Peronosclerospora maydis

Scientific Name
Peronosclerospora maydis (Racib.) C.G. Shaw

Synonyms:
Peronospora maydis and *Sclerospora maydis*

Common Name
Java downy mildew, downy mildew of corn, and corn downy mildew

Type of Pest
Fungal-like pathogen

Taxonomic Position
Phylum: Oomycota, **Class:** Oomycetes, **Order:** Sclerosporales, **Family:** Sclerosporaceae

Reason for Inclusion in Manual
CAPS Target: AHP Prioritized Pest List – 2009

Pest Description
Java downy mildew, caused by *Peronosclerospora maydis*, was discovered by Raciborski (1897) in Java, Indonesia in 1897 and has the distinction of being the first downy mildew disease reported on corn (Bonde, 1982). Initially it was misidentified as *Sclerospora maydis*. The disease was reported in India by Butler (1913) and has continued to spread.

Peronosclerospora maydis is an obligate parasite that will not grow on artificial media. The pathogen produces two kinds of hyphae: straight and sparsely branched, and lobed and irregularly branched. The mycelium has many haustoria with different forms (Semangoen, 1970). Clustered conidiophores arise from stomata and are dichotomously branched two to four times. The branches are robust and 150-550 µm long with basal cells 60-180 µm long. Conidia (17-23 x 27-39 µm) are hyaline and spherical to subspherical (Smith and Renfro, 1999). Semangoen (1970), however, indicated that the conidia are smaller (12-29 x 10-23 µm). Oospores have not been reported (Smith and Renfro, 1999).

Biology and Ecology
Infected corn plants grown during the dry season are the primary source of inoculum in Indonesia. The fungus may also survive as mycelium in kernels, but this is thought to be a minor source of inoculum. Infection by conidia occurs through stomata of young plants, and lesions elongate toward the meristem, inducing systemic infection. *P. maydis* caused high levels of systemic infection from 8 to 36°C (46 to 97°F) (Bonde et al., 1992). If infection arises from seed, the cotyledonary leaf is always infected. Seed

transmission occurs when freshly harvested seeds from diseased plants are used. No seed transmission has been detected from seeds dried prior to planting (Smith and Renfro, 1999).

Large numbers of conidia and conidiophores are produced on the upper leaf surface on wet leaves (dew for 5-6 hours) in the dark from 18-23°C (64-73°F) (the optimum temperatures for sporulation) (Inaba et al., 1980; Bonde et al., 1992). *P. maydis* has a very broad optimum temperature range for conidial germination (at least 10-30°C, 50-86°F) and germ tube growth (18-30°C, 64-86°F) (Bonde et al., 1992). Conidia germinate under these conditions to produce germ tubes with free water being required (Semangoen, 1970; Smith and Renfro, 1999). Conidia formation is initiated from 12:00 AM to 1:00 AM, and the peak of conidial release is at 3:00 AM to 4:00 AM. Most conidia remain within a 16 meter radius of their source plant (Tantera, 1975), and Mikoshiba et al. (1977) concluded that secondary infection from a single disease cycle is limited to within a radius of about 42 meters from the inoculum source. Semangoen (1970) reported that conidia lost their ability to infect after 10-hour storage in saturated air in petri dishes, but at least a few conidia remained viable for 20 hours in saturated air on young corn leaves.

Symptoms/Signs

White to yellow streaks, which become necrotic and brown, are the characteristic leaf symptoms of *P. maydis*. The fungus may become systemic, causing severe chlorosis in the upper leaves (Fig. 1.). Infected plants may be stunted and sterile and often lodge. Plants may develop multiple and deformed cobs, leaflike tassels and cobs, combined tassels and cobs, and either elongated or shortened stalks. Downy growth on the chlorotic streaks is common. Plants more than 4 weeks old are highly resistant to infection (Smith and Renfro, 1999).

Figure 1. Maize plants growing on the bunds of rice fields in West Java, showing typical chlorosis of systemic downy mildew. Photos courtesy of Rob Williams, CAB International. www.cabicompendium.org.

Pest Importance

Downy mildew of sorghum, maize, and sugarcane are among the world's most destructive diseases (Bonde et al., 1992). Heaviest losses are incurred when the disease becomes systemic (spreads throughout the plant host) (Kenneth, 1981). Java downy mildew is of great importance in Indonesia, where yield may be reduced by 40%. The most severe damage occurs when corn is planted late or the rainy season begins early, especially if the crop has been over fertilized with nitrogen or planted after corn or sugarcane (Smith and Renfro, 1999). Semangoen (1970) reported nearly 100% loss of late-planted maize in Java, Indonesia.

Known Hosts

Saccharum spontaneum (wild sugarcane), *Sorghum arundinaceum* (wild sorghum), *Sorghum plumosum* (plume sorghum), *Zea mays* (corn), and *Zea mexicana* (teosinte). are reported hosts of *P. maydis* (Ramsey and Jones, 1988). Smith and Renfro (1999) indicate that *Tripsacum, Euchlaena*, and *Pennisetum* spp. are also hosts of *P. maydis* by inoculation.

Known Vectors (or associated insects)

P. maydis is not a known vector and does not have any associated organisms.

Known Distribution

Asia: China, India, Indonesia, Israel, Japan, and Thailand. **Africa:** Congo Democratic Republic. **Caribbean:** Jamaica. **South America:** Argentina. **Oceania:** Australia.

Reports from Africa are thought to be erroneous (Semangoen, 1970; Kenneth, 1976).

Potential Distribution within the United States

This pathogen is expected to pose a relatively low threat to maize in the United States, because most of the crop is seasonally planted with periods of fallow between planting and harvest that will break the disease cycle. However, most of the corn growing regions of the United States have climatic conditions that would support plant infection, particularly during the months of May and June. A recent risk analysis by USDA-APHIS-PPQ-CPHST indicates that portions of Illinois, Indiana, Kentucky, and Ohio have the greatest risk for *P. maydis* establishment based on host availability and climate within the continental United States. The remaining states have low to moderate levels of risk for establishment of *P. maydis.*

Survey

CAPS-Approved Method: Use visual survey, sentinel plots, spore trapping, or a combination of methods. For visual survey collect symptomatic plants. Spore traps, similar to those used in soybean rust monitoring, can be used to detect spores. Unsprayed, susceptible plants (sentinel plots) that are scouted regularly can also be used for early detection.

Literature-Based Methods:

Visual survey: Surveys should occur in areas of the country that are at the greatest risk for establishment. Survey for Java downy mildew is conducted via visual survey of plants for symptoms of the disease (white to yellow streaks on leaves, stunted plants, sterile plants or those with multiple or deformed cobs) and signs of the pathogen (downy growth on underside of leaves consisting of conidia and conidiophores).

Trapping: Spore trapping using Burkhard spore traps and sentinel plots (unsprayed, susceptible plants that are scouted regularly) are suggested for early detection and have been employed for resistance screening for other exotic downy mildews (Cardwell et al., 1997; Expert Panel, 2006).

Key Diagnostics

CAPS-Approved Method: Confirmation of *P. maydis* is by morphological identification. Pathogen may be identified morphologically by conidiophore structure and dimension and spore (conidia) shape and size. Isozyme comparisons have been used to identify *Peronosclerospora* spp., including *P. maydis*

Literature-Based Methods: *Peronosclerospora* spp. and other downy mildew genera (including *Sclerospora* and *Sclerophthora*) are primarily differentiated by pathogen morphology, including conidiophore structure and dimension and spore (conidia) shape and size. However, these characteristics can vary considerably under different culture conditions, at different developmental stages, and on different hosts. Identification of *Peronosclerospora* species often is difficult. They may be easily divided into three categories according to the shape of conidia: globose, ovoid to slightly elongate, and long or slipper-shaped, but within each group there are usually only minor morphological differences. Species are differentiated only by variations in the size and shape of their conidia and conidiophores, and sometimes differences in host ranges, presence or lack of oospores, and differences in morphology (Bonde et al., 1992). Characters for downy mildew pathogens are listed in Appendix A.

Isozyme comparisons have been used to identify *Peronosclerospora spp.*, including *P. maydis* (Micales et al., 1988).

Some DNA-based approaches have been reported for other *Peronosclerospora* spp., which indicates that a molecular method for identification may be available in the future. Yao et al. (1991a) created a DNA clone that could be used as a species-specific hybridization probe for the detection and identification of *P. sorghi*. Yao et al. (1991b) then developed a DNA probe from a *P. maydis* genomic library to detect *P. sacchari* in maize leaves and seeds. Ladhalakshmi et al. (2009) used a DNA sequence characterized amplified region (SCAR) marker for identification of isolates of *P. sorghi* from maize using PCR. There has been some work on SSR markers for *P. sorghi* and related species that include this pathogen and will be helpful for identification and future PCR primer development (Perumal et al., 2008).

Easily Confused Pests

Downy mildews on corn are caused by up to ten different species of Oomycete fungi in the genera *Peronosclerospora, Sclerophthora,* and *Sclerospora. Peronosclerospora maydis* may be confused with other *Peronosclerospora* spp. occurring on corn and other downy mildew genera. Other indigenous downy mildews (*e.g., P. sorghii*) and physiological conditions (fertility, weather, etc.) can cause similar symptoms.

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