Wheat blast *Magnaporthe oryzae* (Catt.) (synonym to *Pyricularia oryzae* Cavara 1892)

Taxonomy & Description

Kingdom: Fungi

Phylum: Ascomycota

Class: Sordariomycetes

Order: Magnaporthales

Family: Magnaporthaceae

Genus: Magnaporthe

Species: *Magnaporthe oryzae*

Field symptoms of wheat blast (Magnaporthe oryzae)

Pathotypes:

Pyricularia, the anamorphic name for the fungus, was established by Saccardo (1880) based on the pyriform shape of the asexual conidia of P. grisea on crabgrass. In 1892, Cavara designated rice isolates as *P. oryzae*. Sprague (1950) applied *Pyricularia* species names based on host, with *P. oryzae* for rice isolates and *P. grisea* for isolates from all other cereals and grasses. This back and forth for genus and species names explains why the rice and wheat blast pathogens are commonly referred to in the blast literature as *Pyricularia* or *Magnaporthe*, each with species identifiers of *grisea* or *oryzae*. *Magnaporthe* was chosen as the official name and *Pyricularia* as the synonym, and both names will continue to be used.

There are a number of subpopulations or pathotypes within M. oryzae based on host they attack. There is the *Oryza* pathotype (MoO) specific to rice, the *Triticum* pathotype (MoT) specific to wheat, the *Eleusine* pathotype (MoE) specific to finger millet, *Setaria* pathotype (MoS) specific to foxtail millet and the *Lolium* pathotype (MoL) specific to turf grasses.

The original rice blast disease caused by the MoO population appears to have arisen from a host jump from *Setaria* pathogens around the time rice was domesticated ~7000 years ago. The wheat pathogen in Brazil was originally suggested to have jumped from rice because blast was endemic in rice produced in northern Paraná state in 1985. However, it was soon shown that the rice pathogen population was not the source for wheat blast, based on lack of cross-infectivity of rice and wheat isolates and on the high level of sexual fertility of the wheat isolates compared to local infertile rice isolates.

Strains of the *M. oryzae Triticum* pathotype can affect all above-ground parts of the wheat plant. Other hosts such as annual ryegrass, tall fescue, and weeping lovegrass appear to be ‘universal suscepts’ with potential for infection by fungal strains from several pathotypes in laboratory studies. Barley is broadly susceptible under laboratory conditions, but there are only a few reports of barley blast in the field, possibly due to cooler climates where barley is grown. It remains to be determined if these hosts are universally susceptible under field conditions. Different plant-by-strain combinations presented a continuum of disease symptoms, ranging from no visible symptoms to non-sporulating dark brown resistance lesions to small susceptible lesions with sporulating centers to the maximum-sized sporulating lesions characteristic of host-adapted strains (Valent et al. 1991).

Distribution

The disease is widespread in South American countries such as Brazil, Argentina, Bolivia, Panama and Paraguay since the 1980s. It was first observed in 1985 in the Brazilian state of Paraná, where commercial wheat fields in six municipalities were severely affected. In 1996, blast was reported for the first time outside of Brazil, in Bolivia’s most important region for wheat production, the Santa Cruz Department. Wheat blast reached Itapúa and Alto Paraná Departments of Paraguay in 2002, and the province of Formosa in north eastern Argentina in 2007.

The pest was previously (2011) present in the Kentucky state of the US but it no longer is. This strain was found in a research plot from the University of Kentucky and as a less virulent strain it was believed to have evolved from the annual ryegrass pathogen via a host jump.

There had been previous fears of wheat blast possibly spreading from Latin America to the regions of Africa and Asia where climatic conditions are similar to the former. This was confirmed in 2016 with the first introduction of wheat blast outside of the Americas to the Asian country of Bangladesh and it has subsequently spread to India. The wheat blast strains might be migrated from South America to Bangladesh via man-made transport due to imports of wheat to the country. A local Bangladeshi newspaper reported that seeds imported from Brazil in 2015 for the consumption purpose were seen as unhealthy and these might have been infected by the blast pathogen.

Host range

Collectively, the *M. grisea/oryzae* species complex causes disease on more than 100 grass species including rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), finger millet (*Eleusine coracana*), Italian (foxtail) millet (*Setaria italica*), perennial and annual ryegrass (*Lolium* species), oats (*Avena sativa*), barley (*Hordeum vulgare* L.) and crabgrass (*Digitaria sanguinalis* (L.) Scop).

Symptoms

Spike/Grains: The most visible symptom of wheat blast in the field is bleaching of the spike. An infection in the rachis or peduncle can block the translocation of photosynthates and kill the upper parts of the spike. As a consequence, partial or total spike sterility can occur depending on susceptibility of cultivar, timing, and point of infection. Infected awns show brown to whitish discoloration while infected glumes show elliptical lesions with reddish-brown to dark-gray margins. Lesions have grey centers during sporulation and white to tan centers after spore release. Grain fill is better when MoT infections occur later in the season; however, later infections may increase the chance of seed transmission of the pathogen with infected seeds. Grains from blast-infected spikes from highly susceptible cultivars are often small, shriveled and deformed, with low test weight. Small, shriveled seeds can be mixed with normal-appearing seeds on symptomatic spikes. MoT is a seedborne pathogen and the fungus can be isolated even from asymptomatic seeds.

Leaves: Initial macroscopic lesions are water soaked to gray-green. Blast lesions have grey centers during sporulation, and white to tan centers after sporulation. Mature lesions often have a dark brown to reddish-brown margin that stops lesion expansion, and they also often have yellow chlorotic halos. Individual lesions are generally eye-spot shaped (sometimes elliptical), but they coalesce in moderate to severely infected seedlings, sometimes resulting in total death of the plant. Although the largest lesions on rice tend to occur on younger leaves; lesions on wheat occur more frequently on older leaves, including senescent leaves at the base of the plant. Lesions can also rarely be seen on the leaf collar, culm, culm nodes, and stem.

Life cycle

A recent study suggested that MoT follows a mixed reproductive system in which sexual recombination is followed by asexual dispersal of better-adapted clones. This is in contrast to rice blast, which has strictly asexual reproduction in most parts of the world. Pathogens with a mixed reproductive system are considered to have the highest level of evolutionary potential and to be hardest to control. Indirect evidence suggests that the original MoT population in the 1980s was capable of reproducing sexually and this form of reproduction was much more common then.

Infection

The disease produces conidia and ascospores which can germinate and form appressoria on hydrophobic surfaces. Appressoria that develop in water droplets, such as dew, generate very high turgor pressure to puncture the host leaf surface and colonize the tissues.

Economic Importance

Blast is an explosive threat to wheat production that can cause up to 100% yield losses on susceptible cultivars and under the right environmental conditions. The economic importance of this disease derives from the fact that the fungus can reduce yield and grain quality.

Control

Chemical control:

CIMMYT stated that fungicides have not been successful in controlling the disease. This is especially so under warm, rainy weather occurring during the heading stage. Some studies show that fungicides partially control wheat head blast and offer better control on cultivars with at least moderate levels of resistance. Early applications (before symptoms) in areas where the disease is a problem have been proposed, as well as seed treatments (with benomyl) being effective as they reduce inoculum early on. There have also been reported issues of fungicide resistance in Brazil where extensive use of *strobilurin* (QoI) fungicides led to widespread distribution of *cyt b* mutations. A biological agent *Bacillus methylotrophicus* has been suggested as an efficient and alternative control means against wheat blast.

Cultural control:

Crop rotation with alternative crops such as oil seed crops and pulses instead of wheat is one of important cultural practices which can reduce the pathogen inoculums from the field. Eliminating crop residues immediately after harvesting of wheat and keeping crop fields weed-free will destroy the alternative hosts of the blast pathogen because inoculums can also survive on weeds and in crop residues. In South America, where the disease was previously endemic, delaying the planting date significantly reduced yield losses due to wheat blast. Silicon treatment enhances resistance to wheat blast.

Wheat blast is favoured by early planting, warm weather as well as high application rates of nitrogen fertilizers. Optimum temperature for disease development ranges between 25 and 30 °C with continuous spike wetness from 25 to 40 hour.

Resistance:

Resistance to wheat blast remains elusive despite intense searches for sources of resistance since 1985. While dozens of blast R genes have been identified in rice, blast R genes appear to be rare in wheat. Although wheat blast can be both a spike and a leaf disease, poor correlation is observed between the two reactions, possibly indicating different resistance mechanisms. *Rmg2* and *Rmg3* from bread wheat variety Thatcher conferred seedling resistance to MoT strains isolated from 1990 to 1992, but highly-aggressive strains isolated since 2011 devastate Thatcher and therefore appear to have overcome these genes. *Rmg7* from tetraploid T. dicoccum and *Rmg8* from bread wheat conferred resistance when fungal infection with strains from 1990 to 1992 occurred on both seedlings and spikes.

Field tests in Bolivia in 2014 and 2015 confirmed that the 2NS segment from *Aegilops ventricosa* confers head blast resistance under natural epidemic conditions. This fragment has already been incorporated into diverse cultivated wheat varieties due to its useful rust and nematode R genes. However, it is important to note that not all lines with 2NS show a significant reduction in head blast and resistant parents should be selected with caution.