REVIEW

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REVIEW

Wheat disease dynamics in south east Asia under changed climate scenario

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Wheat is cultivated in the world over a large area and under varied climatic conditions ranging from sub - tropical to temperate climate. Spot blotch caused by *Bipolaris sorokiniana* is a major disease of wheat in warm humid area. Earlier this disease was confined to North East Plain Zone of India and now it is also spreading towards western part of south Asia because of global warming and erratic behaviour of rains in winter. Considering the crop loss due to this disease and future threat, the disease management by different approaches like seed treatment, cultural and biological methodshave been discussed. Finally, an integrated approach, with host resistance as a major component, has been advocated for controlling the disease. Beside spot blotch, the importance of wheat blast caused by *Magnaporthe oryzae* pathotype *Triticum* in Indian subcontinent and its containment strategy has also been discussed.

Key words: Wheat, Spot blotch, blast, disease management

INTRODUCTION

Wheat, the second important staple food of the world, is known to suffer from a large number (at least 50 fungal, 7 bacterial and 36 viral) of diseases (http/www//APS*net.org*). Among several biotic constraints rusts and spot blotch are considered as major pathogens throughout the world. Spot blotch also referred to as *Helminthosporium* leaf blight (HLB) or foliar blight caused by *Bipolaris sorokiniana* is a disease of great concern especially in South Asia and Latin American countries, where warm-humid conditions persist during wheat cropping system (Saari, 1998; Joshi *et al*, 2007, Chowdhury *et al*,2014). Globally, more than 25 million hectares of wheat cultivated area are affected by spot blotch disease and around 14 million hectares are in the South Asian countries of India, Pakistan, Nepal, and Bangladesh and about 11 million hectares are in India alone (Joshi *et al*, 2007). This disease is now expanding towards non-traditional cooler reasons of India and some other parts of the world (Singh *et al*, 2008). Again with the increase in temperature due to climate change, the foliar blight pathogens in wheat has become more important and has spread into new geographic areas, where they come in contact with new potential hosts.

The announcement of wheat blast by the Government of Bangladesh on March 27 2016 is the first report on incidence of this disease in Asia (Malaker *et al*, 2016). The extent of yield loss was ranged from 20% to 90%.Its emergence in Bangladesh emphasizes the potential of a number of foliar crop diseases to spread unless effective control strategy is not taken in India particularly in eastern states. The causative pathogen of wheat blast is the ascomycete fungus *Magnaporthe oryzae* B.C. Couch and L.M. Kohn (synonym *Pyricularia oryzae*). The disease was first recorded in 1985 in the Brazilian state of Paraná (Igarashi *et al*, 1986), from where it has gradually spread across South America, remaining however, until now, confined to that continent Around 3 Mha of

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wheat crops are regularly infected and the disease is recognized as being a significant production constraint in Brazil, Bolivia and Argentina. Considering the climate change particularly terminal heat during the cropping season and untimely rain during anthesis period makes the crop more vulnerable to the disease.

Yield Loss

Yield losses due to foliar blights are variable but are considered to be very significant. The disease affects all plant parts and cause up to 100 per cent yield loss (Mehta, 1993). Duveiller and Gilchrist (1994) reported that losses up to 20 per cent in farmer's fields in several areas of South-East Asia but same are up to 30 per cent in experimental studies (Dubin and Bimb, 1994). At Poza Rica, in Mexico which is the hot spot for screening resistance to spot blotch, 49-90 per cent yield losses have been recorded (Duveiller *et al*, 1997). In farmers' fields in Bangladesh, the average losses due to these foliar blights were estimated to be 15 per cent (Alam *et al*, 1997). Yield loss assessment studies in Nepal have shown losses were around 27 per cent (Devkota, 1994). In West Bengal, the extent of yield loss was recorded up to 35% (Chowdhury *et al*, 2014).

Pathogen

A detail description of *Bipolaris sorokiniana* (Sacc.) Shoemaker [stat. anam.]is available at International Mycological Institute (UK) formerly C.M.I. (Sivanesan and Holliday,1981). A key for distinguishing species of *Bipolaris* was described by Subhramanian (1971). *B. sorokiniana* is characterized by thick-walled, elliptical conidia (60-120 µm ×12-20µm) with 5-9 cells. In axenic culture, the mycelium is composed of hyphae interwoven as a loose cottony mass and appears as white or light to dark grey depending on the isolates (Kumar *et al*. 2002). These fungi are differentiated from the *Bipolaris* genus on the basis of morphological features of conidiophores and conidia. Tan spot (also known as yellow spot) is caused by *P. tritici-repentis*, which is the sexual stage of *Drechslera tritici-repentis* (Died.) Shoemaker (Syn. *H. tritici-repentis*Drechs). On the leaf, lesions are due to anamorph *Bipolaris sorokininana*, characterized by long multicellular spores, whereas the ascospores of *Cochliobolus sativus* are formed in pseudothecia developed on the wheat residue. The anamorph is also found on stems, glumes, seeds and stubble. Septate conidiophores measure 80-400 × 6-9 µm and bear a single sub- hyaline 1-9 septate conidium, which is 80-250 × 14-20 µm in size and easily recognized by its basal cell suggesting a snake head (Schilder and Bergstrom, 1993). On PDA, the pathogen grows as dense, fluffy, greenish-grey mycelium without sporulation (Schilder and Bergstrom, 1993). On V8 agar medium, the mycelium is white to light grey. Conidia are produced after exposure to 12-24 hours near-UV light followed by 12-24 hours of darkness. Immature pseudothecia are formed only in old cultures. The pseudothecia are black, erumpent, 0.2- 0.35 mm in diameter with dark spines surrounding the short beaks and produced on weathered stubbles or straw. At maturity, they contain asci with ascospores measuring 40-60 µm long × 18-25 µm wide (Zillinsky, 1983). The mature ascospores are yellow to brown, oval shaped, having three transverse septa and 1 to 2 longitudinal septa. Ascopores and conidia may both serve as primary inoculum.

Host Range

Bipolaris sorokiniana acts as a causal agent for various diseases like head blight, seedling blight, foliar blight, spot blotch, common root rot and black point of wheat, barley, other small cereal grains and grasses (Zillinsky, 1983). Itinfects barley, oat, rye, *Phalaris, Agropyron, Lolium, Polac, Setaria, Bromus, Festuca*, etc.

Survival and Occurrence

B. sorokiniana is characterized by a profuse production of conidia that germinate within 5-7 hours in the presence of free-water (Mishra, 1973). The pathogen survives in soil, plant debris and on seed (Reis *et al,* 1998). The survival of *B. sorokiniana* on seed is probably a major source of primary inoculum (Pandey *et al,* 2005). Survival in soil is accomplished by the ability of the fungus to colonize diseased straw and the inoculum density of the pathogen in soil is related to the amount of its sporulation occurring in crop residues. The survival of *B. sorokiniana* conidia in the soil is well documented and free dormant conidia can survive up to 37 months under aerobic conditions (Reis, 1990).

The infected seeds, and soils infested either with

conidial suspension or colonized grains may serve as potential sources for the survival of *B. sorokiniana* resulting in germination failure, seedling mortality and spot blotch development in wheat. Conidia directly produced on living tissues are characterized by a rapid bipolar germination allowing the pathogen to complete several infection cycles and fast conidia multiplication during the cropping season. *B. sorokiniana* conidia belong to two different physiological categories corresponding to the pathogen's infection phase and its survival respectively (Chand *et al,* 2002). The infection phase is characterized by a high germination percentage as opposed to the survival phase harboring apparent dormancy (Chand *et al,* 2002).

Symptoms

The main symptom caused by the pathogen is spot blotch, which is a disease of leaves. The early lesions on leaves are 1-2 mm long, small and dark brown in colour. There is no sign of chlorotic margin at the initial stage of infection. In the later stage, in case of a susceptible genotype, the small lesion extends very rapidly and ultimately reaches into several centimeters. When the infection occurs in the spikelet; it results in shrivelled grain and the embryo end of the seed becomes dark in colour. Diseased seedlings develop dark brown lesion on the coleoptiles, crowns, stems and roots. Death of the seedlings may occur before or soon after emergence. Common root rot is distinguished by dark brown to black necrotic lesion on roots, subcrown, internodes and basal portion of the stem. At severity, multiple lesions often coalesce to form large areas of necrosis. Plants with common root rot produce fewer tillers and fewer kernels per ear.

Management of Disease

The management of spot blotch becomes critical particularly under favourable environmental regime, as they are highly sporulating with shorter life cycle as well as easy dissemination. Generally multipronged strategy becomes essential and application of a single tactics results in obvious failure. Conventionally foliar spray has been a first choice to researchers, extension agents and to practicing farmers. Unfortunately, the Integrated Disease Management (IDM) against the disease has not been adopted by the farmers in South Asia.

Seed treatment

Seed treatment with different fungicide and various other substances including non-conventional chemicals may provide variable protection against foliar blight incidence of wheat. As early as in 1986, Hait and Sinha reported that phytoalexin inducers like cupric chloride, ferric chloride at 10^{-3} M conc. protected the wheat seedlings from foliar blight infection. Similar observation was recorded by Mukherjee (2008).The other effective fungicides includes captan, mancozeb, thiram, pentachloronitrobenzene, proline and tridemefon (Mehta,1983). The foliar pathogen can be controlled with seed treating fungicides like guazatine and guazatine+ imazalil (Neema and Joshi, 1973).

Pavolva *et al* (2002) indicated that seed treatment with flutriafol + thiabendazole, carboxin + thiram, difenoconazole +cyproconazole, carbendazim, fludioxonil, triticonazole, tebuconazole and diniconazole provided protection against root rot caused by *Fusarium, Helminthosporium,Bipolaris* and *Rhizoctonia* spp.The efficacy of Raxil(tebuconazole) was studied on spring wheat cultivar and seed treatment with tebuconazole controlled root rots caused by *Bipolaris sorokiniana* (*Cochliobolus sativus*) and *Alternaria* sp. (Korobov and Korobova, 2002).Seed treatment with Vitavax 200 B and Bavistin increased seed germination by 43 per cent and reduced seedling infection by *B.sorokiniana* in Nepal (Shrama and Duveiller, 2004).The seed treatment of a newly developed fungicidal formulation Vitavax 200 WS (carboxin + thiram 1:1) @ 2.0, 2.5 and 3.0g /kg gave good results in reducing seedling mortality, incidence of foliar diseases at multi-locations of India including Uttar Banga Krishi Viswavidyalaya, West Bengal (Singh *et al*,2008).Sarker *et al* (2010) reported some organotin compounds against spot blotch pathogen in seed.

Cutural Practices

The manipulation of agronomic practices suggest that different mineral nutrients may reduce foliar blight (Krupiniski and Tanaka, 2001).Although soil moisture and soil nutrient stress occur together in the wheat fields of South Asia, little quantitative information is available on the effect of low soil moisture and poor soil fertility on foliar blight severity (Razzaque and Hossain, 1991).

In long term trials with differing nutrient management in rice-wheat cropping system, Gami *et al*.(2001) and Regmi *et al*(2002) reported that declining soil fertility affects foliar blight severity. Factors that may alter the severity of wheat foliar blight caused by nonspecific pathogens include change in seeding date and mineral nutrients (Razzaque and Hossain, 1991). Sharma and Duveiller (2004) opined soil fertility stress has pronounced effect on foliar blight severity and/or disease levels than moisture stress. They observed that under low soil fertility, reduction in grain yield and Thousand Kernel Weight due to HLB were 52.1 per cent and 15.5 per cent respectively, compared to 26.1and 8.05 under optimum soil fertility whereas HLB caused yield reduction of 22.1 per cent under low soil moisture compared to 11.85 under optimum soil moisture.Clearing or ploughing the stubble, grass weeds and volunteer cereals reduce inoculum similar to crop rotation (Diehl *et al,*1982). They further noted that eradicant fungicide treatment of the seed and crop rotation with non- host crops can control spot blotch. However, Cook and Veseth (1991) contradicted the views of Diehl *et al* (1982) in reducing the blight incidence.

Studies conducted in Nepal from 2000-2002, on experimental station and in farmers fields, comparing plots sprayed with fungicides with untreated check , exhibited that yield losses due to HLB was 17-34% when losses were recorded up to 14-19 per cent, the recommended level of NPK 120-60-30 kg/ha was used. Similarly losses due to disease increased from 14 per cent to more than 19 per cent when supplementary irrigation was not available and physiological stress was higher (Sharma *et al*, 1987). In different locations and of north-eastern plains zones of India, application of higher doses of potash in combination with other nutrients (120:60:60 kg N, P, K/ha) reduced foliar blight incidences as compared to 120:60:40 kg N,P,K/ha (Singh *et al*, 2007). Application of farm-yard manure 210 t/ha, led to decline of AUDPC by 30 per cent, suggesting not only that Farm Yard Manure contains a significant amount of potassium, but that copious levels of organic matter impart beneficial role and reduce disease severity.

In recent years conservation agriculture (CA) has become more popular in South Asian countries due to various reasons. There is a knowledge gap about the effects of conservation agriculture on soil health and its long term effect on soil biota (Bimb and Dubin, 1994) as well as the disease dynamics which is bound to change with the cultivation practices, the level of host specificity of the pathogen, it's biology and mechanism for dispersal, survival, weather and micro-climate effects. There was an increase in the number of leaf spot lesions caused by *Septoria tritici* and *Pyrenophora tritici-repentis* under zero tillage as compared to conventional tillage in Indiana Head, SK. Although spot blotch is a minor disease of wheat on the prairies, it was observed that foliar lesions caused by *C. sativus* decreased under zero tillage. This pathogen causes both foliar and root symptoms on cereals and as noted above, reduced inoculum levels with zero tillage resulted in reduced the intensity of infection for both spot blotch and common root rot diseases. In Ontario, consecutive crops of wheat promoted tan spot and *Septoria nodorum* blotch under reduced tillage, but leaf blotch caused by *S. tritici* increased under conventional tillage (Sutton and Vyn 1990).

Rees (1987) reported higher severities of tan spot and septoria blotch of wheat and scald of barley with increases in surface residues in numerous fields in Australia. He observed that neither the tan spot nor scald pathogens have spore dispersal mechanisms for successful spread of spores over long distances to other fields; thus, infections were limited to the fields which had residue. However,*S. tritici* was capable of producing spores for widespread dispersal and caused severe infections in fields with or without the residues.

In Nepal, Mahto *et al* (2006) compared the foliar blight incidence on three different wheat varieties Rohini, BL 1473 and Bhrikuti under surface seeding conditions and conventional tillage. Surface seeding was superior to conventional tillage. The results indicate that the average foliar blight induced reductions in grain yield, thousand grain weight and Kernel per spike were 16, 12 and 155 respectively under conventional tillage whereas the corresponding reductions were 23, 13 and 195 under surface seeding. Recently, Chowdhury *et al* (2017) reported that spot blotch disease severity under CA was higher in the first two years than conventional tillage , however, from 3rd year onwards, the gap in between the systems is narrowed down and after four years, no differences in disease severity was recorded.

Chemical Management

Despite the harmful effect of fungicides, it is useful and economical in the control of spot blotch disease (Loughman *et al*, 1998).In Brazil foliar fungicides which includes non systemic and systemic belonging to the dithiocarbamates (viz. mancozeb) and triazoles (viz. propiconazole, tebuconazole, flutriazol, procloraz, and triadimenol) and dicarboxymides (viz. iprodione) are known to be effective against spot blotch (Mehta ,1998). Foliar applications specially with systemic fungicides such as tebuconazole, epoxiconazole, flutriafol, cyproconazole, flusilazole, epoxiconazole, and metaconazole,applied between heading and grain filing stages, have been proved to be cost effective. Under severe disease levels, a second spray can result in a grain yield increase by 38-61 per cent (Velazquez,1994).

In Argentina, Annone (1997) observed positive response with foliar fungicides for reduce disease development under conditions of moderate to low inoculum pressure but inconsistent results under high inoculum pressure. Among fungicides tested under field conditions, tebuconazole and propiconazole achieved the highest level of control, though results varied widely (30-80%).Tewari and Wako (2003) reported that the mixture of tebuconazole (folicur)and metacid applied as foliar spray at the boot stage of wheat crop effectively suppressed all the foliar diseases (brown and yellow rusts, powdery mildew and leaf blight) showing curative property with no phytotoxic effect on the plant. They also observed that Sencor and Propiconazole (Tilt) was incompatible and highly phytotoxic.

INDUCED RESISTANCE AND BIOLOGICAL CONTROL

Yield losses in wheat indicate the need to search for alternative strategies of disease control. On a global basis one of the promising strategies is induced resistance. Chemical induction of resistance to *Bipolaris sorokiniana* in barley by pre-treatment with inducers 2,6 – dichloroisonicotinic acid (DCINA), benzo (1,2,3) thiadiazole –7-carbothioic acid –s-methylester (BTH) or jasmonates leads to symptom reduction in the range of 10-20 per cent (Kumar, 2006).

Pre-treatment of wheat leaves with the inappropriate *Bipolaris oryzae* (inducer organism) reduced spot blotch lesion numbers and lesion size of *Bipolaris sorokiniana* on the same level (Sarhan *et al.* 1991). Plant growth-promoting fungal rhizosphere isolates of *Phoma spp.* from Zoysia grass (*Zoysia* sp.) suppressed *Bipolaris sorokiniana* due to the competitive root colonization. Successful antagonists against seed borne *Bipolaris sorokiniana* were *Chaetomium* sp., *Idriella bolleyi*, and *Gliocladium roseum* (Knudsen *et al*, 1995).The antagonistic potential of *Chaetomium globosum* against *Drechslera sorokiniana* was confirmed by Biswas *et al.* (2000). Suppressions of soil-borne fungi, including *Bipolaris sorokiniana***,**was observed in the presence of isothiocyanates released into soil by *Brassica* species (Kirkegard, 1996). Biological control of leaf blight of wheat with botanicals has been successfully done by many scientists (Hossain *et al*. 2005). Islam *et al.* (2006) reported reduction in disease severity in flag leaf stage, flowering stage, milking stage and hard dough stage which was achieved by seed treatment with *Allium sativum* clove extract and *Polygonum hydropiper* leaf and stem extract and yield enhancement to 29.74 per cent over untreated control.

BREEDING FOR RESISTANCE

The use of resistant variety is the best approach to manage foliar blight disease. Sources of spot blotch resistance indicate that it is governed by one or more genes. The origin of resistance was differentiated into three categories: Latin America, China and wild relatives of wheat or alien species (van Ginkel and Rajaram, 1998). Early Chinese sources of resistance used at CIMMYT include Shanghai# 4, Suzhoe# 8, and Yangmai# 6 and alien sources used at CIMMYT had centered around crosses involving *Thinopyrum curvifolium* (Mujeeb- Kazi *et al*. 1996; Villareal *et al*. 1992). Two outstanding lines Mayoor and the Chirya series were developed by using these alien sources in combination with Chinese resistance sources. Significant progress of research has been done in India by using more than 14,000 entries of wheat and related wild species, representing 13 genera and 136 species, for spot blotch resistance (Dhaliwal *et al*. 1993). The identified promising entries are *Ae. triaristata, Triticum dicoccoides, Ae.cylindrical and T. boeoticum.*

Studies on the inheritance on spot blotch resistance

with Latin American and Indian resistance sources had shown one or two genes to be involved (Srivastava *et al*. 1971; Adlakha *et al*. 1984). Velazquez- cruz (1994) observed six genes to be segregating in four moderately resistant to resistant lines (Gisuz, Cugap, Chirya 1, and Sabut) developed at CIMMYT, with two to three genes providing good resistant levels. Conner (1990) had shown that foliar and seed infection by *B. sorokiniana* may be determined by different genetic systems.

Though, sources of higher levels of resistance have been identified, little progress has been achieved using conventional breeding methods, mainly because of the polygenic nature of this resistance. It is therefore necessary to identify the quantitative trait loci (QTLs). Once the genes corresponding to QTLs are cloned, transformation methods may offer new options for combating the disease in future. Induced variation for higher levels of resistance is also expected through somatic embryogenesis (Bohorova *et al*. 1995). A high level of resistance to spot blotch was achieved by crossing Chinese hexaploid wheat with a moderately resistant commercial cultivar in Nepal by Sharma *et al* (1997).

Recently, Singh, G. *et al* (2013, 2014) worked on three sets of mapping populations made for spot blotch resistance in wheat viz. Sonalika/BH1146 (set-I), Kanchan/Chirya1 (set-II) and HUW234/ YM#6 (set- III) in three hot spots in India and identified 23 resistant lines across the location. They further reported that in population I (BH1146 ×Sonalika), through composite interval mapping (CIM) two stable QTLs were identified for the DS on chromosome 7B and 7D at LOD score above the threshold value of (2.4) that explained 11.6 % and 9.8 % mean phenotypic variation (R^2)respectively. These two stable QTLs were detected in three environments and three years consecutively. Similarly in population II (Chirya 1 × Kanchan), using CIM, one stable and consistent QTL was detected on chromosome 7D over the two years and two locations with a LOD score value of 6.4 explaining mean phenotypic variation (R^2) of 10.5 %.

Arun *et al* (2007) reported that somaclones (R_2, R_3 and R_4 generations) regenerated from immature embryos of two popular wheat varieties in eastern India, HUW-206 and HUW-234 displayed improved earliness, enhanced resistance to spot blotch disease and yield over the parent. The superiority of variants for both yield traits and spot blotch resistance was established in R_4 generation. This confirmed the possibility of wheat improvement through somaclonal variation. Singh *et al.* (2014, 2015) evaluated a total of 1,281 genotypes and varieties of wheat (*Triticuma estivum* ,*T. dururm* and *T. dicoccum*) and also Triticale at 14 hot spot locations in India against *B. sorokiniana* and *A. Triticina.* They observed that 11 genotypes viz. HD 3081, HS 513, HP 1913 KARAWANI/4NIF/ 3/SOTY/ /NAD63 /CHRIS, NIAW 1846, PBW 629, PBW 665, PDW 314 (d), TL 2978 (T), VL 971 and VL 972 were highly resistant to foliar blight pathogens. CIMMYT developed 56 genotypes for specific objective of spot blotch resistance and when evaluated in different hot spots of South East Asia, it was observed that 8 genotypes were highly resistant against the disease across the locations (Singh, P. *et al*. 2015).

MANAGEMENT OF WHEAT BLAST

Considering the future disease problem in the eastern states of India, it is worthwhile to mention the disease management principles against blast.

Genetic resistance

The resistance to wheat blast is generally low. Though a number of commercial cultivars have been proposed as potential sources of resistance/ tolerance, but mostly these have been proven to be unreliable (Kohli *et al.*, 2011). Maciel *et al.* (2014) observed that no resistant lines against 27 blast isolates in Bolivia. Cruz *et al.* (2012) have identified the cultivars Postrock, JackPot, Overley, Jagalene, Jagger and Santa Fe as promising resistance sources, on the basis that they permitted only very low levels (<3% leaf area) of infection. More recently, lines bearing a distal segment of chromosome arm 2NS from *Aegilops ventricosa* translocated to wheat chromosome arm 2AS have shown an improved level of resistance to wheat blast in the spike, although surprisingly not so on the leaf (Cruz *et al.* 2016). Though eight major resistance genes (*Rmg1-Rmg8*) have been identified but only four of these (*Rmg2*, *Rmg3*, *Rmg7* and *Rmg8*) determine an appreciable level of resistance (Maciel *et al.* 2014).

Fungicide treatment

The efficacy of a number of fungicides has been

widely tested (Sussel *et al.* 2013; Oliveira *et al.* 2015) with variable results. It was also observed that the pathogen is capable of evolving resistance against both strobilurin and quinone oxidase inhibitor compounds(Oliveira *et al.* 2015).

Crop management

A number of cultural practices have been suggested as providing a measure of protection against (or escape from) blast infection: these include planting date, plowing depth, the removal of alternative hosts and appropriate crop rotation (Saharan *et al*. 2016; Chowdhury *et al*. 2017).

CONCLUSION

Wheat is now cultivated on over 24 to 27 million hectares in India, depending on the moisture availability at the post monsoon phase. Out of these areas, 9.0 million hectares is exposed to various types of leaf diseases other than rusts and powdery mildew. The delayed wheat sowing under difficult field conditions where the crop stand is invariably poor and high level of organic matter (rice stubble) and poor nutrient application results in spot blotch. The increased blight severity in eastern India is a second generation problem arising from crop intensification. The strong association of foliar blight with the rice – wheat system is not fully understood. Two possibilities could be (i) an increase in the inoculum potential, or (ii) a predisposition for the disease. The disease has become more significant due to terminal heat and high moisture during the crop growth. Spot blotch takes a heavy toll by reduction of annual yields by 20% in the warm, humid climates particularly in eastern India. Moreover, *Bipolaris sorokoniana* though occurs severely in warm and humid environments yet, recently it is also spreading fast to moderate and temperate regions where irrigated rice-wheat cropping system area is expanding. Seed treatment fungicides and crop rotation are cheaper methods of spot blotch management. Application of fungicides like propiconazole and tebuconazole are very effective but these are expensive and also become less effective due to development of resistant /tolerant strains. Biological control methods have been documented but yet to be pervading at the grass root level of farming community. The advancement of genetic resistance against the pathogen has widened the opportunity to breed resistant genotype. The integrated disease management against all foliar blights of wheat may be adopted in wider scale to reduce the crop loss. Regarding wheat blast disease, there is an urgent priority for measures to be adopted to prevent the occurrence of wide-scale epidemics as it has reached the Indian subcontinent. There is urgent need to identify new sources of resistance, to refine crop management practices and to better understand the disease's epidemiology.

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