Isolation and Characterization of Phages Useful for Identifying
Pseudomonas syringae pv. tomato

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ABSTRACT


Sixteen phages were isolated from tomato field soil and plant debris with six Pseudomonas syringae pv. tomato strains as the propagating hosts. Fifty-five strains of P. syringae pv. tomato and 51 strains from other pathovars of P. syringae were tested for lytic responses to these phages. Phage sensitivity patterns did not change with time or after passage through tomato plants. Four of the phages, PT1, PT18, PT20, and PT32 had a high degree of specificity for P. syringae pv. tomato. PT32, for example, lysed 90% of the virulent P. syringae pv. tomato strains tested, but less than 4% of the strains from other pathovars of P. syringae. None of the isolates of P. syringae pv. syringae from tomato and less than half of the avirulent strains of P. syringae pv. tomato tested were lysed by these phages. Phages PT1 and PT18, which have isometric heads and long, striated, noncontractile tails, were members of morphological group B1. Phages PT20 and PT32, which have isometric heads and short, noncontractile tails, were members of morphological group C1. When used in combination with selected physiological characters (s(+) tartrate, erythritol, and DL-lactate utilization and polypeptide degradation), phage sensitivity patterns clearly distinguished virulent strains of P. syringae pv. tomato from the other pathovars of P. syringae that were tested.

Additional key words: bacterial speck of tomatoes, Lycopersicon esculentum.

Since the first major disease outbreak in 1978, bacterial speck has become an increasingly serious problem for the Ontario tomato grower. The disease, characterized by small brown-to-black lesions on tomato fruits and leaves, is caused by Pseudomonas syringae (Okabe) Alstott (P. syringae pv. tomato). This pathovar is difficult to distinguish morphologically and physiologically from other pathovars of the species, particularly P. syringae pv. syringae, which also has been isolated from necrotic lesions on tomato (14). Furthermore, nonpathogenic, oxidase-negative, fluorescent pseudomonads resembling phytopathogens such as P. syringae pv. tomato commonly occur on plant surfaces (6). Therefore, it is essential that rapid, accurate diagnostic tests be developed for the bacterial speck pathogen. At present, the most useful laboratory tests for differentiation are erythritol and DL-lactate utilization (14). The ultimate diagnostic test for a plant pathogen is that of pathogenicity for the suspected host plant. Unfortunately, pathogenicity tests are time-consuming and not always possible.
Phages also can be used to distinguish closely-related bacterial plant pathogens (7). Phage sensitivity patterns, for example, have shown that the cherry and plum pathotypes of *P. syringae pv. morsprunorum* are two distinct homogeneous groups (8). Although *P. syringae pv. tomato* has been tested for sensitivity to phages from *P. syringae pv. syringae* (6), no phages specific to *P. syringae pv. tomato* have been reported.

The present study is concerned with the isolation and characterization of phages specific to *P. syringae pv. tomato*. These phages may be used in combination with selected physiological tests to identify the bacterial speck pathogen.

**MATERIALS AND METHODS**

**Bacterial strains.** A total of 55 strains of *P. syringae pv. tomato*, 10 *P. syringae pv. papulans*, 34 *P. syringae pv. syringae*, one *P. syringae pv. lachrymans*, two *P. syringae pv. glycinea*, two *P. syringae pv. phaseolicola*, one *P. viridiflava*, one *P. syringae pv. antirrhini*, one *P. syringae pv. tabaci*, and two *P. marginalis* were used in this study. The strains of *P. syringae pv. tomato* and 12 strains of *P. syringae pv. syringae* were isolated from infected tomato plants from several different tomato-growing regions of the world, including Canada, the United States, Australia, New Zealand, and Europe.

**Media and culture methods.** Unless otherwise stated, all bacterial cultures were grown on nutrient broth/yeast extract medium (NBY) (24) at 25 C for 48 hr.

**Phage isolation and maintenance.** Thirty-seven phages were isolated from samples of soil and plant material from four different tomato plant infected with *P. syringae pv. tomato*. The tomato plants were collected from seven different locations in southern Ontario, Tillbury, Picton, Simcoe, Ridgeway, St. Thomas, and Wellesley. *P. syringae pv. tomato* AV80, SM78-1, PST6, DCT6D1, 167, and 804 were used as the propagating strains. A 100-ml sample of soil and decaying tomato plant tissue was added to 50 ml of a log phase NBY culture of the propagating strain and the mixture was incubated at 24 hr for 6 hr at 25 C on a rotary shaker (175 rpm). The culture was filtered through a Whatman N. 1 filter paper and the filtrate was centrifuged at 8,000 rpm for 15 min. The supernatant was shaken with chloroform (5%, final concentration), allowed to settle 1-2 hr at 22 C, serially diluted, and spotted onto lawns of the same propagating strain. Single plaques were removed from the soft agar and the phage were purified by two more passages through the propagating strain. High-titer (10^10-10^12 plaque forming units [pfu]/ml) phage stocks were prepared as previously described by Billing (5) and stored at 4 C for up to 8 wk. Phage stocks can also be stored at -75 C for at least 6 mo without a significant loss of titer.

**Detection of lysogeny in the propagating strains.** The procedure for propagating high titer phage stocks (5) was followed exactly except that no viable was added to the propagating strains of *P. syringae pv. tomato* (DCT6D1, AV80, SM78-1, 167, 804, and PST6). The resulting preparations were diluted and assayed for plaques on five *P. syringae pv. syringae* strains, seven *P. syringae pv. papulans* strains, and 11 *P. syringae pv. tomato* strains. The assay was done in triplicate for each propagating strain.

**Purification of phage.** Phages were purified by cesium chloride (CsCl) block density gradients followed by CsCl equilibrium gradients (10). Purified phage stocks were stored in xylene (10 M tris-HCl and 10 M MgSO_4_-7H_2O, pH 7.5) plus 25% glycerol at -75 C.

**Phage sensitivity tests.** Phage stocks were diluted in 10 M potassium phosphate buffer (pH 7.2) containing 1 M ammonium sulfate (PM) to their routine test dilution (RTD). The RTD is the dilution which just gives confluent lysis of the propagating host strain (2). Bacteria from 24-hr-old NBY agar cultures were suspended in PM buffer. This suspension was used to prepare bacterial lawns with NBY soft agar (0.7% agar) (10^7 colony-forming units [cfu]/per lawn). These lawns were spotted (15 μl per drop) with the phage RTD and incubated at 25 C for 24 hr. Turbid confluent zones, clear confluent zones, and zones with individual plaques were recorded as positive reactions; no lysis and extremely faint zones of lysis were recorded as negative reactions.

**Electron microscopy.** A drop of purified phage (~10^12 pfu/ml) was placed on a carbon-backed copper grid for 2 min and then removed. The grid was washed with 0.1 M ammonium acetate and then stained with 0.6% phosphatase plus 150 μg/ml bacitracin for phages PT20 and PT32 and with 0.6% ammonium molybdate plus 150 μg/ml bacitracin for phages PT1 and PT18. Fifty particles of each phage strain were measured for head diameter and tail length.

**Characterization of purified phages.** Nucleic acid was extracted from purified phage by a previously described procedure (10). A 1- to 2-μg sample of the nucleic acid was then treated with either 3 μg of deoxyribonuclease (DNase) I (Sigma) in the presence of 10 mM MgSO_4_7H_2O and 3 μg of ribonuclease (RNase) A (Sigma Chemical Co., St. Louis, MO 63178) for 25 min at 32 C. The nucleic acid was subjected to electrophoresis on a 0.7% agarose gel in a tris-borate buffer as described previously (9). As a control, the nucleic acid was subjected to electrophoresis without prior nuclease treatment.

Phages PT1, PT18, PT20, and PT32 were tested for stability at 50, 60, 70, and 80 C. Small tubes containing 0.5 ml of phage suspension (~2 x 10^10 pfu/ml in 0.1 M tris, pH 7.2) were placed in a water bath at the designated temperature for 10 min and then rapidly chilled on ice. The phage suspension subsequently assayed for pfus on the appropriate host strain.

**Physiological test methods.** All bacterial strains used in this study were tested for oxidase and fluorescent pigment production (15). Procedures for determining their ability to degrade polyphosphate at pH 4.9 and 8.3 also have been described (13). Utilization of C- (+) tartrate, p- lactate, erythritol, and homoserine as carbon sources was determined with the minimal medium of Ayers et al. (3, 20). Ayers' medium, supplemented with the desired carbon source, was spot-inoculated with 15 μl drops of a bacterial suspension (5 x 10^5 cfu/ml in PM buffer, pH 7.2) and incubated 4 days at 25 C.

**Pathogenicity tests.** All bacterial strains were tested for pathogenicity on 4- to 6-week-old tomato plants (*Lycopersicon esculentum* Mill. 'Bonny Best') approximately 15 cm tall that had been preincubated in plastic bags at 24 C for 24 hr immediately prior to inoculation. The second set of true leaves was sprayed with a water suspension of carbendazim (45-μg/ml IGN). Fisher Scientific Co., Pittsburgh, PA 15219, and then washed with distilled water. Bacterial test strains were grown on NBY agar overnight at 25 C. A distilled water suspension of the bacteria (~2 x 10^7 cfu/ml) then was sprayed on the carbendazim-treated leaves. When the leaves had dried, the plants were covered with plastic bags and incubated for 24 hr at 25 C. The bags were removed and the plants were incubated another 6 days. Lesions that developed on the second set of true leaves were counted, leaf areas were measured with a portable Lambda area meter (Lambda Instruments Corp., Lincoln, NE 68504), and the number of lesions per square centimeter was calculated.

**RESULTS**

Six strains of *P. syringae pv. tomato* (804, 167, DCT6D1, PST6, SM78-1, and AV80) were used as enriching-propagating strains in the isolation of 37 phases from Ontario tomato field soil and infected tomato plant debris. A preliminary survey of the sensitivity of 38 phases of *P. syringae pv. tomato*, 22 *P. syringae pv. syringae*, and three *P. syringae pv. papulans* to the RTDs of these phases indicated that only 16 of the 37 were distinct phase strains. The remaining 21 phase strains were discarded. The origins, propagating strains of *P. syringae pv. tomato* strains, RTDs, and plaque morphologies of these 16 strains are listed in Table 1.

Thirty-three strains of *P. syringae* were used as indicators to test the six propagating strains (Table 1) for the presence of temperate phage. All propagating strains, except PST6, released phage without induction. The highest temperate phage titer (pfu/ml) was obtained with indicator strain *P. syringae pv. syringae* NCPPB281: DCT6D1, 1.9 ± 0.9 x 10^7; 804, 5.5 ± 0.8 x 10^7; SM78-1, 4.3 ± 2.5 x 10^7; 167, 8.8 ± 3.7 x 10^7; and AV80, 3.5 ± 2.1 x
of the strains of *P. syringae* pv. *toma*to were lysed by 13 of the PT phages. *P. syringae* pv. *papulans*, an apple pathogen, was also lysed by several PT phages. In addition to the three pathovars shown in Fig. 1, the PT phages were tested against *P. marginalis* (two strains), *P. viridiflava* (one strain), and five other pathovars of *P. syringae*: *P. syringae* pv. *tabaci* (one strain), *P. syringae* pv. *lachrymans* (one strain), *P. syringae* pv. *antirrhini* (one strain), *P. syringae* pv. *glycinae* (two strains), and *P. syringae* pv. *phaseolicola* (two strains). No zones of lysis or plaques were formed on lawns of any of these strains except *P. antirrhini*. PT10, PT11, PT15, PT19, PT23, and PT34 formed confluent zones of lysis on this strain.

Phage PT27, which represented 14 of the original 37 phage strains, was the most common PT phage, but it also had one of the more restricted host ranges. Only 33% of the strains of *P. syringae* pv. *toma*to were lysed by PT27. Four of the phages, PT1, PT18, PT20, and PT32, had a pronounced, although not absolute, specificity for the strains of *P. syringae* pv. *toma*to (Fig. 1; Table 2). Only two strains from the other pathovars of *P. syringae* were lysed by PT20 and PT32: *P. syringae* pv. *syringae* NCPPB281 (lilac) and GN2 (corn). Likewise, PT1 lysed only three strains from the other pathovars (one *P. syringae* pv. *syringae* from lilac and two *P. syringae* pv. *papulans*) and PT18 only five strains from other pathovars (*P. syringae* pv. *syringae* from lilac and soybean and three strains of *P. syringae* pv. *papulans*). PT1, PT18, PT20, and PT32 did not form plaques or zones of lysis on lawns of the strains of *P. syringae* pv. *syringae* from *toma*to.

The morphology of phages PT1, PT18, PT20, and PT32 that attack *P. syringae* pv. *toma*to was studied by electron microscopy of negatively-stained preparations. PT1 and PT18, which had isometric heads and long noncontractile tails, belonged to Ackermann's viral morphological group B1 (Fig. 2). The head and tail of PT1 measured 60 ± 3.9 nm and 227 ± 7.7 nm, respectively; those of PT18 measured 60 ± 3.4 nm and 226 ± 9.2 nm, respectively. The tails of PT1 and PT18 are markedly striated with a basal plate and four fibers at the tip. PT1 and PT18 had almost identical patterns of thermal stability (Fig. 3). Complete

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**TABLE I. Source, RTD**, and plaque morphology of *Pseudomonas syringae* pv. *toma*to phages

<table>
<thead>
<tr>
<th>Phage</th>
<th>Sourceb</th>
<th>Enrichment host strain</th>
<th>RTD</th>
<th>Plaque morphology</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT 1</td>
<td>Tilbury</td>
<td>SM78-1 (Georgia)</td>
<td>3.0 x 10^3</td>
<td>&lt;1 mm, C, H</td>
</tr>
<tr>
<td>2</td>
<td>Picton</td>
<td>SM78-1 (Ontario)</td>
<td>1.3 x 10^3</td>
<td>&lt;1 mm, C, H</td>
</tr>
<tr>
<td>8</td>
<td>Simcoe</td>
<td>167 (Ontario)</td>
<td>1.0 x 10^3</td>
<td>2-1 mm, C, H</td>
</tr>
<tr>
<td>10</td>
<td>Ridgeway</td>
<td>804 (Ohio)</td>
<td>1.6 x 10^3</td>
<td>5-4 mm, C, H</td>
</tr>
<tr>
<td>11</td>
<td>Tilbury</td>
<td>AV80 (Nebraska)</td>
<td>8.0 x 10^3</td>
<td>5-4 mm, C, H</td>
</tr>
<tr>
<td>15</td>
<td>Trenton</td>
<td>AV80 (Nebraska)</td>
<td>4.8 x 10^3</td>
<td>5-4 mm, C, H</td>
</tr>
<tr>
<td>16</td>
<td>Picton</td>
<td>AV80 (Nebraska)</td>
<td>4.0 x 10^3</td>
<td>&lt;1 mm, C</td>
</tr>
<tr>
<td>17</td>
<td>Simcoe</td>
<td>DCT61D (Ontario)</td>
<td>5.0 x 10^3</td>
<td>5-4 mm, C, H</td>
</tr>
<tr>
<td>18</td>
<td>Simcoe</td>
<td>DCT61D (Ontario)</td>
<td>4.3 x 10^3</td>
<td>2-1 mm, C, H</td>
</tr>
<tr>
<td>19</td>
<td>Ridgeway</td>
<td>DCT61D (Ontario)</td>
<td>4.0 x 10^3</td>
<td>2-1 mm, T</td>
</tr>
<tr>
<td>20</td>
<td>Talbotville</td>
<td>DCT61D (Ontario)</td>
<td>1.5 x 10^3</td>
<td>2-1 mm, T</td>
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<tr>
<td>23</td>
<td>Tilbury</td>
<td>AV80 (Nebraska)</td>
<td>2.5 x 10^3</td>
<td>5-4 mm, C, H</td>
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<tr>
<td>27</td>
<td>Wellington PS19</td>
<td>AV80 (Ontario)</td>
<td>4.6 x 10^3</td>
<td>&lt;1 mm, T</td>
</tr>
<tr>
<td>32</td>
<td>Tilbury</td>
<td>804 (Ohio)</td>
<td>7.5 x 10^3</td>
<td>2-1 mm, C, H</td>
</tr>
<tr>
<td>34</td>
<td>Tilbury</td>
<td>AV80 (Nebraska)</td>
<td>3.0 x 10^3</td>
<td>6-5 mm, C, H</td>
</tr>
</tbody>
</table>

*RTD = routine test dilution. The lowest concentration (plaque-forming units per milliliter) of phage required to produce confluent lysis on a lawn of the propagating strain.

*Phage were isolated from tomato field soil and plant debris collected at various locations throughout Ontario, Canada.

*C = clear, H = halo, and T = turbid.*
inactivation occurred at 60°C.

PT20 and PT32 had isometric heads with short, thin, noncontractile tails and thus were members of morphological group CI (Fig. 2). The heads were 57 ± 3.6 nm and 61 ± 2.8 nm, respectively; the tails, partially obscured by negative staining, were difficult to measure, but were ~27–29 nm long. PT20 was more heat-stable than PT32 at 50°C, but both were totally inactivated at 60°C (Fig. 3).

Nucleic acid extracted from purified particles of PT1, PT18, PT20, and PT32 was treated with either DNAse I or RNase A. The products of the reactions, along with untreated controls, were subjected to electrophoresis on a 0.7% agarose gel. Only the

<table>
<thead>
<tr>
<th>TABLE 2. Differentiation of Pseudomonas syringae pv. tomato from other closely-related P. syringae pathovars</th>
<th>Number of positive strains from P. syringae:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic test</td>
<td>pv. tomato (55)</td>
</tr>
<tr>
<td>Homoserine</td>
<td>0</td>
</tr>
<tr>
<td>Erythritol</td>
<td>0</td>
</tr>
<tr>
<td>DL-lactate</td>
<td>0</td>
</tr>
<tr>
<td>D(-) tartrate</td>
<td>55 (100)</td>
</tr>
<tr>
<td>Pectate degradation at: pH 4.9, pH 8.3</td>
<td>54 (98)</td>
</tr>
<tr>
<td>Sensitivity to phage:</td>
<td></td>
</tr>
<tr>
<td>PT1</td>
<td>49 (89)</td>
</tr>
<tr>
<td>PT18</td>
<td>49 (89)</td>
</tr>
<tr>
<td>PT20</td>
<td>45 (82)</td>
</tr>
<tr>
<td>PT32</td>
<td>48 (87)</td>
</tr>
<tr>
<td>Bacterial speck symptoms on tomato</td>
<td>51 (93)</td>
</tr>
</tbody>
</table>

¹Number of strains tested.  
²Slightly positive.  
³Percent positive.

Fig. 2. Electron micrographs of negatively-stained Pseudomonas syringae pv. tomato phages A, PT1, B, PT18, C, PT20, and D, PT32. Bar = 100 nm.
controls and the RNase-treated samples gave ethidium bromide-stained bands. Thus, the nucleic acid of all four phage strains was deoxyribonucleic acid (DNA). Since all four DNAs could be removed from 70% ethanol by being wound onto a glass rod, they were assumed to be of high molecular weight and double-stranded.

PT1 and PT18 were very similar, differing mainly in host range.

When they were propagated in two different bacterial strains, their host sensitivity patterns differed by three bacterial strains. However, when they were propagated in the same bacterial strain, PST6, their sensitivity patterns differed by only one bacterial strain. In contrast, PT20 and PT32, when propagated in the same bacterial strain, 804, continued to have a host range difference of four bacterial strains. Whether PT18 and PT1 are different isolates of the same virus or two distinct viruses will require further characterization.

Strains of *P. syringae* pv. *tomato* have been included in several taxonomic studies of the phytopathogenic pseudomonads (6,13,14,18,19,22,25). Based on these studies, the physiological tests listed in Table 2 appeared to be among the best for differentiating *P. syringae* pv. *tomato* from related pathovars of *P. syringae*. Every strain of *P. syringae* tested (Table 2) was oxidase-negative and fluorescent. The majority of strains of *P. syringae* pv. *syringae*, all strains of *P. syringae* pv. *papulans*, but no strains of *P. syringae* pv. *tomato* were able to use Dl-lactate and erythritol as carbon sources.

All strains of *P. syringae* pv. *tomato*, with one exception, were able to use D(-) tartrate and degrade polypectate at pH 4.9. Pectate degradation at pH 4.9 was a good test for differentiating *P. syringae* pv. *tomato* from *P. syringae* pv. *syringae*, but not from *P. syringae* pv. *papulans*. Conversely, utilization of D(-) tartrate separated strains of *P. syringae* pv. *tomato* from *P. syringae* pv. *papulans*, but not from *P. syringae* pv. *syringae*. Several representative strains of *P. syringae* pv. *tomato*, *P. syringae* pv. *syringae*, and *P. syringae* pv. *papulans* also were tested for production of glycoside hydrolases (12). No enzymes unique to *P. syringae* pv. *tomato* were found (unpublished).

Phage sensitivity tests showed high specificity for *P. syringae* pv. *tomato* as did the Dl-lactate and erythritol utilization tests (Table 2). Three of the four avirulent strains of *P. syringae* pv. *tomato* tested were not lysed by PT1, PT18, and PT20 and two of the four were not lysed by PT32. If these avirulent strains were excluded from the survey, even higher percentages of the strains of *P. syringae* pv. *tomato* were sensitive to PT1, PT18, PT20, and PT32; 96, 96, 88, and 94%, respectively. Only one pathogenic strain of *P. syringae* pv. *tomato* was resistant to all four phages.

If phage sensitivity tests are to be used in bacterial identification or typing schemes, it is essential that the sensitivity patterns be reproducible. Thirty bacterial strains were retested for sensitivity to the 16 PT strains 1–2 mo after the initial survey had been performed. New RTDs were prepared from the phage stocks stored at -75°C. Changes occurred in only 3% of the 480 phage-bacteria combinations that were examined. The stability of the phage sensitivity patterns of two pathogenic strains of *P. syringae* pv. *tomato*, 804 Str' and PST6 Str', after passage through the host plant also was determined. No changes occurred in the phage pattern for either strain.

**DISCUSSION**

PT1, PT18, PT20, and PT32 were the first phage strains to be isolated with a high degree of specificity for *P. syringae* pv. *tomato*. The most probable source of phages highly specific for a particular plant pathogen is the soil beneath infected host plants (7). Thus, it was not unexpected that other *P. syringae* phages isolated from soil, manure, and manure had no differential value for *P. syringae* pv. *tomato* (6). PT1, PT18, PT20, and PT32, although isolated from Ontario tomato fields, were able to infect *P. syringae* pv. *tomato* strains from all over the world, including Australia, New Zealand, Europe, and the U.S. Conversely, strains of *P. syringae* pv. *syringae* having the same habitat (tomato plant surfaces) as *P. syringae* pv. *tomato*, were not lysed by these phages.

Phage sensitivity tests can offer greater specificity in identifying bacteria than physiological or even serological tests (17,21,23). However, they rarely show an absolute specificity and thus cannot serve as the sole basis for identification. Billings and Garrett (7) recommend that, for bacterial identification, more than one phage be used and that physiological tests be employed in conjunction with phage sensitivity patterns. Although several
taxonomic studies (6,13,14,18,19,22,25) have included P. syringae pv. tomato, relatively few strains of this pathogen have been characterized. Based on these studies as well as our own, Nt-lactate, D(-) tartrate, and erythritol utilization combined with polypectate degradation at pH 4.9 were good diagnostic characters for differentiating P. syringae pv. tomato from P. syringae pv. papulans and P. syringae pv. syringae, which are two closely-related pathogens. When used in combination with phage (PT1, PT18, PT20, and PT132) sensitivity tests, they presented a rapid, reliable means of identifying the bacterial speck pathogen. Although more avirulent strains must be tested, phage sensitivity also might be a means of separating avirulent and virulent strains of P. syringae pv. tomato. All avirulent strains tested had reduced phage sensitivity; however, not all phage-resistant strains were avirulent (unpublished).

All phage sensitivity tests were performed at the RTDs of the phages since false-positive reactions caused by lethal adsorption, bacteriocins, or temperate phages in the propagating strains are possible if undiluted phage preparations are used. None of the propagating strains produced bacteriocins active on other strains of P. syringae pv. tomato (unpublished). Temperate phages, however, were present in 12 of 25 strains of P. syringae pv. tomato that were tested (unpublished). Five of the six PT phage-propagating strains released temperate phages, but the concentration in the PT phage stocks was not high enough to interfere with phage sensitivity tests. Lysogeny is regarded as the norm, rather than the exception, for bacteria (11). Given the proper indicator strain and induction conditions, it is likely that most isolates of P. syringae pv. tomato would release temperate phage.

All phage strains, stored at -75°C in crude lysate or Adil plus 25% glycerol, maintained a high titer (10^10-10^12 pfu/ml) with no evidence of plaque or host range mutation. Furthermore, the PT phage sensitivity patterns, like the plum and cherry phage types of P. syringae pv. syringae (8), were reproducible over time and after passage of the pathogen through the host plant. These results with phytopathogenic pseudomonads are in direct contrast to those obtained with the animal pathogen, P. aeruginosa, for which phage sensitivity patterns have been erratic (4).

LITERATURE CITED