Beat back the blast:

Development and implementation of a spatially and phenologically explicit wheat blast (*Magnaporthe oryzae* Anamorph *Pyricularia oryzae Triticum)* early warning system in Bangladesh and Brazil

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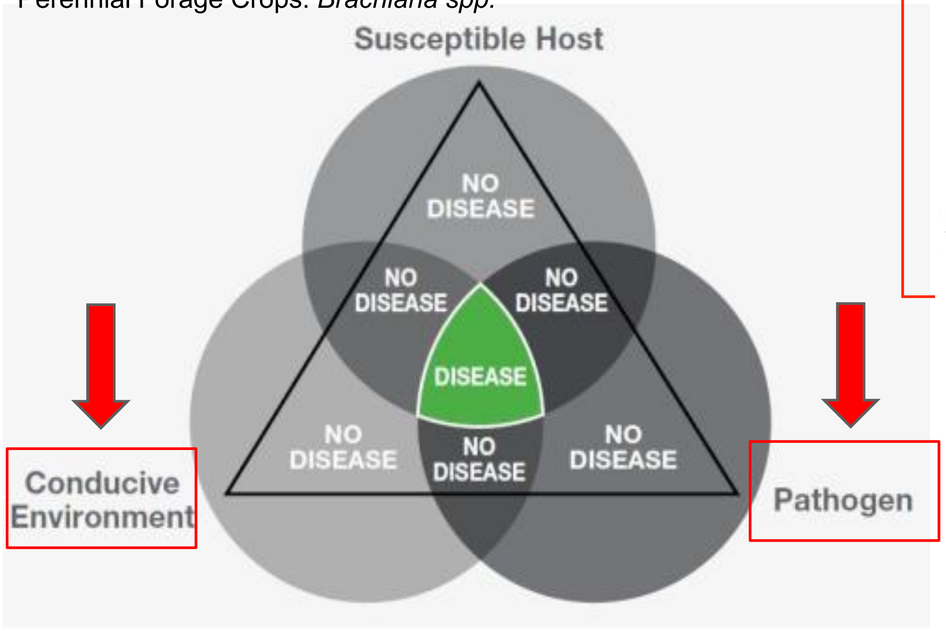
In today's presentation

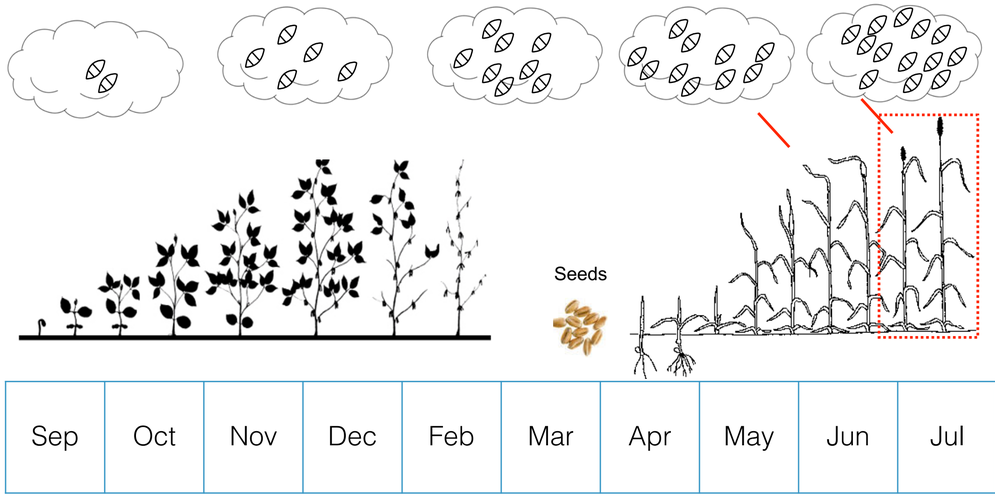
1. Background on wheat blast in Brazil and Bangladesh
2. Blast model structure
3. Field observations and spore trapping
4. Integrating crop and disease models for spatial yield reduction assessments
5. Wheat blast early warning system
6. Conclusions

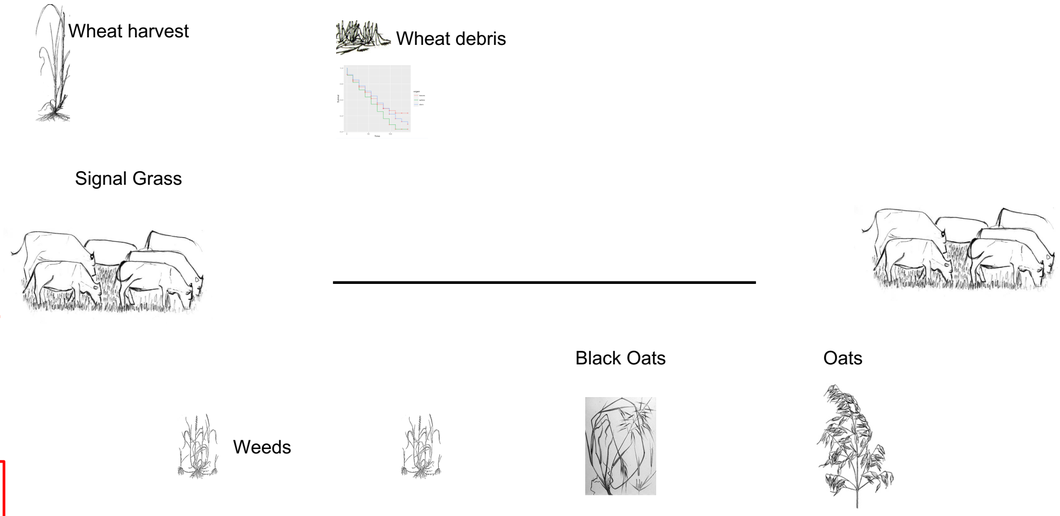
The situation in Brazil

Perennial Forage Crops: *Brachiaria spp.*

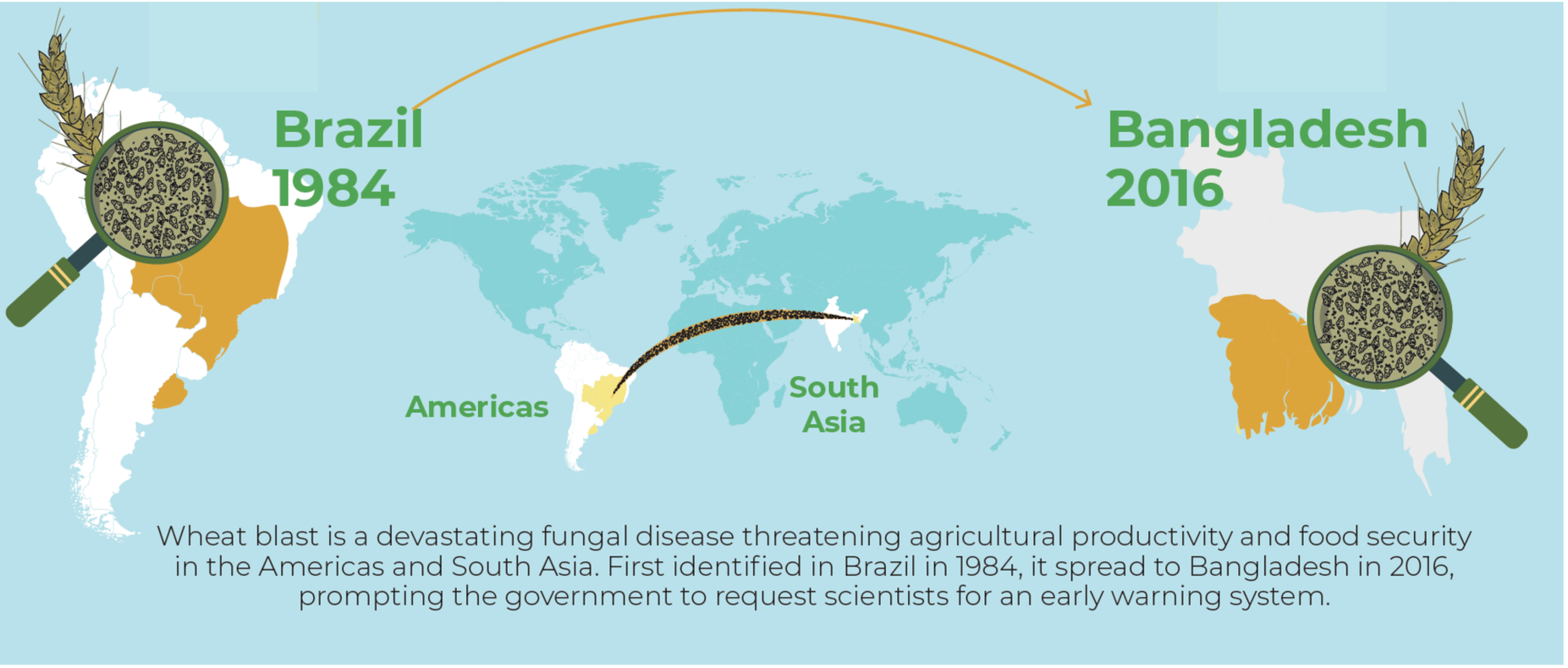


Source: Kevin Robson, BASF, 2014



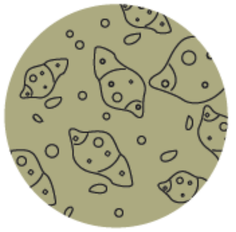


Background on wheat blast in Bangladesh



Wheat blast is a devastating fungal disease threatening agricultural productivity and food security in the Americas and South Asia. First identified in Brazil in 1984, it spread to Bangladesh in 2016, prompting the government to request scientists for an early warning system.

Fungal lesions on wheat or grassy weeds near farmers' fields



The lesion sporolates

Spores float up into the atmosphere

IN BANGLADESH

25% - 30%

25 to 30 percent of wheat was negatively affected, threatening progress in regional food security.

85M Tons

Blast disease has the potential to reduce wheat production by up to 85 million tons in Bangladesh

$13M loss

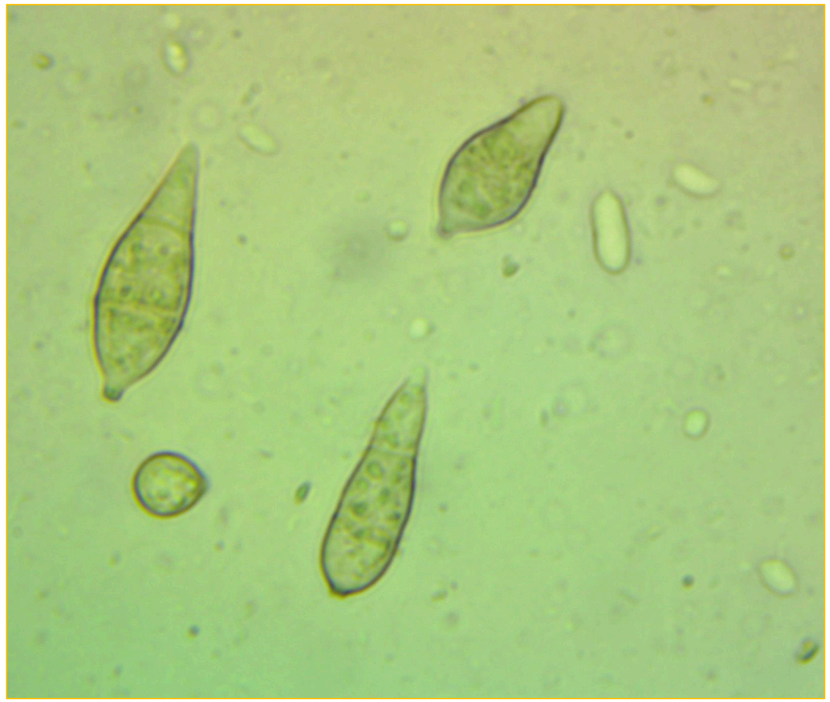
A projected $13 million loss in farmers' profits each year when an outbreak occurs.

Mature plants have large yield losses

Spore Index model

The rate of conidiophore formation and inoculation potential (IP) is a function of hourly air temperature and relative humidity according to the equation:

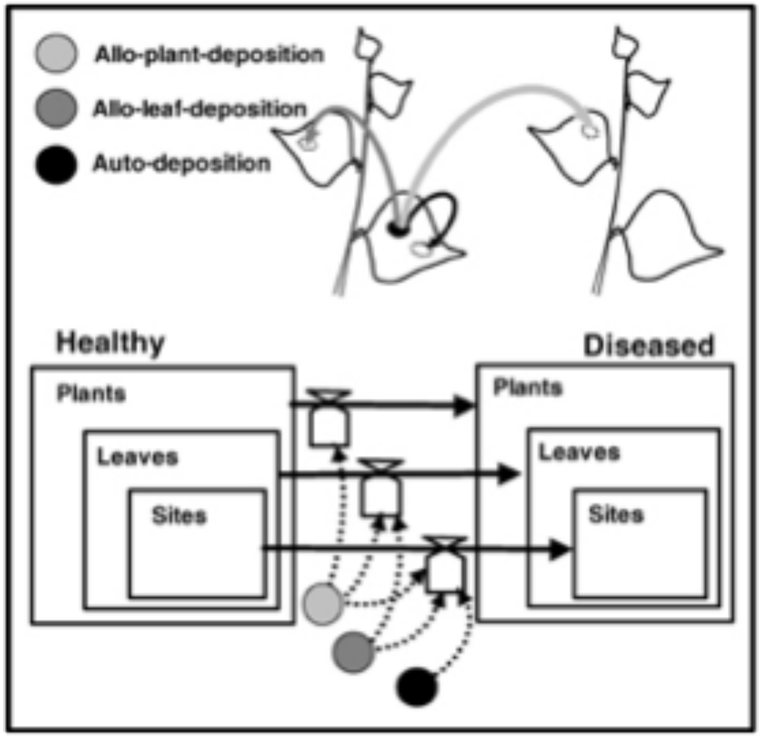
$$IP = \begin{cases} 14.35 - 0.25*T \text{ if } 15C < T < 27C \text{ and } RH \geq 93\% \\ -8.5 - 0.59*T \text{ if } 27C < T < 35C \text{ and } RH \geq 93\% \\ 0 \text{ otherwise} \end{cases}$$

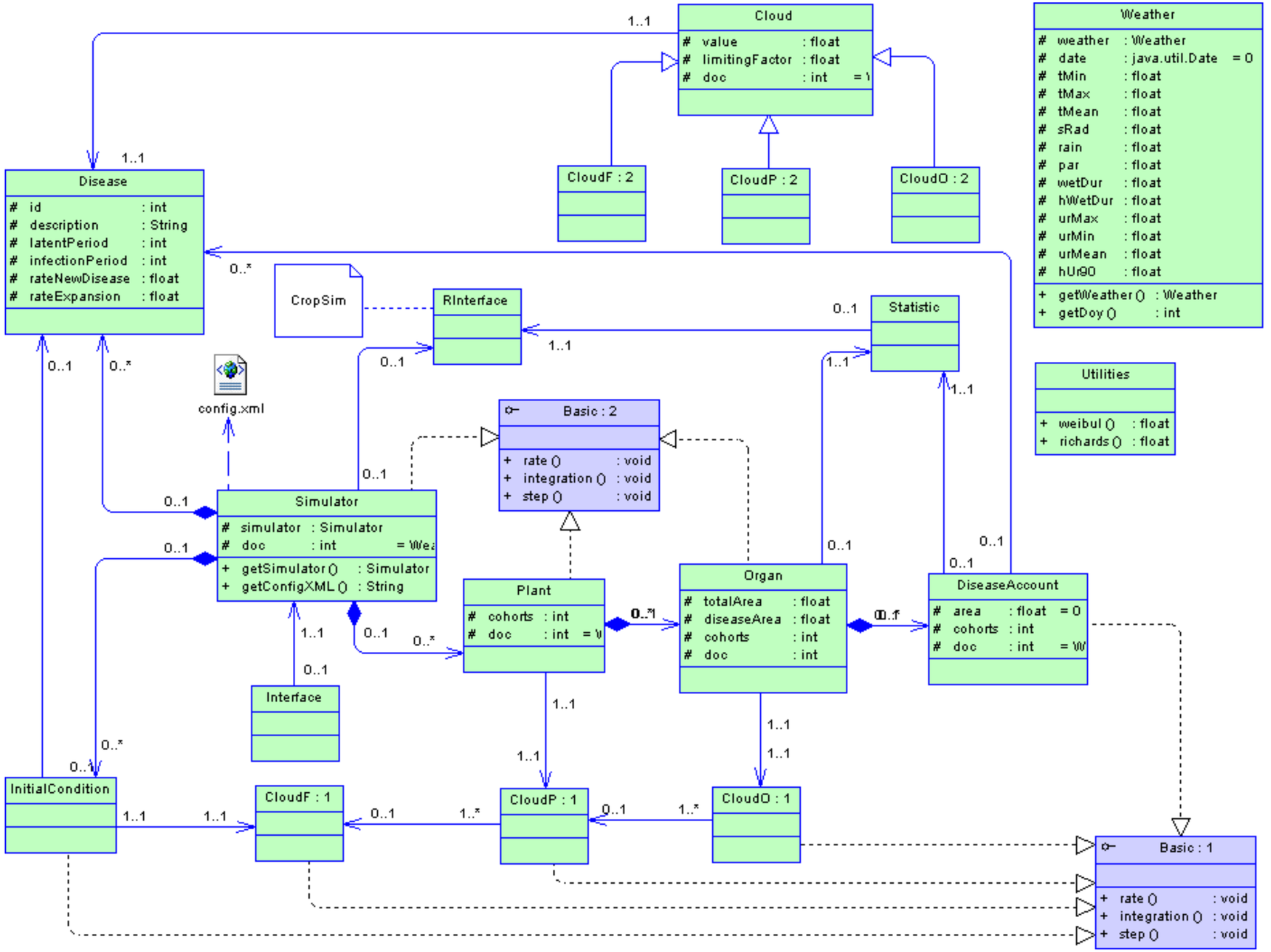


Spore Cloud Density model

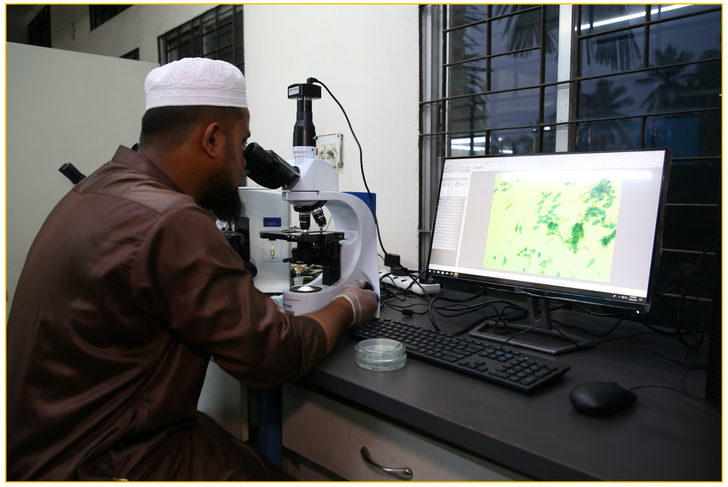
Parameter	Value	Parameter	Value
Daily Spore Production (No. per Lesion)	1500	Initial Pustule Size	0,001
Spore Production Efficiency based on cohort age (Min, Opt1, Opt2, Max)	6,15,22,30	Latent Period (days)	7
Sporulation Crowding Factors	0.98669,10.71894, 0.93374	Infection Period (days)	21
Maximum Spore Clouds Density	15000	Wetness Threshold (hours of humidity)	8
Attainable Spore Rate	0,044	Host Resistance Factor (1 no resistant; 0 resistant)	0.7
Spore Proportion that moves from Organ cloud to Plant cloud (%)	25	Dispersal Rain Effect	0.367753*(x+0.001)^ 0.129605*exp(-0.085252*(x+0.001))
Spore Proportion that moves from Plant cloud to Field cloud (%)	45	Wetness Function	1/(1+exp(4.948-0.348*x))
Cloud compartimentalization (days till leave the system - die/remove) (Field, Plant, Organ)	6,8,10	Invisible Growth Function	0.01+(x*0.2/9)
Initial Inoculum	100	Visible Growth Function	0.0161858*exp(-exp(1.563509-0.441721*x))
Temperature Favorability Set (maximum, minimum and optimal)	30,15,28	mm of rain to reduce spores cloud number (mm)	15
Infection Efficiency	0.08	RHFac	1
Dispersion Frequency - Proportion of spores	0.15		

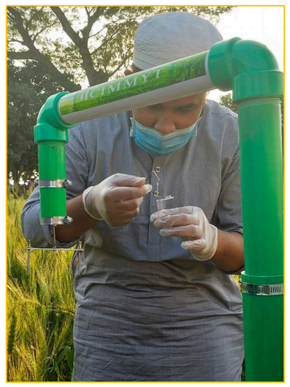
Generic Fungal Life Cycle Model Structure

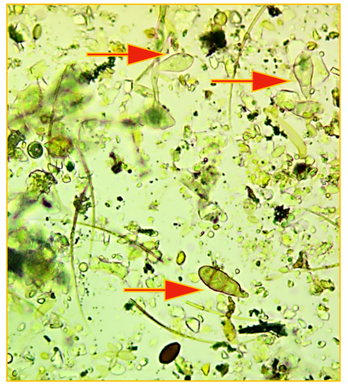




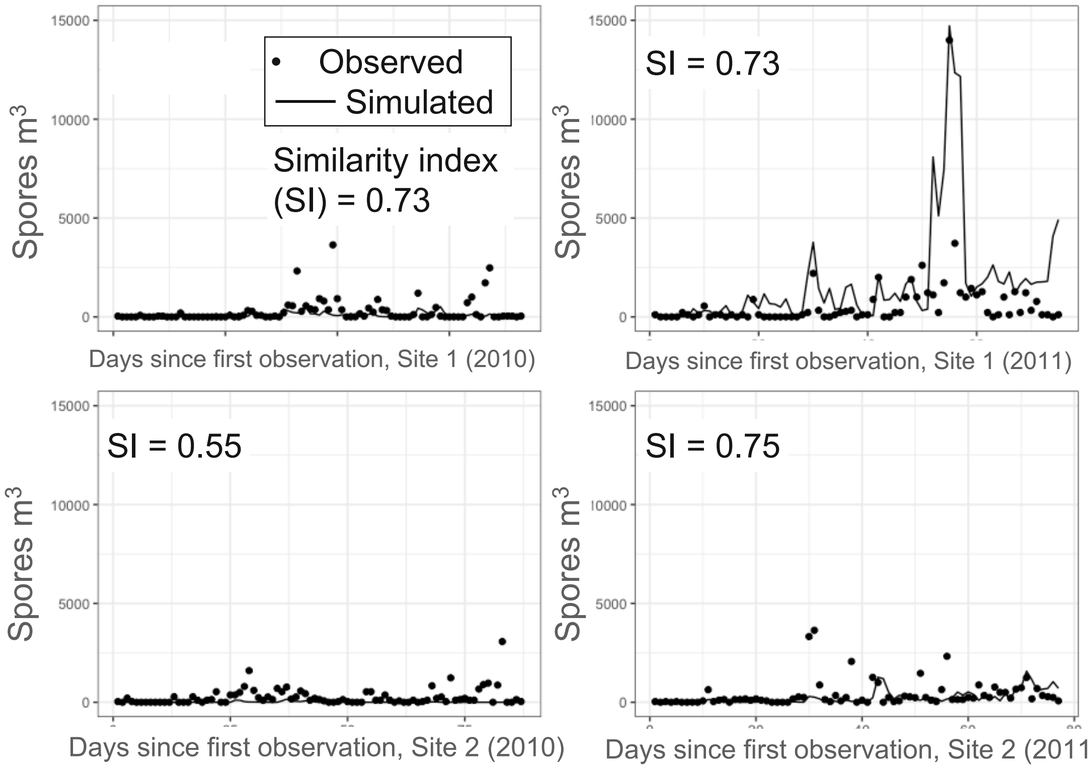
Spore Cloud Density Model Validation







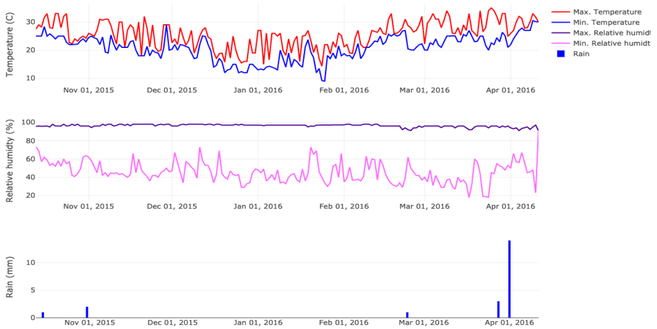
Year	Location	Days with spores present/ Number of days observed	Highest number	Lowest number
2018	Meherpur	26/31	1.2*	0.05*
2018	Faridpur	6/32	0.8	0.5
2018	Rajshahi	20/28	0.9	0.1
2018	Dinajpur	0/26	0	0
2019	Meherpur	26/28	1.5	0.05
2019	Faridpur	12/26	0.7	0.05
2019	Rajshahi	4/26	0.5	0.1
2019	Dinajpur	0/26	0	0

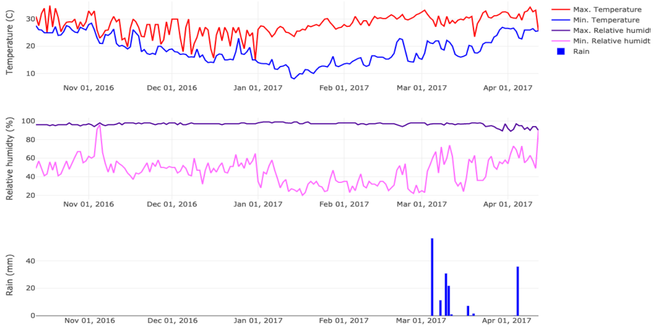


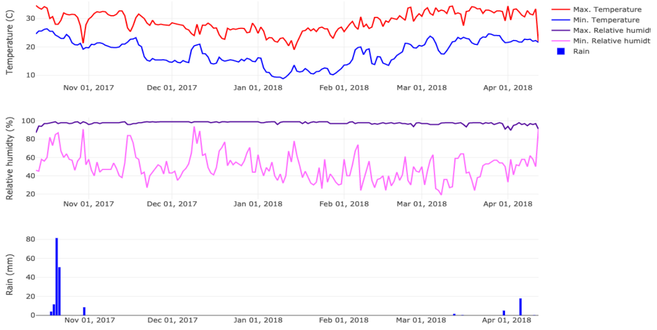
Li, Y. 2013. Factors influencing the development of gray leaf spot of perennial ryegrass turf seasonal availability of the inoculum. PhD Dissertation, Penn State University.

*Spores observed per cubic metre of air over the 8 hour period.

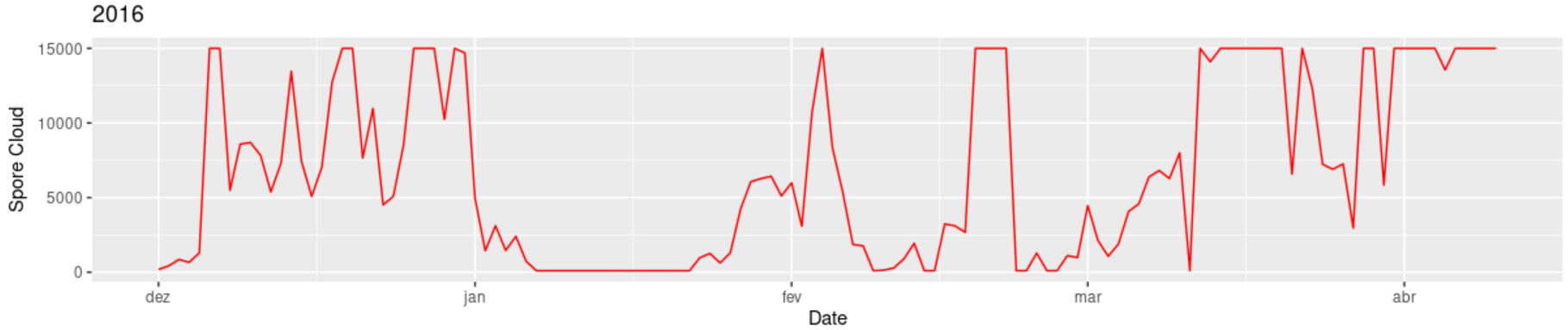
'Back testing' the spore cloud model

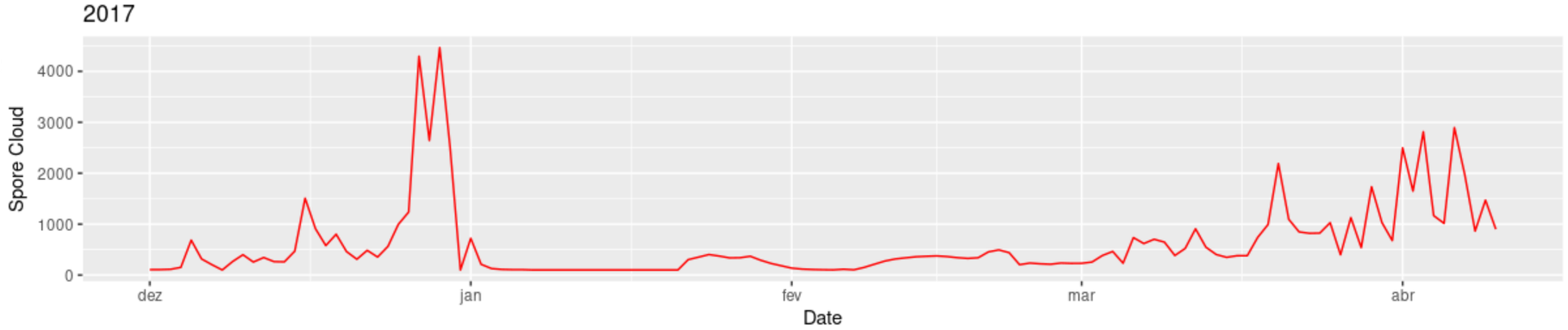


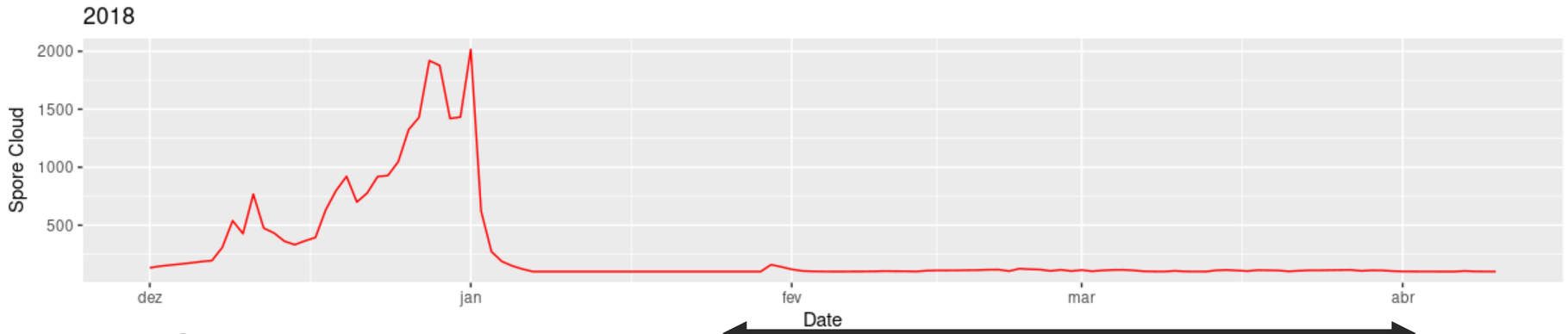




Observed weather data in Bhola, Bangladesh.



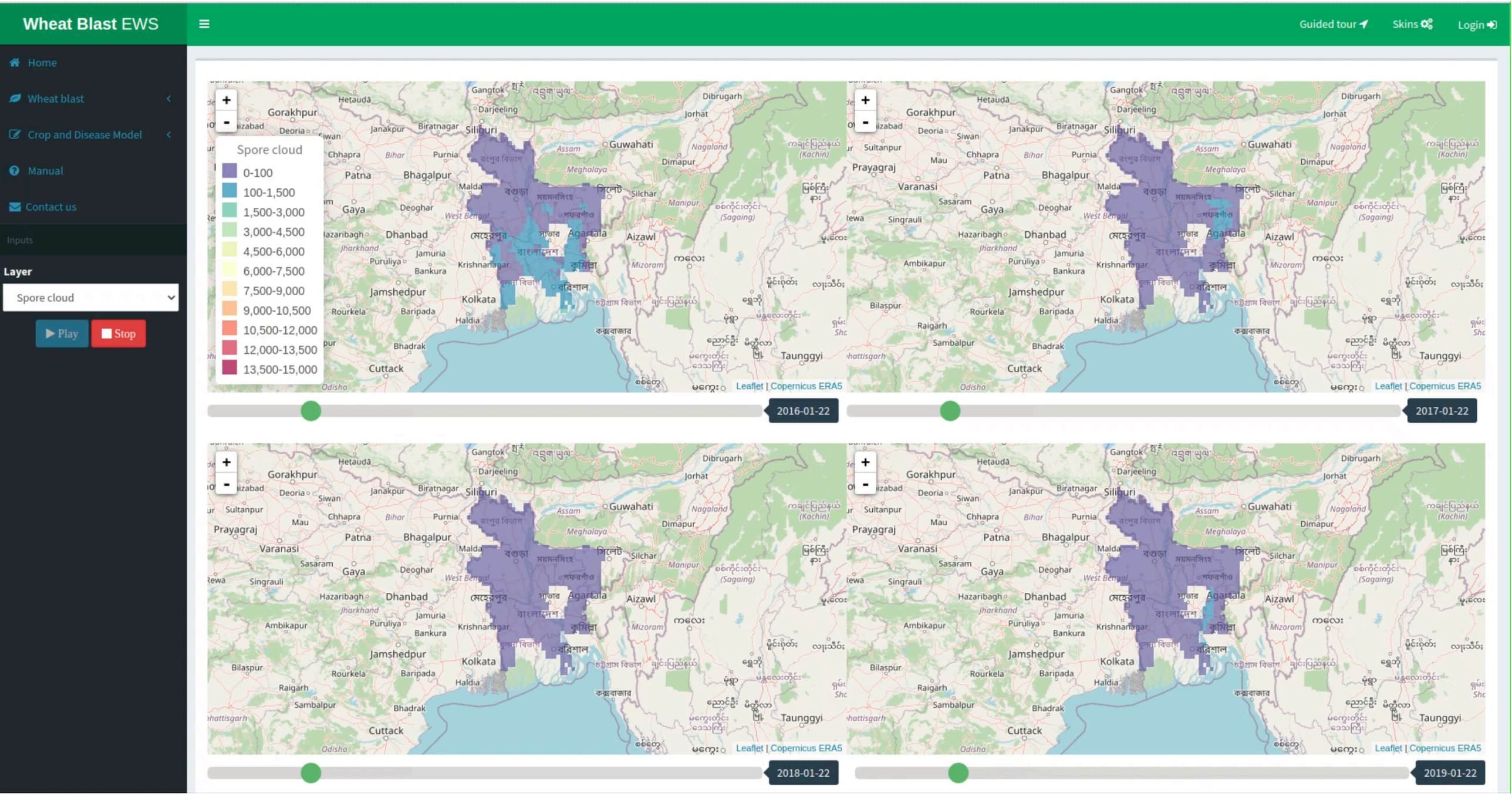




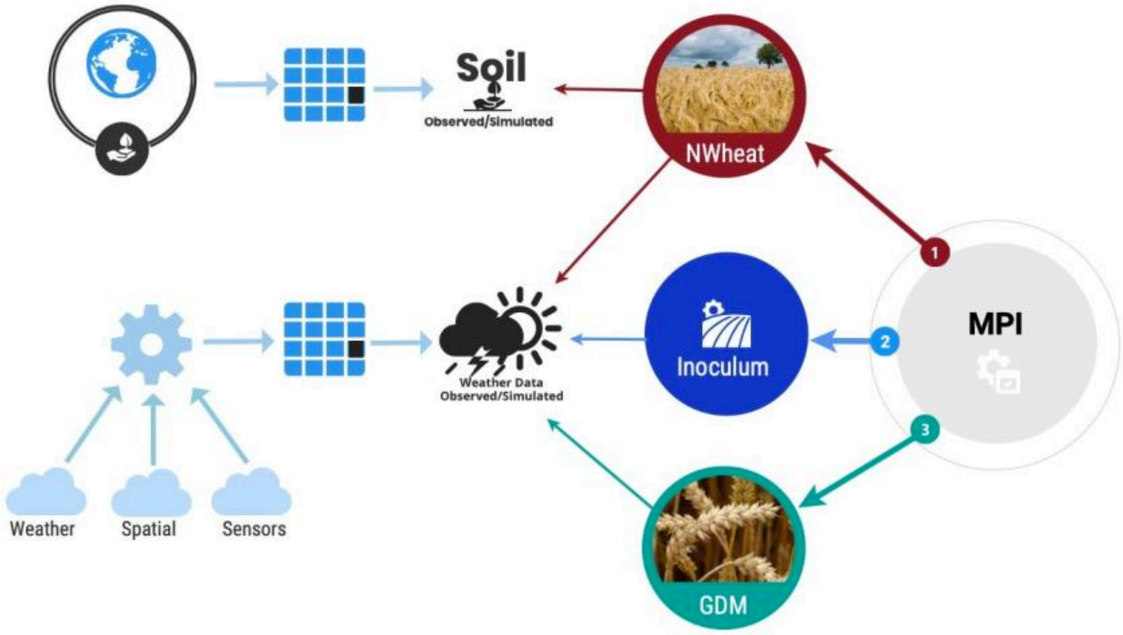
Simulated spore cloud density, Bhola, Bangladesh.

Primary reproductive and susceptible wheat period

Historical simulation: ERA5 Hourly weather data (2016-2019) Solar Radiation, Temp, RH, DP, Rain



Application of DSSAT-Nwheat and the wheat blast model for *ex-ante* assessments



- G × E × M
- Three environments
- Multiple genotypes
- Multiple sowing dates
- Multiple years
- Disease incidence and severity observations

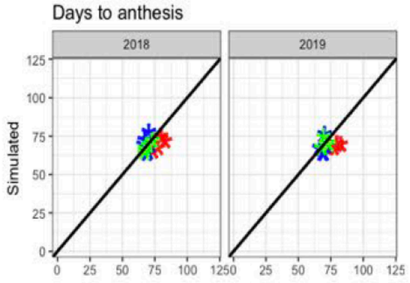
Locations

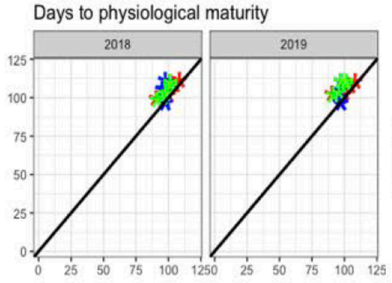
* Dinajpur

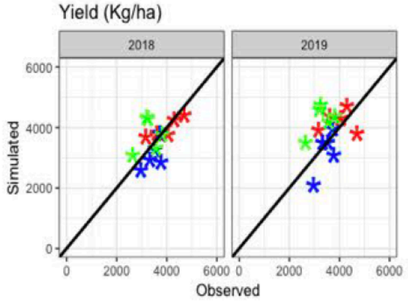
* Jashore

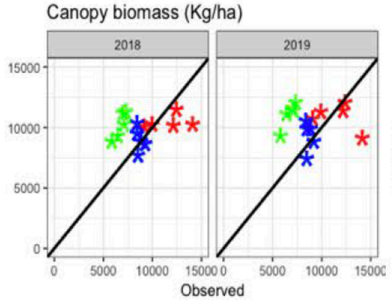
* Rajshahi

Bari Gom 26

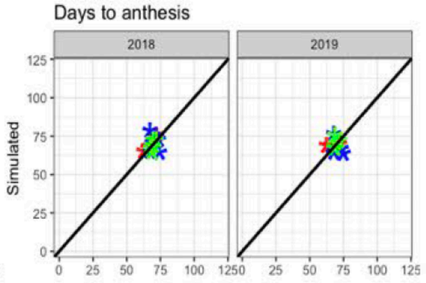


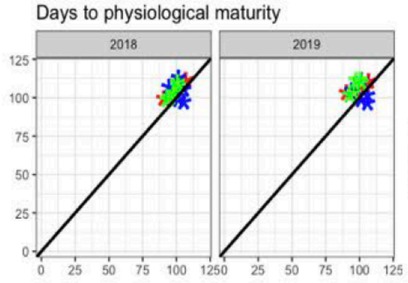


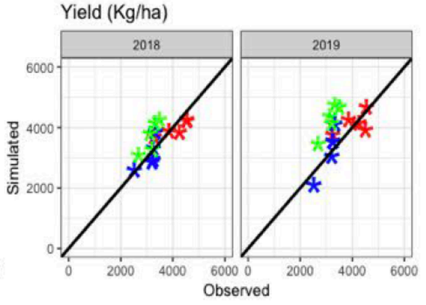


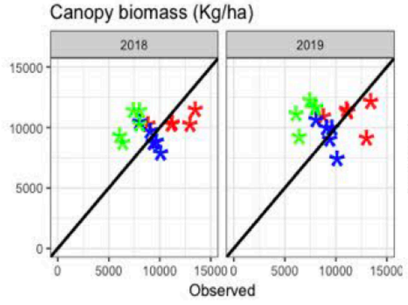


Bari Gom 28

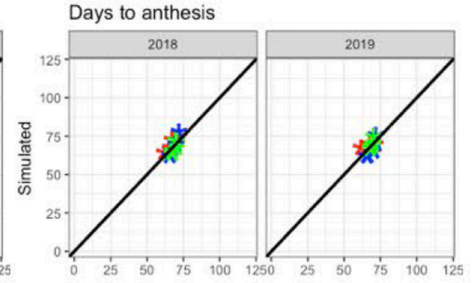


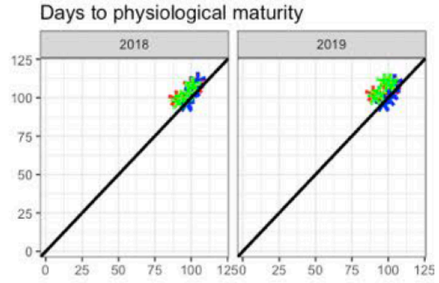


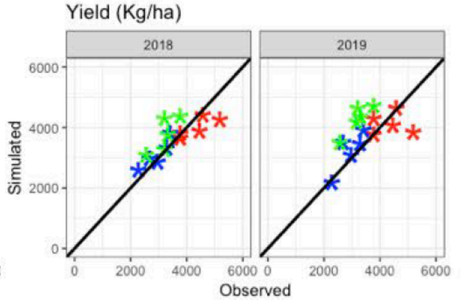


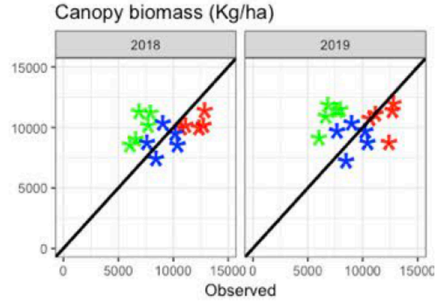


Bari Gom 30









Coupled crop-disease model: Historical yield reduction risk assessment

Meteorologically driven wheat blast development model

Inputs and processes

- High temporal and spatial resolution weather data
- Disease inoculum development, spore cloud build-up and decline routines

Relevant outputs

- Simulations indicating days favoring wheat blast infection infection during the cropping season

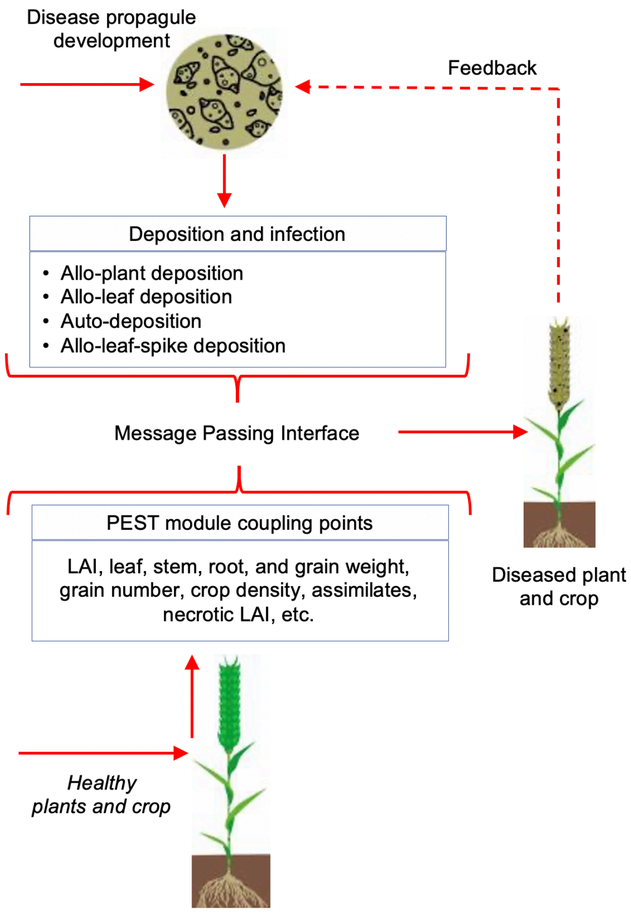
DSSAT / Nwheat crop growth simulation model

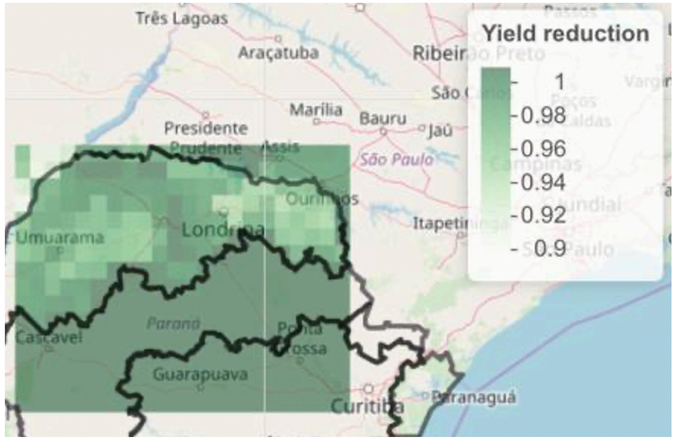
Inputs and processes

- High temporal and spatial resolution weather data
- Cultivar genetic coefficient
- Soil–plant – atmosphere module
- PEST module
- Crop management module
- Nwheat Plant module

Relevant outputs

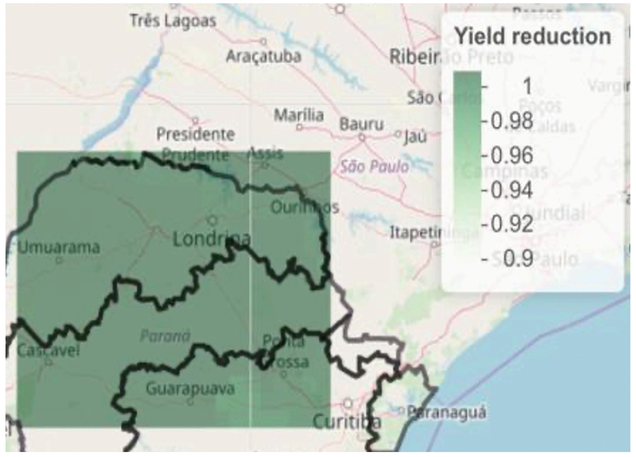
- Crop development and phenological prediction of when wheat is blast sensitive
- Yield estimates





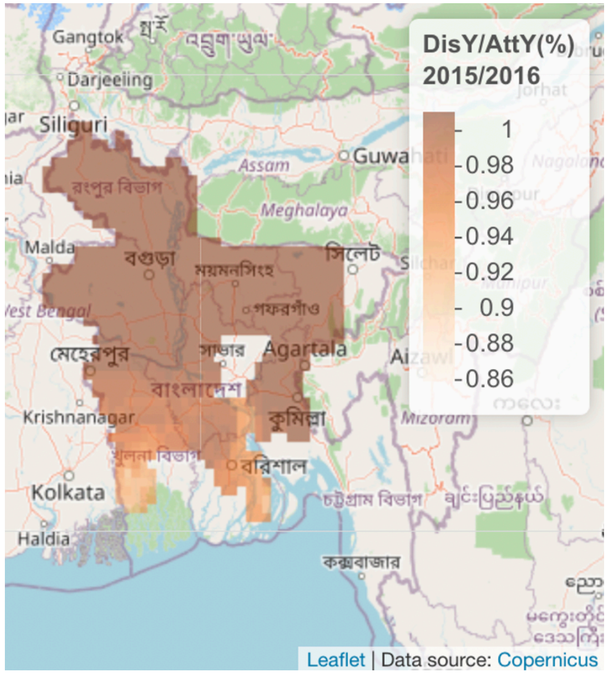
Brazil (2015)

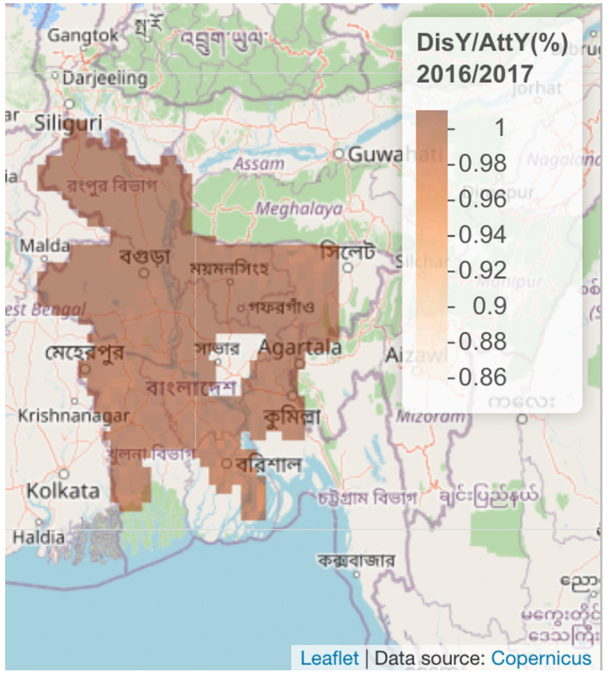
Bangladesh (2016)



Brazil (2016)

Bangladesh (2018)





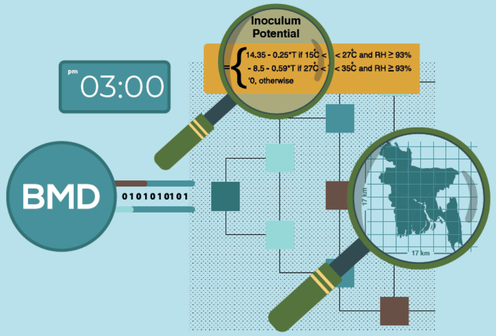
Research to action: The wheat blast early warning system

1

A new digital early warning system can help extension officers and farmers get ahead.

2

Three-hourly numerical weather forecasts supplied by BMD drive a disease model developed by CIMMYT and EMBRAPA.



3

Weather forecast grids are integrated with spore population growth simulations and generate location-specific -5day warnings of blast outbreak risks.

4

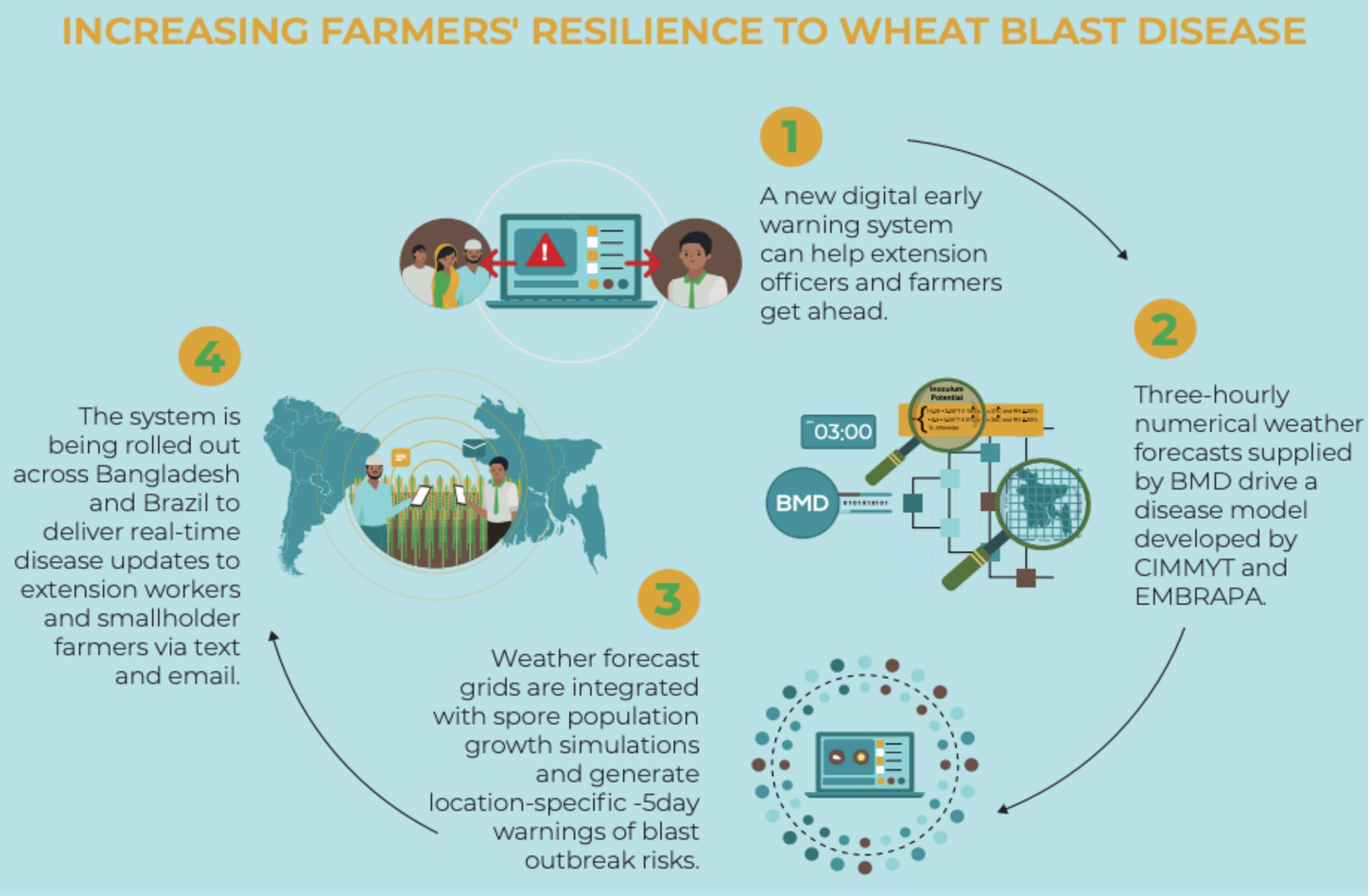
The system is being rolled out across Bangladesh and Brazil to deliver real-time disease updates to extension workers and smallholder farmers via text and email.

বাংলাদেশ আবহাওয়া অধিদপ্তর

Embrapa

CIMMYT
International Maize and Wheat Improvement Center

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
কৃষি সম্প্রসারণ অধিদপ্তর



Forecasted risk level	Phenological stages and potential date range corresponding to this stage			
Spore cloud density ↓	9 Jan – 18 Feb	19 Jan – 28 Feb	29 Jan – 10 March	23 Feb – 4 April
	Largely heading	Largely Flower	Largely Ripe	Largely Mature
<4,000 m^{-3}	A[1]	B	C	D
>4,000 m^{-3} to < 10,000 m^{-3}	E	F	G	H
>10,000 m^{-3}	I	J	K	L

Examples in practical terms: Trigger thresholds for advisories

A. The crop is largely at heading and the date is between 9 January to 18 February. No risk of disease outbreak. No advisory is provided.

G. The crop is largely ripe, and the date is between 29 January to 10 March. Advisory language structure:

You are receiving this advisory because nighttime temperatures have recently been above 15°C and it has been relatively humid. These conditions favor wheat blast disease infection. If wheat is at flowering and farmers have not yet applied fungicides, then you may wish to advise farmers to act in the next few days to prevent infection.

Farmers should use officially recommend registered fungicide practices given in the link here. Remember to advise farmers not to use the same fungicide more than one time during a crop. Fungicides are poison and they should be only applied by experienced applicators trained in use of fungicides while wearing gloves, a mask, gum boots, rubber pants and coveralls. Advice on how to prepare and apply fungicides can be found by clicking here. If wheat is at ripening, then fungicides are not. advised.

Farmers are also advised to grow wheat blast resistant varieties such as BARI Gom 33 and to plant their fields as early as possible. This will reduce risk of disease and improve yield.

L. The crop is largely ripe, and the date is between 23 February to 4 April. As the wheat crop is likely to be largely mature, the risk of disease outbreak. No advisory is emailed or provided.

Conclusions and learnings

- Don’t recreate the wheel
- Field data + validation are crucial
- Tactical use of secondary data
- Partnerships × 3!
- Keep it simple – and actionable
- Zambia…

Thank you!

Questions?

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beattheblastews.net

What can I do about wheat blast?

Cultural practices to provide a measure of protection against blast


Crop rotation


Use disease free seed

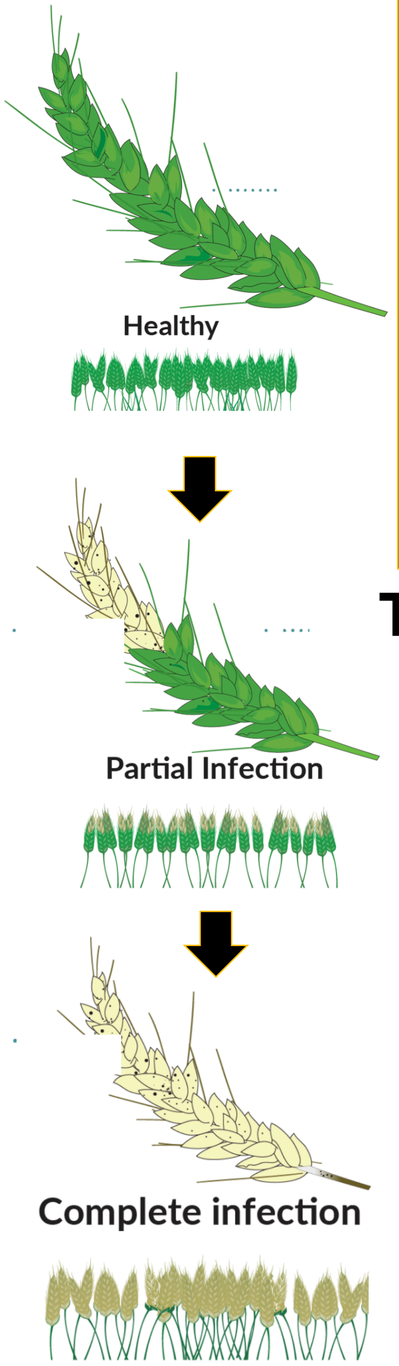

Sow early


Spray fungicides if advised by extension services


Remove grassy weeds

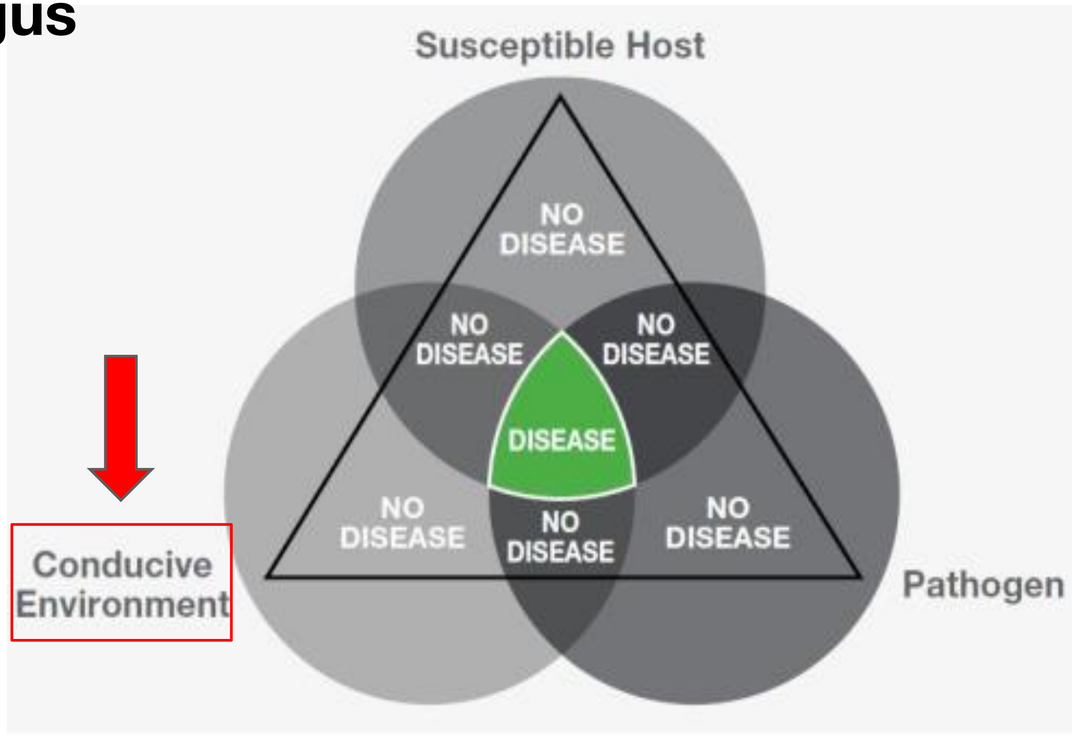

Do not replant seeds from a disease infected field

For more information: https://repository.cimmyt.org/xmlui/bitstream/handle/10883/4740/57653.pdf



The *Magnaporthe oryzae* Triticum fungus

- Physiologically + genetically complex;
- Can infect many grasses, but specific isolates generally infect limited species;
- MoT first identified in Brazil in 1985, affected >3 m hectares in the early 1990s, periodic outbreaks;
- In 2016, wheat blast spread to Bangladesh, 15 districts affected.
- 2017, ‘18, ‘19, ‘20 – Limited infection



Source: Kevin Robson, BASF, 2014