Aecial Host Range of *Puccinia substriata* var. *indica*

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ABSTRACT

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Potential aecial hosts of *Puccinia substriata* var. *indica* were tested for resistance or susceptibility to better understand their potential role in epidemics of pearl millet rust. Thirty-one accessions of *Solanum melongena*, each collected from a different country, and accessions of twenty-seven other *Solanum* species were evaluated. Resistance or susceptibility was determined from natural infection in an isolated field location and inoculations in the greenhouse. All accessions of *S. melongena* were susceptible, except PI 413784 from Burkina Faso and PI 401533 from the Ivory Coast, countries that are near the center of origin of pearl millet. Newly identified aecial hosts include *S. anguivi*, *S. ferox*, *S. gilo*, *S. incanum*, *S. linaeanum*, *S. nodiflorum*, and *S. rostratum*. All other *Solanum* species evaluated were resistant. Accessions of two weed species from the United States, *S. americanum* and *S. aviculare*, were resistant and may play no role in the epidemiology of pearl millet rust in the United States.

Pearl millet (*Pennisetum glaucum* L.R. Br.) is primarily adapted to agriculture practiced in harsh environmental conditions, but there is increasing interest in its use for forage and grain in milder climates. Rust, caused by *Puccinia substriata* Ellis & Barth. var. *indica* Ramachar & Cummins, occurs in many countries of Asia and Africa and in the United States (8) and can cause considerable reduction in forage quality and grain yield (7,11). Several sources of resistance have been identified in pearl millet, the host of primary economic importance, but there have been limited evaluations of the aecial hosts, which may be important in the epidemiology of the disease.

Eggplant (*Solanum melongena* L.) was originally identified as the aecial host of *P. substriata* var. *indica* (4). Later studies revealed that *S. melongena* var. *insanum*, *S. pubescens*, *S. torvum*, and *S. xanthocarpum*. were also aecial hosts, but *S. trilobatum* was resistant (5). In the United States, Wells (10) determined that eggplant is an aecial host of pearl millet rust but obtained no infection of *S. dulcamara*, *S. nigrum*, *S. sisymbriifolium*, *S. carolinense*, *S. floridanum*, and *S. perplexum*. In contrast to all other reports in the literature, a later study suggested that *Euphorbia pulcherimma* Willd. is another aecial host in India (6).

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Pearl millet and eggplant are commonly cultivated in India, and rust is frequently observed on both crops (5). There is little published information concerning natural occurrence of rust on *Solanum* species in the Western Hemisphere. Natural infection of eggplant has been observed in Brazil (3), but the only infections reported in the United States have resulted from deliberate inoculations (10).

As pearl millet cultivation spreads into nontraditional areas, the potential exists for more widespread rust epidemics if other *Solanum* species can serve as a source of inoculum for early epidemic initiation. The objective of this study was to assess *Solanum* accessions collected from diverse geographic sites as possible aecial hosts of *P. substriata* var. *indica*.

MATERIALS AND METHODS

Pearl millet hybrid Tifleaf 1 was planted in a 0.25-ha field at the Hodnett Farm near Tifton, GA, during August 1992. Plants were inoculated during mid-September with a bulk aqueous suspension of urediniospores by spraying inoculum into the whorls of plants along the length of several rows. Plants were severely infected by rust prior to being killed by frost and were allowed to remain standing during the winter. During the spring, four 2-m-wide strips were disked and rototilled to prepare beds for *Solanum* transplants. Beds were separated and surrounded by 4 m of undisturbed pearl millet debris.

Several *Solanum* accessions (Table 1) selected from the Germplasm Resources Unit (formerly the Southern Region Plant Introduction Station, Griffin, GA) were started in the greenhouse. Approximately five seeds were planted in each cell of polystyrene transplanting flats. Plants at about the 5- to 8-leaf stage were transplanted into the field on 1 June 1993. Two to three hills of each accession with several plants in each hill were planted 0.6 m apart within rows spaced 1 m apart. An average of four plants of each accession was evaluated in each of four replications arranged in a randomized complete block design. Plots were irrigated after transplanting and periodically during growth. Plants were examined at 2- to 3-day intervals for spermagonia on leaves. To reduce the possibility of developing and releasing new races of rust, plants with visible spermagonia were counted and cut off at the base before aecia developed. Spermagonia develop within hypertrophied leaf tissue, in which a yellow lesion surrounded by a well-defined orange border is formed. Plants with spermagonia were considered susceptible, and infected plants were removed from the field and destroyed. After 7 weeks, the remaining uninfected plants were counted, and the plot area was disked to destroy the remaining plants.

Remnant seed of each of the accessions was planted in three 10-cm^2 pots (replications) in the greenhouse during December 1994. An average of four plants was grown and evaluated in each pot. Pots were arranged in a randomized complete block design.

Plants were inoculated at the 3- to 5-leaf stage. Dry pearl millet leaves with telia, collected during October 1994 from naturally infected field-grown plants, were hydrated by soaking in warm (approximately 38°C) water for 15 min. Hydrated leaves were draped over *Solanum* seedlings placed in an inoculation chamber. Seedlings were automatically misted with water for 60 s at 30-min intervals for 48 h. Inoculation-chamber temperatures averaged 16°C, and plants remained in the dark during the incubation interval. After the misting period was terminated, the inoculation chamber was opened for about 6 h until most of the foliage had dried, and plants were returned to the greenhouse bench.

Seedlings were examined for infection at 3- to 4-day intervals. Infections were allowed to progress to the formation of aecia before susceptible, infected plants were cut out. Plants without infection were reinoculated twice, as described above, to insure no plants escaped infection. Each subsequent inoculation of the *Solanum* seedlings was performed with pearl millet leaves not used in previous inoculations.

Field and greenhouse data were analyzed separately. Data of percent infected plants were analyzed by analysis of variance with sums of squares partitioned into replication and accession. Means of infected plants were differentiated by Fisher's LSD.

RESULTS AND DISCUSSION

Of 31 accessions of *S. melongena*, all plants of 23 accessions were susceptible in the field and greenhouse (Table 1). Six accessions had some uninfected plants in the field, but all were susceptible in the greenhouse. Two accessions, PI 401533 and PI 413784, from the Ivory Coast and Burkina Faso, respectively, were resistant in both evaluations.

Most of the *Solanum* species other than *S. melongena* reacted similarly in the field and greenhouse evaluations (Table 1). All plants of *S. anguivi*, *S. ferox*, *S. incanum*, and *S. xanthocarpum* were susceptible in both evaluations. Some or all plants of *S. gilo*, *S. linnaeanum*, *S. nodiflorum*, and *S. rostratum* were uninfected in the field, but most or all plants were susceptible in the greenhouse.

Some of the differences in reaction between field and greenhouse evaluations may be the result of escape from infection in the field. Several accessions were unadapted to the growing conditions in the field. Small, poorly growing plants are less likely to become infected than more robust plants as a result of a lower probability of spore contact and less conducive microenvironmental conditions for spore germination and infection within the plant canopy. Later intermittent dry periods in the field and the onset of higher temperatures may have been less favorable for teliospore germination or infection by basidiospores.

Susceptibility predominated among the *S. melongena* accessions. This was expected because most of the accessions were collected in areas where pearl millet is not grown and, thus, there is little advantage for resistance. Resistance was identified in two eggplant accessions collected near the center of origin of pearl millet (1). Although rust is a monocyclic, minor disease of eggplant, resistance may confer a selective reproductive advantage in these areas. The evolutionary relationship between *P. substriata* var. *indica* and its hosts may be difficult to trace because the center of origin of eggplant is generally accepted to be India (2).

The species listed in Table 1 that were not infected in the field and greenhouse inoculations will require further evaluation to unequivocally determine that they are not hosts of *P. substriata* var. *indica*. The single accession of the species tested represents only a small portion of the variability within their respective gene pools. In addition, it also is possible that the rust population in the southeastern United States does not possess genes for virulence to these species. These species may be susceptible to the rust population in other locations.

Regardless of the problems inherent in identifying nonhosts, host species were clearly identified. Although plants were removed from the field prior to the full development of aecia, all plants that formed spermagonia in the greenhouse evaluations also developed sporulating aecia. Newly identified aecial hosts identified in these evaluations include *S. anguivi*, *S. ferox*, *S. gilo*, *S. incanum*, *S. linaeanum*, *S. nodiflorum*, and *S. rostratum*.

Table 1. Susceptibility of *Solanum* species to *Puccinia substriata* var. *indica*, determined by natural infection in the field and by inoculations in the greenhouse (GH)

Solanum species	Country of origin	Accession number	Susceptible plants (%)[y] Field	Susceptible plants (%)[y] GH
S. melongena L.	India	PI 115506	100 a	100 a
S. melongena L.	Afghanistan	PI 116953	100 a	100 a
S. melongena L.	Turkey	PI 165059	100 a	100 a
S. melongena L.	Lebanon	PI 181806	100 a	100 a
S. melongena L.	Syria	PI 181807	100 a	100 a
S. melongena L.	Philippines	PI 188816	100 a	100 a
S. melongena L.	Greece	PI 199516	100 a	100 a
S. melongena L.	Myanmar	PI 200856	100 a	100 a
S. melongena L.	Pakistan	PI 217962	100 a	100 a
S. melongena L.	Japan	PI 230333	100 a	100 a
S. melongena L.	South Africa	PI 232078	100 a	100 a
S. melongena L.	El Salvador	PI 233916	100 a	100 a
S. melongena L.	Taiwan	PI 241594	100 a	100 a
S. melongena L.	Puerto Rico	PI 263727	100 a	100 a
S. melongena L.	"USSR"	PI 267104	100 a	100 a
S. melongena L.	Hungary	PI 290467	100 a	100 a
S. melongena L.	Brazil	PI 304839	100 a	100 a
S. melongena L.	Canada	PI 304840	100 a	100 a
S. melongena L.	Papua/New Guinea	PI 349612	100 a	100 a
S. melongena L.	"Yugoslavia"	PI 358232	100 a	100 a
S. melongena L.	Martinique	PI 408974	100 a	100 a
S. melongena L.	Italy	PI 452124	100 a	100 a
S. melongena L.	Republic of Korea	PI 508502	100 a	100 a
S. melongena L.	Iran	PI 140446	94 ab	100 a
S. melongena L.	Ethiopia	PI 193599	94 ab	100 a
S. melongena L.	Thailand	PI 249568	94 ab	100 a
S. melongena L.	Iraq	PI 179500	88 bc	100 a
S. melongena L.	Uzbekistan	PI 102727	80 cd	100 a
S. melongena L.	China	PI 103077	75 d	100 a
S. melongena L.	Ivory Coast	PI 401533	0 e	0 c
S. melongena L.	Burkina Faso	PI 413784	0 e	0 c
S. americanum Mill.	U.S.	PI 268152	0 e	...[z]
S. anguivi Lam.	India	PI 183357	100 a	100 a
S. atropurpureum Schrank	Colombia	PI 305320	0 e	0 c
S. aviculare G. Forster	U.S.	PI 280049	0 e	0 c
S. capsicoides Guatteri ex All.	India	PI 370043	0 e	0 c
S. ciliatum Lam.	Nicaragua	PI 196300	0 e	0 c
S. elaeagnifolium Cav.	Mexico	PI 346963	0 e	0 c
S. ferox L.	Myanmar	PI 200854	100 a	100 a
S. gilo Raddi	Brazil	PI 441874	6 e	71 b
S. incanum L.	India	PI 381155	100 a	100 a
S. khasianum C.B. Clarke	India	PI 312108	0 e	0 c
S. laciniatum Aiton	Hungary	PI 337284	0 e	0 c
S. linnaeanum Hepper & P. Jaeger	Colombia	PI 420415	86 bc	100 a
S. macrocarpon L.	Brazil	PI 441915	0 e	0 c
S. mammosum L.	Mexico	PI 245968	0 e	0 c
S. nigrum L.	Japan	PI 304600	0 e	0 c
S. nodiflorum Jacq.	Congo	PI 247828	0 e	100 a
S. pseudocapsicum L.	"Yugoslavia"	PI 368425	0 e	0 c
S. quinquangulare Willd. Ex Roemer & Schultes	Colombia	PI 305325	0 e	0 c
S. rostratum Dunal	Netherlands	PI 420997	0 e	82 b
S. sauveolens Kunth & Bouche	Mexico	PI 203339	0 e	0 c
S. sessiliflorum Dunal	Venezuela	PI 487467	0 e	...
S. sisymbriifolium Lam.	Uruguay	PI 331140	0 e	0 c
S. spinosissimum Lodd. Ex Loudon	Peru	PI 390818	0 e	0 c
S. stramoniifolium Jacq.	Venezuela	PI 487464	0 e	0 c
S. xanthocarpum Schrader & Wendl.	India	PI 381293	100 a	100 a
S. yungasense	South America	PI 265884	0 e	0 c

[y] Means within a column followed by the same letter are not significantly different according to Fisher's LSD.

[z] No germination of remnant seed.

The susceptibility of *S. anquivi*, *S. ferox*, *S. incanum*, *S. nodiflorum*, and *S. xanthocarpum* suggests that these species may contribute to epidemics of pearl millet rust in or near the areas where these species were collected. Accessions of two weed species collected from the United States, *S. americanum* and *S. aviculare*, were resistant and may play no role in epidemics of pearl millet rust in the United States. However, *S. rostratum* collected from the Netherlands was susceptible. Commonly known as buffalobur, *S. rostratum* also is found in the United States (9). Further evaluations of these species are warranted to more clearly determine their role in the epidemiology of pearl millet rust in the United States.

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