

9. HOST RANGE, GEOGRAPHIC DISTRIBUTION AND PHYSIOLOGIC RACES OF THE MAIZE DOWNY MILDEWS

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Up to the present time there are nine species of two genera of downy mildew fungi reported on maize. Seven of these belong to the genus *Sclerospora* and the rest to *Sclerophthora*. All of them are restricted in host range to the grass family and caused considerable damage to the farm crops, especially in the Asian tropical and sub-tropical countries—India, Indonesia, People Republic of China, Philippines, Republic of China, Thailand, and Nepal. Furthermore, there are reports from Africa, Europe, Israel, Japan, Australia, The United States, Mexico, and some Latin American countries. It is interesting one would not be surprised to learn that the disease is present in many countries.

Host Range and Geographical Distribution

1. *Sclerospora graminicola* (Sacc.) Schroet., 1879. Green ear disease of pearl millet, *graminicola* downy mildew of setaria, maize etc.

Synonyms:

Peronospora graminicola Sacc.

Protomyces graminicola Sacc.

This pathogen is one of the most wide spread, occurring in both tropical and temperate zones of America, Europe and Asia. The disease was first reported in Europe by Schroeter in 1879. The host range includes several species of *Setaria* and some other species of the family Gramineae, both cultivated and wild. It is of economic importance on Italian millet, *Setaria italica*, in Japan, Korea, People Republic of China, India, Russia, Southeast European countries and some states in North America. Furthermore, it is also prevalent on pearl millet (*Pennisetum typhoides*) in India, South Africa, Uganda and Tanganyika (Remakrishnan, 1963).

The following lists are collateral hosts of this pathogen:

Agrotisnalba Linn. Red top (Waterhouse, 1964).

Chaetochloa magna (Griseb) Scribn., Everglade millet (Weston et. al. 1926).

Chetochloa viridis (Scribn., Green bristlegrass (Waterhouse, 1964).

Echinochloa crus-galli (L.) Beauv., Barnyard grass (Andreyeff, 1925).

Echinochloa crus-galli var *frumentacea* (Roxb.) W. F. Wight, Japanese millet (Waterhouse, 1964).

Euchlaena luxurians Durieu & Ascher., Teosinte (Waterhouse, 1964).

Euchlaena mexicana Schrad, Teosinte (Hiura, 1930; Melhus et al., 1928; Uppal & Desai, 1931).

Panicum miliaceum Linn., Broomcorn millet (Sprague, 1950).

Panicum viridis Linn., Green bristlegrass (Melhus et. al. 1928).

Pennisetum leonis (Waterhouse, 1964).

Pennisetum spicatum Wild, Roem. & Schult., Pearl millet (Waterhouse, 1964).

Pennisetum glaucum Linn., Pearl millet (Safeeulla et. al. 1963).

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- Pennisetum typhoides* (Burm.) Stapf & C. F. Hubb., Bajra (Chaudhuri, 1932; Uppal & Desai, 1931).
- Saccharum officinarum* Linn., Sugarcane (Melthus et. al. 1928).
- Setaria glauca* (L.) Beauv., Yellow bristlegrass (Waterhouse, 1964).
- Setaria italica* (L.) Beauv., Italian millet (Hiura, 1930; Melhus et. al. 1928; Sprague, 1950; Uppal, 1931; Uppal & Desai, 1931).
- Setaria lutescens* (Weigel) F. T. Hubb., Yellow bristlegrass (Sprague, 1950).
- Setaria magna* Griseb., Giant bristlegrass (Anon., 1931; Sprague, 1950; Uppal & Desai, 1931).
- Setaria verticillata* (L.) Beauv., Bur. bristlegrass (Mitter & Mitra, 1940).
- Setaria viridis* (L.) Beauv., Green bristlegrass (Anon, 1931; Andreyeff, 1924; Hiura, 1930; Melhus et. al. 1928; Sprague, 1950; Uppal, 1931; Uppal & Desai, 1931).
- Sorghum halepense* (L.) Pers., Johnson grass (Anon, 1950).
- Sorghum sudanense* (Piper) Stapf, Sudan grass (Anon, 1922).
- Sorghum verticilliflorum* (Steud.) Stapf, (Waterhouse, 1964).
- Sorghum vulgare* Pers., Sorghum (Melhus et. al. 1928).
- Zea mays* Linn., Corn (Hiura, 1930; Melhus et. al. 1928).

2. *Sclerospora maydis* (Rae.) Butler, 1897—Java downy mildew of maize.

The disease was first recorded on the Island of Java, Indonesia on maize by Raciborski in 1897. This pathogen is limited to this country in distribution. There were reports from Africa that *S. maydis* was also observed in the Congo (Preter and Vanderweyen, 1960; Steyaert, 1947) and Somaliland (Ciferri, 1949), but Semangoen in 1970 considered these are misidentifications because: (1) there was no clear evidence that the fungus is the same as the Javanese one, (2) there are several confirmed evidences that *S. sorghi* is present in several African countries, and (3) the morphology of the conidial stage of these two fungi are quite similar. He concluded that those diseases in Congo and Somaliland are probably caused by *S. sorghi*. The proper taxonomic position of the Central African species of *Sclerospora* needs to be clarified.

The species reported susceptible to *S. maydis* are:

- Euchlaena mexicana* Schard, Teosinte (Semangoen, 1970).
- Pennisetum typhoides* × *P. spicatum* (Ciferri, 1949).
- Trypsacum* sp., Gama grass (Semangoen, 1970).
- Zea mays* × *Euchlaena mexicana* (Waterhouse, 1964).
- Zea mays* L. (Semangoen, 1970).

3. *Sclerospora miscanthi* Miyake, 1912.—Leaf splitting downy mildew.

Leaf splitting downy mildew disease was first described by T. Miyake in Taiwan in 1912. This pathogen primarily attacks sugarcane clones (*Saccharum* spp.) and *Miscanthus* spp. However, it is able to infect maize under laboratory conditions. This disease has been found in Taiwan and the Philippines. The disease is of minor economic importance on sugarcane.

4. *Sclerospora philippinensis* Weston, 1920.—Philippine downy mildew of maize, sugarcane.

According to Weston (1929), this disease was first reported in 1916 by Baker in the Philippines. The disease is widely distributed in the Philippines, but is most severe in Mindanao. W. H. Weston, Jr., a pioneer researcher on this disease, was sent by the United States Department of Agriculture to study this disease. His paper are considered as classics on the general subject of maize downy mildew. *S. philippinensis* has been reported from India (Uppal and Weston, 1936). Indonesia (Vanhoof, 1954) and in Nepal

(Shah and Tuladhar, 1966). There are unconfirmed report that this pathogen is established on maize in some areas of Thailand.

Besides maize, the pathogen will infect several wild and cultivated species of the gramineae as reported by Exconde, et. al. (1968).

The hosts he listed were:

Avena sativa L., oats

Euchlaena mexicana Schrad., teosinte.

E. mexicana × *Zea mays* hybrid.

Saccharum officinarum L., Sugarcane.

S. spontaneum L., wild sugarcane.

Sorghum bicolor (L.) Moench, grain sorghum.

S. Halapense (L.) Pers., Johnson grass.

S. propinquum (Kunth.) Hitchc.

5. *Sclerospora sacchari* Miyake, 1911.—Sugarcane downy mildew, sugarcane downy mildew of maize.

This disease was first observed in maize in Taiwan by Miyake in 1909 after it was found on sugarcane. However, maize is generally more susceptible than sugarcane. *S. sacchari* has been reported from Australia, Fiji Islands, India, New Guinea, Philippines, Taiwan, Thailand (Hughes and Robinson, 1961), Nepal, and Japan (Renfro, personal communication). The informal report of the presence of this pathogen in Thailand could not be confirmed (Pupipat et. al., 1971).

The host range of *S. sacchari* is relatively narrow. It is reported to occur only on maize and sugarcane; teosinte (*Euchlaena mexicana* Schrad.), gama grass (*Tripsacum dactyloides*), and broom corn (*Sorghum vulgare* var. *technicum*) have also been reported to be susceptible to infection of *S. sacchari* by artificial inoculation (Chang, 1966: Chang et. al., 1965; Miyake, 1911). It was shown that isolates from maize can infect sugarcane and *vice versa*, although maize was generally more susceptible to the fungus (Leu and Chu, 1959). The origin of this fungus was believed to be in New Guinea and then spread to Australia. Taiwan imported the fungus embedded in sugarcane seed sets from Australia. Very likely, the pathogen has been spread to other countries by the same means.

6. *Sclerospora sorghi* Weston & Uppal, 1932.—Sorghum downy mildew. Sorghum downy mildew of maize.

Syn. *Sclerospora graminicola* var. *andropogonis*—*sorghi*.

Sclerospora sorghi—*vulgaris* (Kulkarni) Mundkur.

Sorghum downy mildew, caused by *Sclerospora sorghi* Weston & Uppal, is one of the most prevalent and most widest distribution among the downy mildew on maize. It occurs in many countries in Asia—India, Israel, Pakistan, People Republic of China, Thailand; almost every country in Africa; Europe—Italy (questionable report); North America—several southern states of U.S.A. up to Indiana; Latin America Countries Mexico, Peru and Argentina. This disease caused considerable losses in several countries. Besides maize, the pathogen has been found on several species of the Graminicolous plants as follows:

Andropogon sorghi (L.) Brot. (Uppal & Desai, 1932).

Euchlaena mexicana Schrad. (Uppal & Desai, 1932).

Heteropogon contortus Beauv. (Dange et. al., 1973).

Panicum typheron Schult. (McRae., 1934).

Pennisetum typhoides (Burm.) Stapf & C. E. Hubb, Pearl millet. (Castellami, 1939).

Sorghum alnum. Perodi, Columbus grass. (Tarr, 1962).

- Sorghum arundinaceum*. Roen & Schult (Anon., 1939).
Sorghum cafforum (Retz.) Hubb. & Rehder., kaffircorn. (Roux, 1961).
Sorghum halapense (L.) Pers., Johnson grass. (Frederiksen et al. 1965).
Sorghum sudanense (Piper) Stapf, Sudan grgass. (Wallace, 1934).
Sorghum verticilliflorum (Steud) Stapf. (Tarr, 1962).
Sorghum vulgare Pers, sorghum (Tarr, 1962).
S. vulgare×Sudan grass hybrid. (Futrell & Bain, 1967).
S. vulgare var *technicum* (Koern.) Jav., Broom corn. (Tarr, 1962).

7. *Sclerospora spontanea* Weston, 1921.—Spontaneum downy mildew.

The disease was first found by Weston in 1921 who also furnished a description of the causal.—It occurs naturally on wild sugarcane (*Saccharum spontaneum*) and maize in the Visayan Islands, Philippines. Weston called it the Visayan *Sclerospora*, latter Ullstrup (1973) used the name "Spontaneum downy mildew" which is accepted by many workers. Other hosts of this fungus are *Euchlaena luxurians*. Durien & Ascher, *Miscanthus japonicus*. Address., *Saccharum officinarum* L., and *Sorghum* spp. (Waterhouse, 1964). However, this disease is not of economic importance and is confined to the Philippines. There is one report from Thailand in 1938 by Stevenson and Rand, but its presence has not been subsequently confirmed.

8. *Sclerophthora macrospora* (Sacc.) Thirumal., Shaw & Naras., 1953.—Crazy top of maize, etc., Yellow wilt of rice.

Syn. *Sclerospora macrospora*. Sacc.
Sclerospora kriegeiana. Magnus.

Sclerospora oryzae. Brizi.

Nozemia macrospora (Sacc.) Tasugi.

Phytophthora macrospora (Sacc.) Tanaka.

The fungus was first found occurring on *Alopecurus* sp. in Australia in 1890 and was described as *Sclerospora macrospora* Sacc. (Saccardo, 1890). It occurs in most maize growing areas with temperate or warm—temperate climate. Crazy top of maize is generally of minor economic importance, it is much less damaging to the maize crop of the world than the downy mildews of maize incited by *Sclerospora sorghi*, *S. philippinensis*, *S. sacchari*, *S. maydis*, and *Sclerophthora rayssiae* var. *zeae*. The pathogen has a wide host range within the grass family. The host, more than 140 species, included many economically important crops like rice, wheat, corn, sorghum, oats, pearl millet, barley and sugarcane. The following list of hosts and geographic distribution is compiled by Raghavendra (1974) with the courtesy of K. M. Safeulla.

Host	Country	Author & year
<i>Agropyron repens</i> Beauv.	U. S. A.	Miles & Epps, 1924
	Japan	Akai <i>et al.</i> , 1964
	U. S. A.	Semeniuk & Mankin, 1964
* <i>A. tsukushiense</i> var. <i>transsiensiens</i> (Hack.) Ness	Japan	Katsura, 1954
	Japan	Akai <i>et al.</i> , 1964
<i>A. smithii</i> Rydb.	U. S. A.	Semeniuk & Mankin, 1964
<i>A. cristatum</i> (L.) Gaerth.	U. S. A.	Semeniuk & Mankin, 1964
<i>A. trachycaulun</i> (Link) Malta.	U. S. A.	Semeniuk & Mankin, 1964
<i>Agrostis clavata</i> var. <i>nukabo</i> Ohwi.	Japan	Katsura <i>et al.</i> , 1954
<i>A. hiemalis</i> (Walt.) Britt. Sterns et Roggenb.	Japan	Akai <i>et al.</i> 1964

Host	Country	Author & year
<i>A. paulstris</i> Huds.	U. S. A.	Miles & Epps, 1942
	Japan	Akai <i>et al.</i> , 1964
<i>A. stolonifera</i> L.	U. S. A.	Semeniuk & Mankin, 1964
* <i>A. alba</i> L.	Japan	Tasugi, 1953
<i>Alopecurus agrestis</i> L.	U. S. A.	Miles & Epps, 1942
<i>Alopecurus</i> sp.	Australia	Saccardo, 1890
<i>A. aequalis</i> Sobol.	Japan	Akai <i>et al.</i> , 1964
		Katsura <i>et al.</i> , 1954
* <i>A. fulvus</i> L.	Japan	Tasugi, 1953
<i>Andropogon nardus</i> var. <i>georingii</i> Hack.	Japan	Tasugi, 1953
<i>Arthraxon hispidus</i> (Thunb.) Makino	Japan	Katsura <i>et al.</i> , 1954
* <i>A. ciliaris</i> Beauv.	Japan	Tasugi, 1953
<i>Arrhenatherum elatius</i> L.	Japan	Akai <i>et al.</i> 1966
<i>Arundinella hirta</i> (Thunb.) Tanaka	Japan	Tasugi, 1953
<i>A. anomala</i> Steud.	Japan	Tasugi, 1953
<i>Avena fatua</i> L.	U. S. A.	Semeniuk & Mankin, 1964
<i>A. sativa</i> L.	Italy	Peglion, 1910
	France	Arnoud, 1915
	Japan	Tanaka, 1940
	U. S. A.	Miles, 1941
	U. S. A.	Stanton <i>et al.</i> , 1943
	U. S. A.	Cooper, 1947
	U. S. A.	Miller, 1949
	U. S. A.	Goto & Moore, 1951
	U. S. A.	Earhart, 1952
	U. S. A.	Summera, 1952
	Canada	Welsh <i>et al.</i> 1953
	U. S. A.	Roana <i>et al.</i> , 1955
	U. S. A.	Whitehead, 1958
	U. S. S. R.	Novotelnova, 1963
	U. S. A.	Semeniuk & Mankin, 1964
<i>Avena nigra</i> Wallr.	U. S. A.	Leukel, 1921
<i>Axonopus compressus</i> (Swartz.) Beauv.	U. S. A.	Leukel, 1921
<i>Beckmannia syzigachne</i> (Steud.) Fernald.	Australia	Padwick, 1950
* <i>B. erucaeformis</i> Host.	Japan	Tasugi, 1953
<i>Brachiaria mutica</i> (Forsk.) Stapf.	Japan	Katsura <i>et al.</i> , 1954
** <i>B. reptans</i> (L.) C. A. Gardner et. C. E. Hub.	India	
<i>Bromus japonicus</i> Thunb.	U. S. A.	Semeniuk & Mankin, 1964
<i>B. commutatus</i> Schrad.	U. S. A.	Weston W. Jr., 1921
<i>B. inermis</i> Leyss.	U. S. A.	Semeniuk & Mankin, 1964
<i>Cymbopogon tortilis</i> var. <i>georingii</i> (Steud.) Hand.	Japan	Akai <i>et al.</i> , 1964
<i>Cyopsis aculeata</i> L.	Italy	Peglion, 1910
<i>C. aropecuroides</i> L.	Italy	Peglion, 1930
<i>C. schonoides</i> L.	Italy	Peglion, 1930
<i>Dactylis glomerata</i> L.	Japan	Akai <i>et al.</i> , 1966

Host	Country	Author & year
** <i>Dactyloctenium aegypticum</i> (L.) Beauv.	India	
<i>Digitaria sanguinaris</i> Scop.	Japan	Tanaka, 1940
	U. S. A.	Ullstrup, 1955
	U. S. A.	Whitehead, 1958
	Japan	Akai <i>et al.</i> , 1964
** <i>Digitaria marginata</i> var. <i>imbriata</i> (Link) Stapf.	India	
<i>D. ischaemum</i> (Schreb.) Muhl.	U. S. A.	Semeniuk & Mankin, 1964
* <i>D. violascens</i> Link.	Japan	Tasugi <i>et al.</i> , 1953
<i>D. adscendens</i> (H. B. K.)	India	Safeella, 1955
** <i>Dinebra retroflexa</i> (Vahl) Panz.	India	
<i>Echinochloa crus-galli</i> (L.) Beauv.	U. S. A.	Koehler, 1939
<i>E. crus-galli</i> var. <i>hispidula</i> (Retz.) Honda.	Japan	Takatsu, 1959
<i>E. colonum</i> (L.) Link	Peru	Revilla, 1955
<i>Eleusine coracana</i> (L.) Gaertn.	India	Venkataraman, 1946
<i>E. indica</i> (L.) Gaertn.	U. S. A.	Ullstrup, 1955
	Japan	Akai <i>et al.</i> , 1964
	U. S. A.	Dale & Templeton, 1960
<i>Elymus macounii</i> Vasey.	U. S. A.	Semeniuk & Mankin, 1964
<i>Elytrophorus spicatus</i> (Willd.) A. Camus.	India	Thirumalachar, 1949
	India	Safeeulla, 1955
<i>Eragrostis cilianensis</i> (All.) Link.	U. S. A.	Semeniuk & Mankin, 1964
	U. S. A.	Ullstrup, 1955
<i>E. pectinacea</i> (Michx) Nees.	U. S. A.	Ullstrup, 1955
<i>E. ferruginea</i> (Tunb) Beauv.	Japan	Tasugi, 1953
<i>E. niwahokori</i> Honda.	Japan	Tasugi, 1953
<i>E. major</i> (L.) Host.	U. S. A.	Miles & Epps, 1942
* <i>E. multicaulis</i> Steud.	Japan	Tasugi, 1953
** <i>E. nutans</i> (Retz.) Nees.	India	
<i>Festuca elatior</i> L.	U. S. A.	Miles & Epps, 1942
<i>F. arundanacea</i> Schreb.	U. S. A.	Dale & Templeton, 1960
<i>Glyceria martina</i> Wahlb.	U. S. A.	Miles & Epps, 1942
<i>G. acutiflora</i> Torr.	Japan	Tanaka, 1940
<i>G. festucaeformis</i> (Host) Heynh.	Italy	Peglion, 1910
* <i>Hemarthria compressa</i> (L.) R. Br.	Japan	Takatsu & Toyama, 1957
<i>Holcus lanatus</i> L.	Italy	Peglion, 1930
<i>H. sorghum</i> var. <i>japonicus</i> Makino.	U. S. A.	Whitehead, 1958
<i>Hordeum jubatum</i> L.	U. S. A.	Mackie, 1930
	U. S. A.	Kingslover, 1950
	U. S. A.	Oswald, 1951
	U. S. A.	Roane <i>et al.</i> , 1955
	U. S. A.	Wells, 1956
	U. S. S. R.	Novetelnova <i>et al.</i> 1963
	U. S. A.	Dale & Templeton, 1960
	U. S. A.	Semeniuk & Mankin, 1964
<i>H. sativum</i> var. <i>vulgare</i> Hack.	Japan	Tasugi, 1953

Host	Country	Author & year
<i>H. sativum</i> var. <i>hexastichon</i> (L.) Rich	U. S. A.	Rothman <i>et al.</i> , 1961
<i>Imperata cylindrica</i> var. <i>koenigi</i> (Retz). Durand et Schniz.	Japan	Akai <i>et al.</i> , 1964
<i>I. arundanacea</i> L.	Japan	Tasugi, 1953
<i>Isliema laxum</i> Hack.	India	Thirumalachar & Narasimhan, 1949
* <i>Leersia japonica</i> Makino.	Japan	Tasugi, 1953
<i>Lolum perenne</i> L.	U. S. A.	Miles & Epps, 1942
<i>L. multiforu</i> Lamk.	U. S. A.	Rothman <i>et al.</i> , 1961
<i>L. temuletum</i> L.	U. S. A.	Miles & Epps, 1942
<i>Microstegium vimineum</i> (Trin.) A. Camus.	Japan	Katsura <i>et al.</i> , 1954
* <i>M. sinensis</i> Anders.	Japan	Tasugi, 1953
<i>Muhlenbergi asperfolia</i> (Nees & Mey) Parodi	U. S. A.	Semeniuk & Mankin, 1964
<i>Miscanthus floridulus</i> (Labill) Warb.	Japan	Tasugi, 1953
<i>Oplismenus undulatifolius</i> var. <i>japonicus</i> Steud.	Japan	Tasugi, 1953
<i>O. burmanni</i> Beauv.	Japan	Tasugi, 1953
<i>Oryza sativa</i> L.	Japan	Yamada, 1911
	Italy	Brizi, 1912
	Italy	Gobboto, 1915
	Japan	Takasugi, 1934
	Australia	Noble, 1937
	Australia	Padwick, 1950
	Japan	Tasugi, 1953
	China	Ciferri, 1955
	China	Pai, 1957
	Japan	Akai, 1964
	U. S. A.	Templeton, 1961
<i>Panicum antidotale</i> Retz.	U. S. A.	Miles & Epps, 1942
<i>P. bisulcatum</i> Thunb.	Japan	Tasugi, 1953
* <i>P. violascens</i> Kunth.	Japan	Tasugi, 1953
<i>P. capillare</i> L.	U. S. A.	Ullstrup, 1952
<i>P. sanguinale</i> var. <i>ciliare</i> Doell.	Japan	Tasugi, 1953
	Japan	Akai <i>et al.</i> , 1964
	U. S. A.	Semeniuk & Mankin, 1964
<i>P. barbides</i> L.	Peru	Revilla, 1955
<i>P. crusgalli</i> var. <i>frumentaceum</i> Hook.	Japan	Tasugi, 1953
<i>P. maximum</i> L.	France	Messiaen, 1957
* <i>P. crus-galli</i> var. <i>submuticum</i> Mey.	Japan	Tasugi, 1953
<i>P. virgatum</i> L.	U. S. A.	Semeniuk & Mankin, 1964
<i>P. indicum</i> var. <i>oryzorum</i> Mak.	Japan	Tasugi, 1953
<i>P. milaceum</i> L.	U. S. A.	Semeniuk & Mankin, 1964
<i>P. acroanthum</i> Steud.	Japan	Tasugi, 1953
<i>Pennisetum alopecuroides</i> (L.) Spreng.	Japan	Tasugi, 1953
** <i>Pennisetum pedicellatum</i> Trin.	India	
** <i>Pennisetum typhoides</i> (Burm.) Stepf & Hubb.	India	
<i>Pennisetum purpureum</i> Schum	U. S. A.	Miles, 1930

Host	Country	Author & year
<i>Paspalum thumbergii</i> Kunth.	Japan	Tasugi, 1953
<i>Phalaris arundanacea</i> L.	Germany	Magnus, 1895
	Japan	Akai <i>et al.</i> , 1964
	U. S. A.	Semeniuk & Mankin, 1964
<i>P. canariensis</i> L.	U. S. A.	Miles & Epps, 1942
<i>P. coerulea</i> Desf.	U. S. A.	Miles & Epps, 1942
<i>P. tuberosa</i> L.	Australia	Chambers, 1962
<i>Phleum pratense</i> L.	U. S. A.	Semeniuk & Mankin, 1964
<i>Phragmites communis</i> Trin.	Japan	Tasugi, 1953
<i>P. coerulea</i> Steud.	U. S. A.	Miles & Epps, 1942
* <i>P. longivalvis</i> Steud.	Japan	Tasugi, 1953
<i>Poa pratensis</i> L.	U. S. A.	Semeniuk & Mankin, 1964
<i>P. acroleuca</i> Steud.	Japan	Takatsu & Toyama, 1957
<i>P. annua</i> L.	Japan	Tasugi, 1953
<i>P. nipponida</i> Koidz.	Japan	Tasugi, 1953
<i>Pollinia inberbis</i> var. <i>genuina</i> Hack.	Japan	Tasugi, 1953
<i>Polygomon interruptus</i> H. B. K.	Peru	Revilla, 1955
<i>Rottboellia compressa</i> L.	Japan	Tasugi, 1953
<i>Sacciolepis indica</i> var. <i>oryzetorum</i> (Makino) Ohwi.	Japan	Akai <i>et al.</i> , 1959
<i>S. interrupta</i> (Willd.) Stapf.	India	Safeeulla, 1955
<i>Schedonnardus paniculatus</i> (Nutt) Trel.	U. S. A.	Semeniuk & Mankin, 1964
<i>Saccharum officinarum</i> L.	South Africa	Steindal <i>et al.</i> , 1952
	U. S. A.	Farrar & Steib, 1952
	Mauritius	Orian, 1954
	Peru	Revilla, 1955
	Australia	Mungomery, 1956
	South Africa	Roth, 1967
<i>Secale cereale</i> L.	Bulgaria	Atanasoff & Kovashevsky, 1929
	U. S. A.	Miles & Epps, 1942
	Australia	Noble, =1944
	Italy	Peyronel, 1948
	U. S. A.	Dale & Templeton, 1960
	U. S. A.	Rothman <i>et al.</i> , 1961
<i>Setaria luescens</i> (Weigel) Hubb.	U. S. A.	Semeniuk & Mankin, 1964
<i>S. viridis</i> (L.) Beauv.	Italy	Peglion, 1910
	France	Arnoud, 1915
	U. S. A.	Ullstrup, 1955
	Japan	Akai <i>et al.</i> , 1964
	U. S. A.	Semeniuk & Mankin, 1964
* <i>S. glauca</i> Beauv.	Japan	Tasugi, 1953
<i>S. pumilla</i> (Poir) R & S.	Japan	Takatsu & Toyama, 1957
<i>S. viridis</i> var. <i>purpurascens</i> Maxim.	Japan	Tasugi, 1953
<i>S. verticillata</i> (L.) Beauv.	Peru	Revilla, 1955
** <i>S. tomentosa</i> Kunth (Roxb.)	India	

Host	Country	Author & year
<i>Sorghum vulgare</i> Pers	U. S. A.	Whitehead, 1958
	U. S. A.	Semeuiuk & Mankin, 1964
<i>S. vulgare</i> var. <i>sudanense</i> (Piper) Hitch.	U. S. A.	Semeniuk & Mankin, 1964
<i>S. halepense</i> (L.) Pers.	U. S. A.	Whitehead, 1958
<i>S. verticilliform</i> (Roxb.) Kuntze.	U. S. A.	Sprague, 1950
<i>Sporobolus neglectus</i> Nash.	U. S. A.	Semeniuk & Mankin, 1964
* <i>S. elongatus</i> R. Br.	Japan	Tasugi, 1953
<i>Stenothrum secundatum</i> (Walt) Kuntze.	U. S. A.	Jones & Amador, 1969
<i>Syntherisma sanguinalis</i> (L.) Dulac.	U. S. A.	Miles & Epps, 1942
<i>Triticale</i>	U. S. A.	Troutman <i>et al.</i> , 1972
<i>Triticum aestivum</i> subsp. <i>vulgare</i> (Host) Mackey.	U. S. A.	Kent <i>et al.</i> , 1964
<i>T. vulgare</i> Will.	Italy	Severini, 1913
	France	Arnoud, 1915
	Australia	Carne, 1924
	Australia	Noble, 1926
	U. S. A.	McDonough, 1929
	Italy	Peyronel, 1929
	Italy	Perotti, 1932
	Austria	Verona, 1932
	Austria	Goidanich, 1932
	Japan	Tanaka, 1940
	U. S. A.	Miles & Epps, 1941
	Mexico	Rupert <i>et al.</i> , 1949
	Australia	Radwick, 1950
	U. S. A.	Wells, 1956
	U. S. A.	Whitehead, 1958
	Mexico	Jerks <i>et al.</i> ,
	U. S. A.	Dale & Templeton, 1950
	Australia	Chambersm, 1962
	India	Tyagi, 1968
	Pakistan	Kamal & Junenjo, 1969
<i>Zea mays</i> L.	Italy	Cugini & Traverso, 1902
	Italy	Peglion, 1910
	Australia	Noble, 1934
	U. S. A.	Koehler, 1936
	Japan	Tanaka, 1940
	U. S. A.	Ullstrup, 1952
	U. S. A.	Whitehead, 1954
	Italy	Zanardi, 1957
	France	Messiaen, 1957
	Yugoslavia	Panjan, 1959
	Japan	Akai <i>et al.</i> , 1964
	India	Singh, 1963
	U. S. A.	Semeniuk & Mankin, 1964

Host	Country	Author & year
<i>Zinania latifolia</i> Turez.	Austria	Zwatz Bruno, 1966
	Fustria	Granhall & Darke, 1967
	Japan	Tasugi 1953

* Artificially inoculated

** Host records from Mysore

9. *Sclerophthora rayssiae* var. *zeae* Payak & Renfro, 1967.—Brown stripe downy mildew of maize.

This disease is first recorded on maize in India and described as *S. rayssiae* var. *zeae* in 1967 by Payak and Renfro. It is a major disease in North and Central India, it is found in Nepal, Pakistan (Renfro, personal communication), and Thailand. However, it is not of economic importance in the latter country. The host range is relatively narrow and so far, only maize and crab grass (*Digitaria sanguinalis* (L.) Scop. have been reported.

Physiologic Specialization

Very little information is available on concerning the physiologic specialization of any maize downy mildew pathogens. Renfro (Personal communications) mentioned that there are known gross differences in virulence within *S. sorghi*. Four cases are known of changes in virulence of *S. sorghi* and one in an elliptical spore type, either *S. philippinensis* or *S. sacchari*.

1. In Thailand maize has been infected for several years but not sorghum. A few sorghum plants were found infected at two locations for the first time in 1971 and 1972.

2. In Israel, sorghum downy mildew was found to severely attack sudan grass (*Sorghum sudanese*), Johnson grass (*Sorghum halapense*) and very rarely corn. The disease was restricted to a few areas in the north and was never found on grain sorghum. However, by 1969, it had spread wider geographically, and was readily infecting sorghum, sudan grass crosses, and corn and sorghum lightly. At present it is described as a definite threat to both maize and sorghum in Israel.

3. In Texas, U.S.A., sorghum downy mildew was first reported in 1961 as severe on sorghum sudan grass hybrids and lighter on grain sorghum. Three years later it was reported on maize and heavy on grain sorghum.

4. In Mysore state of India sorghum downy mildew has been a major disease of sorghum for decades, but was unknown on maize until two plants were found infected in October 1968. An epidemic developed around Bangalore that winter season and has been the most important maize disease in that area eversince.

5. In nature sorghum was found infected in the Philippines for the first time in 1971 on Mindanao Island. Infection was found to be severe in many fields. The pathogen is an elliptical spored type and believed to be either *S. philippinensis* or *S. sacchari*.

The first experiment to determine the possible existence of races of *S. philippinensis* was conducted by Mr. Somkiat Titatarn, in his M.S. thesis under Dr. O. R. Exconde, University of the Philippines. He inoculated five inbred lines and a synthetic variety of maize under controlled conditions with conidia of seven isolates of *S. philippinensis*. The isolates were collected from different places in the Philippines. On the basis of the reaction these differential hosts, it appears that physiologic races exist in *S. philippinensis* (Table 1). This represents the pioneer work in this interesting aspect of downy mildew of maize research. It would be more precised and internationally recognized if more differential entries were added and if the test plants were grown in a standard nutrient culture.

Table 1. Isolate groups based on reaction of 5 inbred lines and one synthetic maize to 7 different isolates of *Sclerospora philippinensis* in the Philippines under controlled conditions.

Group	Reaction of test materials ¹⁾						Origin of isolate
	DMR-2	MO3	MO5	MO12	MO13	Tx601	
A	R	S	S	S	S	R	College Laguna
B	I	S	S	S	S	R	Kabacan, Cotobato
C	I	S	S	S	I	R	Pili, Camarines Sur
D	I	S	S	S	I	S	Davao City
E	I	I	S	S	I	I	Impasugong, Bukidnon
F	I	S	S	S	S	S	Musuan, Bukidnon
E	I	I	S	S	I	I	Lemery, Batangas

1) Reaction categories used:

R = resistant (0-10% of plants became infected)

I = intermediate (11-50% of plants became infected)

S = susceptible (51-100% of plants became infected)

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Question and Answer

Robert G. Kenneth, Israel: 1) We can add a new country with downy mildew on maize: Iran Dr. VIENNOT-BOURGIN and Dr. ALE AGHA found "*S. GRAMINICOLA*" on maize in 1970. I have some herbarium material with me here, and one photograph of a conidiophore. It more likely is *S. sorghi*, but I cannot be certain.

2) The local lesion symptoms of *S. sorghi* on maize that I described yesterday, have been verified today by Dr. FREDERIKSEN, who unfortunately arrived too late yesterday.

3) I noticed the photo of seed-borne infections (*S. sorghi*) in maize. I noticed that the first leaf was chlorotic. This never happens by oospore infection. It does in seed-borne infection by *S. maydis*. What about in other species?

Answer: 3) It has been reported in *S. sacchari* from Taiwan. Chlorosis and sporulation are the typical symptoms and signs for the disease, especially *S. sorghi* in Thailand, if the air humidity is high. It will show symptoms of sporulation on the first, sometimes second or third leaf, about 6-8 days after the seeds are planted in the rainy season.

Sangam Lal, India: 1) You mentioned in your paper (page 4) that "the pathogen (*S. sacchari*) has spread to other countries by infected sugarcane sets". In India *S. sacchari* does not infect/occur on sugarcane in nature, meaning thereby that it would have come through some other source. Please comment.

2) The symptoms of sorghum downy mildew shown in some of your slides are quite similar to those that occur in Mysore (India, slides shown by Dr. Payak). Does it mean that on the basis of symptoms one cannot differentiate the two biotypes? Please comment.

Answer: 1) Naturally *S. sacchari* can spread through one or more means, i.e., corn seed, sugarcane sets, oospores (in soil or plant debris). However, we should be aware of the possibility of the existence of physiologic races as reported on *S. sorghi* in Thailand vs. India, USA, Israel.

2) I accept that we cannot easily differentiate them based on the manifestation of symptoms. However, there is another similar question from Dr. Safeeulla that I would like to include on this occasion.

Information from several research papers and research workers showed that the manifestation of maize downy mildew symptoms and fungus morphology can vary according to several factors. I would like to propose that each one should study these in his own country using the same standard procedures as well as standard techniques and standard testing materials such as:

- plant genotype
- plant age
- environmental conditions
 - temperature
 - humidity
 - light
 - host nutrition
- fungus should be propagated from a single conidium isolate
- inoculum concentration and method of inoculation
- reading (rating) techniques

These are the factors, I think, that we should be aware of and that should get international recognition.

Kunigal M. Safeeulla, India: (Comment) Symptoms of *S. philippinensis*, *S. maydis* and *S. spontanea* on maize are so similar, as is the morphology of their conidiophores. In view of this, it may be advisable to make a comparative study of all the three downy mildews.

T. Hino, Japan: (Comment) *Sclerospora sacchari* was reported from Japan to be distributed in Taiwan. I think it is very difficult to read the literature written in Japanese. But now, in Japan, *Sclerospora sacchari* is not distributed, even in the southernmost island, Okinawa.

Charles G. G. Shaw, U.S.A.: Do you know if artificial inoculation of teosinte has been attempted with an inoculum of *Sclerophthora macrospora*?

Answer: I don't believe anyone has done it. However, it should be expected that the result will be positive since teosinte seems to be susceptible to all species of maize downy mildew fungi.

Joginder Singh, India: (Comment) Your distribution maps are probably based on few reports and may relate to specific parts of the country. For instance the distribution maps of Sugarcane and Sorghum Mildew as well as brown stripe downy mildew are very different from the ones presented by Dr. Payak. It will be more desirable to show the specific areas of the country rather than the whole country map.

R.A. Frederiksen, U.S.A.: (Comment) For sorghum downy mildew add:

Brazil—R. A. Frederiksen	Unpublished
Venezuela—M. Riccelli	"
Honduras—A. Ortega	"