) and peach (1.1×10^7) isolates were used to inoculate separate limbs on the same trees. McIntosh and Golden Delicious fruit were harvested 17 September and 10 October, respectively, stored at 4 C until 22 December, and then held at 10–15 C for 5 wk.

Apples that developed from uninoculated McIntosh blossoms were inoculated after harvest to determine whether mature fruit were susceptible to infection by *P. mali*. Lots of 25 healthy, unwounded fruit and 25 surface-sterilized (0.5% sodium hypochlorite for 2 min), wounded (2–3 mm deep with 6d finishing nails) fruit were inoculated with spore suspensions from stored-apple (6.0×10^3 alpha spores per milliliter) or peach (9.8×10^4) isolates. The fruit inoculated at harvest were stored at 4 C for 96 days and at 10–15 C for an additional 35 days before they were evaluated for decay.

RESULTS

The unusual water-soaked appearance of the epidermis was the first externally visible decay symptom in apples when the decay originated in the fruit carpels. When fruit with water-soaked spots were held at 22 C in the laboratory for several days, the epidermis turned light brown as the decay progressed. In Delicious apples with calyx-end decay, the decay appeared to originate internally from the calyx (or stylar) tube between the calyx and the carpels. The first external symptoms of the calyx-end decay were light brown spots around the calyx end of the fruit. The calyx-end decay progressed in cold storage (4 C) until more than a third of the apple was decayed. Decayed flesh from fruit with core rot or calyx-end rot initially had a viscid, water-soaked appearance, but later turned to light brown and finally developed an almost translucent, dark brown color. Decayed fruit had a spicy, ciderlike odor, tasted sweet, and remained firm during early stages of decay. Decayed fruit occasionally developed an internal separation (possibly a gas pocket) in the flesh in the decayed area (Fig. 1).

The fungal isolates recovered from three peaches, 20 stored apples with core rot, and 10 Delicious apples with calyx-end decay all showed similar characteristics when grown on PDA and were identified as *P. mali*. All *P. mali* isolates developed white mycelia that covered the surface of 85-mm petri plates in 4–7 days at 22 C and produced abundant pycnidia containing both alpha and beta spores (Fig. 2). *P. mali* (ATCC 24162), peach isolates, and stored-apple isolates were all pathogenic to ripe, wounded apple and peach fruit. The decay spread rapidly from the inoculation site toward the center of the fruit, and fruit incubated at 20–22 C were entirely decayed in 25 days. All isolates were easily recovered from decayed fruit by plating small pieces of decayed flesh on PDA. None of the three isolates of *P. viticola* caused decay in apples or peaches. On PDA, colonies of *P. viticola* in the vegetative growth phase grew only half as fast as colonies of *P. mali*, and *P. viticola* produced pycnidiospores after 2 wk at 24 C, whereas *P. mali* required 4–5 wk.

Because of poor fruit set in the orchard used for 1979 blossom inoculations, only eight fruit developed from inoculated blossoms. *P. mali* was reisolated from two apples in which decay appeared to have progressed from the carpels into the flesh during storage. None of eight check fruit harvested and stored in the same manner developed internal decay. Of 130 fruit developing from inoculated blossoms in 1980, one McIntosh inoculated with the apple isolate and one McIntosh and one Golden Delicious inoculated with the peach isolate developed Phomopsis decay during storage. None of the 100 fruit from uninoculated blossoms decayed. Although the number of infected fruit was small in both years, the chi-square test applied to cumulative results of the 2 yr of tests indicates that the difference in decay between fruit from inoculated and from uninoculated blossoms is significant ($P = 0.05$). None of the intact or wounded fruit inoculated with *Phomopsis* pycnidiospores at harvest in 1980 developed decay during storage.

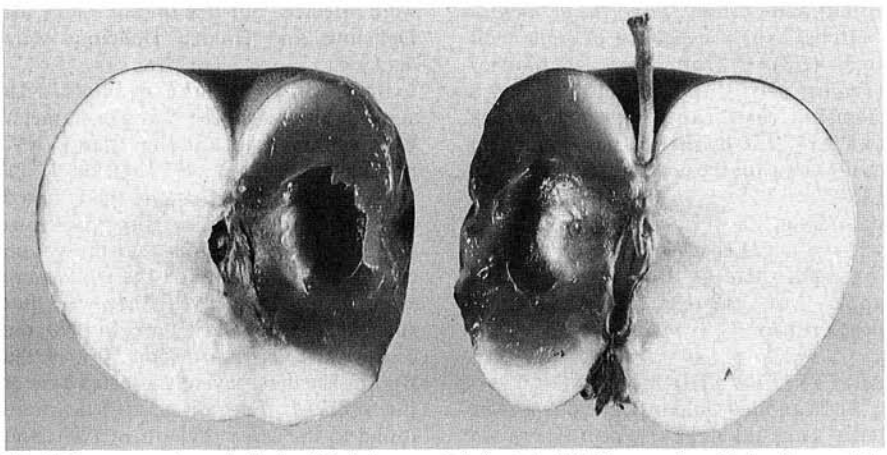

Fig. 1. Decay symptoms in flesh of Delicious apple infected with *Phomopsis mali* showing pocket created by internal separation of the decayed flesh.

DISCUSSION

This is the first time *P. mali* has been identified as the cause of a core rot of apples. Symptoms we observed are distinctly different from the stem-end rot reported in California and Ireland (5,11). The progression of decay (from the carpels or calyx tube outward) that we observed in decayed apples suggests that the infection process for *P. mali* in apples may be similar to that reported for other fungi associated with moldy core disease of apple. Moldy core pathogens invade the calyx tubes during or shortly after bloom (1,10). We isolated *Alternaria* from the carpels of some *P. mali*-infected apples, but only *P. mali* was isolated from the decayed flesh outside the carpels. Moldy core caused by *Alternaria* is common on varieties such as Delicious and Cortland, which are known to have open calyx tubes, but in this study *P. mali* was recovered from McIntosh and Golden Delicious as well.

The fruit decays we found following blossom inoculations provide an additional indication that fruit infection may occur during bloom. Fruit infections in our inoculation experiments may have been reduced by fungicide applications

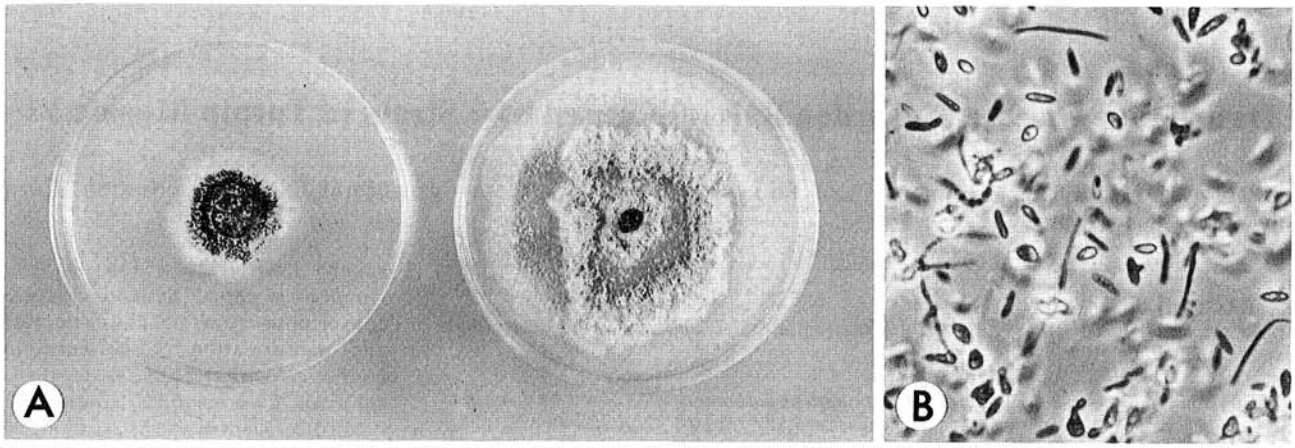

Fig. 2. (A) Comparison of 6-day-old cultures of *Phomopsis viticola* **(left)** and *P. mali* **(right)** growing from mycelial plugs placed on potato-dextrose agar. **(B)** Alpha and beta conidia of *P. mali* (×560).

following inoculation. Benomyl was applied 3 days after our 1979 inoculation, and captan was applied 1 day after our 1980 inoculations.

Nawawi and Swinburne (11) showed that *P. mali* can infect intact fruit through the epidermis via penetration hyphae. No infections resulted from our inoculation of both wounded and healthy fruit with spores immediately after harvest, but storing the inoculated fruit at 4 C may have inhibited spore germination. Results of inoculations made at harvest indicate that the Phomopsis fruit decay we observed cannot be attributed to inoculation with spores carried in postharvest scald-inhibitor drenches.

Although core rot of apple caused by *P. mali* has not been previously reported, we suspect that this pathogen has caused a low incidence of apple core rot for many years. Newton (12) mentioned isolating a *Phomopsis* species from an apple infected with *Alternaria*. Carpel infections by *P. mali* may sometimes be mistaken for Alternaria moldy core. Because Phomopsis core rot was observed only in apples stored for at least 3 mo, we suspect that *P. mali* infections are limited to the carpels or calyx tubes until stored apples reach a certain stage of senescence. Combrink et al (5) reported that Phomopsis stem-end rot occurs only after apples have been stored 4 mo or longer.

Roberts (13) and others (2,6,9) reported *P. mali* infections in fruit tree wood, but we found no noticeable wood infections in apple and peach orchards producing *Phomopsis*-infected fruit. We did not determine the source of inoculum in affected orchards, but differences in growth and pathogenicity between *P. mali* and *P. viticola* verify that these are distinct species and that *Phomopsis*-infected vineyards are not inoculum sources for tree fruits. Representative isolates of *P. mali* from peach and apple have been deposited with the American Type Culture Collection as *Diaporthe eres*, ATCC 42551 and ATCC 42550, respectively.

ACKNOWLEDGMENTS

We thank Frederick W. Meyer for technical assistance, J. M. Ogrodnick for photography, Tom Corell for sending peaches from Long Island, and Roger C. Pearson for providing isolates of *Phomopsis viticola*.

LITERATURE CITED

1. Carpenter, J. B. 1942. Moldy core of apples in Wisconsin. Phytopathology 32:896-900.
2. Cayley, D. M. 1923. Fungi associated with 'die-back' in stone fruit trees. Ann. Appl. Biol. 10:253-275.
3. Chupp, D., and Clapp, G. L. 1923. *Fusicoccum* canker on apples. Phytopathology 13:225-230.
4. Colhoun, J. 1938. Fungi causing rots of apple fruits in storage in Northern Ireland. Ann. Appl. Biol. 25:88-99.
5. Combrink, J. C., Sommer, N. F., Tyler, R. H., and Fortlage, R. J. 1976. Postharvest Phomopsis rot of apple fruits. Plant Dis. Rep. 60:1060-1064.
6. Daines, R. H., and Peterson, J. L. 1976. The occurrence and control of Phomopsis fruit rot of peach. Plant Dis. Rep. 60:141-143.
7. Dunegan, J. C. 1932. The occurrence of the perfect stage of *Phomopsis mali* in the United States. Phytopathology 22:922-924.
8. Kidd, M. N., and Beaumont, A. 1924. Apple rot fungi in storage. Trans. Br. Mycol. Soc. 10:98-118.
9. Marchal, E., and Marchal, E. 1921. Contribution à l'étude des champignons fructicale de Belgique. Bull. Soc. R. Bot. Belg. 64, n.s. 4. 109 pp.
10. Miller, P. N. 1959. Open calyx tubes as a factor contributing to carpel discoloration and decay of apples. Phytopathology 49:520-523.
11. Nawawi, A., and Swinburne, T. R. 1979. Observations on the infection and rotting of apple var. Bramley's Seedling by *Diaporthe perniciosa*. Ann. Appl. Biol. 66:245-255.
12. Newton, G. A. 1928. Some fungi of the *Stemphylium* type and their relation to apple rots. Phytopathology 18:565-578.
13. Roberts, J. W. 1913. The 'rough bark' disease of Yellow Newtown apple. U.S. Dep. Agric. Bur. Plant Ind. Bull. 280. 18 pp.
14. Rosenberger, D. A. 1980. Control strategies for benomyl-resistant postharvest decays of apples. Proc. N.Y. State Hortic. Soc. 125:98-102.
15. Wehmeyer, L. E. 1933. The genus *Diaporthe* Nitschke and its segregates. Univ. Mich. Stud. Sci. Ser. 9. 349 pp.