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Review Article

Wheat blast disease - An overview

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Abstract

Wheat is synonym to global food security and nutrition to a major part of population in developing countries. With intensive cultivation practices, varied genotypes and climatic changes, various biotic and abiotic constraints have emerged. Rusts and blight have been a constant threat to wheat cultivation and constant efforts to contain these are going on globally. However, in 1985, a pathogen which was a major fungal foe of rice called blast was identified in Parana state of Brazil on wheat. As name indicates blast causes enormous loss to wheat production. Wheat blast has also been reported from Uruguay, Paraguay, some parts of Argentina. Slowly it has spread to other South American countries. The biggest shock for wheat cultivation was occurrence of blast on wheat in Bangladesh during February 2016. It is a caution and warning for wheat cultivation in tropical and sub-tropical areas in the world. Till now wheat blast has not been reported from any part of India. A summarized account of the disease caused by *Magnaporthe oryzae* **pathotype in** *Triticum***, epidemiology and other aspects are reviewed in this publication.**

Keywords: Wheat blast, *Pyricularia* species, epidemiology, control

1. Introduction

Wheat forms the base of global food security, providing 20% of protein and calories of majority of the population in developing countries. Wheat is cultivated in the world over a large area and under varied climatic conditions ranging from sub tropical to temperate. However, this widespread cultivation of wheat has always attracted a number of constraints and resulted in the emergence of various biotic and abiotic constraints. Among these, blast is one of the very devastating diseases of wheat. It is called variably as leaf blast, collar rot node blast, spike blast or rotten neck blast depending on the portion of wheat infected.

Wheat blast or *brusone do trigo* caused by fungus *Pyricularia* was first identified in the state of Parana, Brazil in 1985 (Igarashi *et al.*, 1986) and caused a large scale destruction of wheat. A 2009 outbreak in wheat cost Brazil one-third of that year's crop. There are regions in South America where they don't grow wheat because of the disease (Callaway, 2016). Later on it was observed in Bolivia, Paraguay, Argentina and Uruguay. The disease is also known to occur on Triticale, barley and black oats. Spike infection is commonly seen and many times it occurs in combination with *Fusarium* species. Wheat blast was spotted in Kentucky in 2011, however, vigorous surveillance helped to stop its spread in United States of America (Callaway, 2016). The disease can cause losses to the tune of 40% (Kohli *et al.*, 2011) to 100% (Goulart and Paiva, 1990; Goulart *et al.*1992). Recently occurrence of wheat blast in Bangladesh (Callaway, 2016; Malaker *et al.*, 2016) has rung alarm bells for many wheat growing nations. Wheat blast is mainly a disease of spike, however, it can produce lesions on all above ground parts under hot and humid conditions. Depending on the point of infection on rachis, it can cause breaking or drying of spike. Recent observations have revealed that many lines derived from CIMMYT material Milan carry high level of resistance (Kohli *et al.*, 2011).

2. Distribution

Wheat blast has remained restricted to South American countries, Brazil, Bolivia, Paraguay, Argentina and Uruguay (Kohli *et al.*, 2011). However in April 2016, it was observed in Bangladesh (Callaway, 2016; Malaker *et al.*, 2016). It has been now observed in 15% of wheat area in Bangladesh. Areas in the districts of Kushtia, Meherpur, Chuadanga, Jhenaidah, Jessore, Barisal, Bhola and several others (Malaker *et al.*, 2016). There were report that wheat production was affected in 15000 hectares with resultant fall in production by 20%. Standing wheat crop was burnt in some areas. Based on the molecular characteristics, wheat blast absolute from Bangladesh was found similar to that of Brazil (Malaker *et al.*, 2016).

3. Production losses

The production losses caused by *Pyricularia* blast can vary from very low to 100% (Goulart and Paiva, 1990; Goulart *et al.*1992). The disease can occur on all above ground parts. Highest loss occurs when fungal infection occurs at the base of the rachis restricting the development of grains and killing of spike (Kohli *et al.*, 2011). First epidemic in Paraguay caused more than 70% losses (Viedma and Morel, 2002). Infection in low lands of Santa Cruz region of Bolivia in 1996 resulted in 80% yield reduction in wheat (Barca and Toledo,1996). Government owned blast infected fields were burnt in Bangladesh (Callaway,2016).

4. Causal organism of wheat blast

Initially the causal fungus of wheat blast was thought to be *Pyricularia oryzae* (telemorph *Magnoporthe oryzae*). Some authors named it as *Triticum* isolate of *Pyricularia oryzae*. Sprague (1950) applied the name *P. oryzae* for rice isolates and *P. grisea* for other cereal grasses. Kohli *et al.* (2011) preferred name as *Pyricularia grisea* (Kooke) Sacc. [telemorph *Magnoporthe grisea* (Herbert) Barr]. Using a multilocus phylogenetic analysis, Couch and Kuhn (2002) described *M. oryzae* distinct from *M. grisea* and used former for isolates of rice, whereas later for perennial rye grass, wheat, millets and other grasses of agricultural importance. Recently Castroagudin *et al.* (2016) conducted phylogenetic assays using 10 housekeeping loci for 128 isolates of *P. oryzae* from sympatric populations of grasses growing in or near wheat fields. The analyses categorized isolates into three clades. Clade 1 comprised isolates associated with *P. oryzae* from rice. Clade 2 isolates belonged exclusively to wheat previously described as *P. oryzae* pathotype *Triticum.* Clade 3 contained isolates obtained from wheat as well as other Poaceae hosts. Clade 3 is distinct from *P. oryzae* and represents a new species *P. graminis tritici.* They claimed it to be the cause of wheat blast in Bangladesh. It appears to be a logical nomenclature of pathogen.

5. Symptomatology

Wheat blast infects all above ground parts of plant (Fig1a). The most conspicuous symptom is head/spike infection (Fig.1b). Head infection can be easily confused with *Fusarium* head blight. Head infection can occur on the glumes, awns and rachis. Infected glumes support elliptical lesions with reddish brown to dark grey margins and white to light brown centre. Blackening of the rachis, lower nodes, shriveling of grains, low test weight has also been observed (Malaker *et al.*, 2016). The pathogen is known to produce non host specific toxin pyricularin (Agrios, 2005). Depending on the place of infection on the head,

Fig. 1a Blast infected wheat field in Bangladesh in 2016

Fig. 1b Blast infected wheat spikes in Bangladesh in 2016

drying of partial or full ear head takes place. Symptoms on heads can vary from elliptic lesions and bleached centers, spike bleaching, sterility and empty grains depending on time of infection. Since infection on spike blocks the translocation of photosynthates and nutrients to spike, therefore, results in partial or total spike sterility. Grain fills can occur in case of late infections but it may lead to seed borne inoculum to the next crop. On leaves lesions vary in shape and size depending on the stage of plants. As plants grow older, lesions are less frequent. Lesions with white centre and of reddish brown margin on upper side, dark grey on the underside of the leaf can be observed on both young and old infected leaves. Infection on seedlings can be very damaging under high temperature and humidity and can lead to total plant death (Igarashi, 1990).

6. Disease cycle and spread

Wheat and rye grass isolates of *Pyricularia* exhibit almost same disease cycle as that of rice. The characteristic feature of this disease is the pyriform conidia Fig. 2 that gives rise

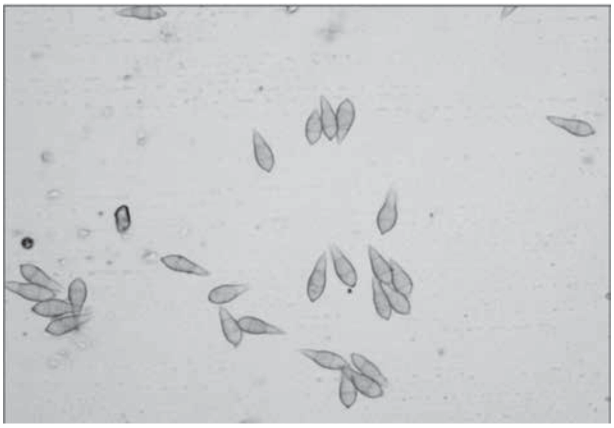

Fig. 2 Two septate pyriform conidia of *Pyricularia* on wheat

to the disease. Conidium has three cells, with each having single nucleus per cell. Isolates can be purified through single conidium. Presence of melamin in the appresoria, arms the conidia to build up a very high pressure essential to puncture the outer plant surface and gain access to the host tissues. Presence of a free film of water is essential during the infection process. After entry into host, the fungus colonizes for 4 days without any visible appearance. Thereafter, conidia are released and process is facilitated by water. In other words disease outbreak is hard to predict as by the time first visible symptoms, appear, blast is already established (Anonymous, 2013). Young and expanding leaves are more susceptible to spores of rice blast fungus. Conidia have been detected up to 1000 meter (Urashima *et al.*, 2007) away from the fields. Seed is the primary sources of inoculum to new areas (Greer and Webster, 2001). However, possibility of a grass strain jumping to wheat can also cause wheat blast (Callaway, 2016).

7. Epidemiology

According to Kohli *et al.* (2011), most severe blast years coincide with wet years (El Nino phenomenon) characterized by several days of continuous rains and average temperatures between 18-20^{o}C during the flowering stage of the crop followed by sunny host and humid days. Cardoso *et al.* (2008) observed under controlled conditions highest blast intensity at 30^{o}C which increased with duration of wetting period and lowest at 25^{o}C with a wetting period of less than 10h. However, with increasing wetting period of 40h at 25^{o}C blast intensity of 85% was observed. In other words, sprinkler irrigation may expose the plants to blast as was observed for *Fusarium* head scab of wheat. Global temperature rise and EI nino may predispose wheat to blast.

8. Source of inoculum

Seed has been shown as a primary/initial source of inoculum (Goulart and Paiva, 1990), however, it plays a minor role in epidemiology. Majority of the spike infection comes from the air borne conidia from various secondary hosts (Prabhu *et al.*, 1992; Urashima *et al.*, 1993). Several grass weeds, *Cenchrus echinatus, Eleusine indica, Digitaria sanguinalis, Brachiaria plantaginea, Echinocloa crusgalli, Pennisetum setosum, Hyparrhenia rufa and Rhynchelytrum roseum* are known to harbor *Pyricularia* species, however, their role in the epidemiology of wheat blast is not very clear (Prabhu *et al.*, 1992). Infection on *Pyricularia* on triticale was reported by Mehta and Baier (1998) and black oats (Mehta *et al.*, 2006).

Prabhu *et al.* (1992) reported that all of the *P. grisea* isolates from rice, wheat and grass weeds were pathogenic to wheat and barley cultivars but none of the 10 isolates from wheat and 7 from grass could infect rice. Host specificity among *P. grisea* isolates has been reported (Mehta and Baier, 1998).

9. Indian scenario

India has wheat area under varied climatic conditions. So far wheat blast has not been sighted anywhere in India. All India Co-ordinated Wheat and Barley Improvement Project under the auspices of ICAR-Indian Institute of Wheat and Barley Research, Karnal with a network of centers and co-operators all over India is very vigilant and equipped to tackle the issue. A network for rapid action against wheat disease outbreak such as wheat rusts is already in place. Moreover, major wheat producing area reels under low temperature whereas central and peninsular India have dry arid climate. Proper diagnosis of disease is very important as sometimes wheat blast symptoms resemble with *Fusarium* head blight and boron deficiency. So familiarization of the researchers / extension staff on symptoms of the disease would be taken up. An action plan is ready to be followed. Special teams would undertake periodic and regular surveys to bordering Bangladesh. Taking a proactive approach a set of 40 lines of wheat have been sent to CIMMYT for evaluation in Brazil and Bolivia.

10. Management of wheat blast

Wheat blast control is a very tactful mechanism. A strict quarantine needs to be followed by not allowing any wheat seed material from the disease prone areas. Crop rotations by skipping wheat for one season will also reduce the blast incidence. Apart from genetic resistance and fungicide application at heading on crop in tropical and sub tropical areas has helped in blast management. There is a need to destroy the auxiliary grass hosts also.

10.1 Avoidance

Wheat seed from blast infected areas should not be used for sowing. Whenever there is prolonged precipitation a watch has to be kept for the blast. Sprinkler system of irrigation can predispose wheat to blast, hence be avoided.

10.2 Host resistance

Complete to date genetic bases of resistance to blast is not very clear due to tricky and variable pathogen. Host resistance to blast is obscure, however, Brazilian wheat cultivars BR18, IPR85, CD113 have shown moderate level of host resistance. Derivative accessions of CIMMYT line Milan have also been shown to possess a high level of resistance (Kohli *et al.*, 2011). Cruz *et al.* (2012) found that among the wheat cultivars tested, a continuum in severity to head blast was observed; cultivars Everest and Karl 92 were highly susceptible with more than 90% disease severity, however, Postrock, JackPot, Overley, Jagalene, Jagger, and Santa Fe showed less than 3% infection. Limited information is available on the identification of quantitative trait loci (QTL) and linked markers associated with blast resistance. Recently a partially blast resistant rice variety Pongsu Seribu 2 was mapped with QTLs linked to resistance genes. QTL linked to the blast resistance was identified and cloned (Fatah *et al.*,2014).

10.3 Chemical application

Systematic and convincing work on chemical control of wheat blast has not been done. However, it is well known in rice blast to use tricyclazole 75WP @2g/kg or carbendazim 50WP 1g/kg seed for controlling seed inoculum. Initial infections can also be controlled by using need based sprays of carbendazim 50WP @1g/L or tricyclazole 75WP 0.6g/L or Propiconazole 25EC/ carpropamid 30SC 1ml/L or Isoprothiolane 40EC 2g/L as and when infection is noticed during at spike initiation or at flowering depending on the situation. Spray at flowering has been effective in controlling.

Fungicides inhibiting melanin production in appresoria have been found effective for the control of blast as sprays or even as seed treatment. Application of silicon containing basic ground granulated blast furnace slag has been found to reduce blast (Agrios, 2005). Among chemicals strobilurins have been found effective. Araki *et al.* (2005), however, observed resistance to strobilurins in rye grass isolate of *Pyricularia.* A need to use fungicides with different modes of action or alternative use of chemicals would be useful. According to Rocha *et al.* (2014) control of wheat blast can be effective for leaves but not for ears. They found epoxiconazole+ pyraclostrobin and tebuconazole+ trifloxystrobin to reduce the disease considerably. Cruz (2013) stated two fungicide active ingredients as tebuconozole and metconazole. But he opined that fungicides are not effective under warm, rainy weather at heading stage.

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