United States Department of Agriculture

Animal and Plant Health Inspection Service

Plant Protection and Quarantine

New Pest Response Guidelines

Teleomorph: *Magnaporthe oryzae* B.C. Couch *Triticum* pathotype; Anamorph: *Pyricularia oryzae* Cavara

Wheat Blast

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First Edition Issued 2015

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Cover Image

Magnaporthe oryzae on *Triticum* sp. causing bleaching of wheat head (image courtesy of Guillermo Barea, Norfield SRL, Santa Cruz, Bolivia)

Chapter

1

Introduction

Magnaporthe oryzae B. C. Couch is a heterothallic ascomycetous fungal pathogen (Maciel, 2011; Valent *et al.*, 2013) that causes blast disease on a variety of graminaceous plants including wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.) and barley (*Hordeum vulgare* L.) (Igarashi *et al.*, 1986; Lima and Minella, 2003; Valent and Chumley, 1991). Wheat blast was first identified in the northern region of the Paraná State of Brazil in 1985 (Igarashi *et al.*, 1986) and is now present in other South American countries.

For information regarding the use of this document, refer to *Appendix A: How to Use the Guidelines* on page A-1.

Chapter

2

Taxonomy

Cavara (1891) first described *P. oryzae* on rice (*Oryza sativa* L.) and *Dactylaria parasitans* (= *Pyricularia grisea* (Cooke) Saccardo, 1880) on crabgrass (*Digitaria* spp.) (Cavara, 1891). *Pyricularia oryzae* was described as causing rice blast in 1891. Controversy has since arisen over whether the species can be reliably separated based on morphological features (Suzuki, 1965) or host specificity (Asuyama, 1965; Sprague, 1950). Padwick (1950) reported seven species on the Gramineae (Poaceae), three on Zingiberaceae and one on Cannaceae. Sprague (1950) retained *P. oryzae* for the species attacking rice and *P. grisea* for that attacking monocots other than rice.

The teleomorphic states of these two species have not been found in nature. Hebert (1971) described the teleomorph *Ceratosphaeria grisea* T.T. Hebert based on an *in vitro* cross between isolates of the anamorph *P. grisea* from *D. sanguinalis.* Barr (1977) transferred the genus to *Magnaporthe*. Teleomorphs produced in crosses of *P. oryzae* isolated from rice are morphologically identical to *M. grisea* (Couch and Kohn, 2002). Based on the morphological similarity of *P. oryzae* isolates from rice, *P. grisea* isolates from different grass hosts and the interfertility among isolates from rice and other grasses, Rossman *et al.* (1990) considered *P. oryzae* a synonym of *P. grisea*.

Rossman *et al.* (1990) stated that *P. grisea* Saccardo = *P. oryzae* Cavara is the correct classification of the anamorph that causes blast disease on rice and gray leaf spots on other monocots, whereas *Magnaporthe grisea* (Hebert) Barr is the correct name for its teleomorph (Rossman *et al.*, 1990). Recent molecular genetic studies indicate that *P. grisea* exists as a number of genetically distinct clonal (asexually reproducing) populations that result from strong selection to maintain host specificity and perhaps geographic isolation (Shull and Hamer, 1994).

Additional work was conducted by Couch and Kohn (2002) who performed a multilocus phylogenetic analysis to distinguish *M. oryzae* as a new species from *M. grisea*. Although these two species are morphologically indistinguishable, they are pathogenic on different isolates: *M. oryzae* on isolates of cultivated cereals and *M. grisea* on isolates of wild grasses including *Digitaria* spp. (Couch and Kohn, 2002).

Couch and Kohn (2002) proposed the name *M. oryzae* for the isolates of *Magnaporthe* from rice (*O. sativa*) and closely related isolates from other crops, including wheat, barley, finger and foxtail millet and many other grasses. The name *M. grisea* (anamorph *P. grisea*) is now applied only to the isolates from *Digitaria.* Polymerase chain reaction (PCR)-based methods have been developed to detect *M. oryzae* (Couch and Kohn, 2002; Harmon *et al.*, 2003).

Magnaporthe oryzae is divided into host-specialized populations including the *M. oryzae Oryza* pathotype (Moo) causing rice blast; the *M. oryzae Triticum* pathotype (Mot) causing the wheat blast disease currently restricted to South America and—in the U.S. and Japan—the *M. oryzae Lolium* pathotype (Mol) causing gray leaf spot (GLS) disease in annual/perennial ryegrass (*Lolium perenne*) and tall fescue (*Festuca arundinacea*) (Valent *et al.*, 2013).

The taxonomic state of wheat blast is again under scrutiny. *Magnaporthe oryzae* and *M. grisea* were recently found to be non-congeneric to the type species of *Magnaporthe*, *M. salvinii*, based on phylogenetic analysis, ecological and morphological characteristics (Luo and Zhang, 2013). Therefore, this fungus requires placement in another genus. Under the Melbourne Code Article 59.1, legitimate names published prior to 1 January 2013 compete equally for priority, and the sole correct name is now the earliest legitimate name, regardless of life history (McNeill *et al.*, 2012; Zhang *et al.*, 2013). However, Article 57.2 states that prior to 1 January 2013, at which time both teleomorph-typified and anamorph-typified names were widely used, “an anamorph-typified name that has priority is not to displace the sexual name(s) unless and until a proposal to reject the former or to deal with the latter has been submitted and rejected” (McNeill *et al.*, 2012; Zhang *et al.*, 2013).

The *Pyricularia* type species, *P. grisea*, is congeneric with the anamorph *P. oryzae* (Couch and Kohn, 2002; Zhang *et al.*, 2013). Therefore, the scientific name could revert to the previously used name of *P. oryzae,* or *M. oryzae* could be considered for conservation (Zhang *et al.*, 2013). A proposal would be required to conserve the generic name *Magnaporthe* but with a different type species, *M. oryzae* (Zhang *et al.*, 2013). Excessive name changes would be necessary in the genus *Pyricularia* if *Magnaporthe* were conserved (Zhang *et al.*, 2013). The reverse would require far fewer name changes.

Currently, *P. oryzae* is listed under the USDA Agricultural Research Service (ARS) Systematic Mycology & Microbiology Laboratory as the correct name for wheat blast (Farr and Rossman, 2013), but discussions are ongoing, and a poll is being conducted by the *Pyricularia*/*Magnaporthe* working group to determine which name should be accepted (Luo and Zhang, 2013; Zhang *et al.*, 2013). Once the issue is resolved, a formal list of names will be sent to the General Committee

of Nomenclature (Luo and Zhang, 2013; Zhang *et al.*, 2013).

The current taxonomy can be located in the Catalogue of Life, Fungal Databases and MycoBank (Farr and Rossman, 2005; MycoBank, 2015; Roskov *et al.*, 2015).

The taxonomic classification of wheat blast is presented in Table 2-1.

Table 2-1 Classification of *M. oryzae*

Rank	Taxon
Kingdom	Fungi
Phylum	Ascomycota
Class	Sordariomycetes incertae sedis
Order	Magnaporthales
Family	Magnaporthaceae
Genus	*Magnaporthe*
Species	*Magnaporthe oryzae* Couch
Pathotype	*Magnaporthe oryzae Triticum* pathotype

Synonyms

Pyricularia oryzae Cavara 1891

Variant spelling *Piricularia oryzae* Cavara 1891

≡ *Dactylaria oryzae* (Cavara) Sawada 1916

= *Magnaporthe oryzae* B.C. Couch 2002

See previous text for historical synonyms

Common Names

- Wheat blast disease
- Brusone (Brazil)

Chapter 3

Identification

Species Description/Morphology

Conidia

Conidiophores are single or clustered, simple, infrequently branched and exhibit sympodial growth (Subramanian, 1968). At the tip of the conidiophore, conidia form at points that ascend sympodially and in succession, narrowed toward the tip, pyriform to obclavate, rounded at the base, 2-septate, rarely 1- or 3-septate, hyaline to pale olive, primarily 19–23 × 7–9 µm with a distinct bulging basal hilum (Subramanian, 1968) (Figures 3-1 and 3-2).

Figure 3-1 Conidia magnified 40× (photo courtesy of C. Cruz, Department of Plant Pathology, Kansas State University)

Figure 3-2 Conidia on wheat seed husk (photo courtesy of C. Cruz, Department of Plant Pathology, Kansas State University)

Asci

Asci are eight-spored, cylindrical to clavate, hyaline, primarily 60–90 × 10–12 µm (55–110 × 8–15 µm), rounded or slightly truncated above, unitunicate, short-stipitate, bases transitory at maturity and asci freed into cavity; apical ring distinct (Hebert, 1971; Yaegashi and Udagawa, 1978). Biseriate ascospores, hyaline, guttulate, fusiform, curved, primarily 18–23 × 5–7 µm (16–25 × 4–8 µm), triseptate, slight constriction at septa, smooth-walled, expelled from ostiole in a gelatinous mass at maturity, germination at one or both ends (Hebert, 1971; Yaegashi and Udagawa, 1978). Paraphyses indistinct, inflated at base, hyaline, septate, unbranched, soon deliquescent (Yaegashi and Udagawa, 1978).

Perithecia

Perithecia occur singly or in groups, nonstromatic, base spherical to subspherical, partially or wholly embedded in substrate, globose, dark brown to black, primarily 100–180 µm (80–260 µm) in diameter, 500–1200 µm long (including neck) (Hebert, 1971; Yaegashi and Udagawa, 1978). Long cylindrical neck, sometimes fused, pale brown, 55–160 µm in diameter, up to 1,100 µm long, wide-ostiolate, walls of textura oblita, interior lined with long threadlike deliquescent periphyses (Hebert, 1971; Yaegashi and Udagawa, 1978). Coriaceous peridium is dark brown, 8–12 µm thick, opaque, pseudoparenchymatous with an outer layer consisting of short brown angular cells 4–12 × 4–8 µm (Hebert, 1971; Yaegashi and Udagawa, 1978).

Diagnostics

Polymerase chain reaction (PCR) has been used to detect *M. oryzae* in infected perennial ryegrass (Harmon *et al.*, 2003). The development of PCR-based diagnostic tools to identify and differentiate wheat isolates from ryegrass isolates is ongoing (Valent *et al.*, 2013).

Similar Species

Rapid identification of wheat blast in the U.S. can prove difficult due to wheat spike infection that resembles *Fusarium* spp. (and causes Fusarium head blight, FHB), a disease prevalent in the U.S. (Valent *et al.*, 2013). Due to the similar symptoms of these two diseases, wheat blast may go undetected when first appearing in the field. Close examination and training are essential to differentiate between FHB and wheat blast because both diseases affect the head and cause bleaching (Valent *et al.*, 2013).

When the rachis is infected with FHB, spikelets above and below the point of infection may also become bleached (Wise and Woloshuk, 2010), and the infected spikelets may contain pink to orange masses of spores (Valent *et al.*, 2013; Wise and Woloshuk, 2010). Wheat blast attacks the rachis causing bleaching only above the point of infection and sporulating gray lesions (Valent *et al.*, 2013).

Chapter

4

Biology

Life Cycle

Wheat blast appears to follow the same disease cycle as the well-studied rice blast (Tufan *et al.*, 2009). Asexual reproduction occurs via mitotically produced conidia from lesions on above-ground plant parts (Couch *et al.*, 2005). One lesion can produce 2,000–6,000 conidia/day for up to 14 days, with numerous infection and reproduction cycles during a single growing season (Couch *et al.*, 2005; Ou, 1985). The optimum temperature and wetting period for spore formation ranges from 25–30 °C, and spike wetness from 25–40 hours (Cardoso *et al.*, 2008). The asexual life cycle is described in Figure 4-1.

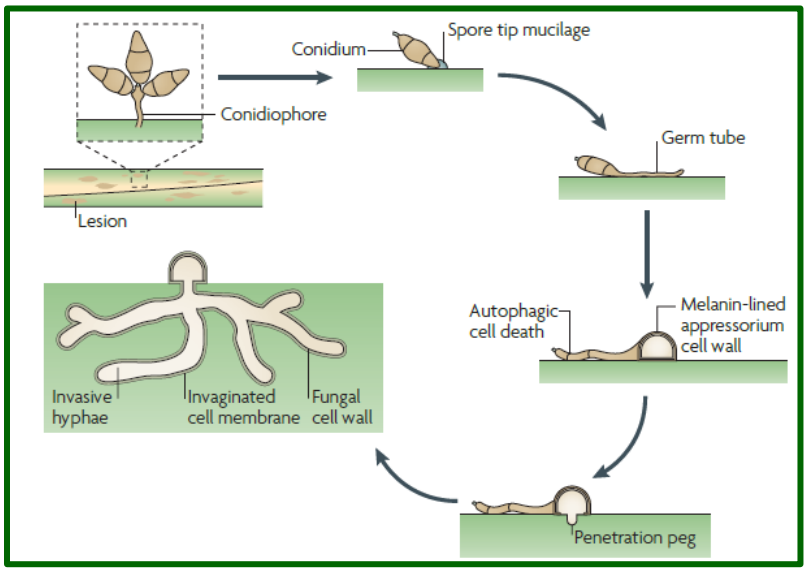

Figure 4-1 Rice blast disease cycle. A pale gray, hyaline, asexual three-celled conidium lands on a host, produces a germ tube that differentiates into a single-celled appressorium. The conidium goes through autophagy (cell degradation), and the conidial contents are moved into the maturing appressorium. The appressorium melanizes and absorbs free moisture from the plant surface. Water absorption generates the tremendous turgor pressure required by the fungal penetration peg to puncture the host outer surface and enter the plant tissue. Next, specialized invasive hyphae colonize the rice cell with lesions appearing 72–96 hours after infection. Humid conditions are needed for both appressorial penetration and sporulation. Aerial conidiophores are carried to new hosts via splashing water and moist air (image courtesy of Wilson and Talbot (2009)).

The sexual cycle of *M. oryzae* has been observed in the laboratory when some strains undergo sexual crosses, but has not been observed in nature on any host (Yaegashi and Udagawa, 1978).

Hosts

All but one of the *M. oryzae* hosts, belong to the family Poaceae. *Avena strigosa* Schreb. is listed as a host in much of the literature because it is susceptible to *M. oryzae*. Recent DNA analysis indicated that *A. strigosa* may not be in the same pathotype as wheat blast, *Triticum*, due to its ability to form a homogenous and genetically distinct group of its own, unlike other hosts including wheat, triticale, rice and barley (Urashima and Silva, 2011). Table 4-1 provides the current reported hosts of the *M. oryzae Triticum* pathotype. The *M. oryzae* complex is known to infect over 50 grass species (Valent *et al.*, 2013).

Table 4-1 Reported hosts of the *Magnaporthe oryzae Triticum* pathotype

Family	Scientific name	Common name	References
Cyperaceae	*Cyperus rotundus* L.	purple nut sedge	Maciel (2013)
Poaceae	*Avena fatua* L.	wild oat	Perelló *et al*. (2015)
	Avena sativa L.	oat	Urashima and Silva (2011)
	Avena strigosa Schreb.	black oat	Urashima and Silva (2011)
	Brachiaria spp.	signalgrass	Fernandes (2013) Maciel (2013)
	Bromus catharticus Vahl var. *catharticus* (=*Bromus unioloides* Kunth)	prairie grass	Perelló *et al*. (2015)
	Cenchrus echinatus L.	southern sandbur	Fernandes (2013) Maciel (2013)
	Chloris distichophylla Lag.	frost-resistant Rhodes grass	Fernandes (2013) Maciel (2013)
	Cynodon dactylon (L.) Pers.	bermudagrass	Perelló *et al*. (2015)
	Cynodon spp.	bermudagrass	Maciel (2013)
	Digitaria sanguinalis (L.) Scop.	hairy crabgrass	Maciel (2013)
	Echinochloa crus-galli (L.) P. Beauv.	barnyard grass	Perelló *et al*. (2015)
	Echinochloa spp.	cockspur grass	Fernandes (2013) Maciel (2013)
	Eleusine indica (L.) Gaertn.	goosegrass	Fernandes (2013) Maciel (2013)
	Eleusine spp.	goosegrass	Perelló *et al*. (2015)
	Elionurus candidus (Trin.) Hack.		Fernandes (2013) Maciel (2013)
	Hordeum vulgare L.	barley	Cruz (2013) Lima and Minella (2003)
	Lolium multiflorum Lam.	Italian ryegrass	Maciel (2013)
	Lolium perenne L.	English ryegrass	Perelló *et al*. (2015)
	Panicum maximum Jacq.	Guinea grass	Maciel (2013)

	Rhynchelytrum repens (Willd.) C.E. Hubb.	natal grass	Maciel (2013)
	Sorghum sudanense (Piper) Stapf	sudangrass	Maciel (2013)
	Setaria spp.	bristle	Perelló *et al*. (2015)
	Stenotaphrum secundatum (Walter) Kuntze	buffalo grass	Perelló *et al*. (2015)
	Triticum aestivum L.	wheat	Cruz (2013) Valent *et al*. (2013)
	Triticum spp.	wheat	Cunfer *et al*. (1993)
	Triticum spp. × *Secale* spp.	triticale	Kohli *et al*. (2011)

Natural Dispersal

The dissemination of *M. oryzae* occurs primarily via airborne conidia (Ou, 1985; Urashima *et al.*, 2007). Extended dew periods and water droplets accumulated on infected leaves increase spore production and release (Ou, 1985; Suzuki, 1969). Ingold (1964) states that the conidium is likely violently discharged across a short distance when the minute stalk-cell attaching it to the conidiophore bursts. In the absence of wind, most spores are trapped near the ground (Ou, 1985).

Ishiguro *et al*. (2002) conducted dispersal studies on rice and found that spores could travel at least 700 m from an inoculated source and remain viable. Urashima *et al*. (2007) performed additional studies to evaluate conidiospore dispersal using isolates from triticale fields and determined that spores could travel up to 1 km (Urashima *et al.*, 2007).

This pathogen can also be dispersed to new geographic locations through infected seeds (Urashima *et al.*, 1999). Faivre-Rampant (2013) demonstrated that *M. oryzae* was primarily located in the seed coat of contaminated seeds and that spores were produced shortly after germination. Further studies conducted by Faivre-Rampant (2013) determined that rice plants produce infected seeds when inoculated prior to the heading stage (flag leaf fully developed), at the heading stage (flowering/immature panicles) or during the ripening stage (mature panicles). Seedlings from infected seeds, which frequently die, serve as inoculum for adjacent healthy plants (Faivre-Rampant *et al.*, 2013).

Geographic Distribution

Ecological Distribution

Wheat blast was first identified in the northern region of the Paraná State of Brazil in 1985 (Igarashi *et al.*, 1986). This fungus has since spread to other wheat-producing regions of Brazil (Goulart *et al.*, 2007; Urashima *et al.*, 2009): Goiás

(Prabhu *et al.*, 1992), Mato Grosso do Sul (Goulart *et al.*, 1990), Rio Grande do Sul (Picinini and Fernandes, 1990) and Sao Paulo (Igarashi, 1990). Wheat blast was also identified in 1996 in the Santa Cruz department of Bolivia (Barea and Toledo, 1996) and in 2002 in the Alto Paraná and Itapúa departments of Paraguay (Viedma, 2005). In 2007, wheat blast was discovered in the province of Formosa in northeastern Argentina (Cabrera and Gutierrez, 2007; Cruz *et al.*, 2012). The current *M. oryzae* distribution is listed in Table 4-2.

Climate plays a vital role in *M. oryzae* distribution, with the most extensive damage occurring during warm, wet, humid years (Kohli *et al.*, 2011). Continuous rain over several days with temperatures averaging between 18 and 25 °C during flowering, followed by hot, humid, sunny days creates prime conditions for wheat blast epidemics (Kohli *et al.*, 2011). Research conducted by Cardoso *et al*. (2008) demonstrated the lowest blast intensity at 15 °C and the maximum between 25 °C and 30 °C with a wetting period of at least 10 hours. The blast intensity exceeded 85% at 25 °C with 40 hours of wetting (Kohli *et al.*, 2011); thus, this pathogen requires tropical and subtropical temperatures to sporulate and survive.

Table 4-2 Reported worldwide distribution of *M. oryzae*

Geographic region	Country	References
South America	Argentina	Cabrera and Gutierrez (2007) Perelló *et al*. (2015)
	Bolivia	Kohli *et al.* (2011)
	Brazil	Igarashi *et al.* (1986)
	Paraguay	Viedma (2005)
	Uruguay*	Valent *et al.* (2013)

* Detected on barley

Potential Distribution

The *M. oryzae Triticum* pathotype is not known to be established in the United States; however, this pathogen could pose a serious potential threat to U.S. wheat production.

Wheat blast epidemics are described as following numerous days of continuous rain and temperatures from 18−25 °C during flowering, followed by sunny, hot and humid days (Kohli *et al.*, 2011). Freezing temperatures limit the survival of the *M. oryzae Lolium* pathotype (Harmon and Latin, 2003), a close phylogenetic relative of the *M. oryzae Triticum* pathotype. Therefore, the *M. oryzae Triticum* pathotype populations could be limited by overwinter survival in the U.S. (Cruz, 2013).

Cruz *et al*. (2013) presumed that wheat blast survival would be limited by frost occurrence and created threshold maps of 105 or more frost days per year based on 10-year daily climatic data. They predicted that wheat blast would not survive

overwintering in the low-temperature regions but may or may not survive in the overlapping or transition zone. Wheat blast overwinter survival will not likely be limited in the zone encompassing the lower half of the U.S. (Figure 4-2).

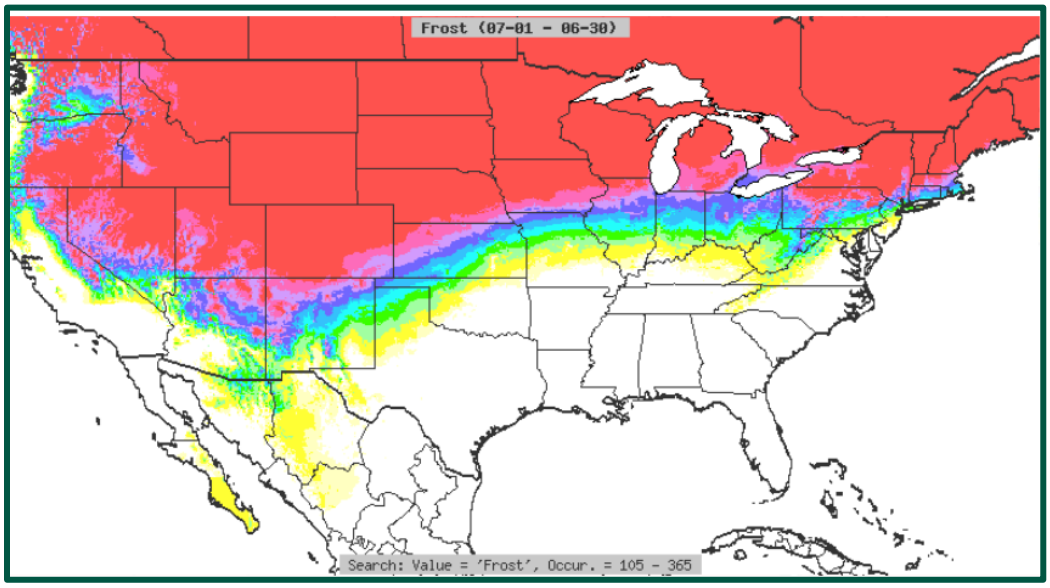

Figure 4-2 Areas with low predicted temperatures capable of preventing the overwinter survival of wheat blast (red) and the zone in which the overwinter survival is not likely limited (white). A transition zone exists in which low temperatures may or may not limit overwinter survival (Cruz, 2013).

Spring wheat is grown in the northern part of the country (Figure 4-3), winter wheat is grown primarily in the mid-west (Figure 4-4), and durum wheat is grown in the northern and western U.S. (Figure 4-5). Further climate suitability studies for the establishment of wheat blast were conducted by Cruz *et al*. (2013) and found that approximately 75% of the areas producing winter wheat in the U.S. are not at risk for wheat blast outbreaks, but in the remaining areas, conditions for wheat blast outbreaks may exist in 1–8 out of every 10 years (Cruz, 2013). Areas in which spring wheat is grown have climates largely unsuitable for wheat blast establishment (Cruz, 2014) Durum wheat areas can be either suitable or unsuitable for wheat blast.

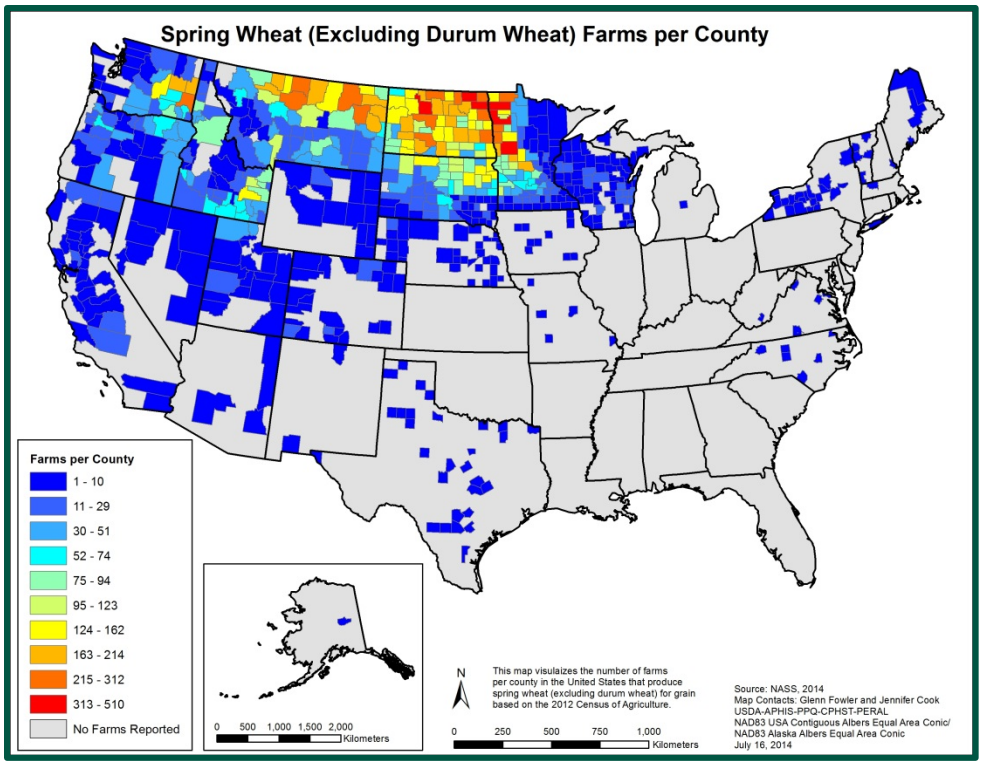

Figure 4-3 Spring wheat farms per county in the U.S. in 2012 (USDA-NASS, 2014b)

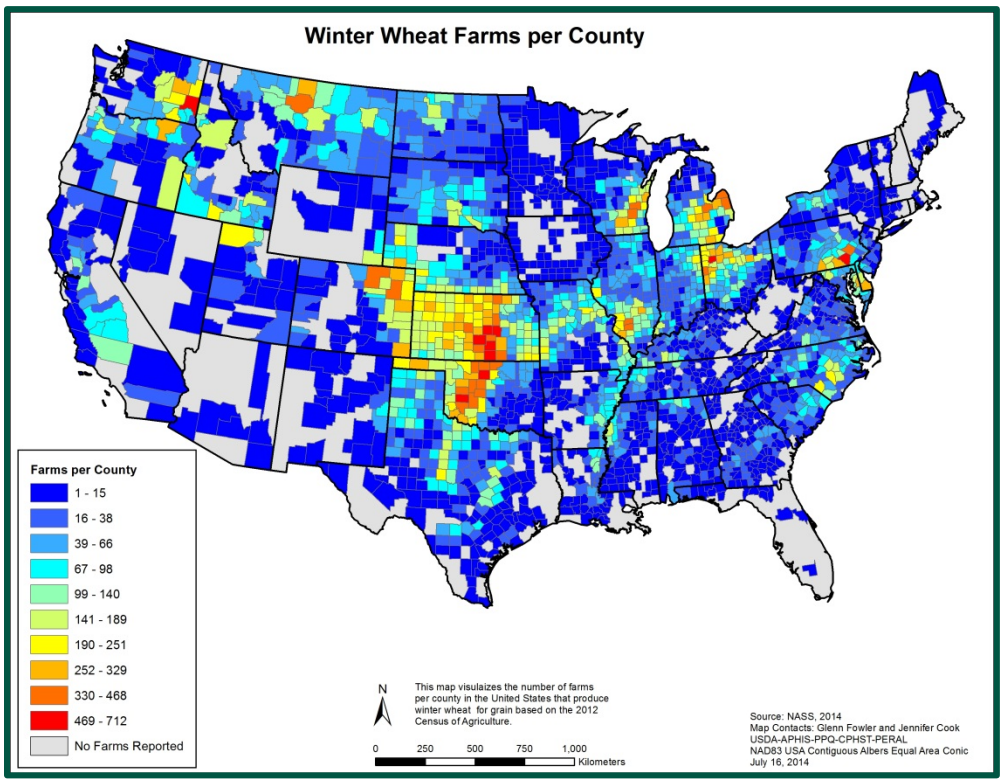

Figure 4-4 Winter wheat farms per county in the U.S. in 2012 (USDA-NASS, 2014c)

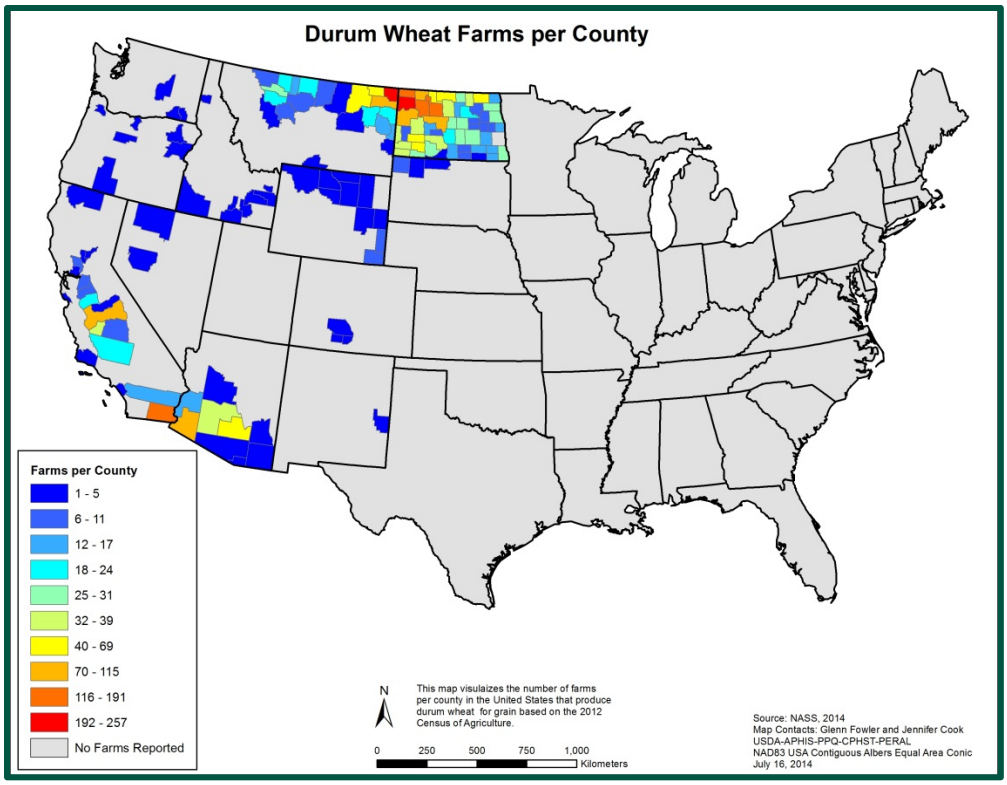

Figure 4-5 Durum wheat farms per county in the U.S. in 2012 (USDA-NASS, 2014a)

Therefore, the areas at greatest risk for wheat blast establishment in the U.S. are located in Alabama, Arkansas, Florida, Georgia, Indiana, Illinois, Iowa, Kansas, Kentucky, Louisiana, Michigan, Mississippi, Missouri, Nebraska, North Carolina, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Virginia and West Virginia (Cruz, 2013) (Figure 4-6). Figure 4-7 presents the probability of a wheat blast outbreak occurring in the aforementioned states.

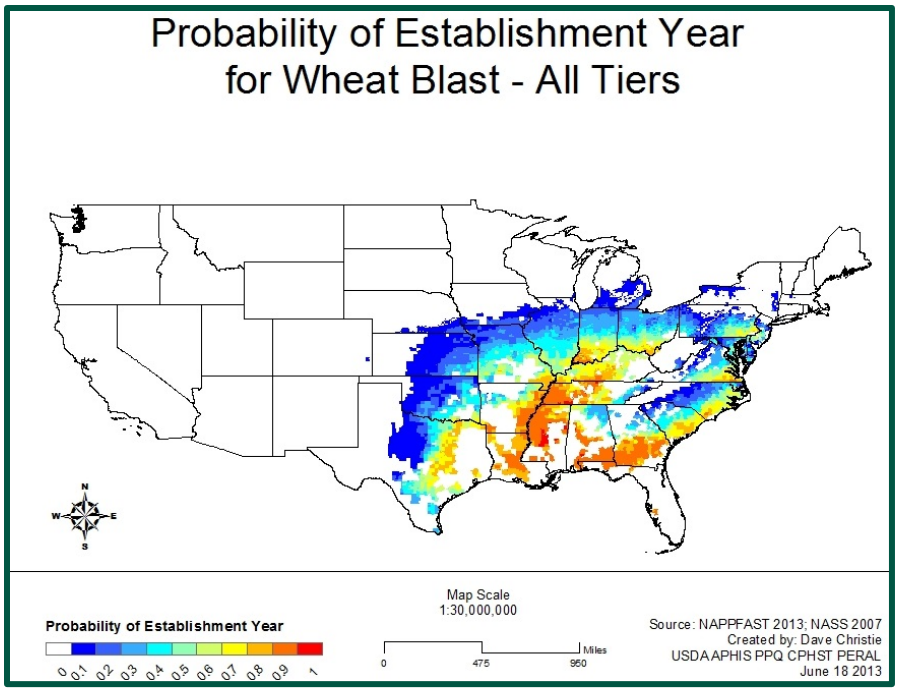

Figure 4-6 Risk map for *Magnaporthe oryzae Triticum* pathotype establishment within the continental United States; risk rankings from 0–1 indicate increased probability of establishment (Map courtesy of USDA-APHIS-PPQ-CPHST-PERAL)

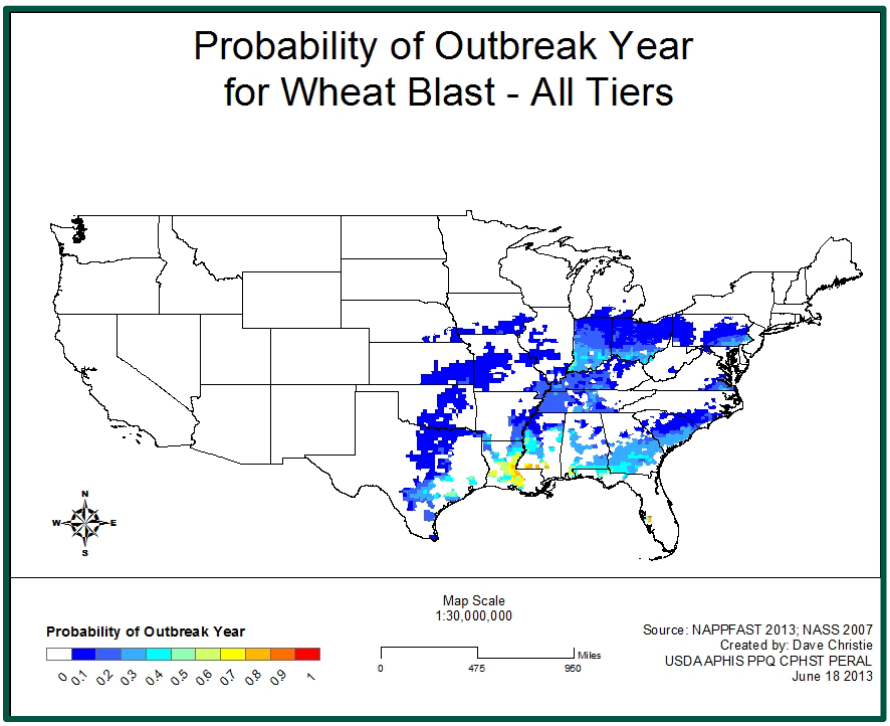

Figure 4-7 Risk map for the probability of *Magnaporthe oryzae Triticum* pathotype outbreak within the continental U.S.; risk rankings from 0–1 indicate increased probability of outbreak (Map courtesy of USDA-APHIS-PPQ-CPHST-PERAL)

Chapter 5

Damage

Signs and Symptoms

All above-ground portions of the wheat plant are susceptible to wheat blast infection, but the most common symptom in the field is head infection, which can occur on the awns, glumes and rachis (Igarashi, 1990; Kohli *et al.*, 2011) (Figure 5-1). A brown to whitish discoloration appears on infected awns, while glumes exhibit elliptical lesions with white to light-brown centers and reddish-brown to dark-gray margins (Igarashi, 1990). An infection of the rachis can cause partial loss to complete death of the head depending on the point of infection (Igarashi, 1990). Typically, all spikelets on the rachis are destroyed above the point of infection and appear bleached (Igarashi, 1990; Urashima *et al.*, 2009) (Figure 5-2). At the infection point, the rachis begins to turn brown to black and later becomes light to dark gray due to heavy sporulation (Urashima *et al.*, 2009). Rachis infection can cause partial or total spike sterility, which can block the translocation of photosynthates to the upper portions of the spike (Cruz, 2013).

Figure 5-1 Head infection on wheat (photo courtesy of C. Cruz, Department of Plant Pathology, Kansas State University)

Figure 5-2 Blast infection on wheat spikelets; detail of rachis infection (photo courtesy of G. Barea)

The size and shape of leaf lesions depend on the age of the plant; younger leaves are more susceptible and exhibit elliptical lesions similar to those of rice blast, while older leaves have smaller, less frequent lesions (Igarashi, 1990). Lesions that are still producing spores appear gray due to the spores and conidiophores and are often ringed with a reddish-brown margin. After sporulation, lesions become straw-colored inside the lesion margin (Igarashi, 1990) (Figure 5-3). Culm, neck and sheath lesions vary in shape from elliptical to elongated, but are similar in size with straw-colored centers and narrow reddish-brown margins (Igarashi, 1990).

Seedling infection can be severe under high humidity and temperature and can result in plant death (Cruz, 2013; Igarashi, 1990). Grain formation can vary from zero to almost normal kernels depending on the growth state during head infection (Igarashi, 1990). Infected grains are typically deformed, small and wrinkled (Valent *et al.*, 2013) (Figure 5-4). Late infection improves grainfill, but fungus can still be isolated from seed that appears healthy. Late infection favors disease transmission (Igarashi, 1990; Urashima *et al.*, 2009; Urashima *et al.*, 1999).

Figure 5-3 Ellipsoid lesions on a wheat leaf exhibiting a gray center (from the color of the spores) with a reddish-brown margin (photo courtesy of G. Barea); note that lesion centers appear straw-colored to white after sporulation has finished

Figure 5-4 Infected (left) and normal (right) kernels (photo courtesy of C. Cruz, Department of Plant Pathology, Kansas State University)

Impacts

Environmental

Introduction of this pathogen could negatively impact the environment. None of the known *M. oryzae Triticum* pathotype hosts present in the U.S. is listed as a species of concern or endangered (USFWS, 2011). Chemical control programs may be initiated if the *M. oryzae Triticum* pathogen is introduced in the U.S., but may negatively impact non-target pests and the environment.

Economic

Globally, wheat accounts for 21% of the world's calories and provides 20% of the protein consumed by an estimated 4.5 billion people in 94 developing countries (NWIC, 2012). Wheat is the most widely grown crop at over 200 million hectares worldwide (Lucas, 2013). The top six wheat-exporting countries and regions are Argentina, Australia, Canada, the European Union (EU), the Former Soviet Union (FSU) and the United States (Taylor and Koo, 2012), with wheat being the third largest crop produced in the United States in 2012 (FAOSTAT, 2014). World wheat production has increased from 521 million tons (1986/87) to 694 million tons (2011/12) (Taylor and Koo, 2012), and the demand for wheat is expected to increase at least 60% by 2050 (Lucas, 2013).

Under favorable conditions, wheat blast can be devastating resulting in 100% yield loss (Kohli *et al.*, 2011). Average temperatures are projected to increase worldwide with global climate change, which could reduce yields during the important grain-filling stage (Asseng *et al.*, 2011). Field experiments conducted by Ferris *et al*. (1998) demonstrated that heat stress of up to 40 °C applied for 12 days before and after anthesis with a temperature gradient tunnel resulted in a 50% reduction in both grain yield and kernels. Additionally, rising temperatures may increase the susceptibility of wheat to blast disease. Failure to enhance wheat production could lead directly to increased food prices, generating global food shortages.

Chapter 6

Pathways

Natural Movement

Recent evidence suggests that some native U.S. strains of the *M. oryzae Lolium* pathotype, which causes GLS on turf grasses, are already able to infect wheat (Gary Peterson and Mark Farman, results unpublished). Gray leaf spot was first reported on annual ryegrass (*Lolium multiflorum)* in Louisiana and Mississippi in 1971 (Bain *et al.*, 1972; Carver *et al.*, 1972) and on tall fescue in North Carolina in 1996 (Fraser, 1996). Gray leaf spot was also reported on perennial ryegrass in Pennsylvania in 1992 (Landschoot and Hoyland, 1992) and has since spread across the U.S. The geographic range of GLS on perennial ryegrass has expanded to California (Uddin *et al.*, 2002) and Nevada (Wong, 2006), Connecticut, Rhode Island (Schumann and Jackson, 1999), Indiana (Latin and Harmon, 2004), Illinois (Pedersen *et al.*, 2000) and Kentucky (Williams *et al.*, 2001) with GLS becoming a major problem in the mid-Atlantic region and south of the Ohio River (Harmon and Latin, 2003). To date, GLS has not been reported in the northern Midwestern states, but occurs intermittently in Iowa, Kanas and Nebraska (Latin and Harmon, 2004).

In 2011, University of Kentucky researchers detected wheat blast on a single wheat head at a research plot in Princeton, KY (Pratt, 2012). This finding represents the first known occurrence of wheat blast outside of South America. Further genetic analysis concluded that this strain was more closely related to the native *Lolium* strains from the U.S. than to the *Triticum* isolates from South America (Farman, Pedley and Valent, unpublished).

Currently in the U.S., peak GLS periods do not correspond to the heading period of U.S. wheat, decreasing the potential for cross inoculation. However, the unknown environmental impact of global climate change on various wheat-producing regions raises the possibility that conditions in the U.S. may approach the warm, humid environments that promote wheat blast epidemics.

Human-Assisted Spread

The risk of introducing aggressive wheat blast strains from South America is high due to both the seed-borne nature of this fungus (Goulart and Paiva, 1991) and the increased trade and travel to the U.S. Although the U.S. is among the principal global producers (54 million tonnes in 2011 (Taylor and Koo, 2012)) and exporters of wheat (32.8 million tonnes in 2011 (FAOSTAT, 2014), it also imports wheat from Brazil as a part of the international grain trade (USDA-FAS, 2013). Thus, contaminated seed could be unwittingly introduced to non-endemic countries and become a crucial source of inoculum for introduction.

Chapter 7

Survey

Survey Types

Plant regulatory officials will conduct detection, delimiting and monitoring surveys for *M. oryzae*. A *Detection Survey* will be conducted to ascertain the presence or absence of *M. oryzae* in an area in which it is not known to occur. After a new detection in the United States, or when detection in a new area is confirmed, a *Delimiting Survey* should be conducted to define the extent and geographic location of the disease. In addition, when a control procedure is applied, its effectiveness should be measured via a *Monitoring Survey*.

Table 7-1 Decision table for selecting survey type

If you:	Use this type of survey:
are not sure whether the pest is present at a location	*Detection Survey* as described on page 7-3. Collect specimens and consult with the authorities listed in *Appendix D* to confirm identification.
know that the pest is present and need to define its geographic location	*Delimiting Survey* after Initial United States Detection as described on page 7-8. Collect specimens and consult with the authorities listed in *Appendix D* to confirm identification.
have applied control measures and need to study their effectiveness	*Monitoring Survey* on page 7-12. Collect specimens and consult with the authorities listed in *Appendix D* to confirm identification.

Survey Preparation

Preparation, Sanitization and Clean-Up

This section provides information that will aid personnel in preparing to conduct a survey, procedures to follow during a survey and instructions for proper cleaning and sanitizing of supplies and equipment after the survey is finished.

1. Prior to beginning a survey, determine whether there have been recent pesticide applications that would render it unsafe to inspect the plants and leaf litter. Contact the property owner or manager and ask if there is a re-entry period in effect due to pesticide application. Look for posted signs

indicating recent pesticide applications, particularly in commercial fields or nurseries.

2. Conduct the survey during a time when infection should be apparent. General surveys should focus on months in which host plants are easily accessible, during active growing phases and when symptoms are known to be expressed.
3. Obtain permission from the landowner prior to entering a property.
4. Determine whether quarantines for other pests or crops are in effect for the survey area. Comply with any and all quarantine requirements.
5. When visiting the area to conduct surveys or take samples, everyone must take strict measures to prevent contamination by *M. oryzae* or other pests between properties during inspections.
6. Prior to entering a new property, ensure that clothing and footwear are clean and free of pests, soil and litter to avoid moving soil-borne pests from one property to another.
7. Wash hands with approved antimicrobial soap. If not using an antimicrobial soap, wash hands with regular soap and warm water to remove soil and debris. Then, use an alcohol-based antimicrobial lotion with an equivalent of 60% ethyl alcohol. If hands are free of soil or dirt, the lotion can be applied without washing. Unlike some antimicrobial soaps, antimicrobial lotions are less likely to irritate the hands and thereby improve compliance with hand hygiene recommendations.
8. Gather all supplies. Confirm that equipment and tools are clean and sanitized. When taking plant samples, disinfect tools with a 5% bleach solution or other approved sanitizing solution to avoid spreading diseases or other pests. A brief spray to runoff or immersion of the cutting portion of the tool in a 5% solution of sodium hypochlorite (bleach) and allowing the tool to air-dry is effective for inactivating plant pathogens and preventing their spread.
9. Flag the plant or sampled location whenever possible and draw a map of the immediate area, indicating reference points so that the areas can be found in the future if necessary. **Do not** rely solely on the flagging or other markers to re-locate a site as they may be removed. Record the GPS coordinates for each sampled area so that the area or plant may be re-sampled if necessary. The re-sampling period for this pest can be short based on environmental conditions.
10. Survey strike teams should consist of an experienced survey specialist or plant pathologist familiar with *M. oryzae* and the symptoms the pest causes.

Homeowner Properties

For positive detections on homeowner properties, ask the owner of the infected

material to determine its point of origin (nursery, neighbors, *etc.*) and any possible sites of further distribution.

Nursery Properties

For nursery hosts, a list of facilities associated with potentially infected nursery stock from those testing positive for *M. oryzae* will be compiled. These lists will be distributed by the state to the field offices and are not to be shared with individuals outside the USDA–APHIS–PPQ regulatory cooperators. Grower names and field locations on these lists are strictly confidential, and any distribution of lists beyond appropriate regulatory agency contacts is **prohibited**.

Each state is only authorized to see locations within their state, and sharing of confidential business information may be restricted between state and federal entities. Check the privacy laws with the State Plant Health Director for the state.

When notifying growers on the list, be sure to identify yourself as a USDA or state regulatory official conducting an investigation of facilities that may have received *M. oryzae*-infected material. Speak to the growers or farm managers and obtain proper permission prior to entering private property.

Several actions should occur immediately upon confirmation that a nursery sample is positive for *M. oryzae*:

- Check nursery records to obtain names and addresses for all sales or distribution sites (if any sales or distribution has occurred from affected nursery during the previous 6 months).
- Evaluate the situation, the location within the nursery and the severity.
- Check nursery records to identify potential sources of the infection including sources of seed outside the nursery.

Detection Survey

Detection surveys determine if a pest is present in a defined area and can be broad in scope to assess the presence of a pest or multiple pests over large areas or restricted to determine whether a specific pest or pests are present in a focused area.

Although negative results from a detection survey may not confirm the absence of a pest at a location, the surveys can provide reasonable confidence regarding pest occurrence.

Procedure

APHIS and state cooperators conduct pest detection surveys through the Cooperative Agriculture Pest Survey (CAPS) program, which is a part of the pest detection line item within USDA–APHIS–PPQ–PDEP. The state CAPS committee meets and develops the survey list for each state.

If the CAPS program determines that the pest should be surveyed, use the following procedure to conduct a detection survey for *M. oryzae*:

1. Determine the potential survey sites: Focus the survey in locations where *M. oryzae* is more likely to occur/detect including the following:
   - **A.** *Potential Distribution* on page 4-3 provides broad information on the geographical areas suitable for pest occurrence and is typically based on favorable environmental conditions and the presence of specific plant hosts as reported in states/counties
   - **B.** Within the potential distribution area, survey specific locations that have *Hosts* suitable for the pest species.
   - **C.** Prior to surveying, consider the pest phenology to determine the time of survey.
2. Sentinel sites/targeted surveys: The aforementioned information may be used to establish sentinel sites or targeted surveys for *M. oryzae*. Sentinel sites are locations regularly inspected along a surveyor's normal route. If sentinel sites are established for the pest species, use GPS to record the host plant locations and draw a map of the immediate area that includes reference points to aid others in finding the area if necessary. Once a sentinel site is established, the surveyor should re-inspect it on a regular basis (bimonthly or monthly) as permitted by their regular survey schedule. GIS can be used to map the sentinel site locations to promote even coverage, particularly in high-risk areas. Targeted surveys can be regularly conducted at nurseries and in areas of regular traffic from countries with known infections.
3. Determine the survey technique(s): After determining the sites and design/bundling of the survey, conduct the survey using the CAPS-approved survey techniques for *M. oryzae*. Refer to the CAPS-Approved Survey Methodology for Negative Data Appendix M-1 for additional information.
4. Procure survey supplies.
5. Safety, sanitization and compliance during a survey: Prior to beginning a survey, determine whether any pesticides have been recently applied rendering it unsafe to inspect the plant hosts and other substrates. Contact the property owner or manager and look for posted signs indicating recent pesticide applications, particularly in commercial fields or nurseries. If pesticides have been applied, pest inspection should occur after the re-entry period. When visiting the area to conduct surveys or take samples, survey

personnel must take strict measures to prevent pest contamination between properties during inspections. Confirm that and the survey tools are clean. Determine and comply with all quarantine requirements that may be effective in the survey area.

6. To confirm disease, collect plants exhibiting typical symptoms. Take a minimum of 30 samples per field (95% confidence in detecting 10% disease prevalence). Place samples in labeled plastic bags. Keep samples cool. Double bag the samples and deliver promptly to a diagnostic laboratory.
7. Data collection during the survey: Data entry forms are available from the CAPS Website for specific pests. If information on *M. oryzae* is not available here, use information from congeneric species or refer to *Data Collection* on page 7-11.
8. Preliminary identification of the survey samples: Morphological characteristics that may aid in preliminary identification of *M. oryzae* are described in *Identification* on page 3-1.
9. After a positive occurrence is suspected in the collected samples, submit the pest specimen(s) to the proper authority to confirm the detection. See *Sample Submission* on page on page E-1 and available *Taxonomic Support for Surveys* for further information.
10. Survey Records: Data should be recorded for each survey site. Survey records and data recording formats should be consistent for standardizing the collection of information. If automated field collection services such as the Integrated Plant Health Information System (IPHIS) are used, ensure that all surveyors are trained in the technology prior to initiating the survey. Use the appropriate IPHIS templates for *M. oryzae*. To reduce the burden on field data collectors, enter any known contact or address information into the database and hand-held data recorders prior to initiating the survey. After the survey is completed, all data should be entered into the designated state or national pest database. For example, if the detection data is entered in the National Agricultural Pest Information System (NAPIS) and publicly viewable from the Pest Tracker interface.
11. If the blast fungus is positively identified, it is critical to use molecular diagnostics or genome sequencing analysis to determine if the fungus isolated from wheat is a native strain that has undergone a host jump to infect wheat (See *Natural Movement* in the *Pathways* chapter) or if it is an imported wheat blast strain from South America.

Visual inspection of wheat crops is vital in determining wheat blast presence because symptoms closely resemble FHB. All above-ground plant parts can be infected, but the head, exhibiting a characteristic bleached appearance, is the most common location for symptoms to occur in the field (Valent *et al.*, 2013). In addition to FHB, several other routinely occurring wheat pests/problems—

Hessian fly, take-all, cephalosporium stripe, dryland foot rot, stem maggot, freeze damage, *etc.*—can produce the symptoms of wheat blast (whiteheads) (Valent, 2014). Scouting can be facilitated by planting 'sentinel' plots in regions of the U.S. most susceptible to the disease. To the extent possible, sentinel plots should include wheat varieties that are highly susceptible to blast and resistant to FHB and other factors associated with similar whitehead symptoms (Valent, 2014).

For additional information, refer to the CAPS survey guidelines (CAPS, 2014).

Visual Inspection for Detection Survey

Use visual inspection as a tool when surveying for wheat blast.

WHEN TO INSPECT: Visual inspections of wheat crops are critical during the warm, wet conditions that favor blast disease. Specifically, severe blast disease develops during extended rainy periods with warm daytime temperatures and cool nighttime temperatures that promote a prolonged dew cycle. Dew provides the free water on the host surface, that blast fungus requires for infection (Figure 4-1). Hot, dry weather does not favor blast disease development. A wheat blast forecast model currently under construction will be a valuable tool to more precisely pinpoint critical periods and locations for focused visual inspections.

WHERE TO INSPECT: Conduct initial visual inspection of wheat fields where trees/windbreak barriers shade the field and allow dew to remain on plant surfaces where symptoms typically first appear. Scout fields with high organic matter or with high rates of N fertilizer use because nitrogen-rich soils in favor disease development. Search for and collect symptomatic plants and examine them for the production of characteristic pyriform *Pyricularia* spores. Regularly scout susceptible plants, preferably but not necessarily unsprayed, for early detection.

Signs and Symptoms

- All above-ground parts of plant can be infected.
- The most characteristic symptom is head infection with bleached spikelets (Figures 5-1 and 5-2).
- Look for a darkened region on the rachis with all spikelets killed distal to that area. The darkened region on the rachis is typical for blast, but can also be a symptom of FHB, which is more pronounced on certain species. At the blast infection point, the rachis turn brown to black and later turn light to dark gray due to heavy sporulation.
- Blast infections lack the salmon-colored sporulation on the outside of the glumes characteristic of the FHB fungus.

- Early spikelet symptoms can appear as lens-shaped lesions on the outside of the glumes (similar to those seen on leaves), a symptom identical to that expressed by FHB on barley. Sporulating blast lesions have gray centers from the color of the spores. Blast lesions typically have a dark border and can continue to expand until they kill the floret/spikelet.
- Younger leaves are more susceptible and exhibit elliptical lesions (Figure 5-3).
- Search for blast symptoms on leaves at different developmental stages (including flag leaves).
- Older leaves have smaller less frequent lesions.
- Sporulating leaf lesions appear gray from the spore color (Figure 5-3) and are often ringed with a reddish-brown margin. The lesions may be surrounded by chlorotic zones.
- After sporulation, lesions become straw-colored within the brownish margin.
- Culm, neck and sheath lesions vary in shape from elliptical to elongated.
- Infected grains are typically deformed, small and wrinkled (Figure 5-4), although the fungus can sometimes also be isolated from grains that appear healthy.
- The blast fungus can, but does not always, sporulate from tissue in the field to produce the diagnostic spores of *M. oryzae* (*Pyricularia*). Sometimes, the suspected infected tissue must be incubated under humid conditions to induce sporulation.
- The aforementioned additional pests/problems have characteristics that distinguish them from blast disease. For example, Hession fly will have ‘flax seeds’ at the base of the tiller, and stem maggot causes isolated white heads on stems that can easily be pulled from the leaf sheath of the plant.
- Take samples of all plant tissue within a field exhibiting symptoms. Obtain a minimum of 30 samples per field (95% confidence in detecting 10% disease prevalence). Place the samples in labeled plastic bags and keep them cool. Double bag the samples and deliver promptly to a diagnostic laboratory.

Symptomatic plants should be compared to a diagrammatic scale (Figure 7-1) to access the severity of the spike (Maciel *et al.*, 2013).

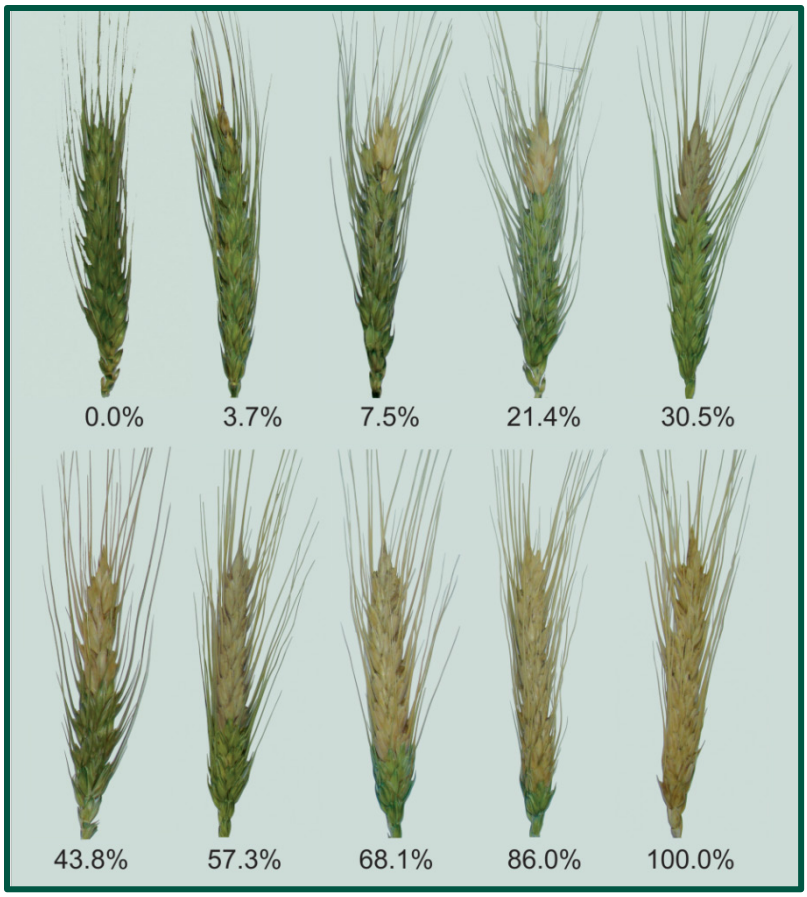

Figure 7-1 Diagrammatic scale for accessing severity of wheat blast on wheat spikes; awns were not considered in determining severity (Maciel *et al.*, 2013).

Delimiting Survey after Initial United States Detection

The objective of a delimitation survey is to determine the spatial extent of an exotic pest incursion following a detection. If *M. oryzae* is detected in the US, surveys will be conducted to determine the occurrence of an infection and its spread. After the initial detection, a Technical Working Group (TWG) is formed to prepare a delimitation survey plan to investigate the spread of *M. oryzae*. The TWG may consider the following information to recommend a delimitation survey plan for the introduced species.

Delimitation Area

The total delimitation area may depend on information provided by the *Trace-Back and Trace-Forward Investigations*, the nearby host distribution, *Pathways* including the extent of natural and artificial dispersal, agency resources and logistics. An index (primary) site (Category A) is the property on which an initial detection of a disease or pathogen occurs. Each cultivated field, residential

property and home garden within 15 m of the index field (Category A) must be sampled using a two-dimensional grid and submitted for laboratory analysis. Samples will be taken during the disease survey to determine if propagules are present. A designated laboratory will screen the samples. Plants may be visually surveyed, if necessary, to determine pathogen viability.

Generic Survey Techniques for Delimitation

Various sampling designs may be used to conduct a delimiting survey for plant pathogens including random, stratified random sampling (SRS), systematic and two-stage designs. Survey timing will depend upon the pathogen life cycle, the plant growth stage when infection is likely to occur and ecological parameters that support pathogen dispersal. Others considerations include the following:

1. Spatial patterns of diseased plants and of soil-borne plant pathogens in fields; a few examples are provided in Figure 7-2

2. Hosts: If *M. oryzae* is detected in the U.S., the technical working group (TWG) should consider the preferred hosts of the pest near the detected area, the spatiotemporal distribution of these hosts and the host phenology suitable for the pest

3. Pathways: The dissemination of *M. oryzae* occurs primarily via airborne conidia (Ou, 1985; Urashima *et al.*, 2007). Extended dew periods and water droplets accumulated on infected leaves increase spore production and release (Ou, 1985; Suzuki, 1969). This pathogen can also be dispersed to new geographic locations through infected seeds (Urashima *et al.*, 1999).

4. Logistics and available resources: Available resources can vary based on the time and location of detection and the pest species

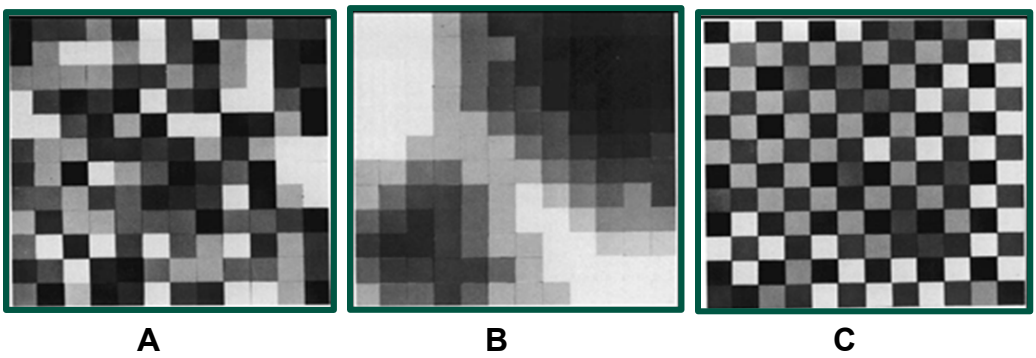

Figure 7-2 Three spatial distributions of plant pathogens: (A) random, (B) aggregated and (C) regular (Nicol *et al.*, 1984)

Delimiting Survey

After determining the delimitation area, a specific survey design can be chosen. An SRS pattern is used for this template.

- Divide field/area into uniform quadrants
  - Field dimensions and plant spacing are needed to divide the quadrants uniformly; quadrants are represented by the squares in Figure 7-3
- Quadrants are two dimensional regions whose size is defined as the total field area divided by number of sample sites; for example, a typical quadrants could be 1 m × 1 m
- Randomly select sample sites in each quadrant
  - Each sample site is composed of a "cluster" of adjacent plants represented by the dots in Figure 7-3; collect plants displaying signs or symptoms and soil samples if needed
- Actual survey will depend on the agricultural system in which the pathogen was initially detected

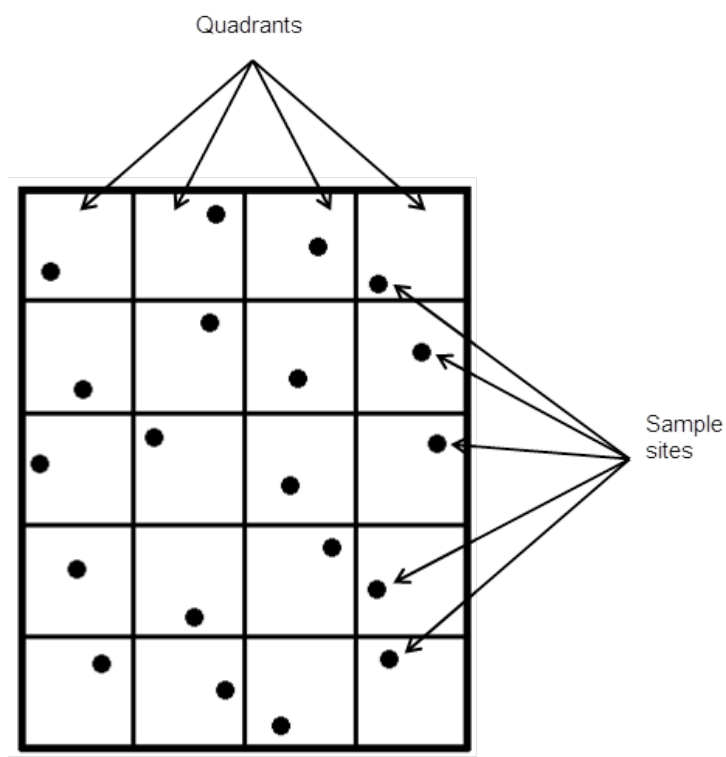

Figure 7-3 Stratified random sampling demonstrating uniform quadrants and sample sites

Data Collection

Flag the plant, tree or sampled location whenever possible and draw a map of the immediate area, indicating reference points so that the areas can be found in the future if necessary. **Do not** rely solely on the flagging or other markers to re-locate a site as they may be removed. Record the GPS coordinates for each sampled area so that the area or plant may be re-sampled if necessary. Survey task forces should consist of an experienced survey specialist or plant pathologist familiar with *M. oryzae* and the symptoms of its damage.

Surveyors visiting sites to place holds or obtain samples should collect the following information:

- Date of collection or observations
- Collector's name
- Grower's field identification numbers
- Full name of business, institution, or agency
- Full mailing address including country
- Type of property (commercial nursery, hotel, natural field, residence)
- GPS coordinates of the host plant and property
- Host plant species and specific crop plant variety, if applicable
- Presence or absence of the pest
- Observations of signs and symptoms
- General conditions or any other relevant information

In the absence of inspection officials, take the following actions immediately if symptoms are noted:

1. Mark the location
2. Take samples of symptomatic and asymptomatic plant parts and flag the location within the field
3. Notify the state or PPQ inspector
4. Place the samples from the infected plant inside two resealable plastic bags
5. Label the sealed bags with the following information:
   - **A.** Date
   - **B.** Name of person responsible
   - **C.** Location of sample collection

6. Keep bagged samples cool or refrigerated until the inspector arrives
7. **Do not** freeze the samples

After a positive occurrence is suspected in the collected samples, submit the pest specimen(s) to the proper authority to confirm the detection; see *Sample Submission* on page E-1.

Survey Records

Data should be recorded for each survey site. Survey records and data recording formats should be consistent for standardizing the collection of information. If automated field collection services such as the Integrated Plant Health Information System (IPHIS) are used, ensure that all surveyors are trained in the technology prior to initiating the survey. Use the appropriate IPHIS templates for *M. oryzae*. To reduce the burden on field data collectors, enter any known contact or address information into the database and hand-held data recorders prior to initiating the survey. After the survey is completed, all data should be entered into the designated state or national pest database.

Monitoring Survey

At this time no control procedures are in place for this pathogen, and ongoing fungicidal efficacy trials are being conducted. If *M. oryzae* is detected in the United States, a technical working group will be assembled to provide guidance on using a monitoring survey to measure the effectiveness of applied treatments on the pathogen.

Refer to *Control Procedures* on page 8-1 for further information regarding control options.

Procedure

Once *M. oryzae* has been confirmed from a particular field and infected and potentially infected plants have been destroyed, additional monitoring will be necessary. Use the following tools:

- Visual inspection in the field
- Collection of samples from wheat crop debris and potential weed hosts for several years and multiple times per season

Trace-Back and Trace-Forward Investigations

Trace-back and trace-forward investigations aid in prioritizing delimiting survey activities after an initial detection. Trace-back investigations attempt to determine the source of the infection. Trace-forward investigations attempt to define further potential dispersion through natural and artificial spread (commercial or private distribution of infected plant material). Once a positive detection is confirmed, efforts should be undertaken to determine the extent of the infection or the potentially infected areas in which to conduct further investigations.

Homeowner Properties

For positive detections on homeowner properties, ask the owner of the infected material to determine its point of origin (nursery, neighbors, *etc.*) and any possible sites of further distribution.

Nursery Properties

For nursery hosts, a list of facilities associated with potentially infected stock from nurseries testing positive for *M. oryzae* will be compiled. These lists will be distributed by the state to the field offices and are not to be shared with individuals outside the USDA–APHIS–PPQ regulatory cooperators. Grower names and field locations on these lists are strictly confidential, and any distribution of lists beyond appropriate regulatory agency contacts is **prohibited**.

Each state is only authorized to see locations within their state, and sharing of confidential business information may be restricted between state and federal entities. Check the privacy laws with the State Plant Health Director for the state.

When notifying growers on the list, be sure to identify yourself as a USDA or state regulatory official conducting an investigation of facilities that may have received *M. oryzae*-infected material. Speak with the growers or farm managers to obtain proper permission prior to entering private property.

Several actions should occur immediately upon confirmation that a nursery host was infected with *M. oryzae*:

- Check nursery records to obtain names and addresses for all sales or distribution sites (if any sales or distribution has occurred from infected nursery during the previous 6 months).
- Evaluate the pest situation, including identification and inspection of the infected plant, the location within the nursery and the severity of infection.

- Check nursery records to identify potential sources of the infection inside or outside the nursery.

Analyzing Information

Use trace-back information gathered from seed lot tags and invoices to determine the origin of the wheat seed. With timely submitted records from growers and wheat storage facilities, on-site planning staff can construct prioritized lists for further surveys. Information available from local water companies or farm organizations can be obtained to construct maps of water sources, irrigation channels and connections in areas with suspect wheat plants and potentially infected wheat seeds. Contact local water companies and farm organizations to obtain the information for use in assessing the need for further surveys of fields associated with irrigation water.

Due to reports indicating that *M. oryzae* is seed borne, systematic seed testing and certifications should be implemented to prevent its accidental introduction into new areas or countries. However, *M. oryzae* can also enter through the illegal importation of seed.

For seed companies, a list of facilities associated with infected seeds from those testing positive for *M. oryzae* will be compiled by CPHST.

Positive Detection in Wheat

Trace-back surveys for positive wheat detections should determine the source of infection by examination or analysis of the following:

- Source of wheat seed planted
- Certified seed documentation
- Wheat storage facilities
- Any other potential movement of plant material, water or machinery that could contribute to tracing the source of contamination

Cooperation with Other Surveys

Other surveyors regularly sent to the field should be trained to recognize outbreaks that could be associated with *M. oryzae*.

Chapter

8

Control Procedures

Overview of Emergency Programs

Plant Protection and Quarantine (PPQ) develops and makes control measures available to involved states. Environmental Protection Agency (EPA)-approved treatments will be recommended when available. If selected treatments are not labeled for use against the organism or in a particular environment, PPQ's FIFRA (Federal Insecticide, Fungicide and Rodenticide Act) coordinator is available to explore the appropriateness in developing an emergency exemption under section 18, or a state special local need under section 24(c) of FIFRA, as amended. The PPQ FIFRA coordinator and pesticide-use coordinators are also available upon request to work with the EPA to expedite approval of a product that may not be registered in the United States, or to obtain labeling for a new use. Refer to *Resources* on page B-1 for information on contacting the coordinator.

Treatment Options

Treatments may include the following:

- *Cultural Control and Sanitary Measures* on page 8-1
- *Chemical Control* on page 8-2
- *Biological Control* on page 8-4
- *Host Resistance* on page 8-4

Cultural Control and Sanitary Measures

The lack of available resistant cultivars has forced farmers to rely on other management methods such as cultural control (Urashima *et al.*, 2004). In South America, the current early planting dates are more likely to coincide with wheat blast conditions during heading (Valent *et al.*, 2013). Altering the sowing dates in

epidemic areas allows heading in a drier environment, reducing yield loss (Urashima *et al.*, 2004). Therefore, planting in Brazil must occur after 10 April and in Bolivia after 15 April (Mehta *et al.*, 1992; Urashima *et al.*, 2004; Valent *et al.*, 2013).

Infested stubble and leaf debris provide seasonal carryover for the *M. oryzae* pathotypes that cause GLS and rice blast (Valent *et al.*, 2013). Studies conducted in northern Indiana by Harmon and Latin (2005) indicate that the fungus can survive the winter in infected residue, but the surviving population may be inadequate as an effective primary inoculum for an epidemic the following year.

At present, no evidence indicates that the wheat blast pathotype utilizes infected plant debris as a source for overwintering (Valent *et al.*, 2013).

Chemical Control

Combining triazoles (tebuconazole and metconazole) with strobilurins has proven effective in wheat blast control during the heading stage on moderately resistant varieties in South America (Kohli *et al.*, 2011; Valent *et al.*, 2013). However, fungicidal applications have produced inefficient control of wheat blast on susceptible varieties (Kohli *et al.*, 2011; Urashima *et al.*, 2009) possibly due to incomplete application, improper timing or poor active ingredient activity (Cruz, 2013).

The treatment of seeds in Bolivia with Benlate® and carbendazim plus thiram provides exceptional control of wheat blast at a rate of 200 mL per 100 kg of seed (Valent *et al.*, 2013). Various researchers in Brazil have further studied the effectiveness of seed treatments (Valent *et al.*, 2013): Goulart and Paiva (1991) used iprodione (50 g ai/100 kg seed) plus thiram (150 g ai/100 kg seed). Lasca *et al*. (2001) found that carboxin (22.5g ai/100 kg seed) plus prochloraz (82.5 g ai/100 kg seed), triflumizole (45 g ai/100 kg seed) plus thiophanate-methyl (135 g ai/100 kg seed), carbendazim (50 g ai/100 kg seed) plus mancozeb (160 g ai/100 kg seed) and carbendazim (52.5 g ai/100 kg seed) plus iprodione (26.2 g ai/100 kg seed) provide excellent control.

The majority of these fungicides are not labelled for use on wheat in the U.S.; therefore, further testing is needed to assess their fungicidal control of wheat blast for seed importation (Valent *et al.*, 2013). The seed treatments currently allowed in U.S. wheat are listed in Table 8-1.

Table 8-1 Fungicidal seed treatments on wheat in the U.S.

Trade name	Active ingredients (ai)	References
Charter®	triticonazole	Osborne and Ruden (2011), Schultz and French (2011)
CruiserMaxx®	thiamethoxam, mefenoxam, fludioxonil	De Wolf (2012), Dyer *et al.* (2012), Schultz and French (2011)
Dividend Extreme®	difenoconazole, mefenoxam	De Wolf (2012), Osborne and Ruden (2011), Schultz and French (2011)
Dynasty®	azoxystrobin	Schultz and French (2011)
Enhance®	carboxin, captan	Osborne and Ruden (2011)
Maxim® 4FS	fludioxonil	De Wolf (2012), Schultz and French (2011)
Proceed™ Concentrate	prothioconazole, tebuconazole, metalaxyl	Dyer *et al.* (2012), Osborne and Ruden (2011), Schultz and French (2011)
Rancona® Pinnacle	ipconazole, metalaxyl	De Wolf (2012), Dyer *et al.* (2012), Osborne and Ruden (2011)
Raxil® MD	tebuconazole, metalaxyl	De Wolf (2012), Osborne and Ruden (2011), Schultz and French (2011)
Sativa® M RTU	tebuconazole, metalaxyl	Osborne and Ruden (2011)
Stamina® F^3 HL	pyraclostrobin, triticonazole, metalaxyl	De Wolf (2012), Schultz and French (2011)
Vitavax®-34	carboxin	Osborne and Ruden (2011)

Efficacy trials were conducted by Bockus *et al*. (2014) on fungicides used in seed-treatment to determine if currently labeled and historically used wheat seed-treatment fungicides (Table 8-2) could inhibit sporulation of *M. oryzae* from infected seed. Sporulation occurred in 38.3−41.7% of the non-treated seed. The incidence of sporulation from seed was reduced in all treatments except Rancona® Crest and triticonazole (Bockus *et al.*, 2014). Reductions in sporulation on 52.2–100% (relative to the non-treated control) were observed in effective fungicides. Only seeds treated with Benlate® 50 wp exhibited no sporulation.

Table 8-2 Wheat seed-treatment fungicides

Trade name	Active ingredients (ai)	Rate
Bayton® 30	triadimenol	1.5 fl oz/cwt
Benlate® 50 wp	benomyl	2.0 oz/cwt
Dividend® 3FS	difenoconazole	4.0 fl oz/cwt
Maxim® 4FS	fludioxonil	0.16 fl oz/cwt
Rancona® Crest	ipconazole, metalaxyl, imidacloprid	8.33 fl oz/cwt
Raxil® MD	tebuconazole, metalaxyl	6.5 fl oz/cwt
RTU-PCNB	terrazole, quintozene, gamma-lindane	4.0 fl oz/cwt
Thiram 42S	thiram	3.3 fl oz/cwt
Triticonazole (2.63%)	triticonazole	3.1 fl oz/cwt
Vitavax®-200FF	Carboxin, thiram	4.0 fl oz/cwt

Labeling

Although a proposed formulation may be approved for an effective eradication or control program, it may not be labeled, at the time of pest detection, for the specific use required. If a formulation is not labeled for the necessary use, one can request a federal crisis or quarantine exemption from the EPA under section 18 of FIFRA. For further information, refer to *Regulatory Procedures* on page 9-1. The prescribed formulation must be labeled for use on the site at which it is to be applied and must be registered for use in the state in which the eradication program is occurring. All applicable label directions must be followed, including requirements for personal protection equipment, maximum treatment rates, storage and disposal.

Biological Control

At this time, no biological control options are available.

Host Resistance

Magnaporthe oryzae has tremendous variability, rendering the search for an acceptable source of resistance problematic (Kohli *et al.*, 2011). Urashima *et al*. (2004) tested twenty commercial Brazilian wheat cultivars for resistance against this species. Only one cultivar (BR 18) exhibited broad-spectrum resistance (Urashima *et al.*, 2004). Other cultivars, such as Paragua CIAT and Parapeti CIAT, tested by Kohli *et al*. (2011) were more resistant to wheat blast.

Spring and winter wheat varieties that contain a less than 10% spike infection have been identified in the U.S. (Valent *et al.*, 2013). Field tests are currently being conducted on these varieties with natural pathogen populations in Bolivia (Valent *et al.*, 2013). Other testing will be conducted in Brazil and Paraguay (Valent *et al.*, 2013).

Chapter

9

Regulatory Procedures

Use *Chapter 9 Regulatory Procedures* as a guide to the procedures that must be followed by regulatory personnel when conducting pest survey and control programs against *M. oryzae*.

Instructions to Officials

Agricultural officials must follow instructions for regulatory treatments or other procedures when authorizing the movement of regulated articles. Understanding the instructions and procedures is essential when explaining procedures to people interested in moving articles affected by the quarantine and regulations. Only authorized treatments can be used in line with labeling restrictions. During all field visits, ensure that proper sanitation procedures are followed.

Regulatory Actions and Authorities

After an initial suspect positive detection, an Emergency Action Notification may be issued to hold articles or facilities pending positive identification by a USDA–APHIS–PPQ-recognized authority and/or further instruction from the PPQ deputy administrator. If necessary, the deputy administrator will issue a letter directing PPQ field offices to initiate specific emergency action under the Plant Protection Act until emergency regulations can be published in the *Federal Register*.

The Plant Protection Act of 2000 (Statute 7 USC 7701-7758) provides the authority for emergency quarantine action. This provision is for interstate regulatory action only; intrastate regulatory action is provided under state authority.

State departments of agriculture normally work in conjunction with federal actions by issuing their own parallel hold orders and quarantines for intrastate movement. However, if the U.S. Secretary of Agriculture determines that an extraordinary emergency exists and that state measures are inadequate, intrastate regulatory action can be taken provided that the governor of the state has been

consulted and a notice has been published in the *Federal Register*. If intrastate action cannot or will not be taken by a state, PPQ may find it necessary to quarantine an entire state.

PPQ works in conjunction with state departments of agriculture to conduct surveys, enforce regulations and take control actions. PPQ employees must obtain permission of the property owner before entering private property. Under certain situations during a declared extraordinary emergency or if a warrant is obtained, PPQ can enter private property without owner permission. PPQ prefers to work with the state to facilitate access when permission is denied; however, each state government has varying authorities regarding entering private property.

A General Memorandum of Understanding (MOU) exists between PPQ and each state that specifies various areas in which PPQ and the state department of agriculture cooperate. For clarification, check with your State Plant Health Director (SPHD) or State Plant Regulatory Official (SPRO) in the affected state.

Tribal Governments

USDA–APHIS–PPQ also works with federally recognized Native American tribes to conduct surveys, enforce regulations and take control actions. Each tribe stands as a separate governmental entity (sovereign nation) with powers and authorities similar to state governments. Permission is required to enter and access tribal lands.

Executive Order 13175, Consultation and Coordination with Indian and Tribal Governments, states that agencies must consult with Native American tribal governments about actions that may have substantial direct effects on tribes. Whether an action is substantial and direct is determined by the tribes. Effects are not limited to tribal land boundaries (reservations) and may include effects on off-reservation land or resources which tribes customarily use or even effects on historic or sacred sites in states where tribes no longer exist.

Consultation is a specialized form of communication and coordination between the federal and tribal governments. Consultation must be conducted early in the development of a regulatory action to ensure that tribes have opportunity to identify resources that may be affected by the action and to recommend the best ways to take actions on tribal lands or affecting tribal resources. Communication with tribal leadership follows special communication protocols. For more information, contact PPQ's Tribal Liaison.

To determine if there are federally recognized tribes in a state, contact the State Plant Health Director (SPHD). To determine if there are sacred or historic sites in

an area, contact the State Historic Preservation Officer (SHPO). For clarification, check with your SPHD or State Plant Regulatory Official (SPRO) in the affected state.

Overview of Regulatory Program after Detection

Once an initial US detection is confirmed, holds will be placed on the property by the issuance of an Emergency Action Notification. Immediately put a hold on the property to prevent the removal of any host plants of the pest.

Trace-back and trace-forward investigations from the property will determine the need for subsequent holds for testing and/or further regulatory actions. Further delimiting surveys and testing will identify positive properties requiring holds and regulatory measures.

Record-Keeping

Record-keeping and documentation are important for any holds and subsequent actions taken. Rely on receipts, shipping records and information provided by the owners, researchers or manager for information on destination of shipped plant material, movement of plant material within the facility and any management (cultural or sanitation) practices employed.

Keep a detailed account of the numbers and types of plants held, destroyed and/or requiring treatments in control actions. Consult a master list of properties, distributed with the lists of suspect nurseries based on trace-back and trace-forward investigations, or facilities within a quarantine area. Draw maps of the facility layout to located suspect plants and/or other potentially infected areas. When appropriate, take photographs of the symptoms, property layout and document plant propagation methods, labeling and any other information that may be useful for further investigations and analysis.

Keep all written records filed with the Emergency Action Notification documents, including copies of sample submission forms, documentation of control activities and related state-issued documents if available.

Issuing an Emergency Action Notification

Issue an Emergency Action Notification to hold all host plant material at facilities that have plant material suspected of direct or indirect connection to positive confirmations. Once an investigation determines the plant material is not infected

or testing determines there is no risk, the material may be released and the release documented on the EAN.

Establishing a Federal Regulatory Area or Action

Regulatory actions undertaken using Emergency Action Notifications continue to be in effect until the prescribed action is carried out and documented by regulatory officials. These may be short-term destruction or disinfection orders or longer term requirements for growers that include prohibiting the planting of host crops for a time. Over the long term, producers, shippers and processors may be placed under compliance agreements and permits issued to move regulated articles out of a quarantine area or property under an EAN.

Results analyzed from investigations, testing and risk assessment will determine the area to be designated for federal and parallel state regulatory actions. Risk factors will consider positive testing, positive associated and potentially infected exposed plants. Boundaries drawn may include a buffer area determined using risk factors and epidemiology.

Regulatory Records

Maintain standardized regulatory records and databases in sufficient detail to carry out an effective, efficient and responsible regulatory program.

Use of Chemicals

The PPQ *Treatment Manual* and these guidelines identify the authorized chemicals and describe the methods and rates of application and any special instructions. For further information refer to *Chemical Control* on page 8-2. Agreement by PPQ is necessary before using any chemical or procedure for regulatory purposes. No chemical can be recommended that is not specifically labeled for this pest. If a formulation is not labeled for the necessary use, one can request a federal crisis or quarantine exemption from the EPA under section 18 of FIFRA.

Chapter

10

Research Needs

- Assess potential sources of resistance to the *M. oryzae Triticum* pathotype in known host plants in the U.S.
- Determine fungicidal treatments for use in the field and on seeds
- Refine PCR diagnostic tools
- Determine the risk of native ryegrass strains on U.S. wheat
- Integrate wheat blast surveillance into ongoing wheat disease monitoring networks
- Develop a wheat blast forecast model
- Develop a delimiting survey for wheat blast

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Appendix

A

How to Use the Guidelines

Use *New Pest Response Guidelines:* Teleomorph: *Magnaporthe oryzae* B.C. Couch *Triticum* pathotype; Anamorph: *Pyricularia oryzae* Cavara (wheat blast) when designing a program to detect, monitor, control, contain or eradicate an outbreak of this pest in the United States and collaborating territories.

The United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine (USDA–APHIS–PPQ) developed the guidelines through discussion, consultation or agreement with staff members at the USDA-Agricultural Research Service and advisors at universities.

Any new detection may require the establishment of an incident command system to facilitate emergency management. This document is meant to provide the information necessary to launch a response to an *M. oryzae* detection.

If *M. oryzae* is detected, a site-specific action plan will be based on the guidelines. As the program develops and new information becomes available, the guidelines will be updated.

Users

The guidelines are intended as a field reference for the following users who have been assigned responsibilities for a plant health emergency involving *M. oryzae*:

- PPQ personnel
- Emergency response coordinators
- State agriculture department personnel
- Others concerned with developing local survey or control programs

Contacts

When an emergency program for wheat blast has been implemented, the success of the program depends on the cooperation, assistance and understanding of other involved groups. The appropriate liaison and information officers should distribute news of the program's progress and developments to interested groups including the following:

- Academic entities with agricultural interests
- Agricultural interests in other countries
- Commercial interests
- Grower groups such as specific commodity or industry groups
- Land-grant universities and cooperative extension services
- National, state and local news media
- Other federal, state, county and municipal agricultural officials
- Public health agencies
- The public
- State and local law enforcement officials
- Tribal governments

Initiating an Emergency Pest Response Program

An emergency pest response program consists of detection and delimitation and may be followed by programs in regulation, containment, eradication and control. The New Pest Advisory Group (NPAG) will evaluate the pest. After assessing the risk to U.S. plant health and consulting with experts and regulatory personnel, NPAG will recommend a course of action to PPQ management.

Follow this sequence when initiating an emergency pest response program:

1. A new or reintroduced pest is discovered and reported
2. The pest is examined and pre-identified by regional or area identifier
3. The pest's identity is confirmed by a national taxonomic authority recognized by the USDA–APHIS–PPQ National Identification System

4. Published New Pest Response Guidelines are consulted or a new NPAG is assembled to evaluate the pest
5. Depending on the urgency, official notifications are made to the National Plant Board, cooperators and trading partners
6. Based on information provided, PPQ Leadership may immediately determine the efficacy of a federal response in which one or all of the following actions may take place: delimitation, regulation, containment, eradication and/or control
7. If additional information is required, the following actions may occur:
   - **A.** A delimiting survey is conducted at the site(s) of detection
   - **B.** Trace-back and trace-forward investigations are conducted
   - **C.** An incident assessment team may be sent to evaluate the site
   - **D.** State departments of agriculture are consulted
8. A recommendation is made, based on the assessment of surveys, other data and recommendation of the incident assessment team or the NPAG as follows:
   - **A.** Take no action
   - **B.** Regulate the pest and its hosts
   - **C.** Contain the pest
   - **D.** Suppress the pest
   - **E.** Eradicate the pest
9. If appropriate, a control strategy is selected
10. A PPQ Deputy Administrator authorizes a response
11. A command post is selected and the incident command system is implemented
12. State departments of agriculture cooperate with parallel actions using a unified command structure
13. Trace-back and trace-forward investigations are conducted
14. Field identification procedures are standardized
15. Data reporting is standardized
16. Regulatory actions are taken
17. Environmental assessments are completed as necessary
18. Treatment is applied for required pest generational time
19. Environmental monitoring surveys are conducted to evaluate program success
20. Pest monitoring surveys are conducted to evaluate program success
21. Programs are designed for eradication, containment or long-term use

Preventing an Infection

Federal and state regulatory officials must conduct inspections and apply

prescribed measures to ensure that pests do not spread within or between properties. Federal and state regulatory officials conducting inspections should follow the sanitation guidelines in the section *Survey Preparation* on page 7-1 before entering and upon leaving each property to prevent contamination.

Scope

The guidelines are divided into the following chapters:

1. *Introduction* on page 1-1
2. *Taxonomy* on page 2-1
3. *Identification* on page 3-1
4. *Biology* on page 4-1
5. *Damage* on page 5-1
6. *Pathways* on page 6-1
7. *Survey* on page 7-1
8. *Control Procedures* on page 8-1
9. *Regulatory Procedures* on page 9-1
10. *Research Needs* on page 10-1

The guidelines also include appendices and a list of literature cited.

Authorities

The regulatory authority for taking the actions listed in the guidelines is contained in the following authorities:

- Plant Protection Act of 2000 (Statute 7 USC 7701-7758)
- Executive Order 13175, Consultation and Coordination with Indian and Tribal Governments
- Fish and Wildlife Coordination Act
- National Historic Preservation Act of 1966
- Endangered Species Act
- Endangered and Threatened Plants (50 CFR 17.12)
- National Environmental Policy Act

Program Safety

The safety of the public and program personnel is a priority in pre-program planning and training and throughout program operations. Safety officers and supervisors must enforce on-the-job safety procedures.

Support for Program Decision Making

The USDA–APHIS–PPQ–Center for Plant Health, Science and Technology (CPHST) provides technical support to emergency pest response program directors concerning risk assessments, survey methods, control strategies, regulatory treatments and other aspects of the pest response programs. PPQ managers consult with state departments of agriculture in developing guidelines and policies for pest response programs.

How to Obtain the Guidelines

The guidelines are a portable electronic document that is updated periodically. Download the current version from its source and then use Adobe Reader® to view it on your computer screen. You can print the guidelines for convenience; however, links and navigational tools are only functional when the document is viewed in Adobe Reader®. Remember that printed copies of the guidelines are obsolete once a new version has been issued.

Conventions

Conventions are established by custom and are widely recognized and accepted. Conventions used in the guidelines are listed in this section.

Advisories

Advisories are used throughout the guidelines to bring important information to your attention. Please carefully review each advisory. The definitions have been updated to coincide with the American National Standards Institute (ANSI) and are formatted as follows:

Example	Example provides an example of the topic.
Important	Important indicates information that is helpful.

CAUTION

CAUTION indicates that people could possibly be endangered and slightly hurt.

DANGER

DANGEROUS indicates that people could easily be hurt or killed.

NOTICE

NOTICE indicates a possibly dangerous situation where goods might be damaged.

WARNING

WARNING indicates that people could possibly be hurt or killed.

Boldfacing

Boldfaced type is used to highlight negative or important words. These words are **never**, **not**, **do not**, **other than** and **prohibited**.

Lists

Bulleted lists indicate information listed in no particular order. Numbered lists indicate that information will be used in a particular order.

Disclaimers

All disclaimers are located on the page that follows the cover.

Control Data

Information placed at the top and bottom of each page helps users keep track of where they are in the guidelines. At the top of the page is the chapter. At the bottom of the page is the year, edition, title and page number. PPQ–Pest Detection and Emergency Programs (PDEP) is the unit responsible for the content of the guidelines.

Decision Tables

Decision tables are used throughout the guidelines. The first and middle columns in each table represent conditions, and the last column represents the action to take after considering all conditions listed for that row. Begin with the column headings and move left-to-right. If the condition does not apply, then continue one row at a time until you find the condition that does apply.

Table A-1 How to use decision tables

If you:	And if the condition applies:	Then:
read this column cell and row first	continue in this cell	TAKE the action listed in this cell
find the previous condition does not apply, then read this column cell	continue in this cell	TAKE the action listed in this cell

Footnotes

When space allows, figure and table footnotes are located directly below the associated figure or table. However, for multi-page tables or tables that cover the length of a page, footnote numbers and footnote text cannot be listed on the same page. If a table or figure continues beyond one page, the associated footnotes will appear on the page following the end of the figure or table.

Heading Levels

Within each chapter and section there can be four heading levels; each heading is green and is located within the middle and right side of the page. The first-level heading is indicated by a horizontal line across the page with the heading following directly below. The second-, third- and fourth-level headings each have a font size smaller than the preceding heading level. The fourth-level heading runs in with the text that follows.

Hypertext Links

Figures and tables are cross-referenced in the body of the guidelines and are highlighted in blue hypertext type.

Italics

The following items are italicized throughout the guidelines:

- Cross-references to headings and titles
- Names of publications
- Scientific names

Numbering Scheme

A two-level numbering scheme is used in the guidelines for pages, tables and figures. The first number represents the chapter. The second number represents the page, table or figure. This numbering scheme allows for identification and updating. Dashes are used in the page numbering to differentiate page numbers from decimal points.

Transmittal Number

The transmittal number contains the month, year and a consecutively issued number (beginning with -01 for the first edition and increasing consecutively for each update to the edition). The transmittal number is only changed when the specific chapter sections, appendices, tables or index is updated. If no changes are made, then the transmittal number remains the unchanged. The transmittal number only changes when a new guidelines edition is issued or changes are made to the entire guidelines.

Acknowledgements

Writers, editors, reviewers, creators of cover images and other contributors to the guidelines are acknowledged in the acknowledgements section. Names, affiliations and Website addresses of the creators of photographic images, illustrations and diagrams are acknowledged in the caption accompanying the figure.

How to Cite the Guidelines

Cite the guidelines as follows:

U.S. Department of Agriculture, Animal Plant Health Inspection Service, Plant Protection and Quarantine. 2014. New Pest Response Guidelines: Teleomorph: *Magnaporthe oryzae* B.C. Couch *Triticum* pathotype; Anamorph: *Pyricularia oryzae* Cavara (Wheat Blast). Washington, D.C.: Government Printing Office. http://www.aphis.usda.gov/import_export/plants/manuals/online_manuals.shtml

How to Find More Information

Contact USDA–APHIS–PPQ–PDEP–Emergency Management for more information regarding the guidelines. Refer to *Resources* on page B-1 for contact information.

Appendix

B

Resources

Use *Appendix B Resources* to find the Website addresses, street addresses and telephone numbers for the resources mentioned in the guidelines.

- Center for Plant Health, Science and Technology (USDA–APHIS–PPQ–CPHST)
- Pest Detection and Emergency Programs, Emergency Management (USDA–APHIS–PPQ–PDEP–EM)
- PPQ Treatment Manual
- Plant, Organism and Soil Permits (APHIS–PPQ)
- National Program Manager for Native American Program Delivery and Tribal Liaison (USDA–APHIS–PPQ)
  14082 S. Poston Place
  Tucson, AZ 85736
  Telephone: (520) 822-5440
- Biological Control Coordinator (USDA–APHIS–CPHST)
- FIFRA Coordinator (USDA-APHIS-PPQ-PDEP)
  4700 River Road
  Riverdale, MD 20737
  Telephone: (301) 851-2243
- Environmental Compliance Coordinator (USDA–APHIS–PPQ–PDEP)
  4700 River Road
  Riverdale, MD 20737
  Telephone: (301) 851-2345
- PPQ Forms
- List of State Plant Health Directors (SPHD)
- List of State Plant Regulatory Officials (SPRO)

- National Climatic Center, Database Administration
  Box 34
  Federal Building
  151 Patton Ave
  Asheville, NC 28801-5001
- CAPS Survey Manual
- GenBank®
- iPhyClassifier

Appendix

C

Forms

PPQ Form 391, Specimens for Determination **C-2**

PPQ Form 523, Emergency Action Notification **C-6**

PPQ Form 391, Specimens for Determination

This report is authorized by law (7 U.S.C. 147a). While you ar not required to respond your cooperation is needed to make an accurate record of plant pest conditions. *See reverse for additional OMB information.*

FORM APPROVED
OMB NO. 0579-0010

U.S. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE

SPECIMENS FOR DETERMINATION

Instructions: Type or print information requested. Press hard and print legibly when handwritten. Item 1 - assign number for each collection beginning with year, followed by collector's initials and collector's number. Example (collector, John J. Dingle): 83-JJD-001.
Pest Data Section – Complete Items 14, 15 and 16 or 19 or 20 and 21 as applicable. Complete Items 17 and 18 if a trap was used.

FOR IIBIII USE
LOT NO.
PRIORITY

1. COLLECTION NUMBER
2. DATE — MO | DA | YR
3. SUBMITTING AGENCY — ☐ State Cooperator ☐ PPQ ☐ Other _____

SENDER AND ORIGIN

4. NAME OF SENDER
6. ADDRESS OF SENDER
ZIP

INTERCEPTION SITE

5. TYPE OF PROPERTY *(Farm, Feedmill, Nursery, etc.)*
7. NAME AND ADDRESS OF PROPERTY OR OWNER
COUNTRY/ COUNTY

PURPOSE

8. REASON FOR IDENTIFICATION *("x" ALL Applicable Items)*

A. ☐ Biological Control (Target Pest Name)	E. ☐ Livestock, Domestic Animal Pest
B. ☐ Damaging Crops/Plants	F. ☐ Possible Immigrant *(Explain in* REMARKS*)*
C. ☐ Suspected Pest of Regulatory Concern *(Explain in* REMARKS*)*	G. ☐ Survey *(Explain in* REMARKS*)*
D. ☐ Stored Product Pest	H. ☐ Other *(Explain in* REMARKS*)*

9. IF PROMPT OR URGENT IDENTIFICATION IS REQUESTED, PLEASE PROVIDE A BRIEF EXPLANATION UNDER "REMARKS".

HOST DATA

10. HOST INFORMATION
NAME OF HOST *(Scientific name when possible)*

11. QUANTITY OF HOST
NUMBER OF ACRES/PLANTS
PLANTS AFFECTED *(Insert figure and indicate* ☐ Number ☐ Percent*)*:

12. PLANT DISTRIBUTION
☐ LIMITED
☐ SCATTERED
☐ WIDESPREAD

13. PLANT PARTS AFFECTED

☐ Leaves, Upper Surface	☐ Trunk/Bark	☐ Bulbs, Tubers, Corms	☐ Seeds
☐ Leaves, Lower Surface	☐ Branches	☐ Buds	
☐ Petiole	☐ Growing Tips	☐ Flowers	
☐ Stem	☐ Roots	☐ Fruits or Nuts	

PEST DATA

14. PEST DISTRIBUTION
☐ FEW
☐ COMMON
☐ ABUNDANT
☐ EXTREME

15. ☐ INSECTS ☐ NEMATODES ☐ MOLLUSKS

NUMBER SUBMITTED	LARVAE	PUPAE	ADULTS	CAST SKINS	EGGS	NYMPHS	JUVS.	CYSTS
ALIVE								
DEAD								

16. SAMPLING METHOD
17. TYPE OF TRAP AND LURE
18. TRAP NUMBER

19. PLANT PATHOLOGY – PLANT SYMPTOMS *("X" one and describe symptoms)*
☐ ISOLATED ☐ GENERAL

20. WEED DENSITY
☐ FEW ☐ SPOTTY ☐ GENERAL

21. WEED GROWTH STAGE
☐ SEEDLING ☐ VEGETATIVE ☐ FLOWERING/FRUITING ☐ MATURE

22. REMARKS

23. TENTATIVE DETERMINATION

24. DETERMINATION AND NOTES *(Not for Field Use)*

SIGNATURE
DATE

FOR IIBIII USE
DATE RECEIVED
NO.
LABEL
SORTED
PREPARED
DATE ACCEPTED
RR

PPQ FORM 391
(AUG 02)
Previous editions are obsolete.

This is a 6-Part form. Copies must be disseminated as follows:
☐ PART 1 – PPQ ☐ PART 2 – RETURN TO SUBMITTER AFTER IDENTIFICATION ☐ PART 3 – IIBIII OR FINAL IDENTIFIER
☐ PART 4 – INTERMEDIATE IDENTIFIER ☐ PART 5 – INTERMEDIATE IDENTIFIER ☐ PART 6 – RETAINED BY SUBMITTER

Figure C-1 Example of PPQ Form 391, Specimens for Determination, side 1

PPQ Form 391, Specimens for Determination (cont.)

OMB Information

According to the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number. The valid OMB control number for this information collection is 0579-0010. The time required to complete this information collection is estimated to average .25 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Instructions

Use PPQ Form 391, Specimens for Determination, for domestic collections (warehouse inspections, local and individual collecting, special survey programs, export certification).

BLOCK	INSTRUCTIONS
1	1. Assign a number for each collection beginning the year, followed by the collector's initials and collector's number **EXAMPLE** In 2001, Brian K. Long collected his first specimen for determination of the year. His first collection number is 01-BLK-001 2. Enter the collection number
2	Enter date
3	Check block to indicate Agency submitting specimens for identification
4	Enter name of sender
5	Enter type of property specimen obtained from (farm, nursery, feedmill, etc.)
6	Enter address
7	Enter name and address of property owner
8A-8L	Check all appropriate blocks
9	Leave Blank
10	Enter scientific name of host, if possible
11	Enter quantity of host and plants affected
12	Check block to indicate distribution of plant
13	Check appropriate blocks to indicate plant parts affected
14	Check block to indicate pest distribution
15	• Check appropriate block to indicate type of specimen • Enter number specimens submitted under appropriate column
16	Enter sampling method
17	Enter type of trap and lure
18	Enter trap number
19	Enter X in block to indicate isolated or general plant symptoms
20	Enter X in appropriate block for weed density
21	Enter X in appropriate block for weed growth stage
22	Provide a brief explanation if Prompt or URGENT identification is requested
23	Enter a tentative determination if you made one
24	Leave blank

Distribution of PPQ Form 391

Distribute PPQ Form 391 as follows:

1. Send Original along with the sample to your Area Identifier.
2. Retain and file a copy for your records.

Figure C-2 Example of PPQ Form 391, Specimens for Determination, side 2

Purpose

Submit PPQ Form 391, Specimens for Determination, along with specimens for positive or negative identification.

Instructions

Follow the instructions in on page C-3. Inspectors must provide all relevant collection information with samples. This information should be shared within both the state and the regional office program contact. If a sample tracking database is available at the time of detection, please enter the collection information in the system as quickly as possible.

Distribution

Distribute PPQ Form 391 as follows:

1. Send the original with the sample to your area identifier.
2. Keep and file a copy for your records.

Table C-1 Instructions for completing PPQ Form 391, Specimens for Determination

Block	Description	Instructions
1	COLLECTION NUMBER	1. ASSIGN a collection number for each collection as follows: 2-letter state code-5-digit sample number (survey identification number in parentheses); example: PA-1234 (0402010001) 2. CONTINUE consecutive numbering for each subsequent collection 3. ENTER the collection number
2	DATE	ENTER the date of the collection
3	SUBMITTING AGENCY	PLACE an X in the PPQ block
4	NAME OF SENDER	ENTER the sender's or collector's name
5	TYPE OF PROPERTY	ENTER the type of property from which the specimen was collected (farm, feed mill, nursery, etc.)
6	ADDRESS OF SENDER	ENTER the sender's or collector's address
7	NAME AND ADDRESS OF PROPERTY OR OWNER	ENTER the name and address of the property from which the specimen was collected
8A–8H	REASONS FOR IDENTIFICATION	PLACE an X in the correct block
9	IF PROMPT OR URGENT IDENTIFICATION IS REQUESTED, PLEASE GIVE A BRIEF EXPLANATION UNDER "REMARKS"	LEAVE BLANK; ENTER remarks in *Block 22*
10	HOST INFORMATION, NAME OF HOST	If known, ENTER the scientific name of the host
11	QUANTITY OF HOST	If applicable, ENTER the number of acres planted with the host
12	PLANT DISTRIBUTION	PLACE an X in the applicable box
13	PLANT PARTS AFFECTED	PLACE an X in the applicable box
14	PEST DISTRIBUTION: FEW/COMMON/ABUNDANT/ EXTREME	PLACE an X in the appropriate block
15	INSECTS/NEMATODES/ MOLLUSKS	PLACE an X in the applicable box to indicate type of specimen
	NUMBER SUBMITTED	ENTER the number of specimens submitted as ALIVE or DEAD under the appropriate stage
16	SAMPLING METHOD	ENTER the type of sample
17	TYPE OF TRAP AND LURE	ENTER the type of sample
18	TRAP NUMBER	ENTER the sample numbers
19	PLANT PATHOLOGY-PLANT SYMPTOMS	If applicable, check the appropriate box; otherwise LEAVE BLANK
20	WEED DENSITY	If applicable, check the appropriate box; otherwise LEAVE BLANK
21	WEED GROWTH STAGE	If applicable, check the appropriate box; otherwise LEAVE BLANK
22	REMARKS	ENTER the name of the office or diagnostic laboratory forwarding the sample; include a contact name, email address, phone number of the contact and the date forwarded to the state diagnostic laboratory or USDA-APHIS-NIS
23	TENTATIVE DETERMINATION	ENTER the preliminary diagnosis
24	DETERMINATION AND NOTES (**Not** for field use)	LEAVE BLANK; to be completed by the official identifier

PPQ 523 Emergency Action Notification

According to the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number. The valid OMB control number for this information is 0579-0102. The time required to complete this information collection is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

FORM APPROVED - OMB NO. 0579-0102

U.S. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE

EMERGENCY ACTION NOTIFICATION

SERIAL NO.

1. PPQ LOCATION
2. DATE ISSUED
3. NAME AND QUANTITY OF ARTICLE(S)
4. LOCATION OF ARTICLES
5. DESTINATION OF ARTICLES
6. SHIPPER
7. NAME OF CARRIER
8. SHIPMENT ID NO.(S)
9. OWNER/CONSIGNEE OF ARTICLES

Name:

Address:

PHONE NO. FAX NO.

SS NO. TAX ID NO.

10. PORT OF LADING
11. DATE OF ARRIVAL
12. ID OF PEST(S), NOXIOUS WEEDS, OR ARTICLE(S)
12a. PEST ID NO.
12b. DATE INTERCEPTED
13. COUNTRY OF ORIGIN
14. GROWER NO.
15. FOREIGN CERTIFICATE NO.
15a. PLACE ISSUED
15b. DATE

Under Sections 411, 412, and 414 of the Plant Protection Act (7 USC 7711, 7712, and 7714) and Sections 10404 through 10407 of the Animal Health Protection Act (7 USC 8303 through 8306), you are hereby notified, as owner or agent of the owner of said carrier, premises, and/or articles, to apply remedial measures for the pest(s), noxious weeds, and or article(s) specified in Item 12, in a manner satisfactory to and under the supervision of an Agriculture Officer. Remedial measures shall be in accordance with the action specified in Item 16 and shall be completed within the time specified in Item 17.

AFTER RECEIPT OF THIS NOTIFICATION, ARTICLES AND/OR CARRIERS HEREIN DESIGNATED MUST NOT BE MOVED EXCEPT AS DIRECTED BY AN AGRICULTURE OFFICER. THE LOCAL OFFICER MAY BE CONTACTED AT:

16. ACTION REQUIRED

☐ TREATMENT:

☐ RE-EXPORTATION:

☐ DESTRUCTION:

☐ OTHER:

Should the owner or owner's agent fail to comply with this order within the time specified below, USDA is authorized to recover from the owner or agent cost of any care, handling, application of remedial measures, disposal, or other action incurred in connection with the remedial action, destruction, or removal.

17. AFTER RECEIPT OF THIS NOTIFICATION COMPLETE SPECIFIED ACTION WITHIN (Specify No. Hours or No. Days):
18. SIGNATURE OF OFFICER:

ACKNOWLEDGMENT OF RECEIPT OF EMERGENCY ACTION NOTIFICATION

I hereby acknowledge receipt of the foregoing notification.

SIGNATURE AND TITLE:

DATE AND TIME:

19. REVOCATION OF NOTIFICATION

ACTION TAKEN:

SIGNATURE OF OFFICER:

DATE:

PPQ FORM 523 (JULY 2002) Previous editions are obsolete.

Figure C-3 Example of PPQ 523 Emergency Action Notification

Purpose

Issue a PPQ 523 Emergency Action Notification (EAN) to hold all host plant material at facilities that house the suspected plant material directly or indirectly connected to positive confirmations. Once an investigation determines that the plant material is not infected or testing determines there is no risk, the material may be released and the release documented on the EAN.

The EAN may also be issued to hold plant material in fields pending positive identification of suspect samples. When a decision is made to destroy plants, or in the case of submitted samples, once positive confirmation is received, the same EAN that placed plants on hold also documents any actions taken, such as destruction and disinfection. More action may be warranted if other fields test positive for this pest.

Instructions

If plant lots or shipments are held as separate units, issue separate EANs for each unit of suspected and associated plant material. The EANs are issued under the authority of the Plant Protection Act of 2000 (state 7 USC 7701-7758). States are advised to issue their own hold orders parallel to the EAN to prevent intrastate movement of plant material.

When using an EAN to hold articles, the EAN language must clearly specify actions to be taken. An EAN issued for positive testing and positive associated plant material must clearly state that the material must be disposed of, or destroyed, and the areas disinfected. Include language that these actions will occur at the owner's expense and will be supervised by a regulatory official. If the EAN is used to issue a hold order for further investigations and testing of potentially infected material, use the same EAN to document any disposal, destruction and disinfection orders resulting from the investigations or testing.

Appendix

D

Taxonomic Support for Surveys

Background

The National Identification Services (NIS) coordinates the identification of plant pests in support of the USDA's regulatory programs. Accurate and timely identifications are the foundation of quarantine action decisions and are essential in the effort to safeguard the nation's agricultural and natural resources.

The NIS employs and collaborates with scientists who specialize in various plant pest groups, including weeds, insects, mites, mollusks and plant diseases. These scientists are stationed at a variety of institutions around the country, including federal research laboratories, plant inspection stations, land-grant universities and natural history museums. Additionally, the NIS Molecular Diagnostics Laboratory is responsible for providing biochemical testing to support the agency's pest monitoring programs.

On 13 June 2007, the PPQ Deputy Administrator issued PPQ Policy No. PPQ-DA-2007-02, which established the role of PPQ NIS as the point of contact for all domestically detected confirmations and communications regarding introduced plant pests. The position of Domestic Diagnostics Coordinator (DDS) was established to administer the policy and coordinate domestic diagnostics for the NIS. Any questions regarding sample routing or communication of results can be directed to the PPQ Survey Field Operations Manager (Brian Kopper: phone (919) 855-7318; e-mail, brian.j.kopper@aphis.usda.gov) or the Domestic Diagnostics Coordinator

Taxonomic Support and Survey Activity

Taxonomic support for pest surveillance is fundamental to conducting quality surveys. A misidentification or incorrectly screened target pest can yield a missed opportunity for early detection when control strategies are more viable and cost effective. The importance of good sorting, screening and identification during domestic survey activity cannot be overemphasized.

Fortunately, most states have, or have access to, good taxonomic support. Taxonomic support should be considered in cooperative agreements as another cost of conducting surveys. Taxonomists and laboratories within the state often

require supplies, develop training materials or hire technicians to meet their screening and identification needs. When considering whether to survey for a particular pest during a given year, consider the challenges of taxonomic support.

Sorting and Screening

For survey activities, the proper sorting and screening of samples prior to examination by an identifier will result in improved turn-around times for identification.

Sorting

Sorting is the first level of activity to ensure samples submitted are of the correct target group for the pests being surveyed. Select those plant samples that are symptomatic if appropriate. A minimum level of sorting is expected of surveyors depending on the target group, training, experience or demonstrated ability.

Screening

Screening for plant pathogens is performed by the laboratory diagnostician.

Check individual survey protocols to determine if samples should be sorted, screened or sent in their entirety (raw) before submitting for identification. If not specified in the protocol, assume that samples should be sorted to some degree.

Resources for Sorting, Screening and Identification

Sorting, screening and identification resources and aids useful to CAPS and PPQ surveys are best developed by taxonomists knowledgeable in the taxa that include the target pests and the established or native organisms in the same group that are likely in the samples and can be confused with the target. These aids are often regionally based and can be in the form of dichotomous keys, picture guides or reference collections. The NIS encourages the development of these resources, and when aids are complete, posts them in the CAPS Website for the benefit of others. Please see the following Website for some available screening aids: https://caps.ceris.purdue.edu/node/34.

Other Entities for Taxonomic Assistance in Surveys

When taxonomic support within a state is inadequate for a particular survey, other entities may assist including PPQ identifiers, universities and state departments of agriculture from other states and independent institutions. Check with the PPQ regional CAPS coordinators regarding the availability of taxonomic assistance.

Universities and State Departments of Agriculture

Depending on the taxonomic group, a few cases involve two entities that are interested in receiving samples from other states. Arrangements for payment, if required for these taxonomic services, can be made through cooperative agreements. The National Plant Diagnostic Network (NPDN) also has several regional hub laboratories that can provide service identifications of plant diseases in their respective regions. PPQ currently has arrangements with to state departments of agriculture (Oregon and Washington) and one university (Mississippi State University) through Farm Bill funding to provide taxonomic services to other states should they desire it. Contact your CAPS NOM for more information.

Independent Institutions

The Raleigh PPQ Field Operations office has set up multi-state arrangements for the Carnegie Museum of Natural History to identify insects from trap samples. They prefer to receive unscreened material and work on a fee basis per sample.

PPQ Port Identifiers

There are over 70 identifiers in PPQ that are stationed at ports of entry to primarily identify pests encountered in international commerce including conveyances, imported cargo, passenger baggage and propagative material. In some cases, these identifiers process survey samples generated during PPQ-conducted surveys and occasionally those from CAPS surveys. They can also enter the PPQ form 391 for a suspect CAPS target or other suspect new pests into our PestID database prior to their being forwarded for confirmation by an NIS-recognized authority. The list of PPQ port identifiers and their areas of coverage can be found on the following Website: http://inside.aphis.usda.gov/ppq/php/manual/mac/identifiers_co-lat_natl_spec.pdf.

PPQ Domestic Identifiers

PPQ has a limited number of domestic identifiers normally stationed at universities who are primarily responsible for survey samples. Domestic identifiers can handle unscreened or partially screened samples with prior arrangement through the PPQ CAPS NOM. They can also act as an intermediary alternative to sending an unknown suspect to, for example, the ARS Systematic Entomology Lab (SEL) depending on their specialty and area of coverage. In addition, these identifiers can enter the PPQ form 391 for a suspect CAPS target or other suspect new pests into our PestID database prior to forwarding the sample for confirmation by an NIS-recognized authority.

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Domestic Plant Pathology Identifier
USDA–APHIS–PPQ
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Kansas State University
4024 Throckmorton Plant Sciences
Manhattan, KS 66506-5502
Cell: (785) 633-9117
Office: (785) 532-1349
Fax: (785) 532-5692
e-mail: craig.a.webb@aphis.usda.gov

Specialty: Molecular diagnostics (citrus health, sudden oak death, cyst nematode screening)

Area of coverage: Primarily western U.S.

ATTENTION SAMPLE SUBMITTERS: When sending domestic samples to domestic identifiers, you must notify them first by e-mail or phone that you plan to send samples, describing what type and how many. Once notification has been sent, forward an e-mail to them with a tracking number for the express carrier through whom the samples were forwarded. If you plan to send a domestic sample to a national specialist, notify the Coordinated Agricultural Project National Operations Manager (CAPS NOM) or the National Domestic Diagnostics Coordinator prior to sending the sample.

Final Confirmations

If identifiers or laboratories at the state, university or institution level suspect the detection of a CAPS target, a plant pest new to the United States or a quarantine pest of limited distribution in a new state, the specimens should be forwarded to an NIS-recognized taxonomic authority for final confirmation. State cooperator and university taxonomists can go through a PPQ area identifier or the appropriate domestic identifier that covers their area to place the specimen into the PPQ system. They will then send the specimen to the NIS-recognized authority for that taxonomic group. In some cases, domestic identifiers can make final confirmation depending on their ID authority, accreditation and proficiency testing.

State-level taxonomists, who are reasonably certain that they have a new United States record, CAPS target or federal quarantine pest, can send the specimen directly to the NIS-recognized authority, but must notify their State Survey Coordinator (SSC), PPQ Pest Survey Specialist (PSS), State Plant Health Director (SPHD) and State Plant Regulatory Official (SPRO).

Before forwarding these suspect specimens to identifiers or to the NIS-recognized authority for confirmation, please complete a PPQ form 391 with the tentative determination. In addition, fax a copy of the completed PPQ Form 391 to ‘Attention: Domestic Diagnostics Coordinator’ at (301) 851-2115, or send a PDF

file in an e-mail to aphis-ppq.nis.urgents@aphis.usda.gov with the overnight carrier tracking number.

The addresses of the NIS-recognized authorities to which suspect specimens are to be sent can be found at the following Website: http://inside.aphis.usda.gov/ppq/php/manual/mac/identifiers_co-lat_natl_spec.pdf.

Only use the 'Urgent' listings for suspected new United States or state records of a significant pest, and the 'Prompt' listings for all others.

When the specimen is forwarded to a specialist for final confirmation, use an overnight carrier, insure proper and secure packaging and include a hard copy of the PPQ form 391 marked 'Urgent' or 'Prompt' as previously described.

Please contact the National Operations Manager assigned to this new pest response by calling (919) 855-7335.

Digital Images for Confirmation of Domestic Detections

For the aforementioned confirmations, send specimens, not digital images. For entry into the National Agricultural Pest Information System (NAPIS), digital imaging confirmations can be used for new county records of widespread pests by state taxonomists or identifiers with their prior approval. These scientists always have the prerogative to request that the specimens be sent. Pests with PPQ regulatory programs may require specimens to be sent to SEL for new county records depending on the species.

Communication of Results

If no suspect CAPS target, program pests or new detections are found, communication of these identification results can be sent by the domestic identifiers or taxonomists at other institutions directly back to the submitter. The information can be presented in a spreadsheet, in a hardcopy of PPQ form 391 or other informal means labelled with the species or 'no CAPS target or new suspect pest species found.' Good record keeping by the intermediate taxonomists performing these identifications is essential.

All confirmations received from the NIS-recognized authorities, positive or negative, are communicated by the NIS to the PPQ Pest Detection and Emergency Programs (PDEP) staff at PPQ headquarters. The PDEP then notifies the appropriate PPQ program managers and the SPHD and SPRO simultaneously. One of these contacts should forward the results to the originating laboratory, diagnostician, identifier and/or submitter of the specimen or sample.

Data Entry in NAPIS

For survey data entered into NAPIS, new country and state records should be confirmed by an NIS-recognized authority, while for others that are more widespread, use the identifications from PPQ identifiers or state taxonomists. When in doubt, contact the PPQ Domestic Survey Coordinator.

Appendix

E

Sample Submission

Taxonomic support for insect surveys requires that samples be competently and consistently sorted, stored, screened (in most cases) and submitted to the identifier.

Sampling

When possible, submit adequate quantities of suspect leaf material (preferably 12 or more leaves per sample) to ensure sufficient material for possible downstream diagnostic techniques.

Storage

Refrigerate samples while awaiting shipment to the diagnostic laboratory. Place leaves **without paper towels** in a sealed and labeled resealable plastic bag.

Documentation

Each sample should be documented in and accompanied by its own completed PPQ form 319, *Specimens for Determination*. You should maintain a partially pre-filled electronic copy of this form on your computer with your address and other information to save time. Please ensure all applicable fields are completed and that the bottom field (block 24, *Determination and Notes*) is left blank for completion by the identifier. Include the phone number and/or e-mail address of the submitter. Other documentation in the form of notes, images, *etc.* can be included if useful to the determination. A method for cross-referencing the sample with the accompanying form is critical. For example, write the collection number on both Form 391 and the sample bag.

Packing

To provide extra insurance against accidental release during shipment, specimens should be double bagged—*i.e.,* first place the specimen in a self-locking plastic bag and place that bag within a second self-locking plastic bag. FORM 391 **SHOULD NOT** BE PLACED IN THE BAG HOLDING THE SAMPLE! RATHER, IT SHOULD BE PLACED INSIDE THE OUTER BAG.

Place the double-bagged samples in a sturdy cardboard box or heavy Styrofoam container to prevent damage to the samples during shipping and handling. Ideally, samples should be packed with cold packs or ice to maintain their integrity during the shipping process. Thoroughly seal all container seams with shipping tape.

Shipping

The identifying laboratory should be contacted prior to forwarding samples. It is helpful to know how many samples are being forwarded, the type of samples (*e.g.,* SOD-suspect camellia leaves), when the samples will be shipped and the package tracking number.

Label the shipping box as ‘URGENT’ and send via overnight express courier (FedEx, UPS, Airborne, DHL, *etc.*) to the appropriate identifier.

Appendix

F

Environmental Compliance

Overview

Program managers of federal emergency response or domestic pest control programs must ensure that their programs comply with all federal acts and executive orders pertaining to the environment as applicable. Two primary federal acts, the National Environmental Policy Act (NEPA) and the Endangered Species Act (ESA), often require the development of significant documentation before program actions may begin.

Program managers should also seek guidance and advice as needed from Environmental and Risk Analysis Services (ERAS), a unit of APHIS' Policy and Program Development (PPD) staff. ERAS is available to provide guidance to program managers and prepare drafts of applicable environmental documentation.

In preparing draft NEPA documentation, ERAS may also perform and incorporate assessments that pertain to other acts and executive orders described below as part of the NEPA process. The Environmental Compliance Team (ECT), a part of PPQ's Emergency Domestic Programs (EDP), will assess ERAS in the development of documents and will implement any environmental monitoring.

Leaders of the programs are strongly advised to meet with ERA and/or ECT early in the development of a program to conduct a preliminary review of applicable environmental statutes as requested by program managers or as suggested to address concerns over controversial activities. Monitoring may be conducted with regards to worker exposure, pesticide quality assurance and control, off-site chemical deposition or program efficacy. Different tools and techniques are used depending on the monitoring goals and control techniques used in the program. Staff from the ECT will work with the program manager to develop an environmental monitoring plan, conduct training to carry out the plan, provide day-to-day guidance on monitoring and provide an interpretive report of monitoring activities.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires all federal agencies to examine whether their actions may significantly affect the quality of the human environment. The purpose of NEPA is to inform the decision maker before taking action and to tell the public of the decision. Actions that are excluded from this examination, that normally require an environmental assessment and environmental impact statements, are codified in APHIS' NEPA implementing procedures located in 7 CFR 372.5.

The three types of NEPA documentation are categorical exclusions, environmental assessments and environmental impact statements.

Categorical Exclusion

Categorical exclusions (CEs) are classes of actions that do not significantly affect the quality of the human environment and for which neither an environmental assessment (EA) nor an environmental impact statement (EIS) is required. Generally, the means through which adverse environmental impacts may be avoided or minimized have been built into the actions themselves (7CFR 372.5(c)).

Environmental Assessment

An environmental assessment (EA) is a public document that succinctly presents information and analysis for the decision maker of the proposed action. An EA can lead to the preparation of an environmental impact statement, a finding of no significant impact (FONSI), or the abandonment of a proposed action.

Environmental Impact Statement

If a major federal action may significantly affect the quality of the human environment (adverse or beneficial) or the proposed action may result in public controversy, then prepare an environmental impact statement (EIS).

Endangered Species Act

The Endangered Species Act (ESA) is a statute requiring that programs consider their potential effects on federally protected species. The ESA requires programs to identify protected species and their habitats in or near program areas and to document how adverse effects to these species will be avoided. The documentation may require review and approval by the U.S. Fish and Wildlife

Service and the National Marine Fisheries Service before program activities can begin. Knowingly violating this law can lead to criminal charges against individual staff members and program managers.

Migratory Bird Treaty Act

The statute requires that programs avoid harm to over 800 endemic bird species, eggs and their nests. In some cases, permits may be available to capture birds, which require coordination with the U.S. Fish and Wildlife Service.

Clean Water Act

The statute requires various permits for work in wetlands and for potential discharge of program chemicals into water, which may require coordination with the Environmental Protection Agency, individual states and the Army Corps of Engineers. Such permits would be needed even if the pesticide label allows for direct application to water.

Tribal Consultation

The executive order requires formal government-to-government communication and interaction if a program might have substantial direct effects on any federally recognized Indian Nation. This process is often incorrectly included as part of the NEPA process, but must be completed before public involvement under NEPA. Staff should be cognizant of the conflict that could arise when proposed federal actions intersect with tribal sovereignty. Tribal consultation is designed to identify and avoid such potential conflict.

National Historic Preservation Act

The statute requires that programs consider potential impacts on historic properties (such as buildings and archaeological sites) and requires coordination with local state historic preservation offices. Documentation under this act involves preparing an inventory of the project area for historic properties and determining what effects, if any, the project may have on historic properties. This process may need public involvement and comment before the start of program activities.

Coastal Zone Management Act

The statute requires coordination with states in which programs may impact coastal zone management plans. Federal activities that may affect coastal resources are evaluated through a process called federal consistency. This process affords the public, local governments, tribes and state agencies an opportunity to review the federal action. The federal consistency process is administered individually by states with coastal zone management plans.

Environmental Justice

The executive order requires consideration of program impacts on minority and economically disadvantaged populations. Compliance is usually achieved within the NEPA documentation for a project. Programs are required to consider if the actions might impact minority or economically disadvantaged populations and if so, how such impact will be avoided.

Protection of Children

The executive order requires federal agencies to identify, assess and address environmental health and safety risks that may affect children. If such a risk is identified, measures must be described and carried out to minimize such risks.

Glossary

M. oryzae

Definitions, Terms and Abbreviations

abiotic. pertaining to the absence of life; diseases not caused by living organisms

acropetal. referring to spore formation in which the most recently formed spore is at the tip of a chain of spores; typically seen as being smaller than the immediate neighbor

actinomycete. Gram-positive filamentous bacteria

acute. less than a 90° angle; pointed

adventitious roots. roots that arise from an atypical place, from a stem rather than as branches of a root

aerobic. requiring free oxygen for respiration

AFLP. Amplified Fragment Length Polymorphism; technique that uses PCR to amplify genomic DNA cleaved by restriction enzymes to generate DNA fingerprints; combines RFLP and arbitrary primer PCR and does not require prior sequence knowledge

amplicon. piece of DNA synthesized using amplification techniques such as PCR

anaerobic. organism that can live without oxygen

anamorph. asexual form of a fungus

annellide. conidiogenous cell elongating during conidiogenesis (progressive) producing blastoconidia in basipetal succession; each conidium is produced through the same opening of the previously formed one and leaves a ring-like band (annellation) at the apex after seceding. The terminal part, which comprises a series of ring-like scars, is termed anellated region

antheridium. male sexual organ (male gametangium) found in some fungi

APA. American Phytopathological Society

APHIS. USDA–Animal and Plant Health Inspection Service

Apiculus. tiny projection on a spore where it is attached to the sterigma

appressed. pressed close to or lying flat

appressoria. swollen, flattened portion of a fungal filament that adheres to the surface of a higher plant, providing anchorage for invasion by a fungus

approved landfill. state-licensed municipal or private landfill managed under state regulation to prevent leaching of potential pollutants into groundwater

AQAS. Agricultural Quarantine Activity System, a Web database accessible from any USDA–APHIS computer

aerial treatment. application of pesticide to a treatment area via aircraft

ARS. USDA–Agricultural Research Service

a**scoma (plural ascomata).** fruit body containing asci

ascospore. sexually produced spore in an ascus

ascus (plural asci). cell of the Ascomycetes in which ascospores are produced after karyogamy and meiosis

aseptate. without a separating wall or membrane

augmentation. intentional addition of natural enemies via mass release in areas in which these enemies are absent, occur too late in the season or pest life cycle or are present in ineffective numbers

autoecious. parasitic fungus that completes the entire life cycle on a single host

barrier. natural or artificial obstacle to movement

basidium. cell of the basidiomycetes which bears on small stalks the basidiospores after karyogamy and meiosis

basidiospore. sexual spore formed externally on the basidium on a sterigma

biological control. development and use of natural means of control through parasites, predators, pathogens and biological tactics to suppress a pest population density below a level that would not occur in their absence, either for a given period or permanently

biological tactics. the use of any natural or derived product or technique utilizing biological applications such as gene transfer, genetic manipulation, pheromone attractants, host substitution or other biological means to suppress a pest population density below a level that would not occur in their absence, either for a given period or permanently

biometric survey. survey succeeding the delimiting survey in which properties are number and letter coded for survey purposes on a rotational basis

biovar. group of bacterial strains that are distinguishable from other strains of the same species on the basis of their physiological characteristics

biseriate. arranged in two rows

block. units of a detection survey (*e.g.*, 1 square mile) in which all survey activities are conducted

boring dust. brownish, dry, crumbly decay of wood caused by fungi decomposing cellulose and leaving the lignin in a modified state

brachyblasts. short lateral branch

buffer area. survey area that is beyond the core block

bullate. appearing puckered as if blistered

calcareous. composed of, containing or characteristic of calcium carbonate, calcium or limestone; chalky

cambium. meristematic tissue in woody plants that exists between the wood (xylem) and the inner most bark (phloem)

cankers. plant disease characterized (in woody plants) by the death of cambium tissue and the loss and/or malformation of bark, or (in non-woody plants) by the formation of sharply delineated, dry, necrotic localized lesions on the stem; may also be used to refer to the lesion itself, particularly in woody plants

CAPS. Cooperative Agricultural Pest Survey program, partnership between all 50 states and the USDA to detect and monitor exotic pests of economic impact

cast needles. premature drop of needles from a tree

catenulate. arranged in a series of rings or chains

CFR. Code of Federal Regulations

chemical integration. direct application of selected chemicals to the host that are nontoxic or relatively nontoxic to selected parasites or predators

chimeric. composed of parts of different origin

chlamydospore. thick-walled asexual resting spore formed from hyphal cells (terminal or intercalary) or by transformation of conidial cells that can function as an overwintering stage

chlorosis. yellowing of normally green tissue due to chlorophyll destruction in infected plants

classical biological control. introduction of exotic natural enemies from the region of origin to provide a permanent, self-sustaining suppression of a pest population density below a level that would not occur in their absence

clavate. resembling a club, becoming increasingly wide from the base to the distal end

coenocytic. having multiple nuclei embedded in cytoplasm without cross walls; nonseptate

cold treatment. exposure of a host product to cold temperatures lethal to a target pest; may be used alone or with fumigants

commercial production area. area in which host material is grown for sale

confirmation detection. positive identification of a submitted specimen

conidiogenous. cell that produces conidia

conidioma (plural conidiomata). fruit body containing conidia (*e.g.,* acervulus, pycnidium, sporodochium)

conidiophore. simple or branched hyphae arising from somatic hyphae which bears at its tip or sides, cells which form or become conidia

conidium. nonmotile asexual spore formed on a conidiophore, formed from or as an extension of the hyphal walls; may be single- or multi-celled, simple or complex, round, elongated or spiral in shape; found only in the Ascomycota or Basidiomycota

containment. application of phytosanitary measures in and around an infected area to prevent spread of a pest

control. application of phytosanitary measures in and around an infested area to prevent spread of a pest

conterminous. having a boundary in common

core area. area of 1 square mile surrounding a confirmed detection

coremium. fruiting bodies of certain fungi, consisting of a loosely bound bundle of conidiophores

corm. solid swollen underground bulb-shaped stem or stem base that serves as a reproductive structure

cotyledons. embryonic leaf in seed-bearing plants

CPB. United States Department of Homeland Security—Customs and Border Protection

CPHST. PPQ–Center for Plant Health Science and Technology

crepuscular. active during twilight hours

cross transect survey. survey designed to detect the infestation in the shortest time possible; strung out along the two lines of an axis and run through the most likely host areas. The survey may eventually be replaced by one based on a grid system for improved coverage

crown. portion of a plant, typically at ground level, at which the stem and roots merge

cultural control. intentional use of simple practices or mechanical measures that may be available to control a pest population

cuneate. wedge-shaped

d.b.h. diameter at breast height.

decontamination. application of approved chemical or other treatment to contaminated implements, materials or buildings for killing or deactivating a pathogen

delimiting survey. survey conducted in a susceptible area not known to be infested with the target pest

deliquescent. tending to melt or dissolve

dendroid. resembling a tree in form and branching structure

denticulate. having a finely toothed margin

destructive sampling. method of observing signs and symptoms of the presence or absence of a pest by destruction of the living sample unit; for example, removal of bark to look for larvae

detection. process of identifying the presence of something concealed

detection survey. survey conducted in an environmentally favorable area in which the pathogen is not known to occur

developmental thresholds. minimum and/or maximum temperatures that support physiological development of a species

DHS. United Stated Department of Homeland Security

dichotomous. forked, with two symmetrical branches

dieback. death of branches on woody plants, shrubs or trees; typically young shoots,

twigs and distal portions of branches dying progressively toward older plant parts

disposal. method used to eliminate diseased plant material or material associated with diseased plant material, usually at an approved landfill

diurnal. active during the day

EAN. Emergency Action Notification

EDP. PPQ-Emergency and Domestic Programs

elicitins. small cysteine-rich lipid-binding proteins

ELISA. Enzyme-Linked Immunosorbent Assay; a serological laboratory technique used to determine the genus and species in a host sampling and testing program; excludes race and biovar

ellipsoid. surface whose plane sections are all ellipses or circles

EM. PPQ–Emergency Management

encysted. to form a cyst or protective covering to lose motility

endophytes. endosymbiont, often a bacterium or fungus, which lives within a plant for at least part of its life without causing apparent disease

entomopathogen. pathogen that induces illness in insects

EPA. United States Environmental Protection Agency

epicenter. initial site of an infestation

epicormic shoot. shoot arising from adventitious or latent buds that form on branches and stems; suckers are produced from the tree base

EPPO. European and Mediterranean Plant Protection Organization

eradication. application of phytosanitary measures to eliminate a pest from an area before it becomes too large in area or numbers for current technology

exotic species. pest species not native to or historically resident in North America

exudate. liquid excreted or discharged from diseased tissues

fascicles. dense cluster or bundle

fastidious phloem-limited. quality of a pathogen that describes its ability to only survive within the phloem capsular system of a plant

FIFRA. Federal Insecticide, Fungicide and Rodenticide Act

flagellum. long tapering process that projects singly or in groups from a cell and is the primary organ of motion of many microorganisms

FONSI. Finding Of No Significant Impact

fructification. the bearing of fruit

fumigation. application of an approved fumigant, such as methyl bromide, as a treatment

funicle. slender stalk or cord; a stalk connecting a seed or ovule with the placenta

fusiform. spindle-shaped; tapering at each end

gametangia. cell containing gametes or nuclei that act as gametes.

generation. period during which a pest completes all stages of development predicted using biological information

geniculate. bent at a sharp angle

germ tube. hypha that emerges from a resting structure

girdle. to circle and cut through a stem or the bark and outer few rings of wood, disrupting the phloem and xylem

GIS. geographic information systems; a computer system capable of capturing, storing, analyzing and displaying geographically referenced information

globose. spherical or almost spherical

Gram-negative bacteria. class of bacteria that do not retain the crystal violet stain used in the Gram staining method of bacterial differentiation

Gram-positive bacteria. class of bacteria that take up the crystal violet stain used in the Gram staining method of bacterial differentiation

ground spray. using ground spray equipment to apply pesticide to the ground, selected resting places, or host vegetation in a target infested area

gummosis. plant disease in which the lesions exude a sticky liquid

guttule. small oil-like drop inside a fungal spore

haustoria. specialized branch of a parasite formed inside host cells to absorb nutrients

heteroecious. parasitic fungus that develops different stages of the life cycle on different host species

heterothallism. condition in which sexual reproduction can occur only in the presence of genetically different mycelia (see homothallism)

hilum. slightly prominent mark or scar present on a conidium at the point of attachment to a conidiogenous cell

homothallism. condition in which sexual reproduction occurs with a single thallus; self-fertile (see heterothallism)

host. plant which is invaded by a parasite or pathogen and from which it obtains its nutrients

host collecting. collection and retention of infested host material for the purposes of determining characteristics of a pest's use of the host; also known as holding

hot-zone survey. choosing an area, typically residential, on which to concentrate surveys based on known pathway information with ZIP code-based demographic information or other scientific information; also known as a targeted survey or demographic survey

hyaline. transparent or nearly so; translucent; often used in the sense of colorless

hyphae. single, tubular filament of a fungal thallus or mycelium; the basic structural unit of a fungus

ICS. Incident Command System

identification authority. authority to confirm the presence of a particular pest contractible issued by the APHIS-National Identification Services to diagnosticians that have demonstrated proficiency in identification

imbricate. shingle-like; having regularly arranged overlapping edges as in roof tiles

incineration. burning of plants and associated soil or media resulting in their complete destruction

indigenous. native

infection. establishment of a parasite on or within a host plant

infestation. to overrun or inhabit in numbers or quantities large enough to be harmful, obnoxious or threatening

infested area. area surrounding a single detection site or a group of sites; the standard designated area of 2.5 square miles is used, unless biotic or abiotic factors dictate adjustment of this area.

inoculative augmentation. biological control method of releasing natural enemies seasonally or periodically to reestablish a balance that has not been maintained naturally

or has been disrupted by other control methods

inundative augmentation. biological control method that involves the massive production and release of natural enemies to control a pest/pathogen quickly

intercalary. positioned between the apex and base

ISIS. Integrated Survey Information System

isozyme. enzymes that differ in amino acid sequence but catalyze the same chemical reaction

leaf spot. plant disease lesion typically restricted in development in the leaf after reaching a characteristic size

lesion. localized diseased area or wound

limoniform. shaped like a lemon

little leaf. development of abnormally small leaves

macrocyclic. rust fungus with a long life cycle consisting of five stages, each with a characteristic spore

management. application of selected phytosanitary measures in and around an infested area to keep an invading population in check when other means of eradication of the population would fail

MLO. Mycoplasma-Like Organisms

MOA. Mode Of Action

monitoring survey. ongoing survey to verify the characteristics of a pest population

mononematous. hypha or conidiophore arising singly from the substrate

monophagous. subsisting on only one kind of food

monotrichous. (of bacteria) having a single flagellum at one pole

mottle. disease symptom comprising light and dark areas in an irregular pattern, usually caused by a virus; often used interchangeably with mosaic

mycelium. mass of hyphae constituting the body (thallus) of a fungus

NAPIS. National Agricultural Pest Information System

NASS. National Agricultural Statistics Service

natural enemies. living organisms found in a natural community that kill, weaken or inhibit the biological potential of a pest species

necrosis. death of tissue or cells, usually accompanied by darkening to black or brown

NEPA. National Environmental Policy Act

NIS. PPQ–National Identification Service

nocturnal. active at night

non-migratory. species in which the individuals typically do not move far from the area of their birthplace

non-native. immigrant

NPAG. PPQ New Pest Advisory Group

NPRG. New Pest Response Guidelines

obclavate. inversely clavate

obligate parasite. organism that can grow only as a parasite in association with its host plant and cannot be grown in artificial culture media

obpyriform. reverse of pear shaped

oogonia. female gametangium of oomycetes, containing one or more gametes

oospore. thick-walled, sexually derived resting spore of oomycetes

ostiole. opening at the top of many fungal fruit bodies (perithecia, pycnidia, puffball basidiomata) through which spores escape or are expelled

papilla. conic or small rounded elevation, generally translucent, of the wall of gametangia and sporangia, which on breaking serves as the point of exit of planogametes and zoospores

paragynous. having the antheridium contact the oogonium on the side as in many *Pythium* spp.

paraphysis (plural paraphyses). sterile hyphae growing up between the asci in the hymenium of many ascomycetes

parasite. An organism that derives its nourishment from another living organism; not necessarily a pathogen

parasite/predator conservation. conservation of natural enemies through integrated

procedures, highly selective predator/parasite friendly insecticides or techniques, biological insecticides or cultural practices favoring parasites/predators

parthenogenesis. development of an unfertilized egg into an adult female; asexual reproduction

PASS. Potentially Actionable Suspect Sample; a presumptive positive sample diagnosed or identified by provisionally approved laboratory or diagnostician with identification authority that would require confirmatory testing by an official APHIS laboratory due to the nature of the plant sampled and the necessity for federal confirmation

pathogen. organism capable of causing a disease; not necessarily as a parasite

pathway. Means by which plant pests are introduced

PCR. Polymerase Chain Reaction; a laboratory technique that amplifies DNA sequences to determine if a host is infected with a known pathogen

PCR primers. short fragments of single-stranded DNA (15–30 nucleotides long), complementary to DNA sequences that flank the target region of interest; necessary components for the polymerase chain reaction

pedicle. slender stalk or support of spores, sporangia, asci, *etc.*

peduncle. stalk bearing a flower or fruit, or the main stalk of an inflorescence

PERAL. Plant Epidemiology and Risk Analysis Laboratory

percurrent. growing through in the direction of the long axis (*e.g.,* of a conidiogenous cell proliferating through the tip)

periclinal. relating to cell walls that are parallel to the surface of a plant part, such as a meristem

peridium: wall of fruit-body

perithecium. globose or flask-shaped, ostiolate ascoma

pest. any organisms that damages plants or plant products

PestID. database containing all the information recorded from the PPQ form 309 Pest Interception Record

phenology. the study of seasonal and cyclic natural phenomena, especially in relation to climate and plant and animal life

phialide. conidiogenous cell which produces a basipetal succession of blastic conidia from an open end without any change in the length of the cell

phialidic. describes conidia produced by a phialide

phloem. food-conducting tissue in vascular plants consisting of companion cells and sieve tubes

phyllody. abnormal development of floral parts into leafy structures

plant hardiness zones. geographically defined area in which a specific category of plant life is capable of growing, as defined by climatic conditions, including the ability to withstand the minimum temperatures of the zone

pleomorphic. capable of assuming different shapes; ability of some bacteria to alter their shape or size in response to environmental conditions

plerotic. oospore filling the oogonium

polyphagus. feeding on a wide range of hosts

positive point. single point at which the target species was detected

PPQ. APHIS-Plant Protection and Quarantine

predator. organism that consumes substantial numbers of prey

proliferation. to grow or multiply by producing new parts, tissue, cells

protuberance. something that protrudes such as a bulge, knob or swelling

pseudoparenchymatous. compact mass of tissue, made up of interwoven hyphae or filaments that superficially resembles plant tissue

p**ycnidium.** asexual fruiting body that is hollow and partially lined inside with conidiophores

pyriform. pear shaped

regulated area. area that extends a given distance in any direction from the epicenter of an infestation

regulated articles. all known or suspected hosts of a confirmed infestation of an exotic species including soil and any other suspected product or article

regulatory inspection. visual examination of host material, containers and transport

reniform. kidney shaped

rhizosphere. microenvironment in the soil, immediate around roots

riparian. relating to or located on the banks of a river or stream

rosaceous. like a rose

sanitation. destruction or removal of infected and infested plants or plant parts; decontamination of tools, equipment, containers, work space, hands, *etc.*

saprophyte. organism that obtains nourishment from dead organic material

satellite site. potentially infected property that is beyond a given distance from an infected property

sclerotium (plural sclerotia). firm, frequently rounded, mass of hyphae with or without the addition of host tissue or soil, normally having no spores in or on it

SEL. USDA–ARS–Systematic Entomology Laboratory

septate. with cross walls; having septa; (describing hyphae) partitioned by cross walls known as septa

setae. often pointed, stiff, erect hyphae which protrude from a fruiting body or fertile layer and may have a protective function

setose. covered with bristles or setae

sinuate. having the margin strongly or distinctly wavy, as a leaf

soil treatment. application of an approved pesticide to the soil of nursery stock or within the drip line of host plants

SPHD. State Plant Health Director

sporangia. saclike fungal structure in which the entire contents are converted into an indefinite number of asexual spores

sporangiophore. hypha that bears a sporangium

sporodochium. a cushion-shaped stroma covered by conidiophores

SPRO. State Plant Regulatory Official

steam sterilization. the use of live steam as a treatment on selected regulated items

stellate. star shaped

sterigma. slender, spine-like process arising from the basidium and bearing the basidiospores

stunting. overall reduction on plant height due to shortening of internodes

subglobose. almost round or spherical

subulate. awl-shaped; tapering into a sharp point from a broader base

suppression. application of phytosanitary measures in an infected area to reduce pest populations

symbiosis. two different kinds of organisms living together that may, but does not necessarily, benefit each organism

sympodial. pertaining to proliferation of axes in which each successive spore or branch develops behind and to one side of the previous apex at which growth has ceased

symptom. an indication of disease by reaction of the host, *e.g.*, canker, leaf spot, wilt

teleomorph. sexual form of a fungus

TESS. threatened and Endangered Species System

trace-back. to investigate the origin of infested plants through intermediate steps in commercial distribution channels to the origin

trace-forward. to investigate the potential distribution of infected plants from a source through steps in commercial distribution channels

trap survey. determining the presence or absence of a pest by the use of traps placed in a predetermined pattern and serviced on a given schedule

true host. host capable of sustaining reproduction

tuberculate. covered with tubercles (wart-like projections)

TWG. Technical Working Group

tyloses. a balloon like extrusion of the a parenchyma cell into the lumina of a contiguous vessel that partially or completely blocks it

uninucleate. a cell having one nucleus

unitunicate. describes a type of ascus with only one distinct, functional wall layer

USDA. United States Department of Agriculture

USFWS. United States Fish and Wildlife Service

vacuole. generally spherical organelle within a plant cell bound by a membrane and containing dissolved materials such as metabolic precursors, storage materials or waste products

vector. carrier of an infectious agent capable of transmitting infection from one host to another, especially the animal that transfers an infectious agent from one host to another,

typically an arthropod

verrucose. covered with warts or projections that resemble warts

viable. the state of being alive; able to germinate as seeds, fungus spores, sclerotia, *etc.*; capable of growth

viresence. development of green color in place of normal flower color

visual survey. examining hosts, substrate or hiding places for eggs, larvae, pupae, adults or visible damage

wilt. drooping of leaves and stems from lack of water (inadequate water supply or excessive transpiration); vascular disease that interrupts normal water uptake

Witches' broom. symptom of plant disease that occurs as an abnormal brush-like cluster or dwarfed weak shoots arising at or near the same point; branches and twigs of woody plants may die back

xylem. the woody part of plants; the supporting and water-conducting tissue consisting primarily of tracheids and vessels

yellowing. leaves lose normal green color and become yellow

zonate. pertaining to a target-like development of a tree canker, characterized by successive, perennial rings of callus; referring to any symptom appearing in concentric rings; marked with concentric color bands

zoospores. fungal spore with flagella, capable of locomotion in water

zygote. cell in which two nuclei of opposite mating type have fused