Wheat Blast and Food Security

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Contributor: Nur Mahmud, Tofazzal Islam

Wheat blast is a fearsome fungal disease caused by a filamentous fungus, *Magnaporthe oryzae Triticum* pathotype. It was first detected in Brazil in 1985, then it spread to some neighboring South American countries such as Bolivia, Argentina and Paraguay. The outbreak of wheat blast was spotted in Bangladesh for the first time in 2016, which devastated 15,000 hectares of wheat with yield losses up to 100%. Recently, it was detected in Zambia (an African country). The disease spreads through seeds and airborne conidia. There is no resistant variety against wheat blast disease. Once the disease symptoms are expressed as the bleached or partially bleached spikes, fungicide application is ineffective to control it. A convenient and rapid molecular diagnostic tool is developed for surveillance and monitoring of the wheat blast. However, our understanding the biology of wheat blast fungus and its interactions with the host plant is limited. A globally concerted effort is needed to develop durable blast-resistant varieties to combat this killer of wheat before the spread to major wheat growing countries in the world.

Keywords: Food security ; Invassive disease ; Climate change ; Pyricularia oryzae ; Wheat blast

Wheat blast: an emerging threat to global food and nutritional security

1. Background

Wheat blast is a fearsome fungal disease of wheat. It was first discovered in the Paraná State of Brazil in 1985. It spread rapidly to other South American countries such as Bolivia, Paraguay, and Argentina, where it infects up to 3 million hectares and causes serious crop losses. The wheat blast was also detected in on spike of an experimental field in Kentucky, USA, in 2011.

Wheat blast is caused by a fungus known as *Magnaporthe oryzae Triticum* pathotype although scientists are still debating its exact identity. The Brazillian wheat blast is supposed to become wheat infecting pathogen through a host jump from an unknown grass (Inoue et al. 2017). However, Kentucky's strain was not the Brazillian one. Its origin was ryegrass and hence knows as Lolium type (Farman et al. 2017). Although *M. oryzae* infects 50 species of grasses, the wheat pathotype never infects rice and vice versa. There is a risk that wheat blast could expand beyond South America and threaten food security in wheat-growing areas in Asia and Africa due to climate change.

In February 2016, the wheat blast disease was spotted in Bangladesh. It was the first emergence of this disease outside South America. In Bangladesh, wheat is the second major cereal food crop after rice. The epidemic of blast disease devastated at least 15,000 hectares of wheat crop in eight southwestern districts viz Meherpur, Chuadanga, Kushtia, Pabna, Jessore, Jhenaidah, Bhola, and Barisal. Yield loss due to this disease was estimated up to 100%. Scientists feared that the pathogen could spread further to other wheat-growing areas in South Asia.

To rapidly respond to this emergency, Prof. Tofazzal Islam of Bangabandhu Sheikh Mujibur Rahman Agricultural University in Bangladesh and Prof. Sophien Kamoun of The Sainsbury Laboratory in the UK made genetic data for the wheat blast pathogen and immediately released publicly without any restrictions through an Open Wheat Blast website (http://openwheatblast.net/) and they invited others to do the same (Callaway 2016). They used an associated Facebook for engaging more researchers and sharing information. The Open Wheat Blast website soon became a hub for information, collaboration, and comment on wheat blast research. Tofazzal Islam and Sophien Kamoun expected that better exploit the genetic sequences would lead to the answers to important questions about the nature of the pathogen and disease. They applied a method described in 2015 called "Field Pathogenomics", which enabled a rapid response to an epidemic by generating highly-specific genetic information directly from diseased plant samples (Hubbard et al. 2015). Their prediction became true and many researchers from across the globe downloaded the transcriptome data of symptomatic and asymptomatic samples of wheat collected from the affected areas in Bangladesh and analyzed. This unique effort leads to the identification of the pathogen as a South American lineage of *Magnaporthe oryzae Triticum* pathotype within six weeks of time (Islam et al. 2016). It is expected that the international collaboration developed through the Open Wheat Blast website would lead to the development of a durable blast-resistant wheat variety for the farmers.

Wheat blast has recently been detected in Zambia for the first time in an African country (Tembo et al. 2020). As wheat blast is a seed- and air-borne pathogen, it may further spread to new wheat-growing areas in the world (Islam et al. 2019; 2020). In Bangladesh, it spread to 12 new districts over the last four years. Clearly, the wheat blast is a new threat to the food and nutritional security of the world.

2. Disease symptoms and diagnosis

The wheat blast disease is primarily a neck blast as in conducive environment symptoms appear in the spikes first (Fig. 1) (Islam et al. 2016). However, symptoms of the disease can be found in all aerial parts of wheat. Foliar symptoms include gray-green and water-soaked leaf lesions with dark green borders resulting in eye-shaped spots in the older leaves (Islam et al. 2019, 2020). Partly or completely bleached spikes (often confused with symptoms of *Fusarium* head blight) and blackened rachises are the most notable symptoms of wheat blast. Grains from blast-infected heads are usually small, light in color, wrinkled, deformed, and have low test weight. The biochemical and antioxidant qualities of wheat grains are severely modulated by the wheat blast (Surovy et al. 2020). The most severe yield losses occur when head infections start during the flowering or early grain formation stage of the wheat plants (Islam et al. 2020). Our knowledge of the biology of wheat blast pathogen and its interaction with host plants is limited.

Fig.1. Symptoms of blast disease in spikes, leaves, and seeds of wheat in a farmer's field in Jhenaidah in Bangladesh, and a micrograph showing two conidia of *Magnaporthe oryzae*. a) A completely bleached wheat spike with traces of gray from blast sporulation at the neck (arrow) of the spike. b) Complete bleaching of a wheat spike above the point (arrow) of infection. c) Two completely bleached spikes with traces of gray (upper arrow) and a lesion (lower arrow) from blast sporulation at the base. d) Typical eye-shaped lesion (arrow) and dark gray spots on a severely dis-eased wheat leaf. e) Mild blast disease-affected slightly shriveled wheat seeds. f) Severe blast-affected shriveled and pale wheat seeds. g) A severely infected rachis with dark gray blast sporulation at the neck (arrow) and severely damaged spikelets. h) Micrograph of two conidia isolated from the infected spike of wheat. Scale bars in e and f= 1 cm and in h=10µm

The diagnosis of wheat blast morphologically is confusing with Fusarium head blight disease. Recently, Kang and co-workers (2020) developed a rapid and convenient molecular diagnostic tool useful for monitoring and surveillance of wheat blast disease.

3. Transmission of the Pathogen

Wheat blast is a seed transmitting disease (Islam et al. 2020). However, seed infection may play a limited role in epidemiology. The spike infection occurs mainly by air-borne conidia from secondary host grasses. The pathogen is believed to survive between wheat crops on wild plants at field borders and in open grasslands, but the plant species that harbor *MoT* has yet to be conclusively determined. Several kinds of grass and weeds occur commonly in wheat fields and are secondary hosts, but their role in the epidemiology of wheat blast is not well understood. The potential role of lower and older wheat leaves in inoculum build-up before ear emergence needs to be clarified. In Brazil, *Eleusine* spp. and "Brachiaria" ("Urochloa") grasses have been found as major secondary hosts of "*MoT*". No information is available about secondary hosts of *MoT* in Bangladesh.

4. Control of wheat blast

Although there is no resistant variety against wheat blast, some varieties have shown moderate resistance to wheat blast. Therefore, the development of durable resistant varieties against wheat blast is needed. Biological control of wheat blast disease by the application of endophytic Bacillus species and bacterial secondary metabolites has shown high promise (Chakraborty et al. 2020a, b; Surovy et al. 2017). The following approaches are suggested to manage the wheat blast disease in the practical field. (1) Improved wheat varieties that carry genetic resistance to *M. oryzae*. (2) Global monitoring of disease appearances, movement, and evolution, in coordination with local governments and research agencies, as well as predictive models. (3) Advanced studies on potentially effective, safe, and affordable chemical control measures. (4) Genetic and epidemiological research to strengthen knowledge of the fungus and its interactions with wheat and other host plants. (5) The development of a durable resistant wheat variety through biotechnological interaction is badly needed.

5. Impacts of wheat blast

Plant diseases are one of the main limiting factors in crop production worldwide, causing billions of dollars in yield loss and tremendous historical human suffering. The two most important agricultural crops in the world are wheat and rice. The availability of these two grains historically has more impact on human health, regional economic stability, and social unrest than any other crop. Scientists think that in near future this disease may occur in other countries like India and China. As this fearsome disease occurred first in Brazil than in Bangladesh and Zambia, the whole of South Asia and Africa are now under a threat of its spread. As this disease is a biosafety level 3 organism, much care is needed in the care of handling of this organism as well as specific biosecurity system should be introduced to stop its spread to other countries and territories. A globally concerted effort is needed to combat this fearsome disease before it becomes catastrophic [1][2][3][4][5][6][7][8][9][10][11][12][13].

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