Effect of Temperature on Incidence and Development of Bitter Rot Lesions on Apples

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ABSTRACT

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Bitter rot of apples, caused by *Glomerella cingulata*, is destructive in orchards of the southeastern United States. Development of the disease is linked to periods of high temperature and rainfall. Mature apples were washed, rinsed, spray-inoculated, and incubated in moisture chambers at 22, 26, 28, 30, and 34 C. Total lesion area (> 1 mm^2) and the number of lesions were determined 12, 15, and 18 days after inoculation. No infection occurred at 34 C or in controls. The highest percentage of apples was infected at 26 C and the lowest at 30 C. The greatest number of lesions occurred at 26 C. The median lesion area was greatest and the lesions expanded most rapidly at 30 C. Thus, the optimum temperature for lesion expansion was 30 C.

Additional key words: *Colletotrichum gloeosporioides*, epidemiology

Bitter rot of apples (*Malus domestica* Borkh.), caused by *Glomerella cingulata* (Ston.) Spauld. & Schrenk, is a destructive disease in orchards of the southeastern United States; it occurs in the midsummer during periods of high temperature and rainfall (6,8). Temperatures greater than 21 C and free moisture are necessary for the development of bitter rot (2,3). When weather conditions are optimal, the disease may cause losses up to 80% in unsprayed orchards, but in other years when conditions are not appropriate, losses may be less than 1% (8).

Many cover sprays (five to seven per summer) are required to control bitter rot in Georgia (7). The objective of this study was to determine the relationship of temperature to development of bitter rot lesions on apples in order to provide the information needed to progress from a rigid calendar-based spray program to a spray-as-needed program based on environmental conditions.

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MATERIALS AND METHODS

Mature Delicious apples (Topred) harvested in August 1978 were washed in a mild detergent solution (Ivory liquid, 25 ml/L), rinsed in deionized water, and allowed to dry. Inoculum was prepared from 11-day-old cultures grown on freshly prepared potato-dextrose agar. Sterile deionized water was poured into the plates and the surface was scraped with a rubber spatula to remove conidia. The resulting suspension was poured through four layers of cheesecloth and adjusted to 10^7 conidia per milliliter by using a hemacytometer. Apples were sprayed to runoff with a DeVilbiss atomizer (DeVilbiss Co., Somerset, PA) at 10 psi and placed in moisture chambers. Thirty apples were incubated at each of the following temperatures: 22, 26, 28, 30, and 34 C. An additional 10 uninoculated apples were incubated at each temperature as controls.

The number of lesions and total lesion area (> 1 mm^2) were determined for each apple at each temperature 12, 15, and 18 days after inoculation. Lesion area was transformed to logarithms for statistical analysis. A one-way analysis of variance was used and the means were separated with Duncan's multiple range test.

RESULTS

Temperature significantly influenced the frequency of infection of apples with *G. cingulata* and lesion development. No infection occurred at 34 C or in controls. At all three recording dates, more apples were infected at 26 C than at other temperatures (Table 1). Eighteen days after inoculation the number of lesions per infected apple was significantly greater at 22 and 26 C than at 30 C.

The mean log lesion areas produced at 30 C were significantly larger than those produced at 22 and 26 C at day 12 (Table 1). The lesions produced at 28 C were significantly larger than those produced at 26 C. By day 18, however, there were no significant differences among 26, 28, and 30 C.

DISCUSSION

There are different optimum temperatures for different aspects of the development of bitter rot lesions on apples. When the number of lesions per infected apple and mean log lesion area are considered together, the optimal temperature range for lesion development is 26–28 C. This is consistent with the optimum for growth of the fungus in vitro, which was also 26–28 C (5). This optimum temperature range is lower than the reported optimum

Table 1. Influence of temperature on the development of bitter rot lesions on Delicious apple (Topred) fruit[y]

	Days after inoculation								
	12			15			18		
Temperature (C)	Apples infected (%)	Mean log lesion area[z]	Lesions/ apple	Apples infected (%)	Mean log lesion area	Lesions/ apple	Apples infected (%)	Mean log lesion area	Lesions/ apple
22	30	1.076 bc	3.6 a	36	1.595 a	4.6 a	73	1.877 b	9.1 a
26	43	0.949 c	3.8 a	56	1.666 a	5.5 a	80	2.433 a	9.1 a
28	30	1.619 ab	7.5 a	46	1.953 a	6.3 a	73	2.375 a	5.4 ab
30	13	2.082 a	1.5 a	33	1.861 a	2.0 a	60	2.315 ab	3.1 b

[y] Thirty apples inoculated at each temperature.
[z] Means followed by the same letter do not differ significantly ($P = 0.05$) as determined by Duncan's multiple range test.

temperature of 32 C for the development of bitter rot in the field (1,4).

Infection, as measured by percent of apples infected and lesions per infected apple, was favored at 26 C. However, 12 days after inoculation, lesion area was greater at 30 C. This rapid expansion is important in terms of the secondary spread of the pathogen, which is accomplished by means of conidia (*Colletotrichum gloeosporioides* Von Arx.) produced in acervuli on the surface of lesions (1,4). Lesions produced at higher temperatures would produce a more abundant source of inoculum. Cooler temperatures, such as may be expected during rainfall, would be necessary to optimize conditions for infection and to complete the secondary cycle.

An apple with one bitter rot lesion would not be marketable. Because more than two-thirds of the apples inoculated at 22, 26, and 28 C were infected, there would be little difference in the economic losses at these temperatures. However, the more rapid development of lesions at the higher temperatures would enhance secondary spread of inoculum and provide more rapid disease development.

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