Differential Resistance of Tomato Cultigens to Biovars I and III of *Pseudomonas solanacearum*

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ABSTRACT


The reaction of six tomato cultigens (Yoshimatsu 4-11, Rotam-4, Rodade, Hawaii 7998, Cl 1131-0-0-13-0-6, and Irat L3) to *Pseudomonas solanacearum* biovars I and III was evaluated in a greenhouse trial. Seedlings were root-inoculated with 11 strains of biovar I and nine strains of biovar III. The plants were individually scored 15 days after inoculation for wilt severity on a scale from 1 (no symptoms) to 5 (dead plant). Cluster analysis grouped strains of biovar III in a lower virulent cluster than those of biovar I. Yoshimatsu 4-11, Rotam-4, and Rodade had specific resistance to biovar III but not to biovar I.

Bacterial wilt caused by *Pseudomonas solanacearum* (Smith) Smith is one of the most damaging diseases of tomato (*Lycopersicon esculentum* Mill.) worldwide. It is particularly limiting when the crop is grown in humid climates at low and medium elevations in tropical and subtropical regions.

One of the most striking characteristics of *P. solanacearum* is the high variability observed among its strains, which can differ in host range, geographic distribution, pathogenicity/virulence, transmissibility by insects, physiological properties, and adaptation to different temperatures (7,11,12). Because no better classification is yet available (7), strains of *P. solanacearum* are separated into races or into biovars, even though these subdivisions are informal groupings, i.e., not accepted by the International Code of Nomenclature of Bacteria (23).

Buddenhagen et al (5) proposed three races; the number was later expanded to five when golden and mulberry (1,13) were reported as susceptible hosts. The five known biovars were defined on the basis of different abilities of strains to utilize and/or oxidize several hexose alcohols and disaccharides (10,12). Races and biovars are poorly correlated, except for race 3, which may be equivalent to biovar II (4,8). This lack of concordance is not surprising, since races are defined by host range (ecological characters) and biovars are defined through biochemical tests (phenotypic characters) (9). The race subdivision for *P. solanacearum* is not taxonomically valid, since it is not based on the pathogenic differential

ability to induce disease on cultivars of the same species (25), and the biovar system is sometimes considered of little biological meaning because it does not represent the pathogenic potential of the strain or its geographic origin (4).

Tomatoes are cultivated throughout Brazil, and *P. solanacearum* is widely distributed as different biovars/races (21). However, the crop has been affected only by biovars I and III (unpublished). Northern and northeastern Brazil are the regions most affected because of the high ambient temperatures. A national survey on vegetable crops indicated that biovar III prevails in those regions, even though biovar I could also be isolated from tomato, pepper, and eggplant.

For breeding purposes, it is essential to know if tomato cultigens react differently when infected by different pathogen biovars. The objective of this work was to establish if tomato resistance to bacterial wilt is strain- or biovar-dependent.

MATERIALS AND METHODS

Bacterial cultures. Eleven strains of *P. solanacearum* biovar I and nine of biovar III (Table 1), from different locations in Brazil, were recovered from a culture collection in CNPH, Brasilia, DF, where they were stored in sterile tap water in screw-cap tubes at room temperature (25 C). From these tubes, cultures were streaked on tetrazolium-chloride (TZC) medium (14), and fluidal colonies, typical of virulent specimens, were selected after 72 hr of incubation at 28 C. The selected colonies were restreaked on the same medium devoid of TZC and incubated for 48 hr at the same temperature. The inocula were then prepared by flooding the plates with tap water (pH 7.0), suspending the cells, and adjusting the concentration to approximately 10^6 cfu/ml, according to a previously calibrated absorbance curve, with a spectrophotometer at 600 nm.

Host plants. The tomato cultigens assayed for bacterial wilt resistance were Yoshimatsu 4-11, Hawaii 7998, Irat L3, Cl 1131-0-0-13-0-6, Rotam-4, and Rodade. The first four were obtained, respectively, from the National Institute for Research in the Amazon (INPA/ Table 1. Strains of *Pseudomonas solanacearum* biovars I and III from different host plants and locations in Brazil

<table>
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<th>No.</th>
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<th>Origin*</th>
<th>Year</th>
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*Letters in parentheses represent geographic regions within Brazil: N = north, MW = midwest, NE = northeast.

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Fig. 1. Bacterial wilt severity on seven tomato cultivars at 15 days after root inoculation with strains of *Pseudomonas solanacearum* biovar I (white bars) and biovar III (black bars). Cultivar L 390 was used as a susceptible control. Disease severity was rated on a scale from 1 (no symptoms) to 5 (dead plant). BWI = \(\frac{\sum(s_i \times n_i)}{t}\), where \(s_i\) = score for \(i\) group, \(n_i\) = number of plants for this score, and \(t\) = total number of plants per plot.
strains of the same biovar followed a defined pattern of clustering. Within three clusters, the strains of the same biovar were placed in the same group, except for strains 3 and 6 of biovar I. Because these were the least virulent to all the tomato cultivars, they were grouped into the cluster of biovar III. Alternatively, the most virulent strain from biovar I, strain 4, was separated into a third group (Fig. 1). To avoid confusion about group comparisons among strains of different biovars, we recommend that the virulence of the strains be evaluated previously in a universal susceptible cultivar such as L. 390 (Fig. 1). The cultivars Hawaii 7998, Irat L3, and CL 1131-0-0-13-0-6 were resistant to most of the strains of both biovars I and III except for strain 4. In contrast, Yoshimatsu 4-11, Rotam-4, and Rodade were generally resistant to the strains of biovar III but susceptible to the strains of biovar I. Moreover, the reaction of Rodade to biovar I strains was similar to that of the susceptible control, L 390.

**DISCUSSION**

Variability in virulence among strains of *P. solanacearum* has been mentioned by many authors (13,15,20,24). Martins et al. (17) previously observed variability in virulence among strains of biovar I and biovar III from different locations in Brazil, but they could not compare biovar differential virulence because their trials were conducted at different times. Prior et al. (20) suggested a linkage between virulence to tomato cultivars and biovar classification. Strains that were more virulent on the cultivar Capitan (moderately resistant) belonged to biovar I, whereas the less virulent strains belonged to biovar III. Cultivar Caraibo (resistant) was consistently resistant to strains of both biovars.

Our results support the hypothesis that biovars I and III differ pathogenically and therefore support the division of *P. solanacearum* into two or more subspecies governed by the International Code of Nomenclature of Bacteria. Hayward (12) suggested that biovars I and III belong to different groups because biovar I is less nutritionally versatile than biovar III, the two biovars are distinct on the basis of DNA probes and RFLP analysis, and the two biovars may be of separate evolutionary origin based on their geographic distribution.

These criteria support separation into distinct phenons by numerical taxonomy, according to Hayward (12).

This study makes it clear that there are some tomato cultivars for which resistance is biovar-specific. We believe this is taxonomically meaningful, since it is linked directly to the epidemiology and control of bacterial wilt. This was apparent particularly in Yoshimatsu 4-11, Rotam-4, and Rodade (Fig. 1). The differential resistance of these cultivars to biovars I and III could be compared with that of cultivar Capitan, evaluated by Prior et al. (20). Therefore, at least for these two biovars, Buddenhagen's statement (4) that "biovar subdivision appears to have little relation to the evolutionary or existing biology of the strains as pathogens" was not confirmed. These results were surprising, since we expected that tomato cultivar response would be only strain-dependent, and not biovar-dependent. Our expectation arose from Buddenhagen's comment on the bias of bacteriologists who attempt to rationalize their results with Hayward's biovars (4).

The breeding materials that possess resistance to only biovar III could have an important role in breeding for tomato resistance to bacterial wilt in the Brazilian environment if their resistance is also heat-stable, because biovar III prevails in regions where high temperatures predominate. Mew and Ho (18) suggested that bacterial wilt resistance can be either dependent or independent of soil temperature, with 32°C being the temperature that separates them. This was also observed by Prior et al. (20) in relation to the cultivars Caraibo and Capitan, which have heat-stable and heat-unstable resistance, respectively. The linkage between virulence of the strains belonging to biovar III and high temperatures, especially high soil temperatures, to some tomato cultivars is still to be determined.

**LITERATURE CITED**


