COMMENTARY

Wheat blast readiness of the Indian wheat sector

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Wheat blast (WB) also known as 'Bruson' (Portuguese for 'burnt') is caused by the fungus *Magnoporthe oryzae* pathotype Triticum (MoT), and has emerged as a deadly disease of wheat in recent times. The fungus can potentially spread through trans-boundary grain shipments, seed exchanges among farmers through infected seeds and through airborne conidia. WB-infected spike appears pale yellow or white yellow as it is bleached and the bleached spike is completely sterile, devoid of grains (Figures 1 and 2). A susceptible cultivar, presence of inoculum, favourable climatic conditions in the form of frequent rainfall, and high winter temperatures (21°–27°C) are all that is required for a blast epidemic to occur. The disease can be managed by the use of fungicides, resistant cultivars and agronomic and cultural practices. However, as far as chemical fungicides are concerned, a combination of triazoles with strobilurins fungicides (quinone outside inhibitors) as suggested by Kohli *et al.*[1] for foliar sprays to control the spike infection was found to be ineffective in wheat fields in Brazil. Moreover, the high-risk fungicides (e.g. QoIs, DMIs or SDHIs as the sole molecule) are associated with the exertion of high selection pressure on the pathogen, consequently rendering it to evolve into resistant pathotypes.

The economic losses caused by WB should be understood in two ways. One is the direct yield loss due to non-formation of grains, and the other is the quarantine-based export losses. It is worth mentioning that WB has a very high propensity of becoming a pandemic around the world and thus making it a disease of very high quarantine importance. Though, the disease was first discovered in Brazil in 1985 by Igarashi *et al.*[2], it spread rapidly in the wheat-growing areas of Argentina, Bolivia and Paraguay. Nonetheless, up to 2016, when the disease remained restricted to Latin America, its damaging potential was neither fully emphasized nor understood. It was only in January 2016 that WB was reported all of sudden from the neighbouring Bangladesh through a series of scientific reports. In few of the affected districts of that country, the area affected was up to 70% and yield loss incurred was up to 51%, which although was significantly lower compared to the initial estimates of as much as 90%. The average yield loss was reported to be 24.5%. The yield loss in the next cropping season pertaining to the year 2016–17 was reported less and ranged from 5% to 10%, but surprisingly, the disease spread to two new districts along with the five original ones despite a drastic reduction in severity. It was considered to be indicative of rapid pathogen adaptation and evolution causing an added concern and sense of urgency, the world over. Wheat cultivation in Bangladesh was discouraged after this incidence and the area under wheat was reduced by a drastic 77.32%, but this could not contain the spread of the disease in the subsequent season, i.e. 2017–18, in which it was reported from six more new districts. Later the Bangladesh pathotype was found to be genetically related to Brazilian and Bolivian isolates. Ceresini *et al.*[3] reported that the pathogen was sourced from Brazil through wheat imports to Bangladesh.

Not only has the initial occurrence of WB in Brazil been attributed to climate change, particularly the rise in winter temperature, but also predictions have been made that the incidences and intensity of WB outbreaks would increase the world over if this trend in climate change continues. Therefore, not only there is a risk of spread of WB to areas with similar agro-climatic conditions, but also into cooler and drier areas which can be potentially converted into humid and warmer ones owing to the global climate change. The average per cent yield loss data under blast epidemic are available from Bolivia, Brazil and Bangladesh. Among these countries, WB has proved most damaging to the wheat production systems of Bolivia, with a huge 69% yield loss over a period of two years. Brazil has suffered a loss of 14–32%, and the most recent epicentre of WB in Asia, i.e. Bangladesh recorded an average yield loss of 24.5% as a consequence reducing the area under wheat significantly. A loss of USD 132–264 million has been predicted for a mere 5–10% reduction in wheat production due to WB[4,5].

Wheat is the second most important crop of India, with the country being the world's second largest producer with a record production of 102.19 million tonnes in 2019. Thus, India is on the verge of being a wheat exporter, setting a production target of 140 million tonnes by 2050. WB although not present in India, could have been a major obstacle in not only the fulfiling of this long cherished national dream, but also in ensuring the food security of its 1.3 billion people. A significant 7 million ha of wheat area, with a major chunk in India, but also including Bangladesh and Pakistan, has been reported to be highly vulnerable to WB in South Asia[5]. India shares a 4096 km-long international border with Bangladesh, the longest with any country. This geographical proximity to the South Asian epicentre of WB, puts 21% of India's total wheat area vulnerable

Figure 1. A half blasted spike in a screening nursery at INIAF, Bolivia.

Figure 2. A completely blasted spike in a commercial wheat field in Okinawa, Bolivia.

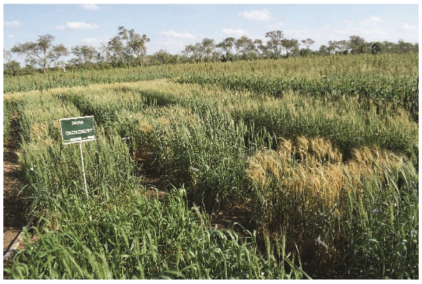

Figure 3. Screening of Indian wheat lines at precision phenotyping platform at INIAF, Okinawa, Santa Cruz, Bolivia.

to this disease. Moreover, to enhance the WB vulnerability besides climatic variables, hot and humid conditions prevailing at the time of flowering to heading stage of wheat crop, most of the wheat varieties cultivated in India at the time of outbreak were either suspected to be susceptible to MoT, or their reaction was unknown with isolated lines showing low to moderate levels of resistance only. Given this, the extent of yield loss could be as high as 70% and this situation with wheat being 27% of the total food production of the country, can prove extremely precarious to a major proportion of our population. Already, weather-based forecasting has shown the very high vulnerability of the north eastern plain zone (NEPZ) and central zone of the country, and if during some hot and humid year WB outbreaks occur in the main north western plain zone (NWPZ), the consequences can be potentially catastrophic. Cardoso *et al.*[6] have already predicted such a scenario in NWPZ under warm and wet winter conditions. The whole of the zone has wheat area planted with a few numbers of highly successful varieties, setting a perfect stage for a WB epidemic[7]. However, the response of the Government of India (GoI) to the threat of WB has been unprecedentedly proactive by creating awareness, surveillance and monitoring modules in the affected/vulnerable India–Bangladesh border areas. A strict internal and external quarantine, proper seed health testing for MoT, enforcement of standard guidelines for safe movement of germplasm, etc. have been put in place by GoI. Moreover, as an extra precautionary step for controlling the transmission of WB into India, the wheat crop in border areas was burnt in 2016 to break the chain of infection. The 'wheat holiday', i.e. banning wheat cultivation in Murshidabad and Nadia districts of West Bengal, India, and 'no wheat zone' within 5 km along the border area with Bangladesh are much-lauded efforts to stop WB from entering into the country. In these areas, alternative non-poaceaous crops like gram, urid, oilseed crops such as rapeseed, and mustard and potatoes have been recommended to farmers during winter season. The impact and success of wheat holiday remains to be seen. The wheat holiday in West Bengal which produces 1.24% of the total wheat of the country, should not have major implications to the total wheat production that has already surpassed a 100 million tonnes. The border areas have also been planted with the 'wheat trap nurseries' to curb the pathogen movement in every season. Sets of Indian wheat varieties have been routinely sent for screening at the precision phenotyping platforms in Bolivia and Bangladesh, and this varietal screening has identified a few WB-resistant varieties (Figure 3). The common observations from the screening trials conducted at the precision phenotyping platforms are that the 2NS carrier wheat lines show stable and good degree of resistance compared to non-2NS lines which are more susceptible. The Indian Institute of Wheat and Barley Research (IIWBR), Karnal under the aegis of the Indian Council of Agricultural Research (ICAR) has recommended five resistant/tolerant, high-yielding wheat varieties for different growing conditions. These include DBW 187, HD 3249 and HD 2967 for irrigated and timely sown conditions, and DBW 252 and HD 3171 for restricted irrigation and timely sown conditions. Among these, HD 2967 is a popular variety of NWPZ, and DBW 187 (Karan Vandana) is a latest and highest yielding variety recently released and recommended for NEPZ. Apart from this, the available potential donors (BH 1146, Milan, SHA7, *Aegilops tauschi* (derivatives), varieties possessing/carrying Lr 34, and genotypes possessing 2NS translocation) are being utilized for introgression breeding for WB resistance in Indian cultivars at ICAR-IIWBR as part of the WB anticipatory breeding programme[7].

The way forward for WB is primarily to come up with strategies for restricting the disease to Bangladesh in Asia and to the hotspot countries of Latin America, if its complete salvation is impossible. The vulnerability of Indian wheat sector needs to be brought down through decreasing the inoculum load in Bangladesh. This can be accomplished through non-wheat seasons, non-poaceous crops in the offseason, supply of disease-free resistant variety seeds, agronomic practices favouring non-development of the disease, development and implementation of integrated disease management practices, and continuous monitoring of disease movement and quarantine. The early warning systems based on climate analogues need to be developed for the vulnerable areas primarily, and economic and quarantine importance of the MoT pathogen needs to be understood well besides attracting investment in the rapid development of high-yielding, WB-resistant wheat varieties utilizing the cutting-edge technologies of speed breeding, genomic selection and gene editing.

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