

Effect of Leaf Wetness Duration and Air Temperature on *Cercospora beticola* Infection of Sugarbeet

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ABSTRACT

Leaf wetness is important in the development of *Cercospora beticola* on sugarbeet. The number of spots produced after a 48- or 72-hr moist period was more than 30 or 80 times, respectively, the number produced after 24 hr. Favorable temperatures for leaf spot development were 24, 27, and 29 C, with 29 the most favorable temperature. Spots appeared 7 days after inoculation with 500, 1,000, and 2,500 spores/cc at moist periods of 48- and 72-hr duration

and at 29 C. Spots appeared in 8 days on plants inoculated with 2,500 spores/cc, and held for a 24-hr moist period. Spots appeared in 9 days at the 12-hr moist period. There was no difference in the amount of leaf spot produced on 10 plants by spore concentrations $\geq 2,500$ /cc. Spore concentration, temperature, and duration of the wet period all influenced the effects of incubation period and disease severity. *Phytopathology* 61:546-549.

Cercospora leaf spot, known as a warm, wet-weather disease, occurs in warm, humid valleys in France (1). Fungicide application was recommended (5) when spots had increased to a given number if conditions favorable for sporulation and infection were forecast (rain coincident with temperatures of 20-25 C) and if 3 weeks had elapsed since the last application. Treatment was recommended at the onset of conditions favoring sporulation and for 5 days after a rain. Darpoux et al. (6) reported no significant leaf infection on sugarbeet plants until they had been exposed to saturated atmospheres for 72 hr. On a susceptible variety, up to 5 days elapsed between spore germination and infection. Treatments could be applied 5 to 8 days after a rain to protect the plants from infection. This information provided a basis for a *Cercospora*-leaf spot warning service. The incubation period of *Cercospora beticola* was 2 to 4 days at 27 C. It increased slightly up to 31 C and decreased at 18 C (7).

In Bavaria (10), the disease is serious in areas similar to the lowlands of the Danube, where thunderstorms and high temperature maxima prevail. Usually, surveys are conducted in mid- to late June when foliage cover is 90-100% and plants are in the 4- to 6-leaf stage to determine when fields have 5 to 20 plants with a few spots. When such a disease level occurs, spray warnings are released immediately. A leaf spot forecasting method was proposed with the conditions for a critical period (11): (i) at least 10 lesions on about 5% of the plants; (ii) 3 days or more of relative humidity 95% for at least 10 hr within the crop; and (iii) a minimum temperature of 10 C in the crop.

Cercospora leaf spot can be severe in the humid Po Valley and other warm, humid valleys of Italy (9), where *Cercospora* spores formed in 12-24 hr at 95% relative humidity (RH) coincident with 25-30 C temperatures (2). The incubation period of *Cercospora beticola* was 19 to 21 days at 15 C, 9 to 10 days at 25 C, and 7 to 8 days at 30 C. No infection occurred at 35 C (3). When sugarbeet plants in Minnesota were inoculated and kept wet for 48 hr at 20 to 25 C, the length of the incubation period or disease severity was

not influenced by differences of 5,000 to 50,000 spores/cc of inoculum (8). With the spinach beet in India (12), an incubation period of *C. beticola* was 9 to 11 days when the mean temperature was 19-27 C. The incubation period was 42 days at 12 C. The shortest incubation period in Bulgaria was 5 days on wet plants held 48 hr at 25 C (4).

We recorded the weather variables associated with the spread of *C. beticola* in sugarbeet fields in western Iowa and eastern Nebraska during the past 7 years and found that leaf wetness periods of 24 hr or more resulted in more extensive spread and rapid development of the leaf spot fungus than did shorter periods (Wallin & Loonan, unpublished data).

The investigations cited above dealt with the influence of leaf wetness and temperature on the development of sugarbeet leaf spot. The results did not reveal the number of spots produced by certain temperatures and duration of the leaf wetness period. The objective of this study was to obtain more precise information about the role of these variables.

MATERIALS AND METHODS.—*Cercospora beticola* was isolated from sugarbeet leaves from western Iowa. Week-old cultures growing on soybean meal-dextrose agar were used for the inoculum.

Spore concentrations were determined from counts in a haemocytometer.

Three-week-old seedlings of the 3 N sugarbeet in the 4-leaf stage were thinned to 10 plants/4-inch pot before inoculation. One cc of an aqueous spore suspension was sprayed on the plants in each pot with a hand atomizer, and two pots were used for each spore concentration. The first trials were conducted at room temperatures in the greenhouse with temperatures in the moist chamber ranging from 21 to 36 C. Later trials were conducted in controlled temperature chambers, and the plants were covered with plastic bags to maintain wet foliage during the desired wetness period.

Individual spots on each leaf per plant were counted. A count of five spots was assessed to a dead leaf, the usual number noted on a dead leaf.

RESULTS AND DISCUSSION.—Young sugarbeet plants

inoculated with concentrations of 50, 100, 500, 1,000, 5,000, and 10,000 spores/cc per 10 plants were held in a moist chamber for 24, 48, and 72 hr at 21 to 36 C, then removed to the greenhouse bench. Greenhouse temperatures were 21-24 C.

Counts made after 14 days revealed that concentrations of 50 and 100 spores/cc did not produce spots at the 10-, 12-, and 24-hr exposures. Only concentrations of 5,000 and 10,000 produced 60 or more lesions/10 plants after a 24-hr moist period (Fig. 1).

In another trial, concentrations of 500, 1,000, 5,000, and 10,000 spores/cc were sprayed on plants, then kept wet 10, 12, 24, 48, and 72 hr. Counts were made 10 days after inoculation (Fig. 2). A few spots were produced by the higher spore concentrations after periods of 10 and 12 hr. The influence of the longer moist periods on the number of lesions that developed after 48 and 72 hr was striking. When 10,000 spores/cc were used, 10 times more lesions resulted at 72 hr than at 24 hr. Five hundred spores/cc after a 48-hr wet period produced 30 times more lesions than were produced after a 24-hr period.

To determine the most favorable temperature for leaf spot development, young sugarbeet plants were sprayed with concentrations of 500, 1,000, 2,500 and 5,000 spores/cc and kept moist for 48 hr at 1 of 8 different temperatures; i.e., 10, 13, 16, 18, 21, 24, 27, and 29 C.

After temperature exposure, the plants were removed to the greenhouse where temperatures ranged between 21 and 24 C. The number of lesions produced on 10 plants were counted after 14 and 21 days (Table 1). Constant temperatures of 27 and 29 C were the most favorable for leaf spot development at the higher spore concentration. At 13 C and above, the greatest number of lesions resulted from the higher spore concentrations.

Counts made 9 days after inoculation revealed that all spore concentrations produced some lesions at 29 C, but at the lower temperatures only the 5,000/cc concentration produced some lesions. This suggested that higher temperatures are important in the rapid increase of inoculum, and that they promote epidemics of *Cercospora* leaf spot.

To prove the influence of high temperatures on the development of *Cercospora* lesions, concentrations of 500, 1,000, and 2,500 spores/cc were sprayed on young sugarbeet plants in each of two pots. The plants were kept wet for 12, 24, 48, or 72 hr under a constant temperature of 29, 32, or 35 C. After temperature exposure, the plants were placed on the greenhouse bench at temperatures of 21 to 24 C until counts were made.

At a concentration of 2,500 spores/cc, a temperature of 32 C was most favorable for leaf spot development at wet periods of 48 hr (Fig. 3). The most favorable temperature at the 72-hr wet period for all 3 spore concentrations was 29 C. Many spots were produced, however, at 35 C at the shorter moist periods of 12 and 24 hr. Presumably, 35 C was too high for the infection processes at the longer wet period because lesion production decreased with the increase in wetness period duration. Again, these results stress the importance of the long leaf wetness period and concentration of inoculum in the quantitative development of sugarbeet leaf spot.

The influence of temperature variation at different leaf wetness periods with 4 spore concentrations was investigated. Two pots of plants, each containing 10 sugarbeet seedlings, were sprayed with 1 cc of either 500, 1,000, 2,500, or 5,000 spores/cc, after which the leaves were kept wet for 24, 48, or 72 hr in a chamber in which they were exposed to different temperatures between 10-29 C during the regime. The plants were held 6-8 hr at 29 C. Leaf spot counts made 28 days after inoculation indicated that at the temperatures employed, the duration of the wet period was the important factor in leaf spot production. The 1,000 spores/cc concentrations produced per 10 plants an average of 0 lesions at the 24, 3 at the 48, and 11 at the 72-hr wet period. Exposure of the inoculated plants to a temperature variation from 10 to 29 C, terminating at 10 C, during the period resulted in no more lesions than were produced after exposure to a 21-C constant temperature for the same length of time.

The importance of the duration of the incubation period on leaf spot development was emphasized by the temperature experiments (Fig. 4). There was an apparent delay in the infection process of *Cercospora beticola* over a 3-week period. For example, inoculation with 2,500 spores/cc at 32 C and a 12-hr wet period resulted in 40 times more spots/10 plants after 21 days

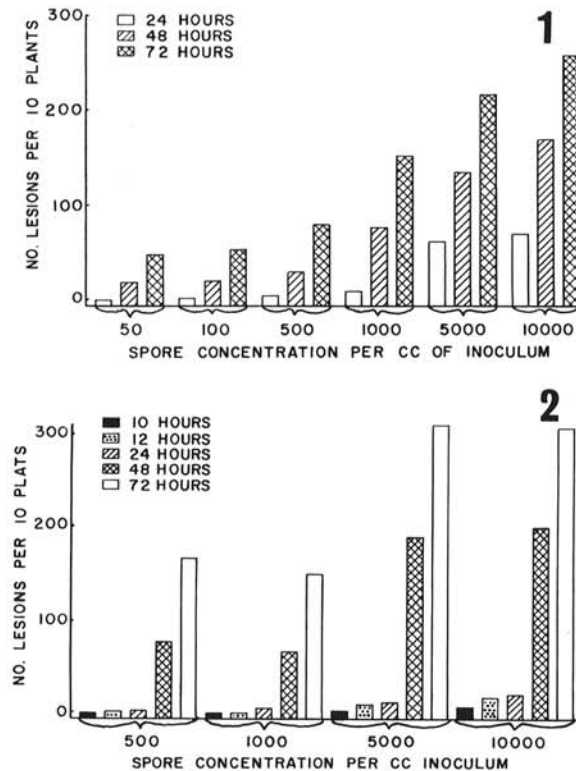


Fig. 1-2. 1) The influence of spore concentration of *Cercospora beticola* at three different leaf wetness periods on lesion development after 14 days. 2) The influence of spore concentration of *C. beticola* at five different leaf wetness periods on lesion development after 18 days.

TABLE 1. The influence of spore concentration and temperature on the production of *Cercospora* lesions on sugarbeets, 14 and 21 days after inoculation (48-hr wet period)

Temp C	Spore concentration/cc									
	0		500		1,000		2,500		5,000	
	Days		Days		Days		Days		Days	
	14	21	14	21	14	21	14	21	14	21
10	0 ^a	0	0	0	0	1	0	2	1	1
13	0	0	0	2	0	1	0	3	1	6
16	0	0	0	1	0	3	3	13	3	13
18	0	0	0	1	5	3	2	11	3	16
21	0	0	6	10	1	4	3	26	7	16
24	0	0	2	3	1	6	8	34	21	37
27	0	0	1	13	1	20	6	25	22	55
29	0	0	4	19	23	58	28	80	38	86

^a Average number of lesions per 10 plants.

than after 10 days. After the 12-hr dew period at 35 C, 50 times more spots/10 plants appeared after 21 days than after 10 days. In evaluating quantity of leaf spot production in the greenhouse at temperatures between 21.1 and 24 C, sufficient time should be allowed for full symptom expression before counts are made.

La's studies (8) showed that length of the incubation

period and disease severity on plants kept moist for 48 hr was the same with 5,000 spores/cc as with 50,000 spores/cc. In his studies, symptoms were observed 13 days after inoculation regardless of quantity of inoculum. Plants held 4 and 5 days in a moist chamber exhibited spots 11 days after inoculation. Lesions appeared 13 and 14 days after inoculation on plants kept wet 48 and 72 hr, respectively. Lesions appeared in 22 days on plants kept wet 24 hr or less.

In our experiments, a greater time period was required for the lower inoculum concentration to produce lesions when exposed to shorter leaf wetness periods. Seven days after inoculation, all concentrations produced numerous lesions on plants exposed to a 72-hr wet period at 29 C, and all concentrations produced a few lesions at the 48-hr wet period. Eight days after inoculation, the heavy spore concentrations produced some lesions after a 24-hr wet period at 29 C. Nine days after inoculation, all concentrations produced lesions after the 24-hr wet period, and the high concentrations produced a few lesions after a 12-hr wet period. Ten days after inoculation, all spore concentrations produced lesions after the 12-hr wet period. We found that temperature, spore concentrations, and duration of the wet period were all variables influencing the incubation period and disease severity.

We found little difference in the production of leaf spot with concentrations above 2,500 spores/cc. Various lower concentrations differed in the amount of leaf spot they produced.

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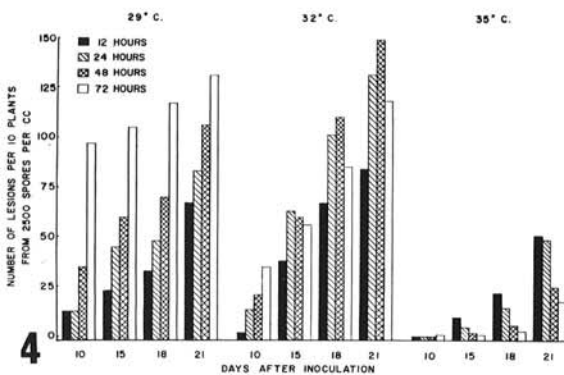
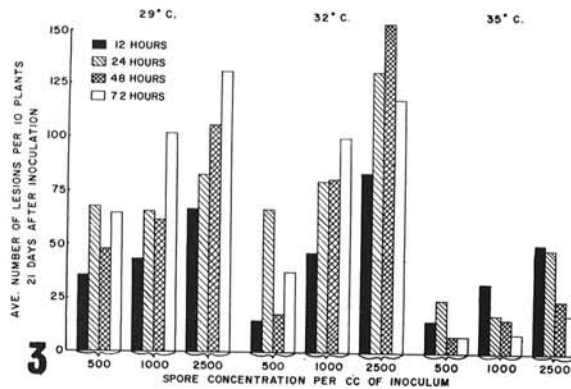


Fig. 3-4. 3) The number of lesions produced by three spore concentrations of *Cercospora beticola*, four leaf wetness periods at three temperatures, 21 days after inoculation. 4) The number of lesions produced by 2,500 spores/cc of *C. beticola* at four different leaf wetness periods at three different temperatures 10, 15, 18, and 21 days after inoculation.

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