Resistance in Tomato to Six Anthracnose Fungi

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ABSTRACT

Resistance to tomato anthracnose, caused by *Colletotrichum coccodes*, has previously been reported in the small-fruited introduction P.I. 272636. This line, and lines derived from the cross of it with the tomato cultivar Roma, are also shown in this paper to be resistant to five other fungi that can cause anthracnose lesions on tomato fruit: *C. dematium* and *C. gloeosporioides* isolated from tomato, *C. fragariae* from strawberry, *C. destructivum* from tobacco, and *Glomerella cingulata* from apples.

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For many years, the fungus causing anthracnose of tomato, *Lycopersicon esculentum* Mill., was generally cited as *Colletotrichum phomoides* (Sacc.) Chester. Since 1957, there has been some discussion about its synonomy either with *C. gloeosporioides* (Penz.) Sacc. or with *C. atramentarium* (Berk. & Br.) Taubenh. and the latter's synonym, *C. coccodes* (Wallr.) Hughes (1, 5, 9, 11). In any case, fungi fitting descriptions of the above fungi, depending in part on whether they do or do not form sclerotia readily (11), have been isolated from anthracnose-diseased tomato fruit. *Colletotrichum dematium* (Pers. ex Fr.) Grove has been isolated from tomato with anthracnoselike lesions (9), and its pathogenicity to tomato fruit demonstrated (7). Several workers have obtained anthracnose lesions after the inoculation of tomato fruit with the fungus causing bitter rot of apple, *Glomerella cingulata* (Stonem.) Spauld. & v. Schrenk, or with isolates of *Colletotrichum* from hosts other than tomato (7, 8, 10, 12, 13, 15).

The small-fruited tomato introduction, P.I. 272636 (*L. esculentum*), has a level of anthracnose resistance that is inherited by progeny (3). Only a few fruits of this line become infected by naturally occurring inoculum in the field or by laboratory inoculation with sclerotia-forming isolates of *Colletotrichum* designated *C. coccodes* in this paper. On those fruit which become infected, lesions expand slowly. If this P.I. line is to be used by plant breeders as a source of anthracnose resistance, its reaction to inoculation with other fungi that can cause anthracnose lesions on tomato fruit should be known. This paper reports the results of challenging P.I. 272636, and lines derived from the cross of it with the tomato cultivar Roma, by inoculation with *C. coccodes* and with several other fungi.

MATERIALS AND METHODS.—Tomatoes for inoculation were harvested from field plots. In 1970, these plots contained a number of rows of the F_3 generation of the cross P.I. 272636 X Roma. These rows were screened on an individual plant basis, and

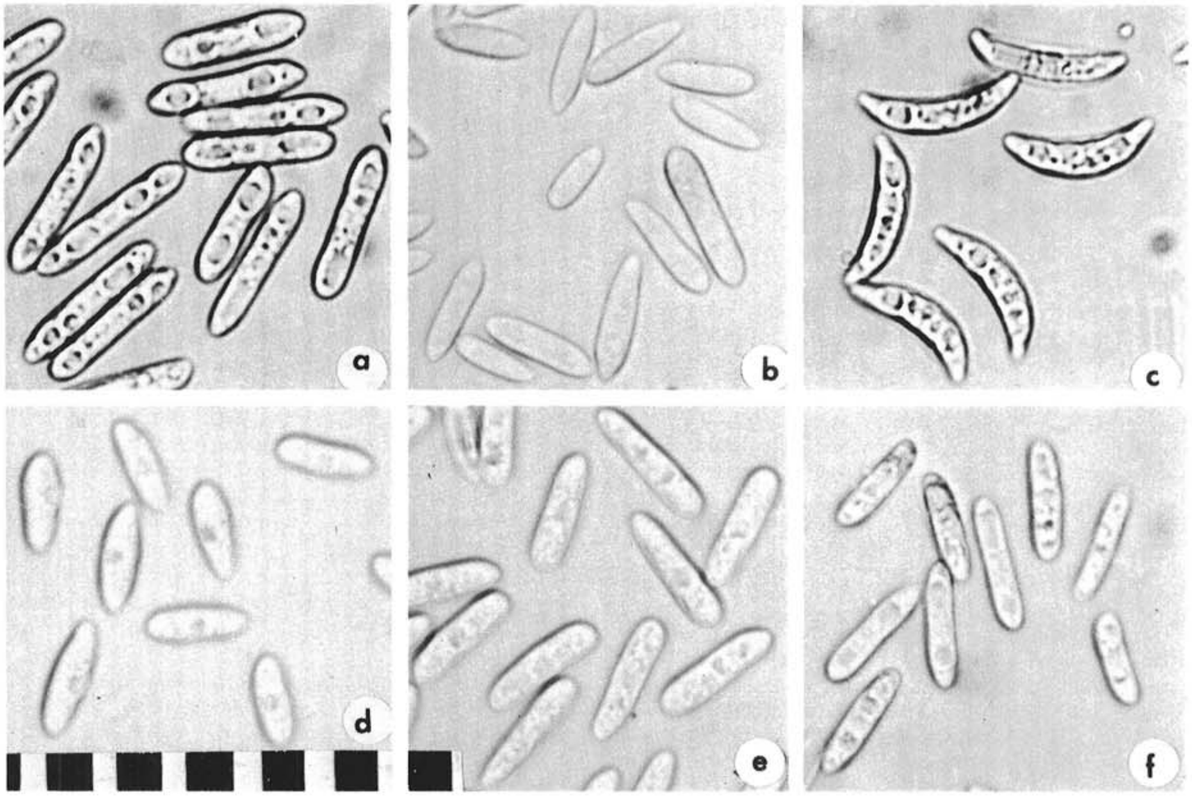

Fig. 1. Conidia of six fungi that cause anthracnose symptoms on tomato fruit: **a)** *Colletotrichum coccodes* isolated from tomato; **b)** *C. gloeosporioides* from tomato; **c)** *C. dematium* from tomato; **d)** *Glomerella cingulata* from apple; **e)** *C. fragariae* from strawberry; and **f)** *C. destructivum* from tobacco. Conidia pictured were grown on V-8 agar media in continuous light (1 scale division = 10 μ).

TABLE 1. Description of fungus isolates used for inoculation of tomato fruit

Isolate no.	Scientific name	Avg spore size, μ[a]	Source[b]
C52	*Colletotrichum coccodes*	23.4 × 4.6	Tomato, Md.
C44	*Colletotrichum gloeosporioides*	14.8 × 4.8	Tomato, Md.
C59	*Colletotrichum dematium*	22.3 × 4.7	Tomato, S.C.
C65	*Glomerella cingulata*	13.8 × 4.7	Apple, Md.
C73	*Colletotrichum fragariae*	17.2 × 4.6	Strawberry, Fla.
C76	*Colletotrichum destructivum*	17.7 × 4.2	Tobacco, Tenn.

[a] Avg for 50 spores grown on clarified 30% V-8 agar and suspended in distilled water.

[b] The author thanks H. L. Keil for providing the diseased apples from which *G. cingulata* was isolated, C. M. Howard for the culture of *C. fragariae*, E. V. Wann for diseased tomatoes from which *C. dematium* was isolated, and J. R. Stavely and R. C. Sievert for the culture of *C. destructivum*.

several plants that showed resistance to typical isolates of *C. coccodes* were selected for challenge inoculation. Seed from these individual plants was saved, and grown the next year in 10-plant rows of the F_4 generation. In 1971, fruit were picked at random in each line. In both years, as far as possible, fruit were picked several days after turning red.

Isolates of six fungi were used in these tests (Fig. 1, Table 1). Inoculum was grown on clarified V-8 juice agar (2), and fruit were puncture-inoculated (4, 14). The inoculated fruit samples were maintained on an unshaded greenhouse bench where daily temperature fluctuations ranged from 22 to 34 C. One week after inoculation, a count was made of fruit showing lesions greater than 1 cm in diam. In addition to inoculation of tomatoes, ripening strawberries and apples were puncture-inoculated with some isolates.

RESULTS.—After puncture inoculation of the tomato cultivars, Roma and C17, *C. coccodes* caused a sunken, circular lesion typical of anthracnose. Small sclerotia developed beneath the lesion surface which gave it a rough, dark appearance. The sclerotia occurred in either a scattered pattern or in a concentric pattern like that described by Davidson (6). The tomato skin over the lesion surface usually remained intact, except when occasional long cracks appeared. Spore masses sometimes developed along these cracks.

The other five fungi listed in Table 1 caused slightly different symptoms on inoculated fruit of tomato cultivars. Initially, they caused a circular, water-soaked lesion that was similar to anthracnose. After lesions expanded for several days, isolates of *C. gloeosporioides* from tomato, of *G. cingulata* from apple, and of *C. fragariae* A. N. Brooks from strawberry often erupted through the tomato skin in an irregular fashion. Lesion surfaces became covered with salmon-colored spore masses when the infected fruit was exposed to high relative humidity. *Colletotrichum destructivum* O'Gara from tobacco and *C. dematium* did not erupt through the lesion surface.

The mycelium of the fungus causing anthracnose often produces sporelike cells underneath the fruit skin within the infected parenchyma tissue of the fruit as described by Davidson (6). When small bits of infected fruit tissue from each of the six isolates used in these tests were used to make squash mounts for microscopic examination, only *C. coccodes* was observed to produce these sporelike cells.

All or most of the fruit of the Roma and C17 samples showed rapidly developing lesions when inoculated with any of the six fungus isolates (Table 2). P.I. 272636 showed resistance to all isolates, although there was less resistance to the tobacco isolate than to the others. Lesion development was more rapid in the 1971 test than in 1970.

Fruit of the F_3 and F_4 generations of the cross P.I. 272636 × Roma showed resistance to all six fungi. However, this resistance was not at as high a level as was shown by the P.I. line itself. The selection, 557-2, that was least resistant to the typical tomato anthracnose fungus was also least resistant to three other *Colletotrichum* species. There was no, or only slight, infection in any of the F_3 selections and F_4 lines by *G. cingulata* or by *C. gloeosporioides*.

When strawberries were inoculated with *C. fragariae*, lesions developed on all inoculated fruit. Isolates of *G. cingulata* and *C. dematium* caused lesions on only half the inoculated strawberries, whereas *C. coccodes* did not cause lesions on any.

When McIntosh apples were inoculated with *G. cingulata*, lesions typical of bitter rot developed on all inoculated fruit, and spore masses developed on lesion surfaces within a few days. Lesions also formed on most apples inoculated with the isolate of *C. gloeosporioides* from tomato; however, no spore masses appeared on the lesion surfaces. A few apples inoculated with *C. coccodes* developed lesions, and one of these lesions had many sclerotial bodies under the epidermis similar in appearance to sclerotia forming under the epidermis of anthracnose lesions on tomato; no spore masses developed on lesion surfaces. The isolate of *C. dematium* did not cause lesions on apple.

DISCUSSION.–It appears that P.I. 272636 has resistance to a range of pathogenic fungi that cause anthracnose spots on ripe tomato fruit. Furthermore, this resistance is heritable, although in progeny it is at a level generally lower than that in the P.I. parent. I have obtained no evidence yet that isolates or "races" of *C. coccodes* exist that would clearly indicate the presence of vertical resistance (16). However, Schmitthenner (15) reported evidence for the existence of races that interact differentially with *Lycopersicon* species. For the present, resistance in P.I. 272636 is thought to be of the horizontal type.

Because several fungi can cause anthracnose symptoms on tomato fruit, some breeders have questioned whether it would be necessary to use sources of specific resistance to each fungus in a

TABLE 2. Number of tomatoes with anthracnoselike lesions greater than 1 cm in diam 1 week after a puncture inoculation of a sample of 10 tomatoes

	C52 *Colletotrichum coccodes*		C44 *Colletotrichum gloeosporioides*		C59 *Colletotrichum dematium*		C65 *Glomerella cingulata*		C73 *Colletotrichum fragariae*	C76 *Colletotrichum destructivum*
Line[a]	1970	1971	1970	1971	1970	1971	1970	1971	1971	1971
C17	8	10	5	8	5	10	7	9	10	10
Roma	9	10	6	9	8	9	6	8	8	8
P.I. 272636	0	0	0	0	0	0	0	0	1	4
541-7	2	6	0	0	3	5	0	0	1	3
543-1	0	6	0	1	0	0	0	0	1	1
543-2	0	5	0	0	0	0	0	0	0	1
557-1	1	1	0	2	1	1	0	0	2	2
557-2	5	7	0	2	5	7	0	3	8	4
591-4	1	4	0	0	0	0	0	0	0	4
591-8	0	6	0	0	0	4	0	2	3	3
598-7	2	7	0	0	0	0	0	0	0	3

[a] All but the first three entries were an F_3 (1970) or an F_4 generation (1971) of the cross P.I. 272636 × Roma.

cultivar development program. For the present, however, the data reported here indicate that P.I. 272636 can be used as a source of general resistance to anthracnose, and that isolates of *C. coccodes* causing typical anthracnose symptoms on tomatoes can be used for screening breeding lines. Of course, when a fungus like *C. gloeosporioides* or *C. dematium* is most commonly isolated in a particular region, then, as a precaution, breeding lines being developed in that region should be challenged with these fungi.

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