Breakdown of Resistance to *Pseudomonas solanacearum* in Tomato

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ABSTRACT

Elevated temperature (32 C) in environmental control chambers significantly increased severity of bacterial wilt in two tomato lines (Philippine 1169 and Hawaii 7580) resistant to *Pseudomonas solanacearum*. The level of resistance of a third line, Venus, to isolate K-60 was not significantly affected by temperature, but this line expressed no resistance to isolate LB-6 at all temperatures tested. Reduced light intensity (8,075 lux) did not reduce resistance to isolate LB-6 in line 1169 at 26.6 C but significantly decreased resistance at 29.4 C. Reduced photoperiod (9.5 and 10 hours) significantly decreased resistance of line 1169 to isolate LB-6 independent of temperature.

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Southern bacterial wilt of tomato (*Lycopersicon esculentum* L.), which is caused by *Pseudomonas solanacearum* E. F. Sm., is the most serious disease of tomato in many tropical, subtropical, and warm temperate regions of the world. In many areas where the disease is prevalent, losses are so serious that commercial tomato production is impractical. In breeding for disease resistance, extensive programs have been undertaken in North Carolina, Hawaii, Puerto Rico, and the Philippines, but the combining of satisfactory levels of resistance with commercial fruit size and quality has proven very difficult (1, 6). Furthermore, reports from Hawaii indicate that the bacterial wilt resistance is not as stable during warm weather (31.0 - 33.3 C) at low elevations than at cooler, higher elevations or during cool weather (21.0 - 26.7 C) at the lower elevations (2). During warm weather, the apparently resistant plants eventually die from the disease. This breakdown of resistance in tomato due to high temperatures has not been studied previously under controlled environments.

This paper reports the effects of temperature, photoperiod, and light intensity on the resistance to *P. solanacearum*.

MATERIALS AND METHODS.—Tomato lines

resistant to *P. solanacearum* were line 7580, received from J. C. Gilbert of the University of Hawaii, line 1169 received from University of the Philippines, and the cultivar Venus, received from S. F. Jenkins of the North Carolina State University. Susceptible cultivars were Bonnie Best and Red Jacket.

Bacterial isolates used were LB-6 (race 1), obtained from a diseased potato plant in the Philippines by Zehr (8), and isolate K-60 (race 1), which was originally isolated from a diseased tomato plant in North Carolina by Kelman (8). Cultures were stored in sterile distilled water at room temperature to reduce development of avirulent mutants (4). Prior to inoculation the bacterial suspensions were streaked onto agar containing triphenyl tetrazolium chloride (TTC) and incubated at 33 C for 48 hours. Virulent colonies were distinguished from avirulent colonies on TTC agar by their appearance (3). Individual virulent colonies were removed and suspensions in distilled water were adjusted to 92% transmittance (4.0×10^7 cells/ml) with a Bausch and Lomb Spectronic 20 colorimeter. Tomato plants were inoculated within 2 hours after preparation of bacterial suspensions.

The tomato plants were grown individually from seed in 4-inch clay pots in the greenhouse at 24(±4) C for 5 weeks before inoculation. Inoculations were made by forcing a sharp needle into the stem through a drop of the bacterial suspension placed in the axil of the second or third expanded leaf below the apex or by cutting the roots along one side of the plant to a depth of about 5 cm and pouring 10 ml of bacterial suspension over the severed roots (7). After inoculation, the plants were moved to environmental control chambers under the conditions specified for each test. Final disease readings were made 10-12 days after inoculation following the system of Winstead and Kelman (7).

To evaluate the effect of temperature on the expression of resistance, plants of each of the tomato lines 1169, 7580, Venus, and Bonnie Best were inoculated with isolate LB-6 or K-60 by the root-injury method and were placed in growth chambers at 26.6, 29.4, and 32.2 (±1) C, 21,500 lux light intensity, and 14-hr photoperiod. Five inoculated plants of each line and five water-inoculated checks were placed in each chamber. The comparison of disease reaction between 26.6 and 29.4 C with isolate LB-6 was repeated twice.

RESULTS.—Disease readings taken 10 days after inoculation indicated that the cultivar Venus was susceptible to isolate LB-6 and resistant to isolate K-60, and bacterial wilt severity on Venus was not significantly altered at the various temperatures tested (Fig. 1). For tomato lines 7580 and 1169, severity of bacterial wilt caused by each isolate increased as temperature increased. Bacterial wilt ratings were significantly greater at 32.2 C than at 26.6 C with each bacterial isolate. At 29.4 C, wilt ratings on 7580 were significantly greater than at 26.6 C for each isolate, while wilt ratings of 1169 were not always significantly altered.

The effect on resistance of different photoperiods was tested on the cultivar Red Jacket and line 1169. Twenty plants were stem-inoculated with isolate LB-6 and were placed into each of two growth chambers with day-night temperatures 21-27 C and 27-32 C, respectively. In each chamber, half of the plants received daily a 14-hr photoperiod, while the other half received a 9.5-hr photoperiod, supplied by combined fluorescent and incandescent lights at approximately 21,500 lux. The shorter photoperiod was obtained by placing a large, fan-ventilated cardboard box over the plants. Alteration of photoperiod did not significantly alter the wilt ratings of Red Jacket; in all cases, the susceptible Red Jacket plants were completely wilted within 10 days after inoculation. However, wilt ratings of 1169 were significantly greater at the shorter photoperiod than at the longer one. Similar results were obtained with photoperiods of 14- and 10-hr and day-night temperatures of 27 - 29 C, respectively. At 14- and 11-hr photoperiods, there was no significant alteration in the wilt rating of line 1169.

To test the effect of light intensity on disease resistance, Red Jacket and 1169 plants were stem-inoculated and placed under light intensities of 19,350 and 8,050 lux at

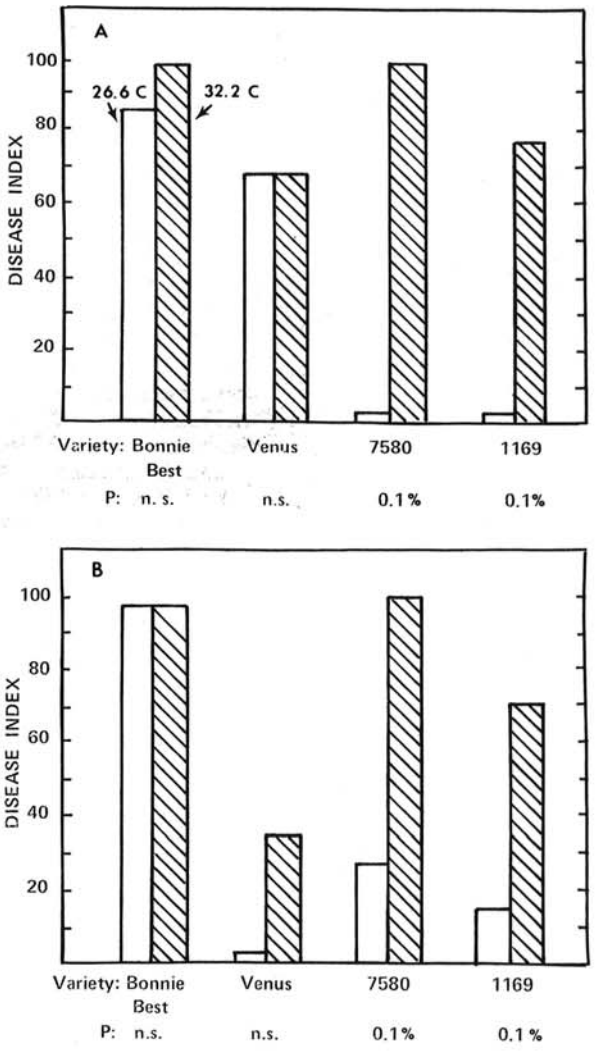

Fig. 1-(A, B). Severity of bacterial wilt (caused by *Pseudomonas solanacearum*) at 26.6 (open bars) and 32.2 C (cross-hatched bars) in one susceptible and three resistant tomato lines ten days after inoculation with **A**) bacterial isolate LB-6, and **B**) isolate K-60.

26.6 (±1) C. No differences in disease indices were noted between the two treatments at this temperature. However, at 29.4 (±1) C wilt ratings on line 1169 were significantly greater at the lower light intensity than at the higher light intensity.

DISCUSSION.—The degree to which severity of bacterial wilt is influenced by temperature is governed by the host variety or line. The resistance of Venus to the two bacterial isolates appears to be relatively temperature insensitive, while the severity of bacterial wilt in lines 7580 or 1169 to the same isolates is relatively temperature sensitive. Zehr (8) determined the optimum growth temperature in vitro for isolates LB-6 and K-60 to be 33 C. Bacterial wilt severity in lines 7580 and 1169 increases as the temperature approaches the temperature optimum for growth of the bacterium in vitro. There also appears to be a temperature-induced change in lines 7580 and 1169 which affects the resistance. This change is apparently not induced in the cultivar Venus.

Work by Lozano and Sequeira (5) demonstrate a possibly related loss of resistance in tobacco to normally incompatible race 2 of *P. solanacearum* under reduced light intensity and photoperiod. The increased susceptibility due to shortened photoperiod and reduced light intensity in these studies with tomatoes may be due primarily to a reduction of photosynthesis in the host plant. However, in most tropical and subtropical regions where *P. solanacearum* is a serious pathogen of tomato, daylengths probably do not become short enough to seriously alter resistance to the pathogen. However, during extensive periods of cloudiness, often characteristic of tropical wet seasons, resultant reduced light intensity might increase the susceptibility of certain tomato cultivars.

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