The Pathogenic Variability among Japanese Isolates of
Fusarium oxysporum f. sp. pisi to Japanese Commercial Pea Cultivars

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Abstract: In Japan, Fusarium wilt of pea caused by Fusarium oxysporum f. sp. pisi (FOP) was recently discovered in Aichi, Shizuoka, Wakayama and Hokkaido prefectures, but each occurrence of the disease is currently under control. In foreign countries, FOP is known for its pathogenic variability among isolates (Kraft, 1995). In this study, in order to compare the pathogenicity among five Japanese isolates with different origins, cross-inoculation tests to three cultivars as sources of tested isolates were conducted using a root-dipping method (Sakoda et al., 2018). As a result, pathogenic differences were observed among the Japanese isolates. The Aichi and Wakayama isolates were only pathogenic to two cultivars (Misasa, Akabana-suzunarisatou), while the Hokkaido isolate was also only pathogenic to two cultivars (Misasa, Hanaka-kinusaya). This is the first report on the pathogenic variability among Japanese isolates of FOP to commercial pea cultivars.

Key words: Fusarium oxysporum f. sp. pisi, resistance, inoculation

Introduction

Fusarium wilt of pea (Pisum sativum L.) caused by Fusarium oxysporum f. sp. pisi (FOP) often causes severe crop losses depending on the population density of the pathogen in the field soil or susceptibility of pea cultivars (Haglund and Kraft, 2001). FOP is known for its pathogenic variability among isolates (Kraft, 1995), and the four common races (1, 2, 5, and 6) occur worldwide in pea growing regions (Neumann and Xue, 2003), but an unknown type whose race was impossible to identify by standard differentials (e.g. Little Marble etc.) was also reported as “unknown race” (Merzoug et al., 2014). In Japan, Fusarium wilt of pea was first discovered in Aichi Prefecture (Matsuzaki et al., 2003) in 2002 and Shizuoka Prefecture in 2003. Subsequently, the disease was also found in Wakayama Prefecture in 2009, 2015 and 2016, and in Hokkaido Prefecture in 2015, but the distribution was restricted within a few areas and each occurrence of the disease is currently under control. As mentioned above, there are pathogenic variabilities among foreign isolates of FOP, but those of Japanese isolates are unknown. Therefore, this study attempted to research if differentiations of pathogenicity existed among Japanese isolates by cross-inoculation tests to commercial cultivars.

Material and Methods

Fungal isolates

The fungal isolates used in this study are shown in Table 1. The Japanese isolates were originated from Fusarium wilt on three pea cultivars which occurred in Aichi in 2002 (Sakoda et al., 2004), Wakayama in 2016 and at Hokkaido in 2015. The classification of pathogen race has not been investigated except for an Aichi isolate (1-5-2-M), which was identified as race 2 (Ueda et al., 2005). The two Aichi isolates were stored in our laboratory as culture disks at −80°C in 10% glycerol until use. The Wakayama and Hokkaido isolates were collected by the Kobe Plant Protection Station, MAFF and Hokkaido Research Organization (HRO), respectively. The three isolates as positive controls classified as race 2A, 2B and 5 originating from the U.S.A. were kindly provided by Dr. Paola Nipoti (Università degli studi di bologna). The import permit number issued by the Ministry of Agriculture, Forestry and Fisheries of Japan is 15Y332. Two races (2A and 2B) belong to different vegetative compatibility groups (VCG). Each isolate was maintained in synthetic low nutrient agar (SNA) (Nirenberg, 1976) for this study.

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Table 1. List of *Fusarium oxysporum* f. sp. *pisi* used in this study and pathogenicity of isolates to three pea cultivars.

<table>
<thead>
<tr>
<th>Isolates location</th>
<th>Cultivar</th>
<th>Year</th>
<th>Disease incidence (DI) 1-2</th>
<th>Cv. Mi</th>
<th>Cv. Ak</th>
<th>Cv. Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1-M Aichi AK</td>
<td></td>
<td>2002</td>
<td>66.7 (8/12) 100 (12/12) 0 (0/12)</td>
<td>1-1-M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-5-2-M Aichi AK</td>
<td></td>
<td>2002</td>
<td>37.5 (3/8) 100 (8/8) 0 (8/8)</td>
<td>1-5-2-M</td>
<td></td>
<td></td>
</tr>
<tr>
<td>215B Wakayama Mi</td>
<td></td>
<td>2016</td>
<td>50.0 (4/8) 85.7 (7/8) 0 (8/8)</td>
<td>215B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39b   Wakayama Mi</td>
<td></td>
<td>2016</td>
<td>50.0 (4/8) 100 (8/8) 0 (8/8)</td>
<td>39b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KKB31 Hokkaido Ha</td>
<td></td>
<td>2015</td>
<td>31.3 (5/16) 0 (0/16) 41.7 (5/12)</td>
<td>KKB31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>race2A U.S.A.</td>
<td></td>
<td></td>
<td>43.8 (7/16) 56.3 (9/16) 0 (9/16)</td>
<td>race2A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>race2B U.S.A.</td>
<td></td>
<td></td>
<td>0 (0/8) 37.5 (6/16) 0 (8/8)</td>
<td>race2B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>race5 U.S.A.</td>
<td></td>
<td></td>
<td>62.5 (5/8) 75.0 (12/16) 6.3 (1/16)</td>
<td>race5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SDW (control)</td>
<td></td>
<td></td>
<td>0 (0/16) 0 (0/16) 0 (0/16)</td>
<td>SDW</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Ak: Akabana-suzunarisatou, Mi: Misasa, Ha: Hanaka-kinusaya
2. Disease incidence (DI) (%) = No. of diseased seedlings / No. of inoculated seedlings x 100.

Pathogenicity of Japanese isolates

The pathogenicity of Japanese five isolates of FOP from three locations is shown in Table 1. All five isolates were pathogenic to cv. Mi. Both Aichi isolates and Wakayama isolates were pathogenic to cv. Ak also, but not to cv. Ha, while a Hokkaido isolate was pathogenic to cv. Ha, but not to cv. Ak. No difference in pathogenicity was observed within the Aichi and Wakayama isolates.

Pathogenicity of known races

The pathogenicity of known isolates originating from the U.S.A. is also shown in Table 1. Race 2A was pathogenic to two cvs. (Mi, Ak), but race 2B was pathogenic to only cv. Ak. The reason for the demonstrated difference in pathogenicity to cv. Mi between race 2A and race 2B was unclear. These two races were not pathogenic to cv. Ha. Race 5 showed pathogenicity to two cvs. (Mi, Ak), but was determined to be less pathogenic to cv. Ha because its disease incidence (DI=6.3%) on cv. Ha was lower than the 25% defined as the borderline of susceptible or resistant cultivars.

Reaction of pea cultivars to FOP

The reaction of three pea cultivars to inoculation with Japanese and U.S.A. isolates is summarized in Table 2 and Fig. 1. Cultivar Mi was susceptible to all Japanese isolates, while cv. Ak and Ha showed different reactions. Cultivar Ak was susceptible to Aichi and Wakayama isolates but resistant to a Hokkaido isolate, while cv. Ha was resistant to Aichi and Wakayama isolates but susceptible to a Hokkaido isolate. The reactions of three pea cultivars caused by the U.S.A. isolate (race 2A or race 5) were consistent with those by Aichi and Wakayama isolates, but not with those by a Hokkaido isolate.

In conclusion, it was demonstrated that pathogenic variability exists among Japanese isolates of FOP. Especially, a Hokkaido isolate showed a characteristic pathogenicity to cv. Ha. In order to determine the race of the Wakayama and Hokkaido isolates, further investigation using the standard differential lines of pea (e.g. Little Marble, etc.) is needed.

Table 2. Reaction of three pea cultivars after inoculation with each isolate of *Fusarium oxysporum* f. sp. *pisi* by the root-dip method.

<table>
<thead>
<tr>
<th>Isolates location</th>
<th>Inoculated cultivars of Pea 1-2</th>
<th>Mi</th>
<th>Ak</th>
<th>Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1-M, 1-5-2-M Aichi</td>
<td>S 2</td>
<td>S 2</td>
<td>R 2</td>
<td></td>
</tr>
<tr>
<td>215B, 39b Wakayama</td>
<td>S 2</td>
<td>S 2</td>
<td>R 2</td>
<td></td>
</tr>
<tr>
<td>KKB31 Hokkaido</td>
<td>S 2</td>
<td>R 2</td>
<td>S 2</td>
<td></td>
</tr>
<tr>
<td>race2A, race5 U.S.A.</td>
<td>S 2</td>
<td>S 2</td>
<td>R 2</td>
<td></td>
</tr>
<tr>
<td>race2B U.S.A.</td>
<td>S 2</td>
<td>R 2</td>
<td>S 2</td>
<td></td>
</tr>
</tbody>
</table>

1. Ak: Akabana-suzunarisatou, Mi: Misasa, Ha: Hanaka-kinusaya
2. S: susceptible, R: resistant

References


和文摘要

我が国で分離されたエンドウ萎凋病菌の病原性の差異

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我が国におけるエンドウ萎凋病菌（Fusarium oxysporum f. sp. pisi : FOP）の発生は、2002年に愛知県、2003年に静岡県、2009年及び2015年、16年に和歌山県、2015年に北海道の各一部地域で確認されたが、その後の防除により発生は確認されていないか又は封じ込めされている。海外で発生するFOPにはエンドウの品種によって異なる病原性を示すレース（race 1,2,5,6）が存在していることから、本試験では、愛知県産2菌株（分離元品種：赤花鈴成砂糖）、和歌山県産2菌株（同：美鈴）及び北海道産1菌株（同：華夏朝英）を供試し、分離元のエンドウ3品種に対する交互接種を行い、病原性の違いを調査した。接種法には浸根接種法（Sakoda et. al., 2018）を用いた。その結果、美鈴に対しては5菌株とも病原性があり、赤花鈴成砂糖に対しては愛知2菌株、和歌山2菌株が病原性を示したが、北海道1菌株は病原性を示さなかった。また、華夏朝英に対しては北海道1菌株のみが病原性を示した。以上から、我が国のFOP菌株間には、国内で栽培されるエンドウ品種に対する病原性が異なるものが存在することが明らかになった。