CAPS Datasheets provide pest-specific information to support planning and completing early detection surveys.

Magnaporthe oryzae Triticum pathotype B.C. Couch

Synonyms:
Pyricularia oryzae Cavara *Triticum* pathotype
Dactylaria oryzae (Cavara) Sawada
Pyricularia graminis-tritici Castroagudín et al.

Figure 1. A wheat spike bleached by *Magnaporthe oryzae Triticum* pathotype (MoT). Courtesy of M. Tofazzal Islam, Institute of Biotechnology and Genetic Engineering (IBGE), Bangabandhu Sheikh Mujibur Rāhmān Agricultural University, Bangladesh.

Common Name
Wheat blast, MoT

Type of Pest
Fungus

Taxonomic Position
Class: Sordariomycetes, **Order:** Magnaporthales, **Family:** Pyriculariaceae

Reason for Inclusion in Manual
CAPS Small Grain Commodity Survey list, 2021

Note on nomenclature: *Magnaporthe oryzae Triticum* pathotype and *Pyricularia oryzae Triticum* pathotype are used interchangeably to refer to wheat blast. *Pyricularia oryzae Triticum* pathotype is the accepted species name, but the wheat blast community has agreed to accept both. *Magnaporthe oryzae Triticum* pathotype (MoT) will be used for the CAPS Program to remain consistent with the name used in the diagnostic protocols.

There are numerous pathotypes of *Magnaporthe oryzae*, and each pathotype is typically host-specific to a single plant genus (Gladieux et al., 2018; Tosa et al., 2016). This datasheet describes the *Magnaporthe oryzae Triticum* pathotype (MoT). In addition to MoT, other pathotypes include: *Oryza* pathotype (MoO), which causes rice blast; and *Lolium* pathotype (MoL), which causes gray leaf spot disease in annual/perennial ryegrass (*Lolium perenne*) and tall fescue (*Festuca arundinacea*) (Valent et al., 2013). The wheat blast fungus was recently assigned to a separate species, *Pyricularia graminis-tritici* (Ceresini et al., 2019). This assignment was incorrect, and is now a synonym of *Magnaporthe oryzae Triticum* pathotype (Valent et al., 2019).

Pest Recognition

This section describes characteristics of the pest and symptoms that may help surveyors recognize possible infections in the field and collect symptomatic material. For morphological descriptions, see Identification Resources on the AMPS pest page on the CAPS Resource and Collaboration website.

Figure 2. Different types of wheat blast infections: A) rachis infection causing death above the point of infection, B, C) spike infections resulting from multiple infections of individual spikelets, D) a dead spike most likely from stem infection, but with dark pigment in the stem below the spike. Photo credits: Guillermo I. Barea Vargas, Coperagro SRL, Bolivia (A, C), C. D. Cruz, now at Purdue (B), Gary L. Peterson, USDA/ARS/FDWSU, Fort Detrick, Maryland.

The most telltale sign in wheat is head infection (Figs. 1-3), but all aboveground plant parts can become infected and show symptoms (Figs. 2-4) (Igarashi, 1991; Fernandez-Campos et al., 2020; Gongora-Canul et al., 2020). Infected heads appear bleached (Figs. 1-3) (Igarashi, 1991).

When the rachis, or stem, is infected, grain development is limited (e.g. shriveled/wrinkled grains with low test weight), and death of the head above the point of infection may occur (Figs. 2, 3) (Igarashi, 1991). Infected rachises are discolored, turning from brown/black to dark gray due to heavy spore formation (Figs. 2, 3) (Igarashi, 1991; Urashima et al., 2009). Conidia, asexually produced spores, are pear or club shaped with a narrow tip, transparent to gray in color, and typically 19–23 *µm* × 7–9 *µm* (Fig. 5) (Subramanian, 1968).

Lesions typically form on older leaves, and the fungus can be isolated from lesions in the deteriorating basal leaves at the base of the plant (Fig. 4) (Cruz et al., 2015). Lesions are elliptical and similar to rice blast leaf lesions (Cruz et al., 2015; Igarashi, 1991). Leaf lesions have a white center and reddish-brown margin on the upper side of the leaf, and a gray appearance on the underside of the leaf where spore formation occurs (Fig. 4) (Igarashi, 1991).

Biology and Ecology

The disease cycle of wheat blast is similar to that of rice blast (Fig. 6) (Tufan et al., 2009; Cruz and Valent, 2017). Asexual reproduction occurs when spores from lesions on aboveground plant parts are dispersed to new host material (Couch et al., 2005; Wilson and Talbot, 2009). One lesion can produce 2,000–6,000 spores per day for up to 14 days, and multiple reproduction cycles may occur during a single growing season (Couch et al., 2005; (Fernandez-

Campos et al., 2020; Gongora-Canul et al., 2020; Ou, 1985). According to research studies, the optimum temperature and wetting period for MoT spore formation is 25–30°C (77-86°F) after 25–40 hours of wetness (Cardoso et al., 2008; Kohli et al., 2011). Intensity of infections is substantially lower at temperatures of 15°C (59°F) or less, and a minimum of 10 hours of wetness is needed for infection at any temperature (Cardoso et al., 2008). Outbreaks are more likely to occur during warmer, wetter growing seasons (Kohli et al., 2011). Epidemics in South America have been associated with El Niño weather patterns that bring high levels of rainfall (CABI, 2019).

Figure 3. Severely infested wheat fields containing bleached spikes and infested rachis (top). Infested grain (bottom). Photo credits: Nick Talbot, Stainsbury Laboratory, UK (A), Guillermo I. Barea Vargas, Coperagro SRL, Bolivia (B), and M. Tofazzal Islam (C, D).

Aerial dispersal plays a significant role in the local spread of MoT (Urashima et al., 2007). Spores are capable of dispersing at least 1,000 meters (3,281 feet) from an infected wheat field (Urashima et al., 2007). MoT is capable of infecting hosts at any stage of growth from vegetative up to reproductive stages as described by multiple authors (Cruz et al., 2015; Cruz and Valent, 2017; Gongora-Canul et al., 2020). Long distance dispersal may occur via the transport of infected seed (Urashima et al., 1999). Plants infected during the heading or ripening stage can produce infected seed, and the pathogen can be present in seed that does not appear to be infected (Urashima et al.,1999, 2009). Infected seed that is planted can produce spores which infect the seedling shortly after germination, and the infected seedlings serve as an inoculum for nearby healthy plants (Cruz and Valent, 2017; Faivre-Rampant et al., 2013).

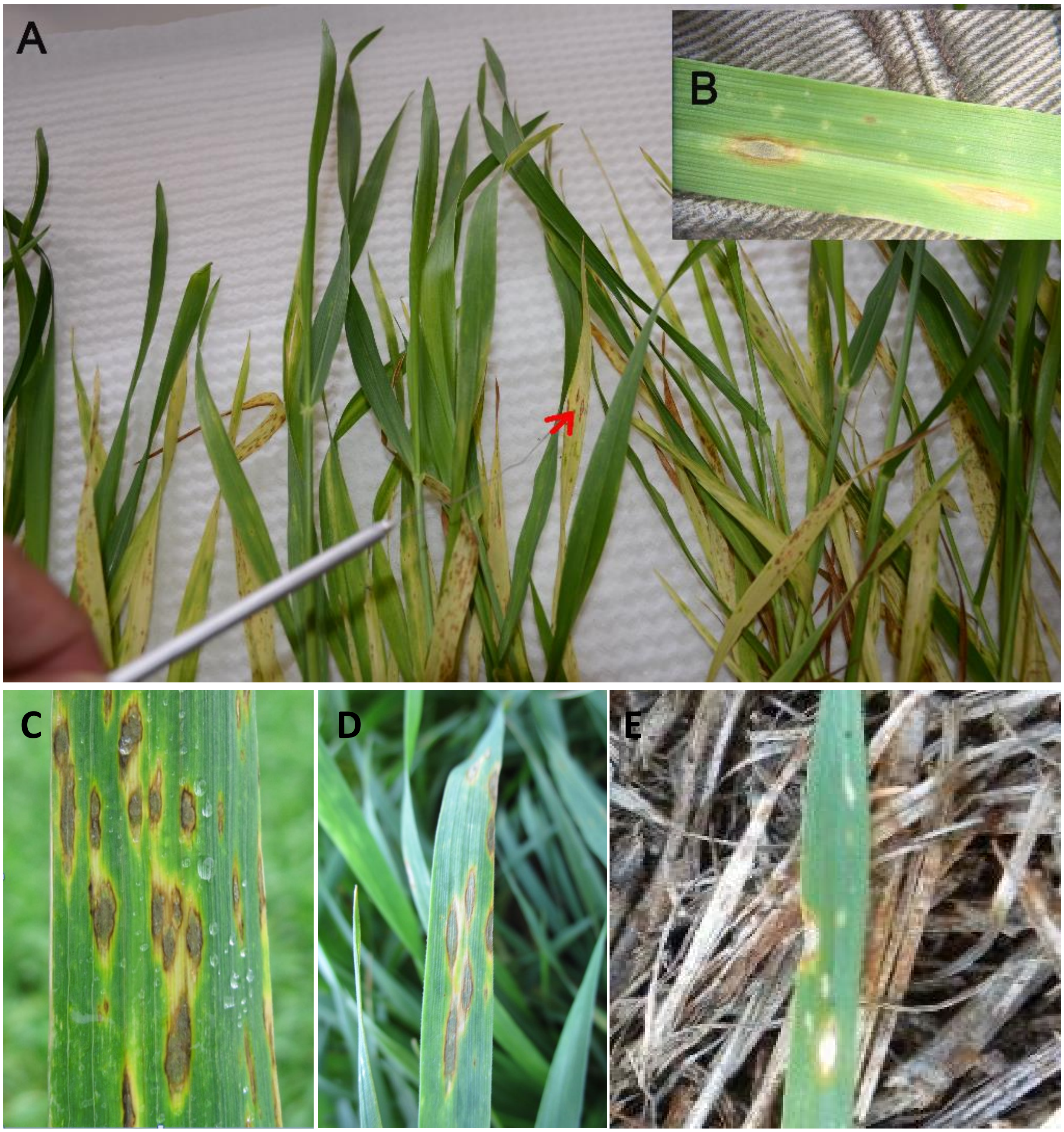

Figure 4. Wheat leaf lesions are typically seen on older leaves (A). Lesions have characteristic grey centers during sporulation (B, C, D) and white to tan centers after spore release (B, E) Photo credits: C.D. Cruz (A, B); Guillermo I. Barea Vargas, Coperagro SRL, Bolivia.(C, D), Nick Talbot (E).

Research demonstrates there are diverse mechanisms that may contribute to wheat blast resistance in certain cultivars (Cruz et al., 2015; Cruz et al., 2016; Cruz and Valent, 2017; Cruppe et al., 2020; Fernandez-Campos et al., 2020; Gongora-Canul et al., 2020). Currently, the major genetic source of resistance for wheat blast is based on the 2NS translocation from the wheat wild relative, *Aegilops ventricosa* (Cruppe et al., 2020). Cultivars without this translocation are more susceptible to the disease (Cruppe et al., 2020).

Figure 5. MoT conidia, magnified 40X (left). Visible conidia on a wheat seed husk (right). Photo: C. D. Cruz, Purdue University.

Magnaporthe oryzae pathotypes have the ability to gain pathogenicity on new hosts as a result of genetic mutation (Cruz and Valent, 2017; Tosa et al., 2016). Wheat blast is believed to have emerged as the result of a 'host jump' in South America (Inoue et al., 2017; Tosa et al., 2016).

Known Hosts

The *Magnaporthe oryzae* complex infects many grass species (Valent et al., 2013). *Magnaporthe oryzae Triticum* pathotype has a wide range of hosts in the Poaceae family, including some cultivated plants, but economic damage is only reported in wheat (Urashima and Silva, 2011; Valent et al., 2013). Weeds and grasses adjacent to wheat fields may become infected with MoT and may serve as an inoculum for healthy wheat plants (Cunfer et al., 1993; Perelló et al., 2015). However, the relative susceptibility of weed hosts to MoT and their importance in the spread of this pathogen is not well known.

The host list below includes cultivated and wild plants that 1) are infected by the pathogen under natural conditions, and 2) have primary evidence for infection documented in the literature. Economically important plants are highlighted in bold.

Preferred host

Triticum aestivum **(wheat)*** (Igarashi et al., 1986).

Other hosts

Avena fatua (wild oat)*, *A. strigosa* (black oat)*, *Brachiaria* spp. (signalgrass), *Bromus catharticus* var. *catharticus* (=*Bromus unioloides*) (prairie grass)*, *Cenchrus echinatus* (southern sandbur)*, *Chloris distichophylla* (frost-resistant Rhodes grass)*, *Cynodon dactylon* (bermudagrass)*, *Cynodon* spp. (bermudagrass)*, *Cyperus rotundus* (purple nut sedge)*, *Digitaria sanguinalis* (hairy crabgrass)*, *Echinochloa crus-galli* (barnyard grass)*, *Echinochloa* spp. (barnyard grass)*, *Eleusine indica* (cockspur grass)*, *Eleusine* spp. (cockspur grass)*, *Elionurus candidus*, ***Hordeum vulgare*** **(barley)*,** *Lolium multiflorum* (Italian ryegrass)*, *Lolium perenne* (perennial ryegrass)*, *Panicum maximum* (Guinea ryegrass)*, *Rhynchelytrum repens* (natal grass)*, *Sorghum sudanense* (sudangrass)*, *Setaria* spp. (foxtail)*, *Stenotaphrum secundatum* (buffalo grass)*, *Triticum* spp. x *Secale* spp. (triticale)* (Cruz, 2013; Cunfer et al., 1993; Kohli et al., 2011; Lima and Minella, 2003; Urashima and Silva, 2011).

*Hosts with known U.S. distribution (Kartesz, 2015).

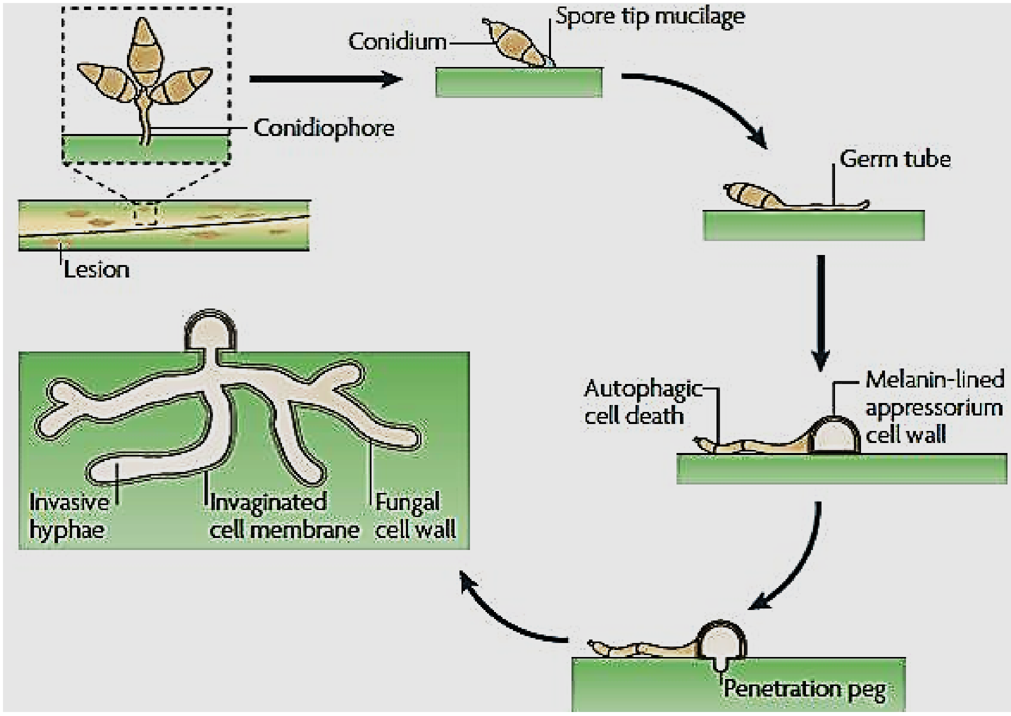

Figure 6. Rice blast disease cycle. Conidiophores are carried to new hosts via splashing water and/or moist air. On the new host, water absorption generates the tremendous turgor pressure required to puncture and enter the plant tissue. Next, specialized invasive hyphae colonize the rice cell with lesions appearing 72–96 hours after infection (used with permission from Wilson and Talbot (2009)).

Pest Importance

Wheat is one of the most valuable crops in the United States. In 2017, wheat was planted on over 46 million acres of land in the continental United States (NASS, 2018). From 2015-2017, an average of 2 billion bushels of wheat with a value of about $9 billion was produced per year in the United States. In 2017 alone, wheat was planted on over 46 million acres of land in the continental United States (NASS, 2018). A large portion of the U.S. wheat crop is destined for export. From 2014-2018, the average value of total U.S. wheat exports ranged from $5-8 billion (FAS, 2020).

Wheat is also a vital crop worldwide, and crop failures are a potential threat to food security. In Bangladesh, an outbreak of wheat blast in 2016 spread through more than 15,000 hectares (37,000 acres) of wheat-cultivated areas of the country, and losses of up to 100% occurred in some fields (BARI, 2016; Islam et al., 2016). After this outbreak, farmers were directed by the Bangladeshi government to plant alternate crops (Islam et al., 2019). Over last four years, wheat blast spread to 12 new districts in Bangladesh and poses a serious threat to food security of this densely populated country. A presumed detection of wheat blast in West Bengal of India (bordering Bangladesh) led to a significant government response, including a wheat growing ban in the region for three consecutive years (Islam et al., 2019). Wheat blast is also a threat to over 3 million hectares (7.4 million acres) of wheat-growing areas in South America, and outbreaks have caused yield losses of up to 100% (CABI, 2019).

The wheat blast fungus is listed, under the synonyms *Pyricularia grisea* and *P. oryzae*, as a harmful organism in Egypt, French Polynesia, Israel, and New Caledonia (PExD, 2020). There may be trade implications with these countries if the fungus becomes established in the United States.

Known Vectors (or associated insects)

Magnaporthe oryzae Triticum pathotype is not a known vector, is not known to be vectored, and is not associated with any organisms.

Known Distribution

Asia: Bangladesh
South America: Northern Argentina, Bolivia, Brazil, Paraguay
(Islam et al., 2016; Islam et al., 2019; Kohli et al., 2011; Urashima and Silva, 2011)

Wheat blast has been reported in India (Islam et al., 2019), but the records were not officially confirmed.

In 2011, a fungal pathogen was isolated from a single wheat head in Kentucky and found to be a strain of *Magnaporthe oryzae* (Farman et al., 2017). However, genetic analysis indicated that the isolate was not the *Triticum* pathotype and was instead more closely related to MoL (Farman et al., 2017). The Kentucky wheat isolate is likely native to the United States and is not severely pathogenic to wheat (Farman et al., 2017).

Pathway

Magnaporthe oryzae Triticum pathotype is seedborne and capable of long distance human-mediated dispersal (Goulart and Paiva, 1991; Urashima et al., 1999). According to a genetic analysis, the MoT pathotype that caused the 2016 outbreak in Bangladesh came from South America (Islam et al., 2016;Malaker et al., 2016), which is about 9,000 miles away. The pathogen was likely transported on infected seed or grain.

Previously, the United States imported wheat from Brazil as part of the international grain trade (Valent et al., 2013). However, the import of *Triticum* spp. seed is currently prohibited from all countries where MoT is known to be present with the exception of Argentina (USDA, 2020). Since 2010, there have been 7 shipments of *Triticum aestivum* seed material from Argentina, containing a total of 169kg of seed (PestID, 2020). The movement of infected host material through international travel and commerce is another potential pathway of wheat blast disease dispersal.

Wheat breeding programs, which involve movement of wheat planting material and seed, may also be a pathway risk for international movement of MoT (Pedley, 2020).

Use the USDA manuals listed below to determine 1) if host plants or material are allowed to enter the United States from countries where the organism is present; and 2) what phytosanitary measures (e.g., inspections, phytosanitary certificates, post entry quarantines, mandatory treatments) are in use. These manuals are updated regularly.

Plants for Planting Manual: This manual is a resource for regulating imported plants or plant parts for propagation, including buds, bulbs, corms, cuttings, layers, pollen, scions, seeds, tissue, tubers, and like structures.
https://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/plants_for_planting.pdf

Treatment Manual: This manual provides information about treatments applied to imported and domestic commodities to limit the movement of agricultural pests into or within the United States.
https://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/treatment.pdf

Potential Distribution within the United States

Wheat is cultivated in all 50 states. In 2017, the top wheat growing states included Colorado, Idaho, Illinois, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, Oklahoma, Oregon, South Dakota, Texas, and Washington, each with over 500,000 acres of wheat cultivation (NASS, 2018).

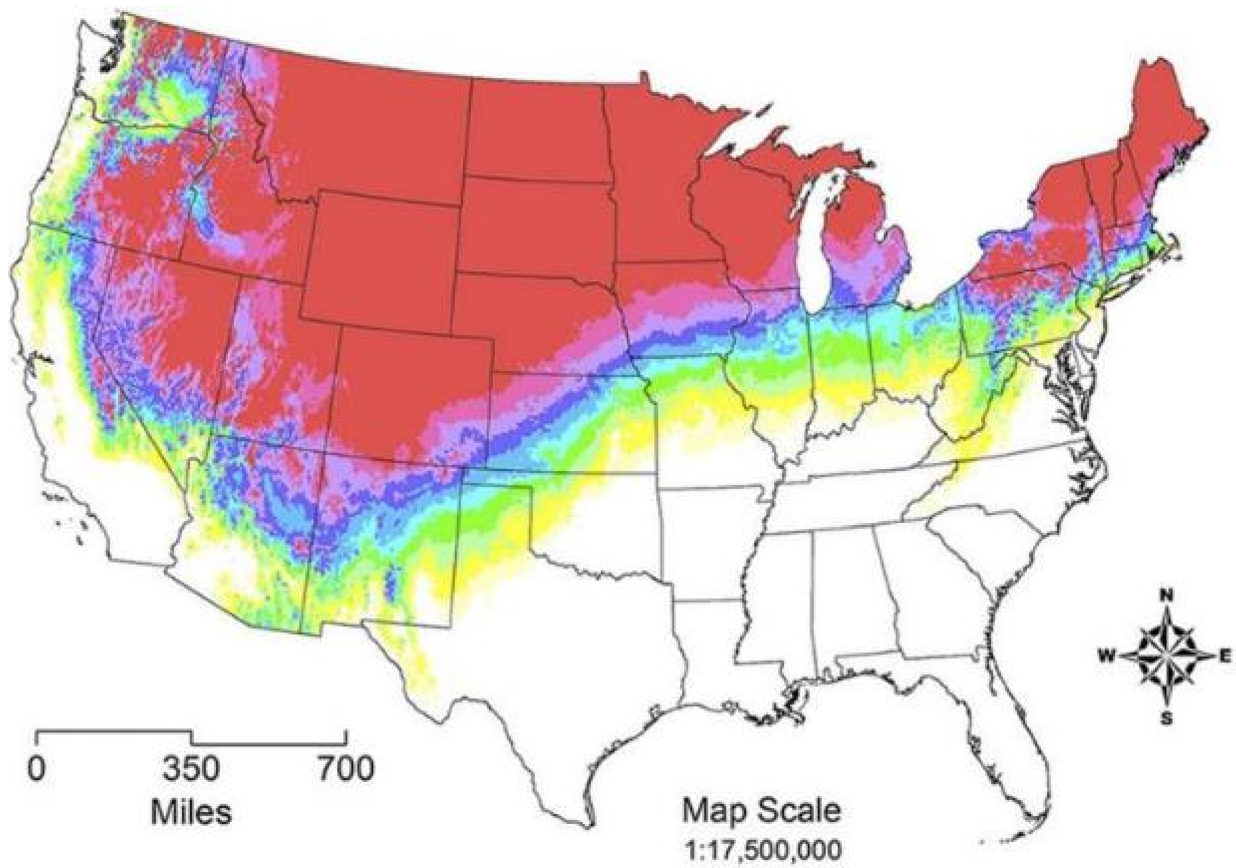

Figure 7. Areas where MoT is likely to overwinter (white), and areas where overwintering is unlikely based on average low temperatures (red). The pathogen may or may not overwinter in the transition zone between these areas (yellow, green, purple, pink). This initial model was based on US weather from 1997 to 2006 (courtesy of Cruz, 2013, Cruz et al., 2016).

A temperature model (Fig. 7) shows that southern states are most vulnerable to MoT based on climatic suitability (Cruz et al., 2015; Cruz, 2013; Cruz et al., 2016). The top wheat producing states in areas with high climatic suitability for MoT (Fig. 7) are Oklahoma, Texas, Kentucky, North Carolina, Tennessee, and Missouri (NASS, 2018). Based on this preliminary climate suitability and forecasting analysis using weather data spanning 1997-2006, all of U.S. Soft Red Winter Wheat (used for cakes and cookies) and half of U.S. Hard Red Winter Wheat (used for bread) are at risk. The pathogen is unlikely to overwinter in northern states but may still spread there during the growing season. The forecasting model did not include potential impacts from climate change.

Survey and Key Diagnostics

Approved Methods for Pest Surveillance*

For the current approved methods and guidance for survey and identification, see Approved Methods for Pest Surveillance on the CAPS Resource and Collaboration Site, at https://caps.ceris.purdue.edu/approved-methods.

Easily Mistaken Species

Wheat blast symptoms closely resemble those of another type of wheat spike infection, Fusarium head blight (FHB) (Fig. 8), which is caused by *Fusarium* spp. fungi that are prevalent in the United States (Schmale and Bergstrom, 2010; Valent et al., 2013). Due to the similar symptoms of these two diseases, wheat blast may be overlooked in the field. Close examination and training are essential to differentiate between wheat blast and FHB (Valent et al., 2013). Wheat blast causes spike bleaching only above the point of infection and produces spore-producing gray lesions at the point of infection (Valent et al., 2013). Conversely, spikes infected by FHB may become bleached above and below the point of infection (Wise and Woloshuk, 2010) and may contain pink to orange masses of spores (Valent et al., 2013; Wise and Woloshuk, 2010).

Figure 8: Fusarium Head Blight – with inset showing masses of orange fungal spores (left). Wheat Blast – with inset showing spikelets removed at the point of head death show gray fungus/spores (right). Photo credits: Erick De Wolf, KSU Extension Publication MF3458 (left); Guillermo I. Barea Vargas (right).

The different pathotypes of *M. oryzae* are morphologically indistinguishable and have some common hosts (Valent et al., 2013). MoL causes gray leaf spot disease in annual/perennial ryegrass (*Lolium perenne*) in the United States (Valent et al., 2013), and was also found in a wheat spike in Kentucky (Farman et al., 2017). Although MoL is not a severe pathogen on wheat, individual infected wheat heads appear identical to MoT-infected heads, and the pathotype of isolated strains must be assessed using the MoT-specific diagnostic protocol (Yasuhara-Bell et al., 2018) and by whole genome sequencing (Gladieux et al., 2018). MoO causes rice blast in the United States but is not pathogenic to wheat (Couch et al., 2005).

Magnaporthe oryzae and the congener *M. grisea* were previously thought to be of the same species (Rossman et al., 1990). However, a subsequent phylogenetic analysis led to the conclusion that *M. oryzae* is a distinct species (Couch and Kohn, 2002). These two species are morphologically indistinguishable but can be distinguished by PCR (Couch and Kohn, 2002; Harmon et al., 2003).

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