Light Intensity as a Factor in Field Evaluations of General Resistance of Potatoes to Phytophthora infestans

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ABSTRACT

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Field plots of potato cultivars Katahdin, Sebago, and Russet Rural were artificially shaded to provide different light intensities. Apparent infection rates (r) by *Phytophthora infestans* were higher for Katahdin and Sebago plants under 47% and 80% shade than under 0% shade. Shading, however, did not affect the apparent infection rate for Russet Rural plants which have little, if any, general resistance; plants of this cultivar died quickly in all treatments regardless of the amount of shade. Field light intensity should be considered when comparative evaluations of general resistance to *P. infestans* are made in different geographical areas.

Additional key words: horizontal resistance, field resistance, *Solanum tuberosum*, late blight.

General or horizontal resistance of potatoes to *Phytophthora infestans* (Mont.) de Bary has a polygenic basis and may involve many quantitative characters (1, 4, 5, 7). Potato plants may vary in their expression of general resistance, depending on plant age, plant nutrition, infection with viruses, and several environmental factors (2, 7). Light also affects the expression of general resistance; potato cultivars subjected to short-day treatments were more susceptible to *P. infestans* than were those exposed to long-day treatments (3, 6). Potato plants grown at lower light intensities developed larger lesions when artificially inoculated than did those grown at higher intensities (9). Since the selection of resistant lines is based on lesser amounts of disease (general resistance) rather than on a hypersensitive reaction (vertical resistance), breeding material with useful resistance may appear susceptible at lower light intensities and, thus, be discarded in error. Cornell University breeding lines are tested in the field in both Ithaca, N.Y. and the Toluca Valley of Mexico. Field light intensity at the higher altitude and lower latitude of the Toluca Valley is higher than that in Ithaca (Table 1) (J. Moore, *personal communication*). The purpose of this study was to determine whether under field conditions general resistance to natural infection by *P. infestans* is affected by light intensity.

MATERIALS AND METHODS

Each field plot was 1.8 × 1.8 m and consisted of 16 clay pots (20-cm diameter) sunk in field soil. The pots contained a greenhouse potting mixture [a mix of composted soil and peat (15:6, v/v) with 5-10-5 fertilizer (30 g per pot)] and one plant each. Tuber pieces of Russet Rural, Katahdin, and Sebago potato cultivars, were planted in each plot. The cultivar Russet Rural has no useful general resistance, but Sebago and Katahdin have low levels of resistance. One extra plant in each plot was necessary to complete the square plots, but was not included in the disease evaluation. The pots were arranged randomly within plots. The twelve field plots were divided into four replicates with three plots per replicate.

The three plots each received, respectively, no shading, 47% shade, or 80% shade (Table 2). The shade was achieved by placing over the plots 1.5-meter-high cages covered with Lumite woven saran shade fabrics (fabric numbers 5180302, 47% actual shade, and 5181702, 80% actual shade, manufactured by the Chicopee Manufacturing Co., Cornelia, GA 30531). The arrangement of the shade treatments within each replicate was random.

Covered sides were hung at an angle on the east and west sides of the cages to allow air movement through the cages without changing the inner light intensity. Each plot was sprinkler watered as needed to keep soil moisture levels similar for all treatments. Individual plants requiring support in the shade cages were staked to reduce microenvironmental differences among treatments. Temperature and relative humidity data for all treatments were recorded with hygrothermographs. Overhead irrigation on the west side of the plots at 0800-0830 hours maintained relative humidity in the plots at greater than 90% each night.

Infected plants in another experiment in the same field served as the source of inoculum. The prevailing winds carried sporangia of races 1, 2, 3, 4, and 1, 4 through the open sides of the shaded cages. When lesions were discovered a diseased leaf-area percentage rating was recorded for each plant every 3 days until all plants had died. Lesions appeared on plants in all treatments within a 48-hr period.

Disease progress curves were changed to straight lines by regression of $\log_e x/(1-x)$ vs. time (8). The average apparent infection rates (r) were obtained from the slopes

of the lines by the formula:

$$r = \frac{1}{t_2 - t_1} \cdot \log_e \frac{x_2(1-x_1)}{x_1(1-x_2)}$$

where t_1 is the time in days for percent disease (x_1) to reach 5%, and t_2 is the time in days for percent disease (x_2) to reach 90%. The number of days varied depending on the cultivar and the shade treatment.

TABLE 1. Difference between the greater solar radiation in the Toluca Valley, Mexico, and that in Ithaca, N.Y.

Sources of difference	Average difference (%)
Difference due to latitude (during the summer half-year)	9.1
Difference due to altitude (variable according to time of day)	25-30
Total average difference	35-40

RESULTS AND DISCUSSION

The plants grown under 47% and 80% shade were taller and had longer internodes, and their individual leaflets were larger and thinner than those for plants grown under no shade. Minimum and maximum values of temperature and relative humidity for plots with different shade treatments did not differ, but changes occurred more quickly in the unshaded plots (Table 3). Conditions conducive to blight occurred every night when the relative humidity was increased by overhead irrigation.

Sebago possessed the greatest amount of general resistance; it had the lowest infection rates (r) in all treatments (Table 4). Katahdin was less resistant, and Russet Rural was least resistant.

Sebago and Katahdin plants under shade appeared more susceptible than unshaded ones. Although the average infection rates for plants under 47% shade and no shade did not differ significantly, the infection rates were consistently higher for Sebago and Katahdin plants under 47% shade than with no shade, and these differences were

TABLE 2. Light intensity and relative shade in the field plots of potatoes at Freeville, N. Y. at the level of the plant tops on 31 July 1975[a]

Shade[b]	Light intensity (lux) and relative shade						
	0930 hours	shade (%)	1200 hours	shade (%)	1430 hours	shade (%)	Average shade (%)
Heavy shade material	22,060[b]	78.6	28,000	77.5	28,250	76.4	77.3
Light shade material	54,600	47.1	71,000	43	66,700	44.3	44.6
No shading	103,300	0	124,550	0	119,700	0	0

[a]The weather was clear but slightly hazy.

[b]Shading was provided by a tinted saran screen enclosure with slanted open east-west(prevailing wind direction) ends. The shading material was woven saran Lumite shade fabric: heavy shade (80% actual), fabric No. 5181702; light shade (47% actual), fabric No. 5180302, Chicopee Manufacturing Co., Cornelia, GA 30531.

[c]Average of readings from all replicates – light intensity in foot-candles as measured by a Weston Illumination Meter #756.

TABLE 3. Averages of temperatures and relative humidity readings over 10 days from 13-22 August 1975 in light-intensity potato field plots at Freeville, N.Y.

Time (hours)	Temperature (C)			Relative humidity (%)		
	80% shade	47% shade	0% shade	80% shade	47% shade	0% shade
2400	16.4[a]	15.8	15	100	95.8	99
0200	15.7	15.9	14.3	99	96.8	98.8
0400	15.6	15.8	15	99	97.8	100
0600	15	15.8	16.4	97	83.9	93.5
0800	14.9	18.6	17.8	92.8	80.1	77.3
1000	16.5	19.7	20	83.6	78.3	63
1200	19.9	22.1	21.9	66.3	66.6	56.6
1400	21.4	21.5	21.2	62.8	66.5	59.3
1600	22	20.5	19.7	65.9	74.2	50.3
1800	21.3	19.5	17.7	80.7	75.2	83.6
2000	20.4	18.5	15	93.6	84.3	96.1
2200	18.3	17	13.3	100	93.6	99

[a]Temperatures were converted from Fahrenheit to Celsius. All readings were recorded with a Bendix Model 594 hygrothermograph.

TABLE 4. The effect of shading on the apparent infection rate (r) for *Phytophthora infestans* on three potato cultivars

Shade (%)	Apparent infection rate per cultivar[x]		
	Russet Rural	Katahdin	Sebago
0%	.6189[y] a[z]	.2796 a	.1897 a
47%	.5008 b	.3504 a	.2058 a
80%	.6210 a	.4670 b	.3256 b

[x]Disease progress curves were changed to straight lines by regression of $\log_e x/1-x$ vs. time (8). The average apparent infection rates (r) were obtained from the slopes of the lines by the formula:

$$r = \frac{1}{t_2 - t_1} \cdot \log_e \frac{x_2(1-x_1)}{x_1(1-x_2)}$$

where t_1 is the time in days for percent disease (x_1) to reach 5%, and t_2 is the time in days for percent disease (x_2) to reach 90%.

[y]Average of apparent infection rates (r) for 20 plants.

[z]Statistical significance determined by Duncan's Multiple Range Test ($P = 0.01$) for each variety individually.

visible in the field. Russet Rural plants were highly susceptible under all light intensities, and most were dead within 3 wk after lesions first appeared. The apparent infection rates for Katahdin and Sebago plants, even when grown under 80% shade, did not approach the extremely high infection rates for Russet Rural plants. The statistical difference between the average infection rates of Russet Rural plants has no explanation except that all of the infection rates were so high that the difference is of no practical significance.

These results indicate that light intensity should be considered when general resistance evaluations are compared for tests made in areas where field light intensities differ. Plants grown under low light intensities may appear to be more susceptible to *P. infestans* than plants grown under high light intensities. In addition, preliminary screenings for resistance, when performed in the greenhouse at very low light intensities (less than 10,000 lux) that are common at Ithaca in winter, may result in breeding material appearing to be more susceptible than if it were tested in the field and, therefore, wrongly causing it to be discarded.

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