Inheritance of Resistance to Zucchini Yellow Fleck Virus in Cucumis sativus L.

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Abstract. Zucchini yellow fleck virus (ZYFV) is a potyvirus that occurs in cucurbits grown in some Mediterranean countries. ‘Market’ cucumber responded to ZYFV infection with a severe mosaic, stunting, and leaf and fruit deformation. A high level of resistance to this virus was found in a single plant selection of ‘Taiichung Mou Gua’ (TMG) cucumber from Taiwan. In F1, and backcross populations involving TMG x ‘Market’, the resistance to ZYFV was determined to be conferred by a single recessive gene, to which the symbol zf was assigned.

Several viruses may cause major losses in cucumber (Cucumis sativus L.), crops, including three potyviruses (zucchini yellow mosaic virus (ZYMV), papaya ringspot virus Type W (PRSV-W), and watermelon mosaic virus type 2 (WMV2)) (Liso and Lecoq, 1984) (Lisa and Lecoq, 1984). Zucchini yellow fleck virus (ZYMV) is considered a distinct member of the potyviruses, different from the other cucurbit potyviruses (ZYMV, PRSV-W, WMV2) regarding serological and host range properties (Vovlas et al., 1981). Nevertheless, a distant relationship exists between ZYMV and PRSV-W (Baker et al., 1987) (Quiot-Douine et al., 1990). ZYMV has been reported in some Mediterranean countries, where it has caused severe epidemics in cucumber and squash (Cucurbita pepo L.) by inducing severe mosaic and vein banding symptoms on leaves and fruit (Avgelis, 1985). Nevertheless, Vovlas et al. (1981, 1983) reported on parents, F1, F2, and the reciprocal backcrosses.

Results and Discussion

Chlorotic lesions generally appeared on ZYMV-inoculated cotyledons or leaves of ‘Market’ and ‘TMG-2’ after inoculation. Severe mosaic symptoms subsequently developed on the ‘Market’ leaves, and fruit produced on these plants were small and mottled. Symptoms were absent on noninoculated ‘TMG-2’ leaves. The virus was detected with high A\text{00} values in greenhouse soil and then transplanted into 500-cm3 square pots filled with the same potting soil. Experiments were conducted in an insect-proof greenhouse maintained at 20 to 25C.

Seeds were sown in flats with potting soil and then transplanted into 500-cm3 square pots filled with the same potting soil. Experiments were conducted in an insect-proof greenhouse maintained at 20 to 25C.

Table 1. Resistance segregation in progenies from crosses between the susceptible ‘Market’ and the resistant inbred line ‘TMG-2’ after inoculation with a French isolate of zucchini yellow fleck virus (ZYMV-Fr).

<table>
<thead>
<tr>
<th>Generation</th>
<th>No. plant</th>
<th>Total</th>
<th>S\textsuperscript{a}</th>
<th>R\textsuperscript{a}</th>
<th>Ratio Value</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>F\textsubscript{1} (P1 × P2)</td>
<td>23</td>
<td>23</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F\textsubscript{1} (P1 × F1)</td>
<td>26</td>
<td>0</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F\textsubscript{1} (P1 × P2)</td>
<td>20</td>
<td>20</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F\textsubscript{1} (P1 × F1)</td>
<td>43</td>
<td>43</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BCr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC\textsubscript{1}</td>
<td>232</td>
<td>168</td>
<td>64</td>
<td>3.1</td>
<td>0.83</td>
<td>0.36</td>
</tr>
<tr>
<td>BC\textsubscript{2}</td>
<td>65</td>
<td>65</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BCr</td>
<td>105</td>
<td>54</td>
<td>51</td>
<td>1.1</td>
<td>0.09</td>
<td>0.77</td>
</tr>
</tbody>
</table>

\textsuperscript{a}S = susceptible plants with mosaic symptoms and high absorbance values at 405 nm in DAS-ELISA.
\textsuperscript{b}R = resistant plants without symptoms and without virus detected in the upper leaves in DAS-ELISA.

Materials and Methods

Seed samples of the Taiwanese cucumber ‘TMG-2’ were provided by R. Provvidenti (Cornell Univ., Geneva, N.Y.). This line was crossed with the susceptible cultivar Market, and the F\textsubscript{1}, BC\textsubscript{1} (‘Market’ × F\textsubscript{1}), and BC\textsubscript{2} (‘TMG-2’ × F\textsubscript{1}) generations were produced. Seeds were sown in flats with potting soil and then transplanted into 500-cm3 square pots filled with the same potting soil. Experiments were conducted in an insect-proof greenhouse maintained at 20 to 25C.

A ZYMV (ZYMV-French isolate (ZYMV-Fr)) isolate was obtained from squirming cucumber collected in south-eastern France (Gilbert-Albertini and Lecoq, 1994) and maintained in Cucurbita pepo L. ('Diamant'). At the cotyledon stage, seedlings were mechanically inoculated by the Lecoq et al. (1979) method commonly used in our laboratory.

Serological tests were conducted in double antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) (Clark and Adams, 1977), using a polyclonal antisera against ZYMV-Fr, IgGs, and alkaline phosphatase-conjugated IgGs obtained in our laboratory (Gilbert-Albertini and Lecoq, 1994).

All absorbance values at 405 nm (A\text{00} values) were measured with a spectrophotometer (Multiscan plus, Labsystems, Helsinki, Finland) after 1.5 to 2 h substrate incubation.

The inheritance of ZYMV resistance was analyzed on the basis of leaf symptoms and DAS-ELISA readings on young leaves 3 and 4 weeks after inoculation. For the genetic analysis, two independent tests were performed on parents, F\textsubscript{1}, F\textsubscript{2}, and the reciprocal backcrosses.

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the inoculated cotyledons, with a mean absorbance value <0.6. In the upper leaves, the virus was neither detected by DAS-ELISA nor was it recovered by back-inoculation to susceptible cucumbers.

Like plants of the susceptible parent, the F1 plants reacted to inoculation with ZYFV with severe mosaic and high A405 values (Table 1). Mosaic symptoms similar to those in the susceptible parent developed on some F2, BCr, and BC plants. No plants showed milder mosaic symptoms than those observed on the susceptible parent. The presence of symptoms was correlated with high A405 values (>1.5), and the virus was either not detected or detected only at low concentrations (A405 < 0.1) in leaves without symptoms. Results of the two tests were homogeneous; F2 and BCr generation segregation was similar in the two tests according to a heterogeneity \( \chi^2 \) test (F2, \( \chi^2 = 0.0004 \) with \( P > 0.9 \); BCr, \( \chi^2 = 0.13 \) with \( P > 0.7 \)). The F2 progeny segregated for susceptibility and resistance in a 3:1 ratio. The BCr progeny segregated in a 1:1 ratio. All plants resulting from BCs were susceptible.

The frequency of ZYFV-Fr-resistant plants in progenies of a 'TMG-2' x 'Marketer' cross may be explained by the action of one recessive gene (symbolized \( zyf \)). To our knowledge, this is the first report of ZYFV resistance in cucumber (Provvidenti and Hampton, 1992).

TMG previously has been resistant against several viruses (ZYMV, PRSV, WMV2, and CMV), and it has excellent horticultural characteristics (Provvidenti, 1985). Studies of genetic relationships between these different resistances will make the selection of a multi-resistant commercial cultivar easier.

**Literature Cited**


