Sclerophthora rayssiae var. zeae

Scientific Name
Sclerophthora rayssiae var. *zeae* Payak & Renfro

Common Name(s)
Brown stripe downy mildew, brown stripe, and maize downy mildew

Type of Pest
Fungal-like

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

Reason for Inclusion in Manual
CAPS Target: AHP Prioritized Pest List – 2009; Agricultural Bioterrorism Protection Act of 2002 (Select Agent)

Pest Description
Brown stripe downy mildew is caused by *Sclerophthora rayssiae* var. *zeae*. *S. rayssiae* var. *zeae* is an obligate parasite that will not grow on artificial media. Sporangia develop at 22-25°C (72-77°F) atop determinate and short sporangiophores that grow from the substomatal spaces. Sporangia are hyaline and ovate to almost cylindrical, operculate 18.5-26 × 29-66.5 and germinate via zoospores at 20-22°C (68-77°F). Sporangia are produced in clusters of two to six and are hyaline, ovate to cylindrical, with an obvious peduncle. Sporangia walls are smooth and contain four to eight zoospores. Zoospores geminate at 15-30°C (59-86°F). Once encysted, the zoospores are hyaline, spherical and range from 7.5-11 µm (Payak and Renfro, 1967; Smith and Renfro, 1999).

The oogonia (33-44.5 µm in diameter) are subglobose, thin walled, and hyaline to light straw colored. Oospores (29.5-37 µm in diameter) are spherical to subspherical with smooth, glistening walls that are 4 µm thick and confluent with the oogonia. They have hyaline contents, including a prominent oil globule. The oospore stage in corn develops more readily and more abundantly where higher temperatures prevail (over 28°C, 82°F) (Payak, 1975). Oospores and oogonia are numerous and scattered in the leaf mesophyll or under stomata (Payak and Renfro, 1967; Smith and Renfro, 1999).

Biology and Ecology
The disease is primarily soilborne, but can be seedborne. Young plants are most susceptible and susceptibility decreases as plants age. Plants may be predisposed to infection when zinc is limiting. Soil temperatures of 28-32°C favor disease development. It has also been shown that the disease severity varies with the rainfall. Where the annual rainfall varies from 4-60 cm the disease intensity was described as low, moderate in areas with 60-100 cm, and high in regions receiving 100-200 cm of rain.

Oospores survive in infected debris in the soil. The infective source responsible for initial outbreaks has been determined to be the oosporic stage (Payak, 1975). The pathogen may survive as oospores for as long as four years in infected plant debris in the soil (Singh, 1971a). When adequate moisture is present for at least 12 hours, the oospore germinates to produce a sporangiophore bearing a sporangium that liberates four to eight zoospores. In the presence of enough moisture or at high temperatures, the sporangium may produce a germ tube that can also infect corn leaves. Secondary spread is by sporangia. Pathogen dissemination is by rain water, and direct contact. Sporangia have been trapped 1.65 meters from an infected field, but the greatest numbers of sporangia were found to move less than 1 meter, suggesting that long distance transport via wind is unlikely (Singh and Renfro, 1971).

Moisture is essential for infection by *S. rayssiae* var. *zeae*. Sporangia production, germination, and infection require a film of water. Twelve hours of leaf wetness were required for infection via zoospores, with longer periods producing greater numbers of infected plants. Most sporangia are liberated at maturity during the day. Sporangial release occurs in the afternoon of sunny days when high moisture is present, rather than on cloudy or rainy days (Singh and Renfro, 1971). Generation time of secondary inoculum (sporangia) from primary inoculum (oospores) can be rapid. Under ideal conditions, sporangial production can occur as soon as 10 days post inoculation. Infected plants placed in a moist environment at 22 to 25°C can produce sporangia in as little as 3 hours, with a second generation of sporangia arising 9 hours later (Singh et al., 1970).

Figure 1. Symptoms of brown stripe downy mildew. Image courtesy C. De Leon. Reproduced from Compendium of Corn Diseases, 3rd Ed., 1999, American Phytopathological Society, St. Paul, MN.

The fungus can be detected within the embryo of corn seeds and has been shown to be seed transmitted when seeds from infected plants are planted in sterile soil immediately after harvest (Singh et al., 1967a,b). Seed transmission was found to occur at less than 1% (Lal and Prasad, 1989). Seeds dried to 14% moisture or less and stored for 4 weeks or more do

not transmit this or other downy mildew diseases. The pathogen can also overseason in crabgrass as oospores or as mycelium from which sporangia are produced (Bains et al., 1978).

Symptoms/Signs

S. rayssiae var. *zeae* causes leaf lesions only (Putnam, 2007). Initially, lesions develop on the leaves as narrow, chlorotic or yellowish stripes, similar to other downy mildews, but only 3-7 mm wide (Fig. 1). They have well-defined margins and are delimited by the veins. The stripes later become reddish to purple in some corn genotypes (Putnam, 2007). Lateral development of lesions causes severe striping and blotching. The disease may first be noticed on the lower leaves, which will show the greatest degree of striping; as a result they appear pale-brown and burnt, and severely affected leaves may be shed prematurely.

Seed development may be suppressed, seed may be smaller in size, and the plant may die prematurely if blotching occurs prior to flowering. Unlike other downy mildews, floral or vegetative parts are not malformed, and the leaves do not shred (Smith and Renfro, 1999; Putnam, 2007). The pathogen apparently does not systemically affect the plant.

Sclerophthora rayssiae var. *zeae* may sporulate on either side of the lesions and appear downy or woolly. Sporangia disappear as the lesions become necrotic. Oospores occur only in necrotic tissue, in the mesophyll, or beneath the stomata, but not in vascular tissue (Putnam, 2007).

Pest Importance

Downy mildews of sorghum, maize, and sugarcane are among the world's most destructive diseases (Bonde et al., 1992). Yield loss of up to 63% has been reported in India (Payak and Renfro, 1967). Singh (1971b) reported 20-70% infection in many corn growing areas in India with an incidence of 80-100% in certain high hilly tracts. Annual losses from this disease in India have been estimated in the million of dollars (Frederickson and Renfro, 1977). Maize genotypes vary in their reaction to *S. rayssiae* var. *zea*e (Payak and Renfro, 1967). Among 2113 Indian maize inbred lines and other germplasm scored in the field, 58 were highly resistant, 667 resistant, 772 moderately resistant, 478 susceptible, and 138 highly susceptible (Singh et al., 1970).

According to CABI (2007), losses due to the disease vary depending on when and how severely the tissue is affected. If three-quarters or more of the foliage is affected prior to flowering, then the loss may be total; ear formation is either totally suppressed or markedly attenuated. Grain yield reductions vary from 20-90%. Losses in the higher range only occur with highly susceptible cultivars in conditions conducive for disease development.

Known Hosts

Digitaria bicornis (southern crabgrass), *Digitaria sanguinalis* (hairy crabgrass), *Sorghum bicolor* (sorghum), and *Zea mays* (corn).

The isolate of *S. rayssiae* var. *zeae* from *D. bicornis* was not able to infect maize (Singh et al., 1970). Additional studies are needed to clarify if the pathogen from *D. bicornis* could play a role in causing infection on corn.

Known Vectors (or associated insects)

S. rayssiae var. *zeae* is not a known vector and does not have any associated organisms.

Known Distribution

Asia: India, Myanmar, Nepal, Pakistan, and Thailand.

Potential Distribution within the United States

Corn growing regions in the country with warm and wet early season growing conditions are suitable for disease development and would be at high risk for damage caused by this disease if the pathogen is introduced. A recent risk analysis by USDA-APHIS-PPQ-CPHST indicates that portions of Illinois, Indiana, Kentucky, and Ohio have the greatest risk for *S. rayssiae* var. *zeae* 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 *S. rayssiae* var. *zeae.*

Survey

CAPS-Approved Method: Visual survey is the method to survey for *S. rayssiae* var. *zeae.* For visual survey collect symptomatic leaves.

Literature-Based Methods:

Visual survey: Young plants should be visually inspected for those with narrow (3-7 mm wide) chlorotic stripes on leaves with well-defined margins and delimited by the veins. The stripes later turn reddish to purple in some genotypes. Check for downy growth on both sides of infected leaves on cool, damp mornings as the downy growth will usually disappear by late afternoon. Infected leaves remain intact.

Key Diagnostics

CAPS-Approved Method: Confirmation of *S. rayssiae* var. *zeae* is by morphological identification. Pathogen may be identified morphologically by conidiophore structure and dimension and spore (conidia) shape and size.

Literature-Based Methods: *Sclerophthora* spp. and other downy mildew genera (including *Sclerospora* and *Peronosclerospora*) are primarily differentiated by pathogen morphology, including conidiophore structure and dimension and spore (conidia) shape and size, and if produced oogonia and oospores. However, these characteristics can vary considerably under different culture conditions, at different developmental stages, and on different hosts. Characters for downy mildew pathogens are listed in Appendix A.

There are no known serological or molecular diagnostic methods available. A standing operating procedure has been developed by the National Plant Diagnostic Network for diagnosing this pathogen.

Easily Confused Pests

Downy mildews of corn are caused by up to ten different species of oomycete fungi in the genera *Peronosclerospora, Sclerophthora* and *Sclerospora. S. rayssiae* var. *zeae* may be confused with other *Sclerophthora* 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.

Brown stripe downy mildew could be confused with two potentially destructive downy mildew diseases of corn already established in the United States: crazy top (*Sclerophthora macrospora*) and sorghum downy mildew (*Peronsclerospora sorghi*) (USDA, 1984). In crazy top, growth in the tassel proliferates into a mass or tangle of leafy structures (phyllody), creating the 'crazy top' appearance. Also, numerous shoots or tillers sprout from the base of the original shoot. Phyllody and excessive tillering are not symptomatic of brown stripe downy mildew (USDA, 1984). Sorghum downy mildew causes infected plants to appear chlorotic and frequently stunted. White stripes may appear on the leaves. Also, the leaves are narrower and more erect than on healthy plants. Phyllodied tassels may be present. None of these symptoms are observed in brown stripe downy mildew (USDA, 1984).

Scleropthora rayssiae var. *rayssiae* causes a downy mildew disease in barley. This pathogen closely resembles *S. rayssiae* var. *zeae*, but they differ in host range (Payak et al., 1970; USDA, 1984).

References

Bains, S.S., Jhooty, J.S., Sokhi, S.S., and Rewal, H.S. 1978. Role of *Digitaria sanguinalis* in outbreaks of brown stripe downy mildew of maize. Plant Disease Reporter 62(2): 143.

Bonde, M.R., Peterson, G.L., Kenneth, R.G., Vermeulen, H.D., Sumartini, and Bustaman, M. 1992. Effect of temperature on conidial germination and systemic infection of maize by *Peronsclerospora* species. Phytopathology 82(1): 104-109.

CABI. 2007. Crop Protection Compendium Wallingford, UK: CAB International. http://www.cabi.org/compendia/cpc/.

Frederiksen, R.A., and Renfro., B.L. 1977. Global status of maize downy mildew. Ann. Rev. Phytopathol. 15: 249-275.

Lal, S. and Prasad, T. 1989. Detection and management of seed-borne nature of downy mildew diseases of maize. Seeds Farms 15: 35-40.

Payak, M.M. 1975. Epidemiology of maize downy mildews with special reference to those occurring in Asia. Tropical Agriculture Research 8: 81-91.

Payak, M.M. and Renfro, B.L. 1967. A new downy mildew disease of maize. Phytopathology 57: 394-397.

Payak, M.M., Renfro, B.L., and Lal, S. 1970. Downy mildew disease incited by *Sclerophthora.* Indian Phytopathol. 23(2): 183-193.

Putnam, M.L. 2007. Brown stripe downy mildew (*Sclerophthora rayssiae* var. *zeae*) of maize. Plant Health Progress doiL10.1094/PHP-2007-1108-01-DG. http://www.plantmanagementnetwork.org/pub/php/diagnosticguide/2007/stripe/.

Singh, J.P. 1971a. Infectivity and survival of oospores of *Sclerophthora rayssiae* var. *zeae*. Indian J. Exp. Biol. 9: 530-532.

Singh, J.P. 1971b. Pathological and histopathological studies of brown stripe downy mildew of maize. Indian J. Exp. Biol. 9(4): 493-495.

Singh, J.P., and Renfro, B.L. 1971. Studies on spore dispersal in *Sclerophthora rayssiae* var. *zeae*. Indian Phytopath. 24:457-461.

Singh, R.S, Chaube, H.S., Khanna, R.N., and Joshi, M.M. 1967a. Internally seedborne nature of two downy mildews of corn. Plant Disease Reporter 51: 1010-1012.

Singh, R.S., Joshi, M.M., and Chaube, H.S. 1967b. Further evidence of the seedborne nature of maize downy mildews and their possible control with chemicals. Plant Disease Reporter 52: 446-449.

Singh, J.P., Renfro, B.L., and Payak, M.M. 1970. Studies on the epidemiology and control of brown stripe downy mildew of maize *(Sclerophthora rayssiae* var. *zeae*). Indian Phytopath. 23: 194-208.

Smith, D.R. and Renfro, B.L. 1999. Pg. 26, 28. *In*: D. G. White (ed.) Compendium of Corn Diseases, 3rd ed. APS Press, St. Paul, MN. 78 pp.

USDA. 1984. Pests not known to occur in the United States or of limited distribution, No. 55: Brown stripe downy mildew. USDA-APHIS-PPQ.