Verticillium Wilt of Potato Caused by *Verticillium albo-atrum* in Daegwallyeong Area in Korea

Jong Tae Kim*, Kyoung Yul Ryu, Jeom Soon Kim, Young Il Hahn and Seung Hun Yu
Highland Crop Research Division, National Highland Agricultural Experiment Station, RDA, Pyungchang, Gangwon 232-950, Korea

1Department of Agricultural Biology, Chungnam National University, Daejeon 305-764, Korea

(Received on March 8, 2003; Accepted on May 30, 2003)

Verticillium wilt was first observed in 2001 on potatoes (*Solanum tuberosum*) cv. Superior at Daegwallyeong area, one of the major seed potato producing areas in Korea. The wilted potato plants showed typical symptoms including gradual yellowing and interveinal necrosis. There was discoloration in the vascular tissues of the infected stems which turned light brown. Fungal isolates from discolored vascular tissues were whitish to creamy with folding on potato dextrose agar medium, where they used to produce resting dark mycelia but no microsclerotia. Conidiophores were septate with side branches, swelled at the base, and arranged in a whorl. Conidia were 2.5-11.2×2.0-4.5 μm in size and were borne in small clusters at the tips of phialides. Optimal temperature range for mycelial growth was 25-30°C. Based on these cultural and morphological characteristics, the fungus was identified as *Verticillium albo-atrum* Reink & Berth. Pathogenicity tests by root dipping method revealed that the fungus caused the same symptoms as observed in naturally infected potato plants. This is the first report of Verticillium wilt on potato caused by *Verticillium albo-atrum* in Korea.

**Keywords**: potato, soil-borne pathogen, *Verticillium albo-atrum*, Verticillium wilt

Verticillium wilt of potato (*Solanum tuberosum*) is caused by the soil-borne fungal pathogens *Verticillium albo-atrum* Reink & Berthier and *V. dahliae* Kelb. Both pathogens infect many plant species, including trees, vegetables, field crops, ornamentals, and weeds. Characteristic symptoms of Verticillium wilt were recoverable true wilting, unilateral permanent wilting, unilateral chlorosis, and necrosis. In addition, plants infected with these pathogens have reduced growth rates of leaves, stems and tubers, and have premature maturation or senescence, which are commonly referred to as potato early dying. *V. albo-atrum* originally recognized as a causal agent of potato wilt, also causes wilt in several plants including hop (John and Heale, 1985; Keyworth, 1953; Sewell and Wilson, 1984), tomato (Kim et al., 2001; Tjamos, 1981), and alfalfa (Jimenezdiaz and Millar, 1988; Keinath and Millar, 1986). *V. albo-atrum* is generally far less common than *V. dahliae* and is more virulent at low temperatures (Ludbrook, 1933; Smith, 1965); vascular infection leads to wilt with or without obvious flaccidity; and the infected xylem vessels are commonly browned. In 2001, symptomatic potato plants were collected from major seed producing areas in the higland (Daegwallyeong area, Gangwon province, Korea). Wilted potato plants showed gradual yellowing in the field and discoloration of the vascular tissues of the infected stems which turned light brown (Fig. 1A).

Stems and roots from diseased plants were washed with tap water. After removal of the outer stem cortex, small pieces of vascular tissues were surface sterilized in 0.5% NaOCl for 30-60 seconds, and then placed on Petri plates containing 2% water agar or acidified potato dextrose agar (APDA). The vascular tissues were incubated at 22°C for 5-7 days. A number of conidiophores were formed on the discolored vascular tissues (Fig. 1B). Fungal isolates from these vascular tissues were whitish to creamy with folding on potato dextrose agar medium (PDA) (Fig. 1C), where they used to produce dark mycelia as resting structures but no microsclerotia (Fig. 1D). The isolates were identified based on published descriptions by Smith (1965) and Hawksworth and Talboys (1970). Conidiophores were septate with side branches as phialides 15.3-27.9×1.0-2.5 μm, swollen at the base, and arranged in a whorl. Conidia were 2.5-11.2×2.0-4.5 μm in size, borne in small clusters at the tips of phialides (Table 1 and Fig. 1D).

Four isolates of *Verticillium spp.*, isolated from potato (*V. albo-atrum*, PV-01 and PV-03) and tomato (*V. albo-atrum*, TV-29; *V. dahliae*, TV-07), were tested for mycelial growth. The isolates were incubated at 15, 20, 25, 30, and 35°C, and colony diameters were measured every 2 days for 2 weeks on PDA in the dark. Optimum temperature for mycelial growth of the *V. albo-atrum* isolates (PV-01, PV-
03 and TV-29) ranged from 25°C to 30°C, whereas, that of V. dahliae isolate (TV-07) was 15°C to 20°C (Fig. 2).

Four isolates of Verticillium were tested pathogenic to potato seedlings, cvs. Superior and Atlantic. Inoculum for each isolate was prepared using two 14-day-old cultures on PDA plates blended with 40-50 ml of sterile distilled water to make a thick slurry, and the inoculum concentration was adjusted to 10³ conidia/ml. Twenty (20) seedlings of each cultivar were inoculated at growth stage upon appearance of the 3-4th true leaf by a root-dip technique (Bender and Shoemaker, 1984). Uninoculated controls (seedlings dipped in PDA suspensions) were included. The seedlings were grown for 30 days after inoculation in a greenhouse maintained at 20-25°C, and disease development on seedling were carried out according to disease index (0= healthy, 1=slight vascular discoloration, 2=slight wilting, 3 =severe wilting and death). Two weeks after inoculation, inoculated plants began to exhibit yellowing (Fig. 1E), chlorosis, and defoliation of lower leaves. The pathogenicity of V. dahliae and V. albo-atrum varied on two potato cultivars; three isolates of V. albo-atrum, PV-01, PV-03 and TV-29, were highly virulent to potato cultivars and the disease index ranged from 1.7 to 2.3, whereas one isolate of V. dahliae, TV-07, only had vascular discolor-
Table 1. Comparison of morphological and cultural characteristics of *Verticillium albo-atrum* isolated from potato, and *V. dahliae* and *V. albo-atrum* isolated from tomato

<table>
<thead>
<tr>
<th>Isolate</th>
<th>Source</th>
<th>Color of colony</th>
<th>Resting structure</th>
<th>Size (μm)</th>
<th>Conidia</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV-01</td>
<td>Potato (V. albo-atrum)</td>
<td>Hyaline to white grey</td>
<td>Dark mycelium</td>
<td>15.3–27.9×1.0–2.5</td>
<td>2.5–11.3×2.0–4.8</td>
</tr>
<tr>
<td>PV-03</td>
<td>Potato (V. albo-atrum)</td>
<td>Hyaline to white grey</td>
<td>Dark mycelium</td>
<td>15.7–26.0×1.0–2.5</td>
<td>2.6–11.2×2.0–4.5</td>
</tr>
<tr>
<td>Kim et al. (2001)</td>
<td>Tomato (V. albo-atrum)</td>
<td>Hyaline to white grey</td>
<td>Dark mycelium</td>
<td>17.5–27.0×1.0–2.5</td>
<td>2.5–10.0×2.3–3.5</td>
</tr>
<tr>
<td></td>
<td>Tomato (V. dahliae)</td>
<td>Hyaline to black</td>
<td>Microsclerotium</td>
<td>17.5–35.0×1.0–2.5</td>
<td>2.5–8.8×2.0–3.0</td>
</tr>
<tr>
<td>Hawksworth &amp; Talboys (1970)</td>
<td><em>V. albo-atrum</em></td>
<td>Hyaline to white grey</td>
<td>Dark mycelium</td>
<td>14.0–26.0×1.0–2.5</td>
<td>3.5–10.5×2.0–4.0</td>
</tr>
<tr>
<td></td>
<td><em>V. dahliae</em></td>
<td>Hyaline to black</td>
<td>Microsclerotium</td>
<td>16.0–35.0×1.0–2.5</td>
<td>2.5–8.0×1.4–3.2</td>
</tr>
</tbody>
</table>

Table 2. Pathogenicity of *Verticillium dahliae* (V-d) and *V. albo-atrum* (V-a) against two different potato cultivars

<table>
<thead>
<tr>
<th>Potato cultivar</th>
<th>Isolates from potato</th>
<th>Isolates from tomato</th>
<th>Con.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PV-01(V-a)</td>
<td>PV-03(V-a)</td>
<td>TV-29(V-a)</td>
</tr>
<tr>
<td>Superior</td>
<td>2.1</td>
<td>2.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Atlantic</td>
<td>2.3</td>
<td>2.0</td>
<td>1.7</td>
</tr>
</tbody>
</table>

* Disease index: 0=healthy; 1=slight vascular discoloration; 2=slight wilting; 3=severe wilting and death.
* Control: seedlings immersed in a pathogen-free agar slurry were used as uninoculated controls.
* Mean number of disease index with symptoms 4 weeks after inoculation, for 20 replicates of each cultivar. Error mean square=0.4.

Fig. 2. Mycelial growth rate of *Verticillium dahliae* and *V. albo-atrum* on PDA at different temperatures 2 weeks after incubation. *Verticillium* isolates were isolated from potato (PV-01, 03) and tomato (TV-07, 29).

Infected plants may not actually wilt, but they turn yellow, wither, and die from the base upward. It is easy to confuse plant symptoms with those of black leg, ring rot, southern bacterial wilt, and Fusarium wilt.

References


John, M. C. and Heale, J. B. 1985. Pathogenesis and colonization studies on wild-type and auxotrophic isolates of *Verticillium*.