Effect of Light on Reactions of Soybean to Pseudomonas glycinea

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ABSTRACT

Bacterial leaf blight of bean, cucumber, cotton, and soybean did not develop when susceptible plants were placed in darkness for 5 days after, or 4 days before, the 5 days after inoculation with their respective natural pathogens. As postinoculation light intensity treatments were increased from 50-60 ft-c to 2,000-2,500 ft-c, size and prevalence of susceptible-type lesions increased on the four hosts. In light regimes of similar energy levels, normally susceptible reactions of bacterial blight of soybean did not occur in green or blue light, but developed fully in white, and to a limited extent in red light. Preinoculation and postinoculation darkness treatments did not alter development of the resistant (hypersensitive) reaction in soybean varieties inoculated with avirulent races of *Pseudomonas glycinea*. Phytopathology 60:723-725.

Failure, delay, or alteration of normal symptom development (water congested lesions) of bacterial blight of soybean in Minnesota greenhouses during winter months led to an investigation of light quantity and quality on pathogenesis of *Pseudomonas glycinea* Coerper. In summer months, under conditions of high light intensity and long days, susceptible and resistant reactions of bacterial blight of soybean are clearly expressed. Although other environmental factors undergo change from winter to summer, light intensity, quality, and periodicity change considerably. Furthermore, inoculated plants subjected to a 2-day postinoculation high humidity treatment in unlighted mist chambers generally develop less severe blight symptoms than those inoculated which receive no additional humidity or reduced light.

Literature on this topic is limited, and for the most part considers the interaction of light and other factors such as temperature or N on disease development, making difficult an assessment of the effect of light alone. Orellana & Thomas (7) observed that in the greenhouse during the winter, and in short-day controlled environments, both the field-resistant variety Brook and the field-susceptible variety P.I. 164801 of guar (*Cyamopsis tetragonoloba*) were susceptible to *Xanthomonas cyamopsidis*. Thomas (15) determined that sesame (*Sesamum indicum*) varieties Venezuela 51 (field susceptible) and Early Russian (field resistant) were susceptible to *Pseudomonas sesami* when subjected to short light periods (12 hr/day). However, without a N supplement, short or long light periods did not alter the normal reaction. Severity of bacterial wilt caused by *Pseudomonas solanacearum* in tomato grown in low light (100-400 ft-c) was more severe than when tomato plants were grown in normal light (400-1,600 ft-c), according to Gallegly & Walker (3).

The influence of light intensity and duration on development of certain fungus and virus diseases is highly variable. An increase in light intensity or duration has been correlated with an increase in disease severity in bunt of wheat (4), *Cercospora* leaf spot of sugarbeet (1), and *Leptosphaerulina* leaf spot of alfalfa (13). However, cruciferous plants immune to *Peronospora parasitica* in normal light may become more susceptible in weak light (16). In rust diseases, some investigators (8, 10, 14) found that high light intensities stimulate disease development, while others observed maximum rust development in reduced light (5, 12). Symptoms of the virus diseases little cherry and tobacco mosaic are reduced by pre-inoculation and postinoculation exposure to low light, respectively (2, 17). However, potato plants exposed to darkness a few days before inoculation were more susceptible to potato virus Y than plants maintained in normal greenhouse light prior to inoculation (9).

MATERIALS AND METHODS.—Various combinations of *P. glycinea* isolates and soybean (*Glycinea max* L. Merrill) varieties were used for most of these studies. Part of our findings were subjected to tests involving three other host-pathogen combinations: cotton (*Gossypium hirsutum* L. 'Acala 4-44') and *Xanthomonas malvacearum* (E. F. Sm.) Dows.; bean (*Phaseolus vulgaris* L. 'Top Crop') and *X. phaseoli* (E. F. Sm.) Dows.; and cucumber (*Cucumis sativus* L. 'Wisconsin SMR 18') and *P. lachrymans* (E. F. Sm. & Bryan) Carsner.

Plants were grown in one of three environments: in a greenhouse with no supplementary light; in a controlled environment chamber (21 C for 8 hr of darkness and 27 C for 16 hr of variable light quantity); or in an Isco environment chamber (14 hr of light with a constant temperature of 21 C, variable light quality and quantity). All references made in the text to a controlled environment chamber or an Isco environment chamber will refer to the environments given above. Leaves to be inoculated were young and succulent (never more than half their normal size when fully expanded), and readings on disease development were made 5 days after inoculation. Methods were similar to those described by Kennedy & Cross (6). Experiments contained three replications, and were repeated at least twice.

Effect of darkness on bacterial blight of soybean.—Plants were exposed to either pre-, post-, or both pre- and postinoculation dark periods of 4 or 5 days' duration by covering them with a metal box (in greenhouse) or cardboard box (in growth chambers) and monitoring temperatures via thermocouples.

In preliminary greenhouse experiments, the cultivars

Acme and Harosoy were inoculated with Race 1 and Race 5 of *P. glycinea*. Acme is susceptible to Race 1, resistant to Race 5; Harosoy is resistant to Race 1, susceptible to Race 5. In combinations normally resulting in susceptibility, brown necrotic lesions (resistant reaction) developed on leaves subjected to pre-inoculation (4 day) and postinoculation (5 day) darkness periods. In a controlled environment chamber, plants inoculated with a virulent race and subjected to a pre-inoculation darkness period developed normal, expanding water-congested lesions within 3-5 days. However, plants inoculated with a virulent race and grown in a postinoculation dark environment developed small, greenish, necrotic areas (Fig. 1). Plants inoculated with avirulent races and exposed to either pre-inoculation or postinoculation dark periods produced small necrotic areas, somewhat modified, but not appreciably different from those occurring normally under ideal conditions. Temperature variation among covered (dark) and uncovered (light) treatments varied ± 2 C. Thus, postinoculation darkness prevented normal development of susceptible reactions, but had little or no noticeable effect on resistant reactions.

Effect of light quantity on bacterial blight of soybean.—Assays on effect of light intensity on soybean blight were made in a controlled environment chamber with light intensity adjusted to 50-60, 125-175, 350-400, 800-850, 1,500 and 2,000 ft-c. Varied light intensities were obtained in rectangular compartments constructed of brown wrapping paper, with cheesecloth layered over the top of compartments. Symptom development was observed in two susceptible host-pathogen combinations, Acme (Race 1) and Harosoy (Race 5).

At the two lowest intensities (50-60 and 125-175 ft-c), development of symptoms indicative of susceptibility was limited around the point of inoculation and without the clear translucent appearance of fully developed susceptible reactions. In the intermediate light intensities (350-400 and 800-850 ft-c), developing lesions were distinctly translucent and were larger than at the lower light intensities; susceptibility was more marked at the two highest light intensities, and approached what we normally expect in the greenhouse under ideal conditions (Fig. 2).

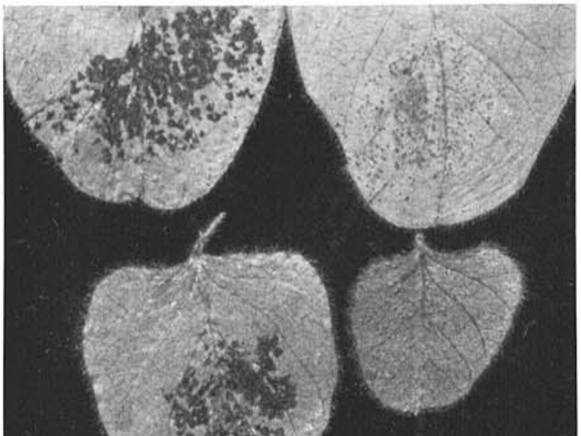

Fig. 1. Leaves of Harosoy soybeans 5 days after inoculation with virulent *Pseudomonas glycinea* Race 5. Top left, leaf grown in white light (2,500 ft-c, 16 hr/day) before and after inoculation; bottom left, leaf grown in darkness 4 days before inoculation and light after inoculation; top right, leaf grown in light before inoculation and in darkness after inoculation; bottom right, plants grown in darkness 4 days before and 5 days after inoculation.

At a later date, studies were extended to include bacterial blight of bean, cotton, and cucumber. After exposure to the three light regimes (0, 100-150 ft-c, and 2,000 ft-c), water-soaked lesions in cotton and bean were largest at the highest light intensity, while size of the water-soaked lesions in cucumber was approximately the same size in the highest and intermediate light intensities. No water-congested lesions developed in any of the three hosts during the 5-day postinoculation darkness treatment.

Effect of light quality on bacterial blight of soybean.—Controlled environment chambers (Isco) were partitioned into three light, tight compartments, each with differing light quality. Filters (cinemoid theatrical filters of dyed acetate sheets, produced by Strand Electrical and Engineering Co., Ltd., London, Eng.) were placed between the white light source and plants in compartments to obtain red, blue, and green light. A fourth compartment was left uncovered to serve as a high light (white) control, and a fifth compartment was covered with cheesecloth to serve as a low light (white) treatment. Absorbance and intensity levels were monitored by a Model radiometer (Yellow Springs Instrument Co.) that measures total energy. Temperature was 21-23 C in all compartments. A summary of these data appears in Table 1.

The susceptible reaction developed typically in white light, although lesions were larger in plants grown at 2,500 ft-c than at 500 ft-c. Water-congested lesions developed in red light; however, they were reduced in size and number as compared to those that developed in white light at approximately the same energy level. In blue and green light, water-congested lesions did not develop, and inoculated areas became greenish brown and necrotic.

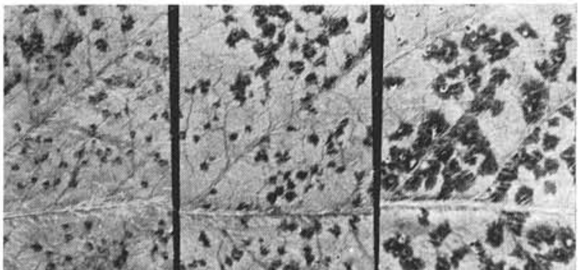

Fig. 2. Leaves of Acme soybean 5 days after inoculation with virulent *Pseudomonas glycinea* Race 1. Plants were grown under light intensities of 55-60 ft-c (left), 350-400 ft-c (middle), and 2,000 ft-c (right). Note increased size of water-congested lesions with increase in quantity of light.

TABLE 1. Effects of light quality and intensity upon development of bacterial blight (*Pseudomonas glycinea*) on soybean[a]

Light color	Intensity level (Ergs/cm^2 —sec)	ft-c	Absorbance in mμ	Disease development
White	26,000	2,500	290-760	+
White	9,500	500	290-760	+
Green	9,500		490-600	—
Red	10,000		610-760	+
Blue	8,000		420-490	—

[a] 14 hr day, temp. 21-23 C.

DISCUSSION.—From these data and those furnished by Orellana & Thomas (7) and Thomas (15), we conclude that light quality and quantity profoundly affects development of certain bacterial blight diseases. In contrast to our findings that high light was conducive to best development of symptoms in four host-pathogen combinations, they found that guar (resistant to *X. cyamopsidis*) and sesame (resistant to *P. sesami*) became susceptible when grown in low light or short-day periods. Furthermore, susceptible varieties of both hosts remained susceptible in low light.

The fact that a susceptible reaction developed in white light (and to a limited extent in red light), while in green and blue light only greenish-brown necrotic lesions developed, may be significant. The photosynthetic rate of a green leaf is most efficient in red and blue light, and least efficient in green. Presumably, leaves grown in red light would produce more carbohydrates and other photosynthetic products that might serve as a nutritive source for bacterial growth. This may also have special significance in view of the fact that starch depletion and development of a susceptible reaction are closely correlated (10).

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