Use of Reaction Types to Identify Downy Mildew Resistance in Muskmelons

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Additional index words. Plant breeding, disease resistance, foliar disease, Cucumis melo, Pseudoperonospora cubensis

Abstract. Resistant reaction types (RT) can be used to evaluate objectively downy mildew resistance on muskmelon foliage. Reaction types 2, 3, and 4 represent increasing levels of resistance compared to the susceptible reaction typified by RT 1. A double-digit classification system for the RT of leaves 1 and 2, respectively, in greenhouse-growth chamber inoculations of two-leaf stage plants is an excellent predictor of the disease reaction of older plants under field conditions. Spore production decreases progressively as the levels of resistance represented by RT 2, 3, and 4 increase.

Muskmelon (Cucumis melo L.) can be tested for resistance to downy mildew incited by Pseudoperonospora cubensis (Berk. & Curt.) Rostow, through artificial inoculations of leaves with sporangial suspensions. Such inoculations can be conducted either under controlled environmental conditions or in the field when leaf wetness periods are of sufficient duration. Depending on environmental conditions, lesions are apparent within 4 to 8 days following inoculation. In the past, lesion development in small plants inoculated under controlled conditions has been evaluated based largely on the yellow vs. brown lesion reaction described by Barnes and Epps (1) in cucumber. A 1 to 9 scale was used to classify the gradations between a highly susceptible yellow lesion reaction and the more resistant types of brown lesion reactions (2). In evaluations under field conditions, a 1 to 5 or 1 to 9 scale usually was used to classify the degree of foliage loss in an effort to identify the more resistant genotypes. Although classes of the yellow vs. brown lesion reaction could be correlated with levels of sporulation under field conditions in susceptible vs. resistant genotypes, respectively, they did not always correlate with the resultant foliage loss (2, 6). For this reason, when Thomas (7) evaluated C. melo genotypes that included some highly resistant PI materials that had not been included in previous tests, he adopted the use of percent leaf loss determined from actual counts to evaluate more accurately resistance under field conditions. In subsequent work related to the study and use of some of these highly resistant PIs as sources of resistance to downy mildew, problems with previous classification systems were magnified. In particular, the differential response of leaf 1 and leaf 2 to infection in young plants (2) and the production of small, chlorotic yellow lesions in some highly resistant genotypes had to be considered. The evaluation protocols and accompanying classification system explained in this paper were developed to solve these problems. As demonstrated by examples from some of our tests, they assess accurately the reaction of muskmelon foliage against downy mildew for the identification of resistance both in young plants under greenhouse-growth chamber conditions and in older plants in the field.

In 1984 and 1985, artificial inoculations under controlled conditions were made to plants of selected inbred breeding lines and cultivars at the two-expanded leaf stage. Plants were grown to this stage in the greenhouse in Jiffy-7 peat pellets at day/night temperatures of 27° ± 3°/20° ± 2° C. Sporangia for inoculum were produced on cotyledons of the susceptible cultivar ‘Perlitu’ using the procedure described below for leaves to be evaluated. The adaxial leaf surfaces of leaves 1 and 2 were sprayed to incipient run-off with a sporangial suspension of P. cubensis. An inoculum concentration of 5.0 × 10^4 sporangia/ml was applied with a Paasche Airbrush at 275 KPA. Following inoculation, plants were placed at 100% RH for 20 hr in the dark. When night temperatures in the greenhouse were not in the range of 18° to 21°, this postinoculation, high-humidity treatment was conducted in a growth chamber at 20° ± 1°. Upon removal from the high-humidity conditions, plants were placed on the greenhouse bench for 6 days. On the seventh night after inoculation, plants were returned to 100% RH for 16 hr to induce sporulation, and evaluations were made on the eighth day.

Leaf 1 and leaf 2 were evaluated separately using the index of reaction types (RT) given in Table 1. Assignment of a separate RT to each leaf resulted in a two-digit numerical classification in which the first digit (tens column) represented the RT for leaf 1 and the second digit represented the RT for leaf 2.

In both 1984 and 1985, after lines had been evaluated, they were transplanted to field

Received for publication 19 Nov. 1986. This research was supported by Grant US-287-81 from BARD—The United States–Israel Binational Agricultural Research & Development Fund. Mention of a trade name or proprietary product does not constitute a guarantee or warranty of the product by the USDA and does not imply approval of it to the exclusion of other products that also may be suitable. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

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4Technician.

Table 1. Reaction types against downy mildew incited by Pseudoperonospora cubensis on muskmelon leaves.

<table>
<thead>
<tr>
<th>Reaction type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10-15 mm, irregular, chlorotic lesions with abundant sporulation that may extend beyond the apparent margins of the lesions.</td>
</tr>
<tr>
<td>2</td>
<td>Type &quot;1&quot; lesions, above, mixed with type &quot;3&quot; lesions, below.</td>
</tr>
<tr>
<td>3</td>
<td>3-4 mm, irregular to circular, chlorotic lesions with water-soaked margins beneath and sparse sporulation.</td>
</tr>
<tr>
<td>4</td>
<td>1 mm, circular, chlorotic lesions with necrotic centers and water-soaked margins beneath and extremely limited or no readily apparent sporulation.</td>
</tr>
</tbody>
</table>
The plants were sprinkled with water for 15 to 30 min prior to inoculation. Ten-leaf stage plants in the field were inoculated with *P. cubensis* and classified 8–10 days after inoculation.

Two-digit classification based on reaction types (RT) 1, 2, 3, and 4. First digit (tens column) represents RT for leaf 1 in two-leaf stage plants or leaves 3–6 in 10-leaf stage plants. Second digit represents RT for leaf 2 in two-leaf stage or leaves 7–10 in 10-leaf stage. Individual plants within genotypes were uniform for RT.

### Table 2. Downy mildew reaction types on inbred lines and commercial cultivars resulting from artificial inoculations of two-expanded leaf stage plants in the greenhouse and 10-leaf stage plants in the field at Charleston, S.C. in 1984 and 1985.

<table>
<thead>
<tr>
<th>Muskamelon genotype</th>
<th>Reaction type(^a)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1984</td>
</tr>
<tr>
<td></td>
<td>Greenhouse</td>
</tr>
<tr>
<td>B16-3</td>
<td>S</td>
</tr>
<tr>
<td>B17-2</td>
<td>S</td>
</tr>
<tr>
<td>B18-3</td>
<td>S</td>
</tr>
<tr>
<td>B19-3</td>
<td>I</td>
</tr>
<tr>
<td>B23-2 (–1)</td>
<td>R</td>
</tr>
<tr>
<td>B25-1 (–2)</td>
<td>R</td>
</tr>
<tr>
<td>B26-3 (–1)</td>
<td>R</td>
</tr>
<tr>
<td>B27-3 (–4)</td>
<td>R</td>
</tr>
<tr>
<td>B28-2</td>
<td>R</td>
</tr>
<tr>
<td>B30-2</td>
<td>R</td>
</tr>
<tr>
<td>B31-1</td>
<td>I</td>
</tr>
<tr>
<td>Cinco</td>
<td>I</td>
</tr>
<tr>
<td>Mainstream</td>
<td>I</td>
</tr>
<tr>
<td>Perlita</td>
<td>S</td>
</tr>
<tr>
<td>Hales Best Jumbo</td>
<td>S</td>
</tr>
<tr>
<td>PMR 45</td>
<td>S</td>
</tr>
<tr>
<td>PMR 6</td>
<td>S</td>
</tr>
<tr>
<td>Edisto 47</td>
<td>S</td>
</tr>
</tbody>
</table>

Percent agreement of greenhouse and field evaluations

1984 = 76
1985 = 89
leaf 1 (greenhouse) with leaves 3–6 (field) = 100
leaf 2 (greenhouse) with leaves 7–10 (field) = 81

\(^a\)S = susceptible, I = intermediate, R = resistant.

\(^b\)Two-expanded leaf stage plants were inoculated with *Pseudoperonospora cubensis* in the greenhouse and leaves 1 and 2 were classified by reaction type 8 days after inoculation. Ten-leaf stage plants in the field were inoculated with *P. cubensis* and classified 8–10 days after inoculation.

\(^c\)Two-digit classification based on reaction types (RT) 1, 2, 3, and 4. First digit (tens column) represents RT for leaf 1 in two-leaf stage plants or leaves 3–6 in 10-leaf stage plants. Second digit represents RT for leaf 2 in two-leaf stage or leaves 7–10 in 10-leaf stage. Individual plants within genotypes were uniform for RT.

### Table 3. Sporulation of *Pseudoperonospora cubensis* on leaves of selected muskmelon genotypes exhibiting reaction types 1, 2, 3, and 4 against downy mildew.

<table>
<thead>
<tr>
<th>Reaction type(^c)</th>
<th>Sporulation/cm² of leaf area × 10³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry</td>
<td>Growth chamber–greenhouse(^d)</td>
</tr>
<tr>
<td>Perlita</td>
<td>52.4</td>
</tr>
<tr>
<td>Cinco</td>
<td>18.3</td>
</tr>
<tr>
<td>B8-1</td>
<td>6.0</td>
</tr>
<tr>
<td>B4-1</td>
<td>0.3</td>
</tr>
</tbody>
</table>

\(^c\)Reaction type is for leaf 1 on two-leaf stage plants in the greenhouse–growth chamber and for leaves 3–6 on 10-leaf stage plants in the field.

\(^d\)20°C, 16 hr leaf wetness.

\(^e\)22°C to 25°C, 10 hr leaf wetness.

\(t\) = trace, a few sporangia produced, but none in samples.

### Results of the greenhouse–growth chamber and field inoculations in 1984 and 1985 (Table 2) show that the predictive value of the double-digit classification technique is high. Since individual plants within genotypes were uniform for RT, the double-digit classifications for leaves of two-leaf stage plants in greenhouse–growth chamber inoculations had high overall frequencies of agreement (76% and 89%) with those for 10-leaf stage plants in the field in each year (1984 and 1985). The RT for leaf 1 under greenhouse–growth chamber conditions always agreed with the RT for leaves 3–6 under field conditions. The RT for leaf 2 in the greenhouse–growth chamber and leaves 7–10 in the field agreed for 81% of the genotypes over both years.

Continued observation of these muskmelon genotypes in the field revealed that the younger leaves near the tips of the stems initially exhibited the RT found on leaf 2 in greenhouse inoculations. As these leaves subsequently matured, the RT exhibited was that of leaf 1 in greenhouse inoculations.
It provides a valid selection
L.) were tested for resistance to lettuce
H on muskmelon leaves exhib­
and seven accessions of
P. cubensis
was planted
V, and
8 (Genn.)
constitute a guarantee or warranty of the product
the exclusion of other products or vendors that
mark, proprietary product, or vendor does not
by the USDA and does not imply its approval to
Thomas. 1984. Evaluating downy mildew re­
Cucumis melo L. Curcubit Genet.
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1979. Components of resistance that reduce the rate of epidemic develop­
other leaf age on the expression of RT to downy mildew. Reduced with different leaf maturation rates among genotypes, probably accounted for those disagreements that were encountered between the double-digit RTs in the greenhouse and in the field. Such disagreements were always due to dif­ferences in the expression of RT on the younger, not the older, leaves.
The high reliability of the double-digit classification for RT on two-leaf stage plants in greenhouse-growth chamber inoculations as a predictor of the performance of older plants under field conditions provides plant breeders with a technique that will expedite selection for downy mildew resistance in muskmelon. Plants can be tested before transplanting to the field to eliminate lines with undesirable levels of resistance, thus reducing the size and number of field plots to be maintained. Progeny from test crosses and recombination can be evaluated reliably in the greenhouse-growth chamber for downy mildew resistance as soon as seed is avail­able, thus providing a substantial time saving.
Other advantages of this classification technique are based on its objectivity. It evaluates the specific type of lesions produced rather than estimating foliage damage as percent chlorotic or necrotic tissue, percent lesion area, percent foliage loss, etc. Since RT is a specific response to infection by P. cubensis, it provides a valid selection criterion when downy mildew disease pressure is light or when other foliar diseases are also present and causing damage.
The results of the studies on sporulation by P. cubensis on muskmelon leaves exhib­iting RT 1, 2, 3, and 4 (Table 3) give an additional measure of the relative resistance level indicated by each RT. Measurements of pathogen sporulation on infected host plants are considered accurate assessments of the resistance of that host (3). Sporulation/cm² of leaf area under greenhouse-growth chamber conditions was profuse. 52.4 × 10³ sporangia/cm² for RT 1. The sporulation rates for RT 2, 3, and 4 were 35%, 11%, and 0.6%, respectively, of the rate for RT 1. Reductions in sporulation on RT 2, 3, and 4 compared to RT 1 under field conditions were even greater. In the field, the sporulation rate for RT 1 was 41.6 × 10³ sporangia/cm². For RT 2 and 3, sporulation was 30% and 5%, respectively, of the RT 1 rate, whereas only a trace of sporulation was detected on RT 4. Since spore production tends to be correlated with lesion size (4), then the re­ductions in sporulation on RT 2, 3, and 4 are indicative of the relative sizes of lesions characteristic of each RT. Small lesions are due to reduced rates of lesion expansion, which result in corresponding reductions in chlorosis and necrosis of leaf tissue, coa­

**Literature Cited**


**Resistance in Wild Lettuce to Lettuce Infectious Yellows Virus**

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Additional index words. Lactuca sativa, Lactuca saligna, Lactuca serriola, Lactuca virosa, whitefly, Bemisia tabaci, genetics, breeding, germplasm

**Abstract.** Lactuca saligna, L. serriola, Lactuca virosa, whitefly, Bemisia tabaci, genetics, breeding, germplasm

**Received for publication 15 May 1986. I thank Antonio V. Duran and Joseph A. Principle for assistance in the field tests; Janet A. Foreman and Jay R.S. Schwed for assistance in greenhouse tests and laboratory assays; and J.E. Duffus and H.Y. Liu for virus isolates and whiteflies. This research was supported in part by the California Iceberg Lettuce Research Program. Mention of a trade­mark, proprietary product, or vendor does not constitute a guarantee or warranty of the product by the USDA and does not imply its approval to the exclusion of other products or vendors that may also be suitable. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.**

Lettuce infectious yellows virus (LIYV) causes a yellowing disease of lettuce in southern California (Coachella Valley, Imperial Valley, and Palo Verde Valley) and Arizona. The disease is transmitted by the sweet potato whitefly [Bemisia tabaci (Genn.)] and causes economic losses in lettuce, sugarbeet, and cucurbits (2). There are differences in tolerance to LIYV among lettuce cultivars and breeding lines (3). The three wild, cross-fertile lettuce species L. saligna, L. serriola, and L. virosa have been used successfully in lettuce breeding as a source of horticultural characters (8) and as sources of genes for insect and disease resis­tance (1, 4–7, 10, 11). My objective was to determine if they were sources of resis­tance to LIYV.

Eighty-two accessions of L. saligna, L. serriola, and L. virosa were tested for LIYV resistance in a greenhouse (Table 1). Because only a few (2 to 5) accessions were tested at a time, the tests were done over an 18-month period beginning in May 1984. Each entry included 10 inoculated and five control plants. Due to poor germination or loss after transplanting, 10 entries had <10 inoculated plants. The susceptible lettuce cultivar El Toro was included in each test for comparison. Greenhouse conditions and inoculation procedures were the same as previously described (3). Symptoms incited by LIYV usually appeared 17 to 21 days after inoculation.

In 1984, L. saligna PI 261653 was planted in the borders of a naturally LIYV-infected lettuce field test previously described (3). In 1985, all of the L. saligna and L. virosa accessions, and 21 of the L. serriola acces­sions (PI 202349 through PI 289065, Table 1) were tested in a replicated field test sub­jected to natural infection. The test was sim­i­lar to previously reported tests of lettuce