Ecology and Epidemiology

Comparison of Host Ranges of Peronosclerospora philippinensis and P. sacchari

M. R. Bonde and G. L. Peterson

Research plant pathologist and biological laboratory technician, respectively, U.S. Department of Agriculture, Agricultural Research Service, Plant Disease Research Laboratory, P.O. Box 1209, Frederick, MD 21701.

Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture and does not imply approval to the exclusion of other products that also may be suitable.

The authors thank O. R. Exconde and S. C. Chang for the isolates of Peronosclerospora philippinensis and P. sacchari, respectively. Accepted for publication 8 January 1983.

ABSTRACT


Seventy-two plant species representing 22 genera within eight tribes of the Gramineae were tested for susceptibility to systemic colonization after conidial inoculation with two isolates of Peronosclerospora philippinensis from the Philippines. All susceptible species were members of the tribe Andropogoneae (genera—Andropogon [one species], Bothriochloa [10 species], Eulalia [one species], Saccharum [one species], Schizachyrium [three species], and Sorghum [three species]) or the tribe Maydeae (genera—Tripsacum [one species] and Zea [three species]). Not all accessions susceptible to one isolate of the pathogen showed systemic symptoms when inoculated with the second isolate; in some instances, only a few plants of an accession developed systemic symptoms. The results were remarkably similar to our previous host range study with P. sacchari from Taiwan, and the information presented here indicates a very close phylogenetic relationship between P. philippinensis and P. sacchari.

Philippine downy mildew of maize, caused by Peronosclerospora philippinensis (Weston) C. G. Shaw, has not been reported in the western hemisphere, but it is a serious problem in the Philippines where disease losses in some fields have been 40-60% (7). Although maize varieties resistant to P. philippinensis have been developed in Asia, maize hybrids currently grown in the United States are highly susceptible to P. philippinensis, and American breeding lines that are highly susceptible to P. sorghi (cause of sorghum downy mildew of maize) in the United States are highly susceptible to P. philippinensis (M. R. Bonde, unpublished).

Weeds and cultivated crops play a major role in the perpetuation of the pathogen in the absence of maize (6). Besides maize (13), P. philippinensis has been reported to infect Avena sativa L. (6), Euchlaena mexicana Schrad. (= Zea mays L. mexicana) (6), E. mexicana × Zea mays hybrids (6), Miscanthus japonicus Andress (14), Saccharum officinarum L. (6), S. spontaneum L. (14), Sorghum arundinaceum (Willd.) Stapf (11), S. bicolor Moench (13), S. halepense (L.) Pers. (6), and S. propinquum (Kunth) Hitchc. (6).

As part of a program to determine the threat of specific foreign downy mildew pathogens to American agriculture should they spread to the United States, we conducted a study to determine whether P. philippinensis could infect additional alternative hosts that might allow the pathogen to overwinter and act as reservoirs of inoculum to infect maize. The information, besides having epidemiologic significance for maize production, also could help resolve the confusion over the taxonomy of Peronosclerospora spp. (2). For this latter purpose, we included plant species that, although not present in the United States, might be useful in differentiating species within the genus Peronosclerospora. The results obtained with P. philippinensis were remarkably similar to those we recently reported for an isolate of P. sacchari from Taiwan (4).

The purpose of this research was to compare the host ranges of the two pathogens by including recent data and data from the previous study of the susceptibility of various plant species to P. sacchari. As far as we are aware, this is the first report of host ranges

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be hereby marked "advertisement" in accordance with 18 U.S.C. § 1734 solely to indicate this fact.

©1983 The American Phytopathological Society
of *P. philippinensis* and *P. sacchari* isolates from different countries being compared using the same techniques on the same plant accessions.

**MATERIALS AND METHODS**

Two cultures of *P. philippinensis* were obtained from the Philippines—one in 1975 and the other in 1979—and two cultures of *P. sacchari* were isolated in our laboratory in 1975 and 1977, respectively, from infected sugarcane sets sent from Taiwan. Seeds of test species were planted in pasteurized soil in 10-cm-diameter clay pots. Seedlings at the two- to three-leaf stage were sprayed with a suspension of conidia collected by the technique of Schmitt and Fryer (9) from infected *Zea mays* 'Pioneer 3369A' or 'DeKalb XL43'. The inoculum dosage used was $5.0 \times 10^{4}$ conidia per milliliter of suspension, 1 ml per pot of seedlings. The number of plants per pot depended on plant species. In a few instances, 20–40 plants were present in a pot; however, usually there were less than 10 per pot. A highly susceptible maize hybrid, either Pioneer 3369A or DeKalb XL43, was included as a control in each experiment.

Recently planted sugarcane sets (with buds about to break) in 15-cm-diameter clay pots were sprayed with a suspension of conidia at $5.0 \times 10^{3}$ conidia per milliliter, 1 ml per set. All inoculated plants were incubated overnight in a dew chamber at 21–22°C and then placed in a greenhouse for disease development. The normal temperature fluctuation in the greenhouse was 21–28°C; however, on a few occasions during the summer months, it peaked as high as 34°C shortly after noon and returned to the normal temperature range within 3 hr. Plants were examined for at least 30 days, and usually for 6 wk, after inoculation and were compared with unoinoculated controls.

To verify infection within a plant accession, a few plants displaying systemic symptoms were placed overnight in dew chambers, and their leaf surfaces were examined for development of conidia and conidiophores typical of *P. philippinensis* or *P. sacchari*. (In instances in which only one or a few plants had systemic symptoms, all were placed in the dew chambers). In addition, leaf pieces displaying systemic symptoms were placed in the whorls of highly susceptible maize seedlings in dew chambers and incubated overnight at an optimum temperature to induce sporulation and subsequent infection of maize. Susceptibility of a plant accession was based on the presence of sporulation and/or reinfection of maize, in addition to symptoms indicating systemic infection.

All plants lacking systemic symptoms also were placed overnight in dew chambers and examined for the absence of conidia formation to substantiate that they were not infected.

A few infected plants of each susceptible plant accession were

---

**TABLE 1. Level of susceptibility of grass accessions susceptible to at least one isolate of *Peronosclerospora philippinensis*, and their susceptibility to *Peronosclerospora sacchari***

<table>
<thead>
<tr>
<th>Plant species</th>
<th>P.I. number</th>
<th>Origin</th>
<th>Proportion of inoculated plants showing systemic symptoms*</th>
</tr>
</thead>
</table>
| **Tribe: Andropogoneae** | | | *P. philippinensis* | *P. sacchari*
| Andropogon gerardii Vitm. | 315656 USA | | 3/10 | 2/20 |
| *B. barbinonis* (Lag.) Herter | 216054 USA | | 7/11 | 3/11 |
| *B. decipiens* (Hack.) C. E. Hubb. | 301290 Australia | | 1/7 | 1/7 |
| *B. edwardsiana* (Gould) Parodi | 337509 Argentina | | 10/54 | 10/54 |
| *B. ischaemum* (L.) Keng var. *ischaemum* | 302508 Hungary | | 48/59 | 48/59 |
| *B. laguroides* (DC.) Pilger | 404289 Brazil | | 33/89 | 33/89 |
| *B. perrotii* (Trin. ex Fourn.) Herter | 228517 USA | | 14/205 | 14/205 |
| *B. springfieldii* (Gould) Parodi | 301727 USA | | 36/79 | 36/79 |
| *B. woodrowii* (Hook f.) A. Camus | 301732 India | | 16/25 | 16/25 |
| *Eulalia falva* (R. Br.) Kze. | 302078 Australia | | 1/67 | 1/67 |
| *Saccharum officinarum* L. "CP-44-101" | 228507 USA | | 4/173 | 4/173 |
| *Schizachyrium hiri* (florum) Nees | 302173 USA | | 3/12 | 3/12 |
| *S. microstachyum* (Desv. ex Hamilt.) Roseng., Arr. & Irr. | 302173 Argentina | | 1/92 | 1/92 |
| *S. scoparium* (Michx.) Nash | 213875 USA | | 1/9 | 1/9 |
| *Sorghum bicolor* (L.) Moench ("drammondi") | 302141 USA | | 1/32 | 1/32 |
| *S. bicolor* ("gambica") | 302150 USA | | 2/102 | 2/102 |
| *S. bicolor* ("hewisonii") | 302173 Sudan | | 8/113 | 8/113 |
| *S. bicolor* ("japonicum") | 228507 Portugal | | 24/84 | 24/84 |
| *S. bicolor* ("melalearicum") | 228507 Algeria | | 2/5 | 2/5 |
| *S. bicolor* ("milliforme") | 257293 Argentina | | 2/49 | 2/49 |
| *S. bicolor* ("migrans") | 302177 Portugal | | 1/39 | 1/39 |
| *S. bicolor* ("miloticum") | 196980 Ethiopia | | 1/5 | 1/5 |
| *S. bicolor* ("saccharatum") | 302198 Argentina | | 1/98 | 1/98 |
| *S. bicolor* ("sudanense") | 302198 USA | | 1/162 | 1/162 |
| *S. bicolor* ("technicum") | 302198 USA | | 1/16 | 1/16 |
| *S. halpeense* (L.) Pers. | 302198 USA | | 2/26 | 2/26 |
| *S. plumosum* (R. Br.) Beauv. | 198999 Australia | | 4/26 | 4/26 |

**Tribe: Maydace**

<table>
<thead>
<tr>
<th>Plant species</th>
<th>P.I. number</th>
<th>Origin</th>
<th>Proportion of inoculated plants showing systemic symptoms*</th>
</tr>
</thead>
</table>
| *Triticeae* dactyloides (L.) L. | | | *P. philippinensis* | *P. sacchari*
| *Zea diploperennis* Illis, Doehley & Guzman | | | 16/34 | 20/34 |
| *Zea mays* L. subsp. *mays* '3369A' and 'XL43' | | | 9/11 | 2/14 |
| *Zea mays* subspp. *mexicana* (Schrad.) Illis | | | 147/149 | 147/149 |
| *Zea mays* subspp. *mexicana* (Schrad.) Illis | | | 72/79 | 72/79 |
| *Zea perennis* (Hitch.) Reeves & Mangelsd. | | | 1/13 | 1/13 |

---

*At the two- to three-leaf stage seedlings of all accessions, except those of *Saccharum officinarum*, were sprayed with a conidial suspension of *P. philippinensis* or *P. sacchari* at $5.0 \times 10^{3}$ conidia per milliliter, 1 ml per pot of seedlings.

*Data were not obtained.

*Sugar cane sets (with buds about to break) were sprayed with a suspension of conidia at $5.0 \times 10^{3}$ conidia per milliliter, 1 ml per set.

*The taxonomic system described by J. M. J. DeWet (5) was used for *Sorghum bicolor*. This system combined 48 previously separate species with *S. bicolor*. The previous specific epithet is given in brackets.

*Another accession of *Sorghum plumosum* not tested against *P. philippinensis* was shown to be susceptible (5/85) to *P. sacchari*.
RESULTS AND DISCUSSION

Results of tests for susceptibility of 72 plant species representing 22 genera within eight grass tribes to *P. philippinensis*, in addition to the susceptibility of many of the same plant accessions to *P. sacchari*, are summarized in Tables 1 and 2 and the text below. The data for each isolate per pathogen were bulked. In several instances, several accessions of the same plant species were tested (Tables 1 and 2). Besides *Sorghum bicolor* 'Tx412' and *S. bicolor* accession 431392, 18 accessions of *S. bicolor* previously considered to belong to separate *Sorghum* species, and one sorghum-Sudan grass hybrid were tested. A major problem with several grass accessions was the poor germinability of the seed, which resulted in only limited numbers of plants.

The following plant species were not susceptible to *P. philippinensis*: *Agrostis stolonifera* and *Alopecurus aequalis* of the tribe Agrostideae; *Avena abyssinica*, *A. barbata*, *A. brevis*, *A. byzantina*, *A. fatua*, *A. longiglumis*, *A. nuda*, *A. eriantha*, *A. sativa*, *A. sterilis*, and *A. striosa* of the tribe Aveneae; *Elymus indica* of the tribe Chlorideae; *Bromus inermis*, *Festuca rubra* subsp. *rubra*, *Poa compressa*, and *P. nemoralis* of the tribe Festucaeae; *Agropyron cristatum*, *A. repens*, and *Lolium multiflorum* of the tribe Hordeae; and *Panicum miliaceum*, *P. virgatum*, *Pennisetum americanum*, and *P. macrourum* of the tribe

<table>
<thead>
<tr>
<th>Plant species</th>
<th>P.I. number</th>
<th>Origin</th>
<th>Proportion of inoculated plants showing systemic symptoms*</th>
<th>Tribe: Andropogoneae</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Andropogon distortius</em> L.</td>
<td>300696</td>
<td>Hungary</td>
<td>0/19</td>
<td>0/24</td>
</tr>
<tr>
<td><em>A. vernarius</em> Michx.</td>
<td>301216</td>
<td>USA</td>
<td>0/41</td>
<td>0/14</td>
</tr>
<tr>
<td><em>Arrhenatherum elatius</em> (Thunb.) Mak.</td>
<td>225866</td>
<td>Japan</td>
<td>0/213</td>
<td>0/62</td>
</tr>
<tr>
<td><em>Bothriochloa inornata</em> (Hitchc.) Henr.</td>
<td>337510</td>
<td>Argentina</td>
<td>0/26</td>
<td>0/13</td>
</tr>
<tr>
<td><em>B. caucasia</em> (Trin.) C.E. Hubb.</td>
<td>300712</td>
<td>USA</td>
<td>0/38</td>
<td>2/16</td>
</tr>
<tr>
<td><em>B. caucasica</em></td>
<td>301737</td>
<td>Pakistan</td>
<td>0/81</td>
<td>0/20</td>
</tr>
</tbody>
</table>
| *B. eurystaenia* (Dumic) C.E. Hubb. | 301308 | Australia | 0/18 | ...*
| *B. glabra* (Roxb.) A. Camus | 300726 | India | 0/40 | 0/4 |
| *B. grahami* (Haines) Bor. | 241498 | New Guinea | 0/15 | 0/15 |
| *B. hybridra* (Gould) Gould | 321437 | USA | 0/26 | 0/12 |
| *B. insculpta* (Hochst.) A. Camus | 300730 | USA | 0/91 | 0/13 |
| *B. insculpta* | 301436 | S. Africa | 0/41 | 0/26 |
| *B. intermediar* (R. Br.) A. Camus | 300806 | USA | 0/138 | 0/40 |
| *B. intermediar* | 300857 | USA | 0/58 | 0/28 |
| *B. italica* (L.) Keng var. *ischaemum* | 301507 | India | 0/15 | 0/13 |
| *B. odosata* (L.) A. Camus | 301632 | India | 0/68 | 0/9 |
| *B. pertusa* (L.) A. Camus | 301638 | India | 0/41 | 0/8 |
| *B. pertusa* | 301641 | India | 0/11 | ...*
| *B. pertusa* | 301645 | ... | 0/12 | ...*
| *B. radicans* (Lerm.) A. Camus | 364533 | Mozambique | 0/145 | 0/13 |
| *Capparidium venustum* (Thw.) Bor. | 301731 | British Guiana | 0/44 | 0/26 |
| *Heteropogon contortus* (L.) Beauv. ex Roem. & Schult. | 216249 | USA | 0/101 | 0/28 |
| *H. contortus* | 271174 | India | 0/172 | 0/26 |
| *Schizachyrium cirtatum* (Hack.) Woot & Standl. | 216107 | Mexico | 0/8 | ...*
| *S. condentum* (H.B.K.) Nees | 203835 | Brazil | 0/76 | 0/14 |
| *Sorghum* X *Alophum* Parodi | 207640 | ... | 0/64 | 0/26 |
| *S. bicolor* (L.) Moench* 'TX412' | 431392 | USA | 0/216 | 0/64 |
| *S. bicolor* | 302135 | India | 0/46 | ...*
| *S. bicolor* [cafforum] | 282834 | Chad | 0/51 | 1/45 |
| *S. bicolor* [caudatum] | 267126 | USSR | 0/58 | 0/12 |
| *S. bicolor* [cerina] | 267105 | USSR | 0/45 | 5/44 |
| *S. bicolor* [dura] | 282857 | Chad | 0/61 | 2/6 |
| *S. bicolor* [melilolus] | 267324 | India | 0/74 | 0/21 |
| *S. bicolor* [nervosum] | 208710 | Algeria | 0/19 | 0/17 |
| *S. halpeiens* [controversum] | 302268 | Africa | 0/29 | 0/63 |
| *S. halpeiens* [milaceum] | 271615 | India | 0/24 | ...*
| *S. plumosum* (R. Br.) Beauv. | 230931 | Australia | 0/14 | ...*
| *S. propinquum* (Kuntl. Hitch.) H. E. | 302191 | Philippines | 0/32 | 1/46 |
| *S. pugionfolium* Snowden | 271240 | India | 0/55 | 2/12 |
| *S. versicolor* Anderss. | 260273 | Ethiopia | 0/44 | 6/29 |
| *S. verticilliflorum* (Steud.) Stapf | 213901 | Rhodesia | 0/25 | 0/36 |

*Seedlings of all accessions at the two- to three-leaf stage were sprayed with a conidial suspension of *P. philippinensis* or *P. sacchari* at 5.0 × 10^6 conidia per milliliter, 1 ml per pot of seedlings.

*Data were not obtained.

*The taxonomic system described by J. M. J. DeWet (5) was used for *Sorghum bicolor*. This system combined 48 previously recognized species with *S. bicolor*. The previous specific epithet is given in brackets.

---

Vol. 73, No. 6, 1983 877
Paniceae. No species of these tribes were susceptible to an isolate of
P. sacchari (4).

The grass accessions that were susceptible to P. philippinensis
(Table 1) represented 19 species in six genera in the tribe
Andropogoneae (Andropogon [one species], Bothriochloa [10
species], Eulalia [one species], Saccharum [one species],
Schizachyrium [three species], and Sorghum [three species]) or
four species in two genera in the tribe Maydeae (Tripsacum [one
species] and Zea [three species]). Not all accessions that developed
symptoms of systemic infection in response to one isolate of P.
philippinensis did so with the other.

Some grass accessions were very susceptible to P. philippinensis
(Table 1). These include Bothriochloa ambigua, B. edwardsiana,
one accession of B. ischaemum var. ischaemum, and Saccharum
officinarum (sugarcane), all with 78% or higher rates of systemic
infection at the inoculum dosage used.

Bothriochloa ischaemum var. ischaemum was represented by
one accession that was not susceptible to P. philippinensis and P.
sacchari (one pathogen isolate of each tested), and one accession
that was susceptible to both isolates of each pathogen.

Eleven accessions of S. bicolor were susceptible to at least one
isolate of P. philippinensis, and nine were not susceptible. This
difference in susceptibility within S. bicolor probably is partly due
to the hetrogeneity in the plant species. However, the incidence,
when present, was always low. S. bicolor (japonicum) P1. 302174
was moderately susceptible to both isolates of P. sacchari and
somewhat less susceptible to the isolates of P. philippinensis.

Exoncote et al. (6) reported that Avena sativa L. in the Philippines
is susceptible to P. philippinensis; however, we were unable to
infect any of 11 species of Avena, including four accessions of A.
sativa. In a further test, A. sativa cultivar Clintland, besides being
inoculated at 5 × 10^4 conidia per milliliter, was inoculated at the
dosage 1.0 × 10^5 conidia per milliliter. None of 298 plants at the
lower dosage or 261 at the higher dosage developed systemic
symptoms, and the pathogen could not be recovered.

According to results presented here and previously (4), P.
philippinensis and P. sacchari are both restricted to host species
within the grass tribes Andropogoneae and Maydeae. Examination
of host range results for the two pathogens on specific plant
accessions within these two tribes indicates a remarkable similarity
in their host ranges. Of 26 plant accessions in these tribes susceptible
to at least one isolate of P. philippinensis, 23 also were
susceptible to at least one isolate of P. sacchari (Table 1). Of 36
accessions in the Andropogoneae and Maydeae not susceptible to
P. philippinensis, 28 also were not susceptible to P. sacchari (Table
2). The differences between pathogen species were similar to the
differences between isolates within the same pathogen species. For
example, of 21 accessions susceptible to at least one isolate of P.
philippinensis, only 13 became infected by the other isolate. Of
eight grass accessions susceptible to at least one isolate of P.
sacchari, seven were susceptible when tested against the other
isolate.

In a few instances where no infection occurred, the number of
test plants was small; had more plants been available for testing,
systemic disease might have developed in at least one or a few plants
of a supposedly nonsusceptible combination.

Several species of Andropogon, Bothriochloa, and Schizachyrium
that were susceptible in this study are common perennial forage
and wild grasses in the United States (8). Big bluestem (Andropogon
gerardii) and little bluestem (Schizachyrium
scoparium) are perhaps the most prevalent constituents of wild hay
in the prairie states (8). These perennial grasses possibly could serve
as reservoir hosts for P. philippinensis or P. sacchari if these
pathogens entered the United States and if infected plants could
survive the winter season.

Oospores were not detected in leaf tissue of any of the
systemically infected plants, even when infected plants were held
to maturity. However, the production of oospores by P. sacchari
in sugarcane has been reported (12).

We believe there is a very close phylogenetic relationship
between P. philippinensis and P. sacchari. Besides having
essentially identical environmental requirements for optimum
sporulation, conidial germination, and infection (1,3), and similar
shapes of conidia and conidiophores (10), their host ranges are
remarkably similar. Further studies may indicate the desirability of
combining these two species. In fact, Weston (13) suggested in 1920
that all oriental forms infecting maize may be a single species. In
a study of ours not reported here (M. R. Bonde, unpublished), one
isolate of P. sacchari that we attempted to test from the Philippines
was pathogenetically very different from the isolates of P.
philippinensis from the Philippines or P. sacchari from Taiwan. It
was only weakly pathogenic to maize to the extent that we could
collect enough conidia from maize to compare the isolate's host
range against those of the other pathogen isolates. The species P.
sacchari needs to be reexamined for homogeneity.

LITERATURE CITED

of Philippine downy mildew of maize and of temperature on conidial


temperature on sporulation, germination of conidia, and systemic
infection of maize by Peronosclerospora sacchari. Phytopathology


Sclerotinia philippinensis Weston in the Philippines. Philipp Agric.
52:175-188.

Philippine corn downy mildew. Philipp Agric. 58:115-120.

The main grasses for farm and home. Pages 639-700 in: Grass
892 pp.

inoculating corn and sorghum with conidia of Sclerotinia sorghi.

Comparison of some morphological characters of several corn downy


Phytopathol. 23:262-269.

Res. 19:97-122.


878 PHYTOPATHOLOGY