ADVANCING PEST and DISEASE MODELING

FEBRUARY 23–25, 2015

UF/IFAS STRAUGHN EXTENSION PROFESSIONAL DEVELOPMENT CENTER | UNIVERSITY OF FLORIDA | GAINESVILLE. FL

Crop Modeling Incorporating Pests and Diseases: What Have We Learned?

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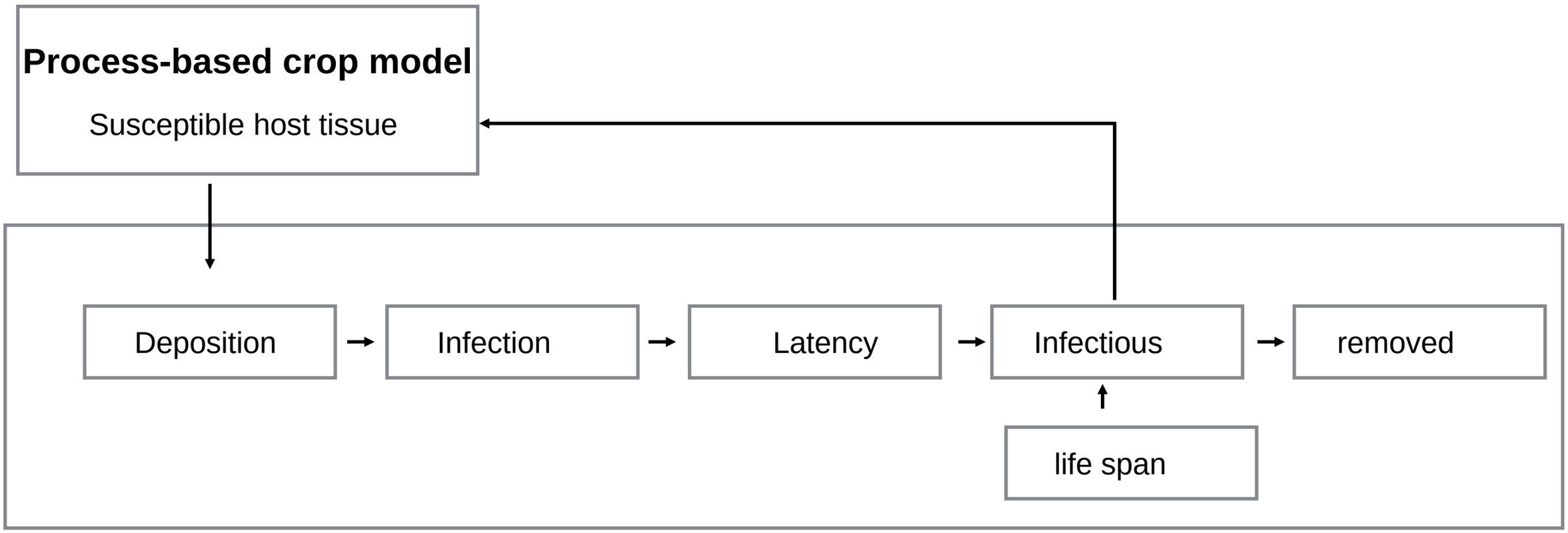
Embrapa, University of Passo Fundo

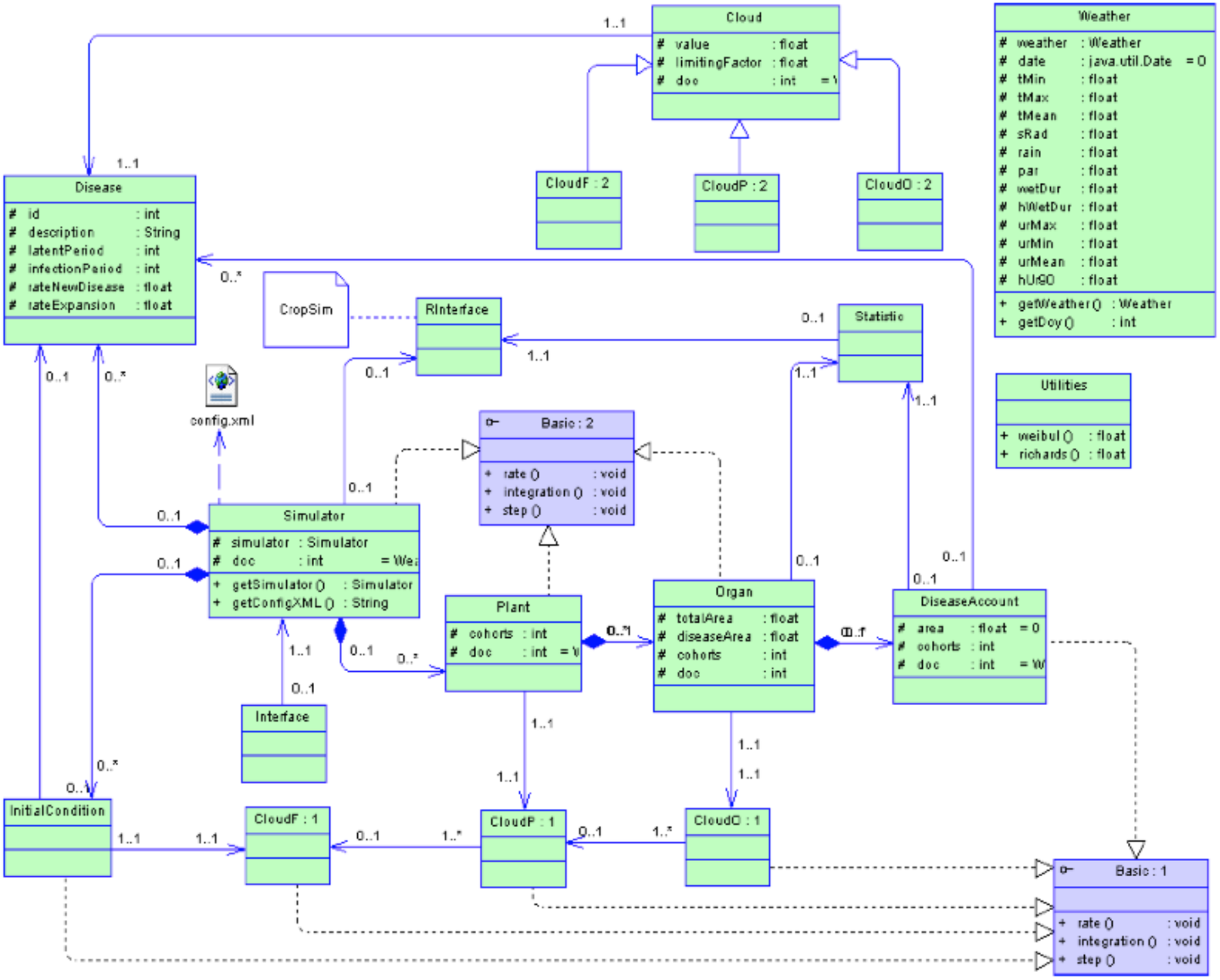
Integrating disease models to crop models….



How to implement?

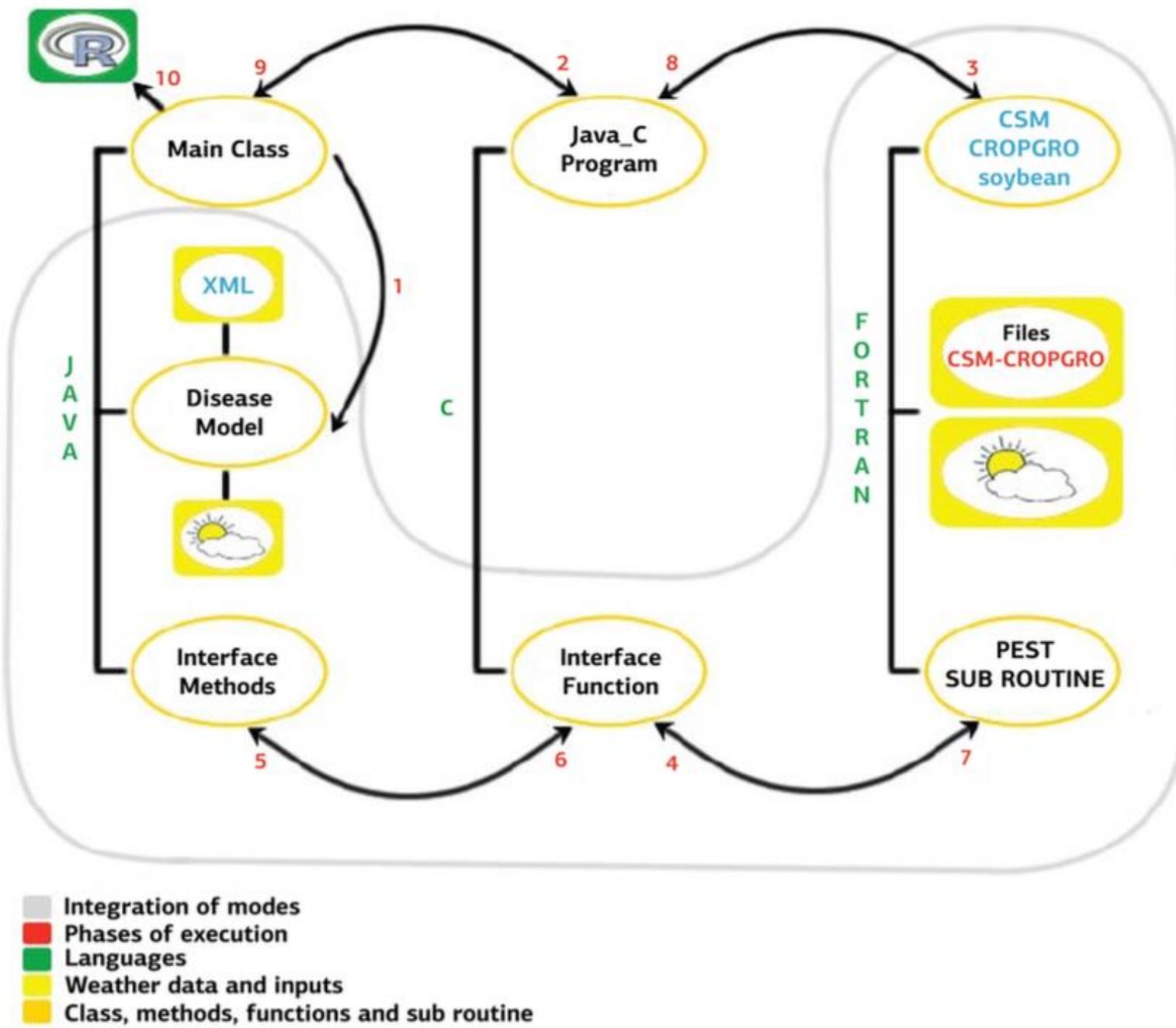
1. CROPSIM:Wheat
Subroutine: Disease

2. Modular and Generic



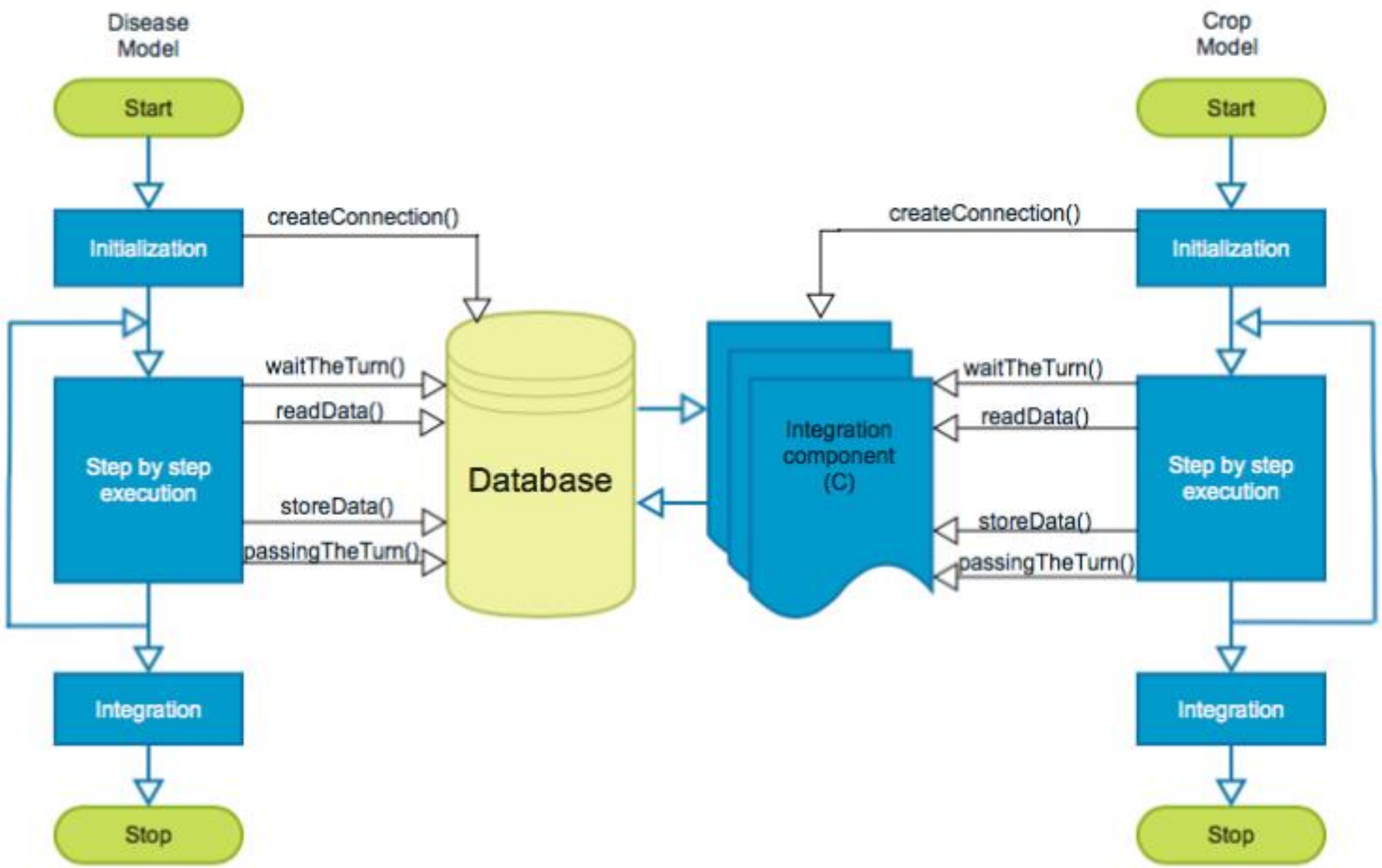
Equation Based Generic Plant Disease Cycle Model

Pavan & Fernandes, 2009



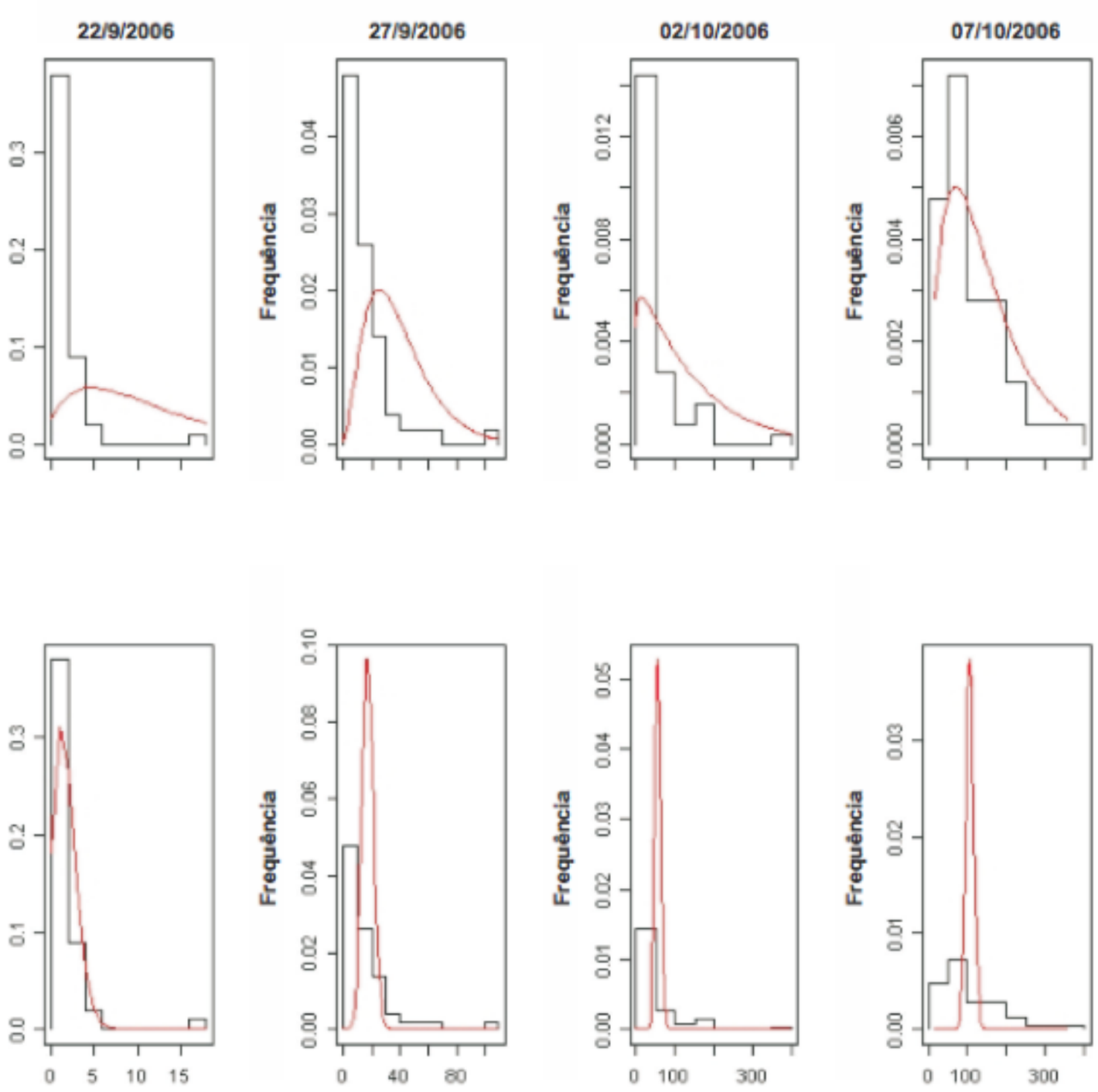
Rodrigues et al., 2012

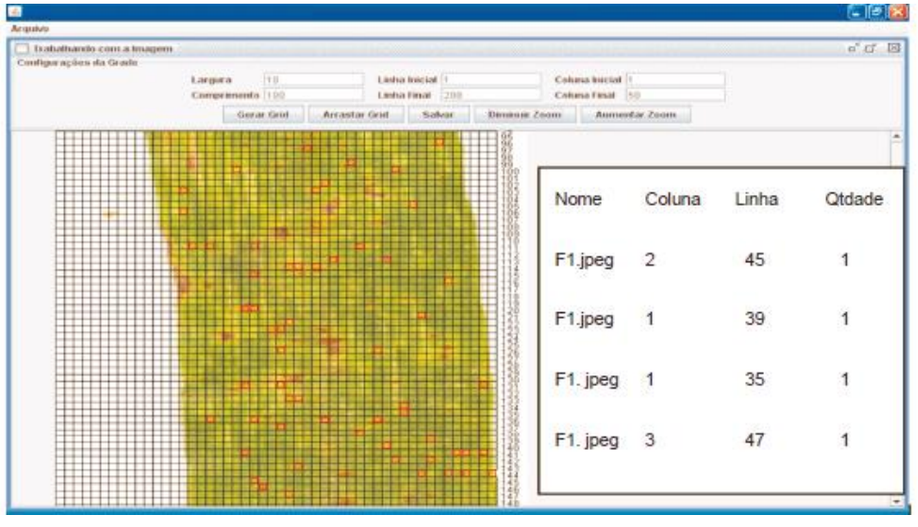
Models Integration Through a Database

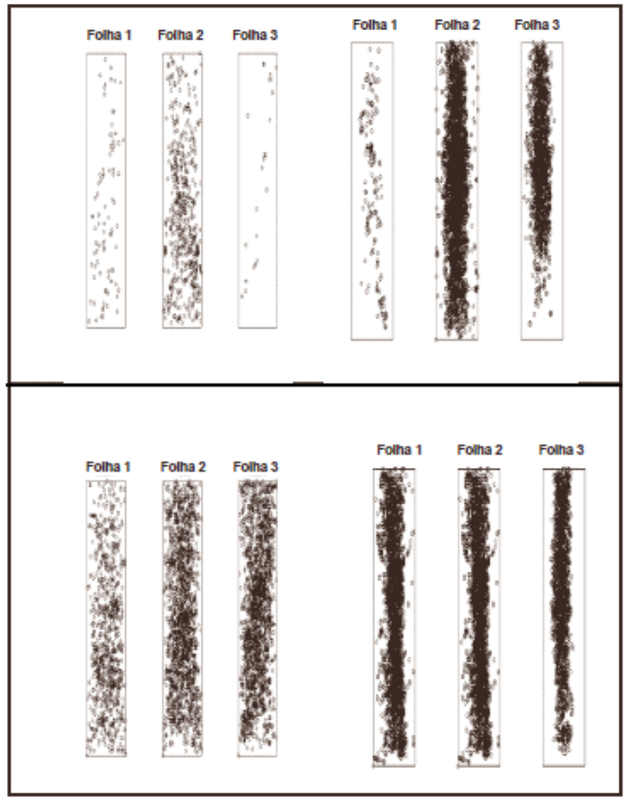


Pavan et. al., 2014

Cereal Rusts





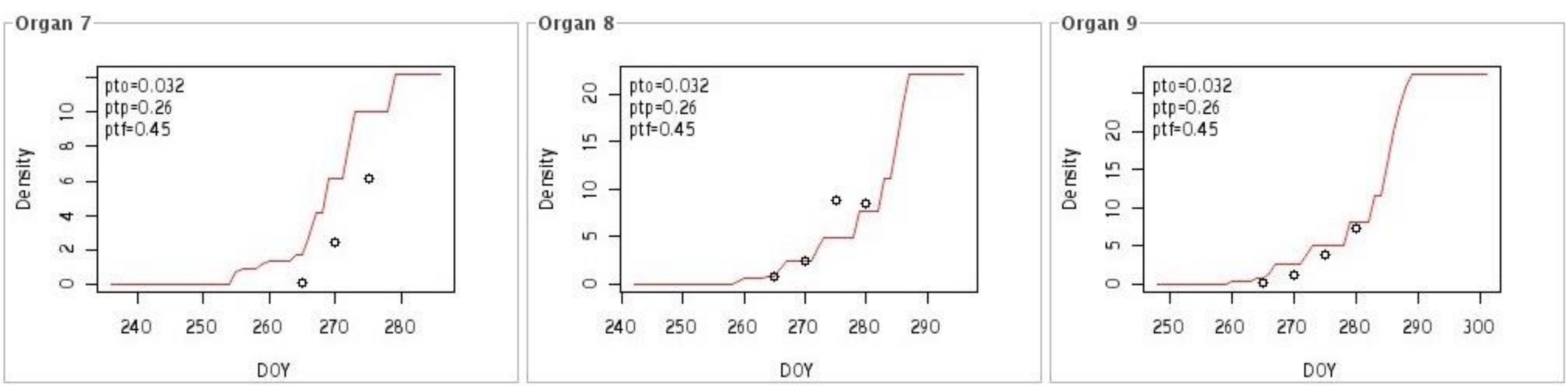


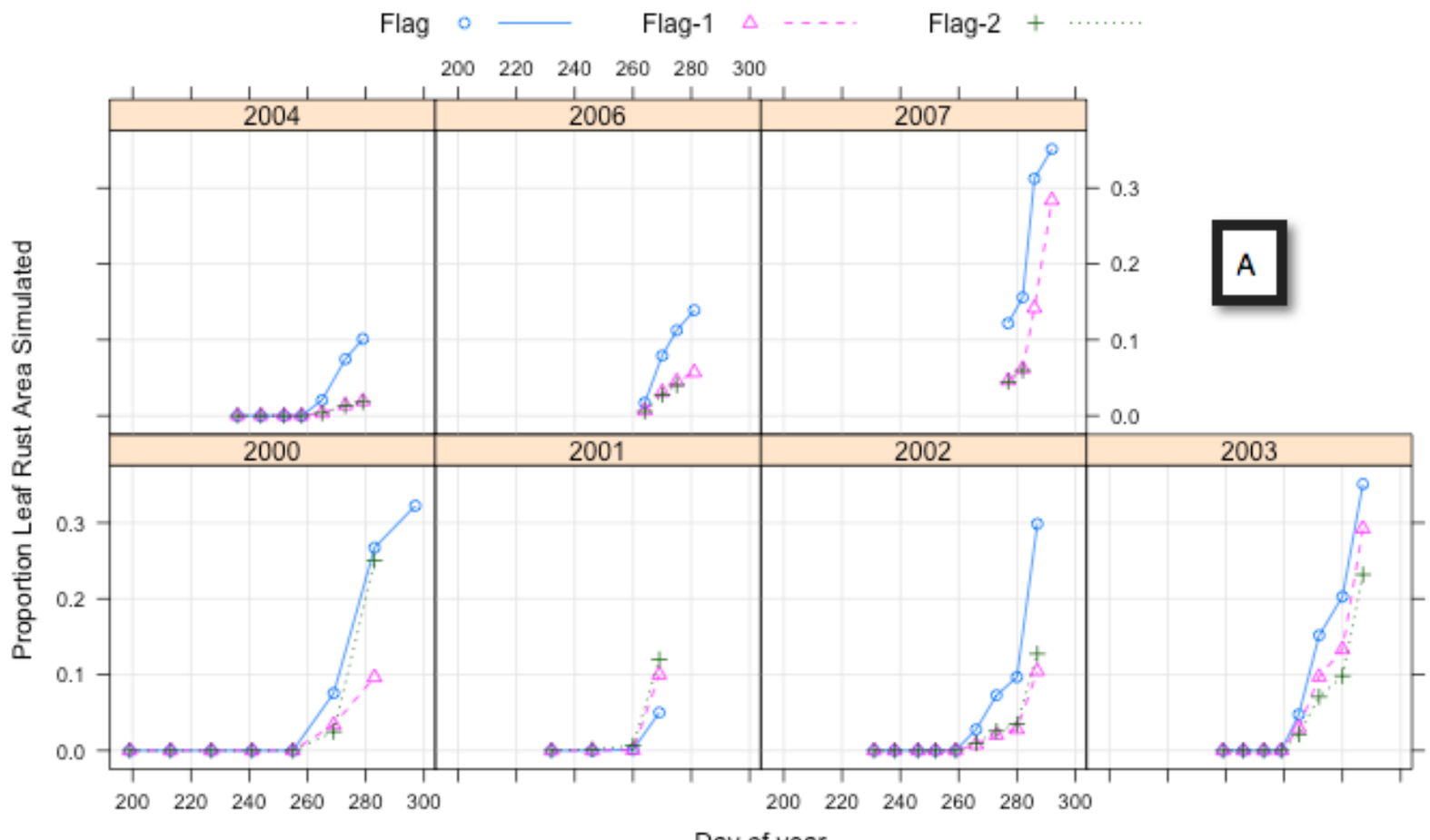
Pires, et al., 2009

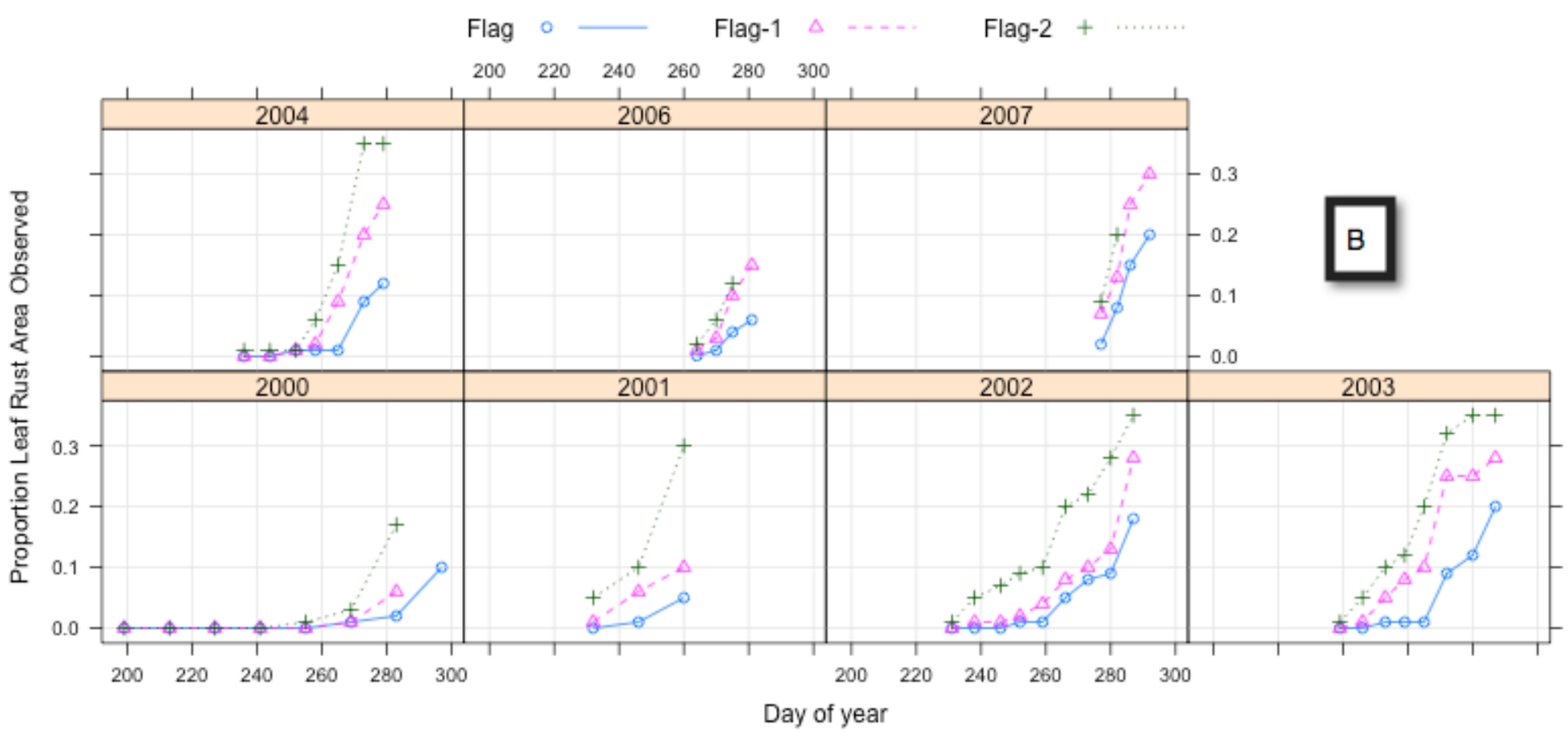
Lesion Counts

```
9    <disease>
10       <description>Wheat Leaf Rust</description>
11       <infectionEfficiency>0.17</infectionEfficiency>
12       <environmentFavorability>1</environmentFavorability>
13       <depositionFrequency>0.05</depositionFrequency>
14       <initialInoculum>10</initialInoculum>
15       <vectorSizeCloudF>5</vectorSizeCloudF>
16       <vectorSizeCloudP>7</vectorSizeCloudP>
17       <vectorSizeCloudO>10</vectorSizeCloudO>
18       <maxSporeProduction>3000</maxSporeProduction>
19       <cohortAge>{7,15,18,37}</cohortAge>
...
30       <latentPeriod>6</latentPeriod>
31       <latentGrowthFunction>gompertz</latentGrowthFunction>
32       <latentGrowthParameter>{0.0161858,1.563509,0.441721}</latentGrowthParameter>
33       <infectionPeriod>20</infectionPeriod>
34       <infectionGrowthFunction>exponential</infectionGrowthFunction>
35       <infectionGrowthParameter>{0.01507,1.0104,0.2125}</infectionGrowthParameter>
...
```

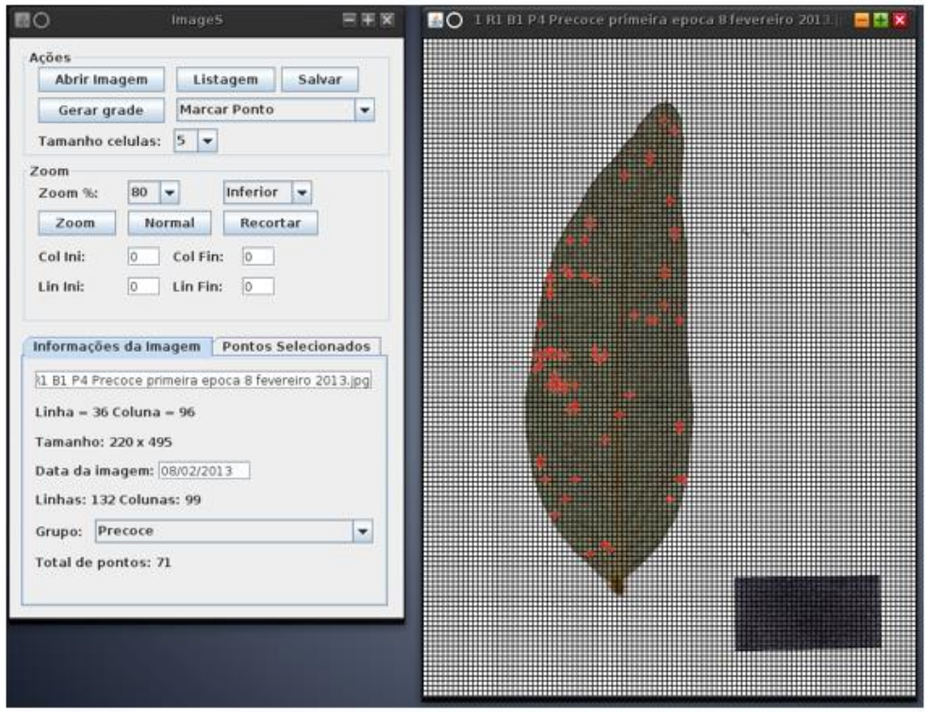
```
tempVisibleArea   = Utilities.growsFunction(disease.getLatentGrowsFunction(),
                                            disease.getLatentGrowsParameter(),
                                            getphysiologicalDay()) *
                    disease.getHostFactor() * cohorts;
tempInvisibleArea = Utilities.growsFunction(disease.getInvisibleGrowsFunction(),
                                            disease.getInvisibleGrowsParameter(),
                                            getphysiologicalDay()) *
                    disease.getHostFactor() * cohorts;
```

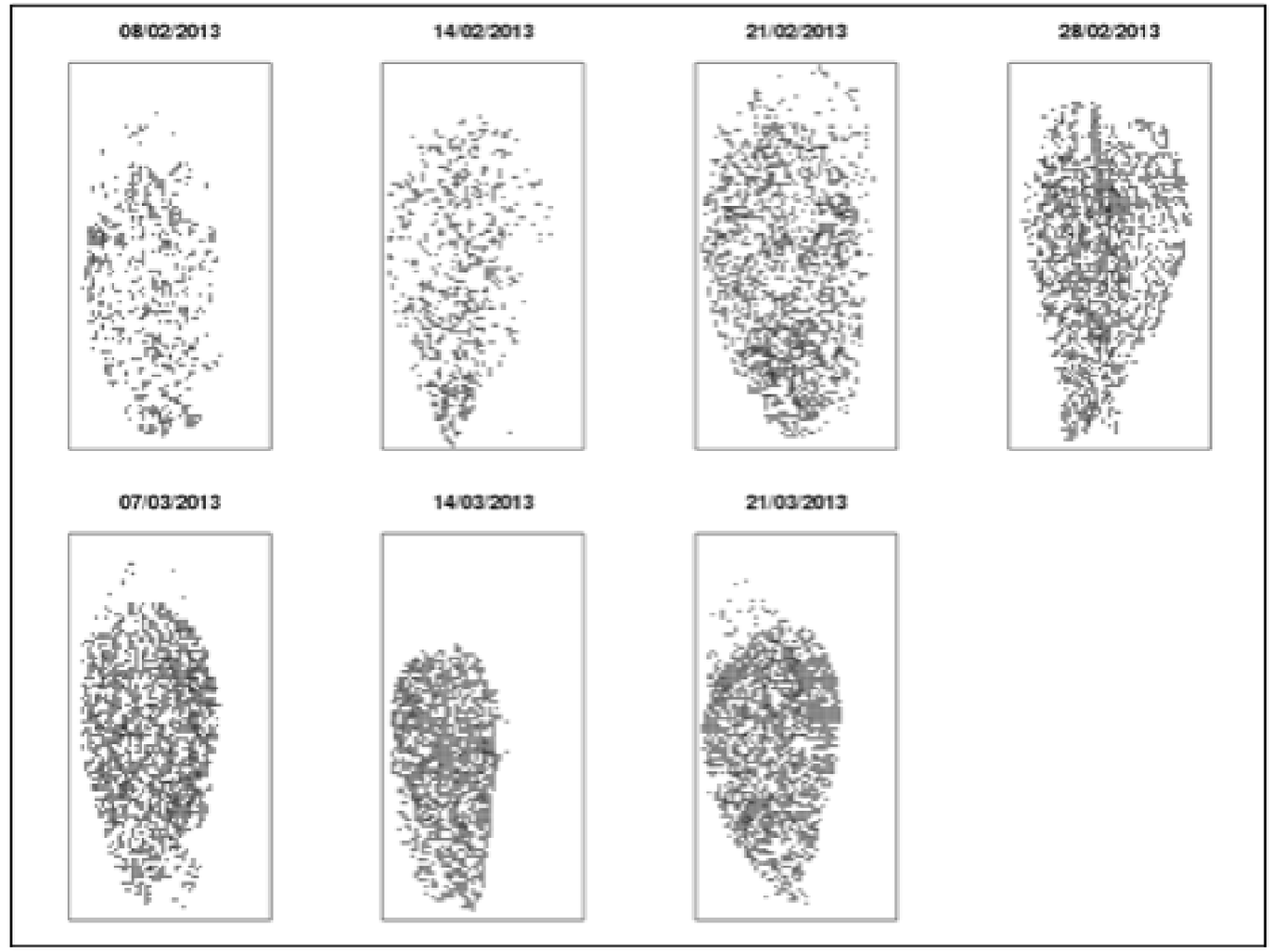


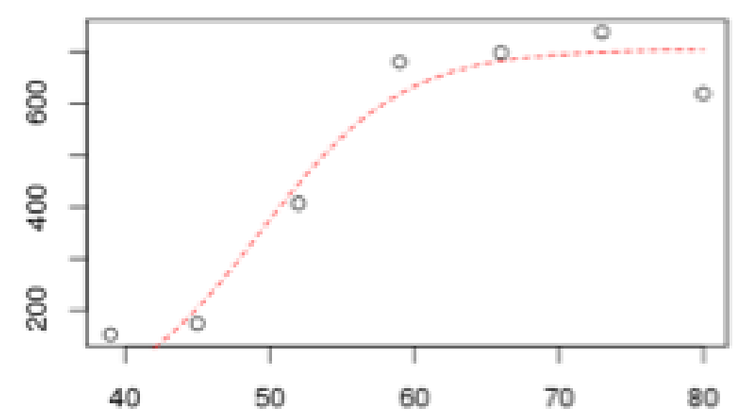

Flag
Flag-1
Flag-2
2004
2006
2007
2000
2001
2002
2003
A
Proportion Leaf Rust Area Simulated
Day of year

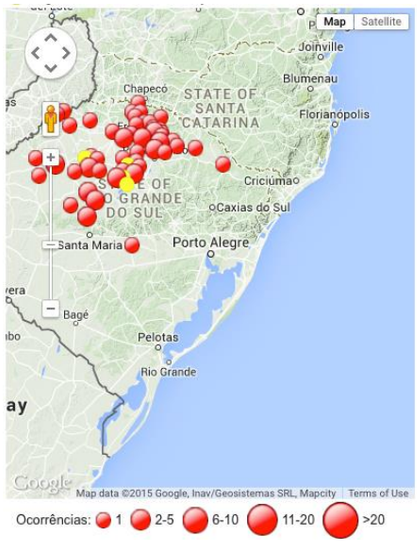

Flag
Flag-1
Flag-2
2004
2006
2007
2000
2001
2002
2003
B
Proportion Leaf Rust Area Observed
Day of year

Soybean Asian Rust

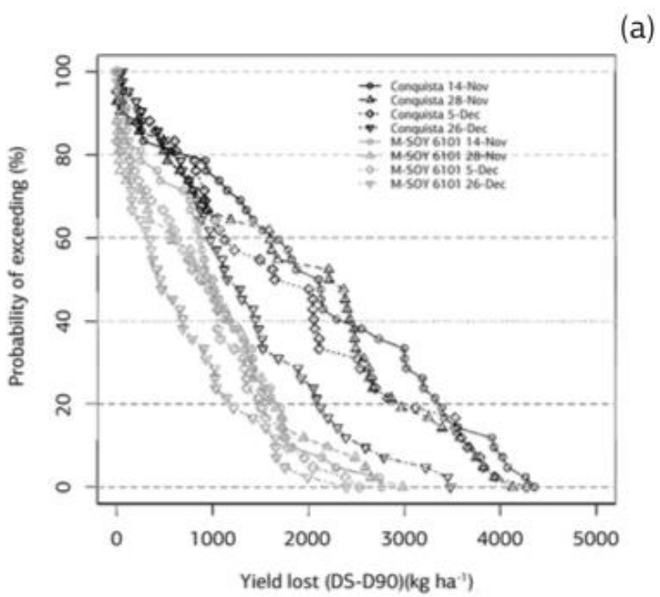








2004/2005 - To present

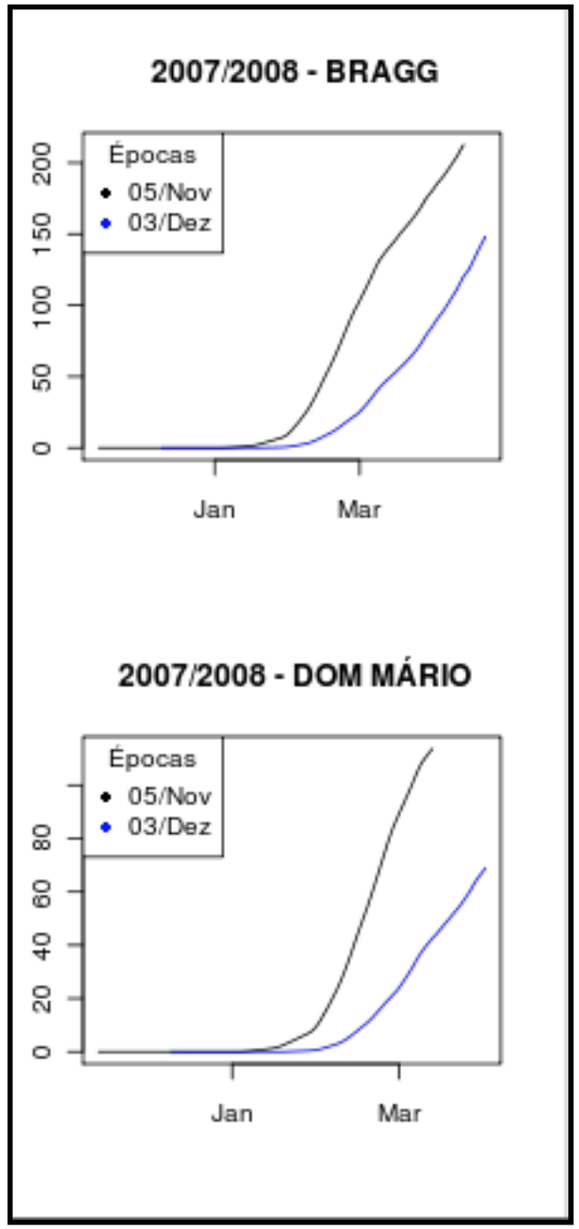


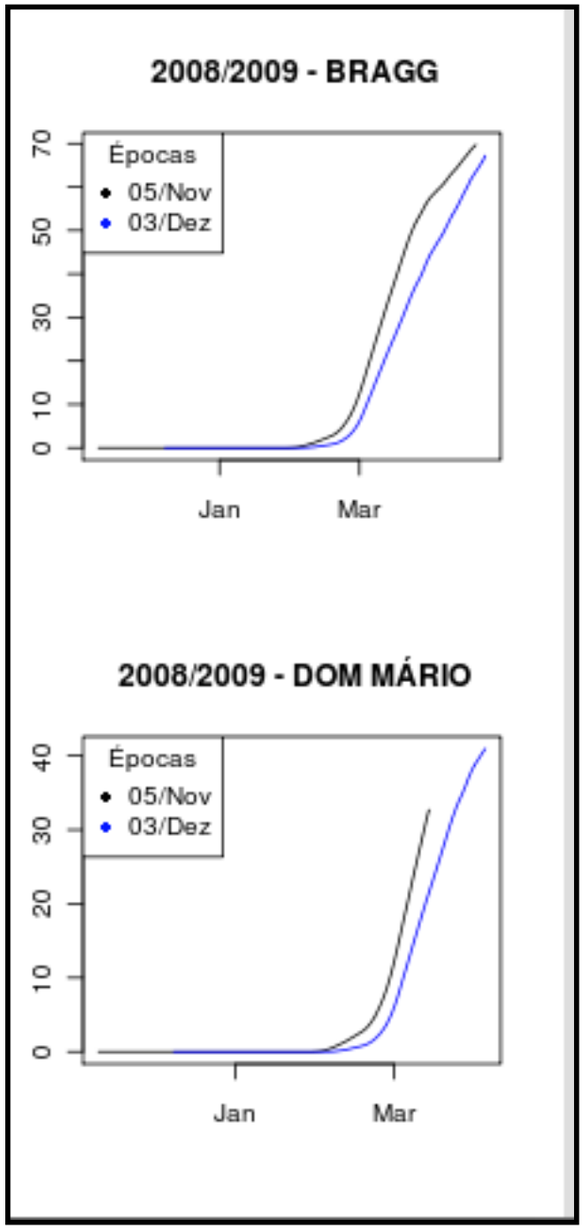
Rodriigues et al., 2012

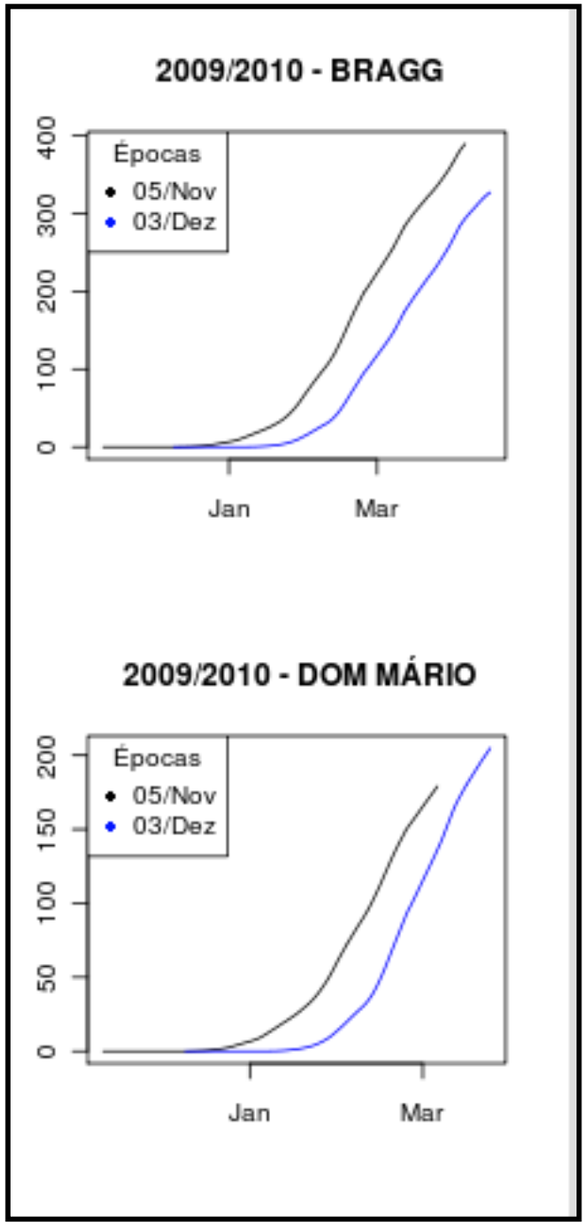
January	February	March
0.31	0.51	0.18

January	February	March
0.09	0.54	0.36

January	February	March
0.72	0.25	0.03





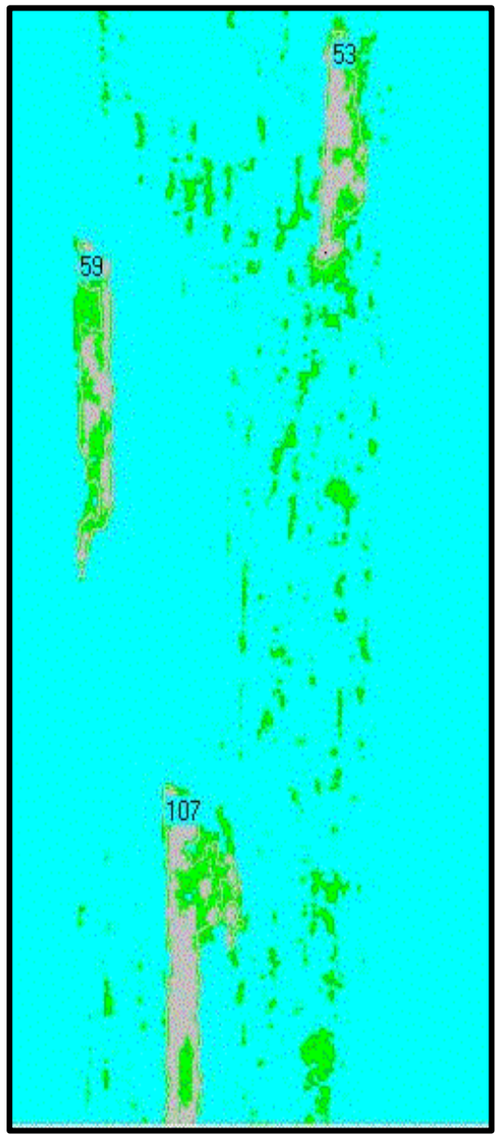


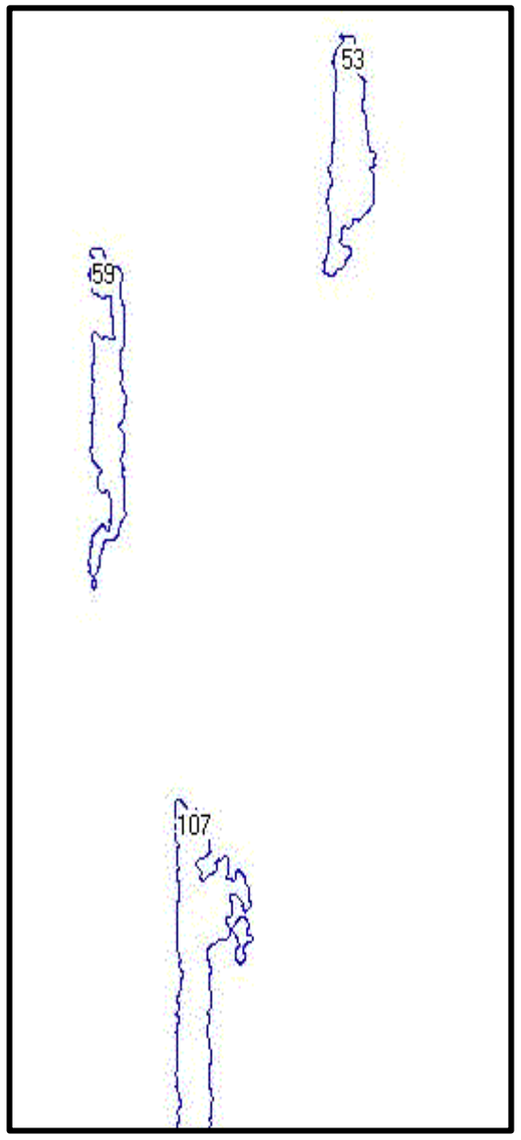
Moderate

Low

High

Leaf Spots

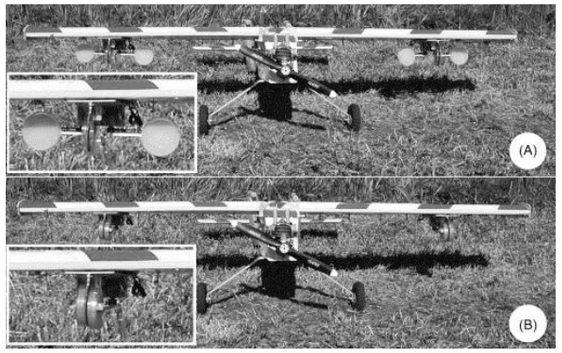


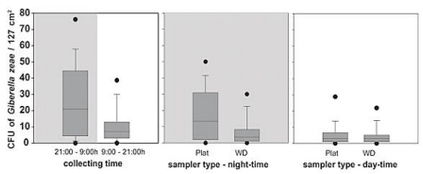


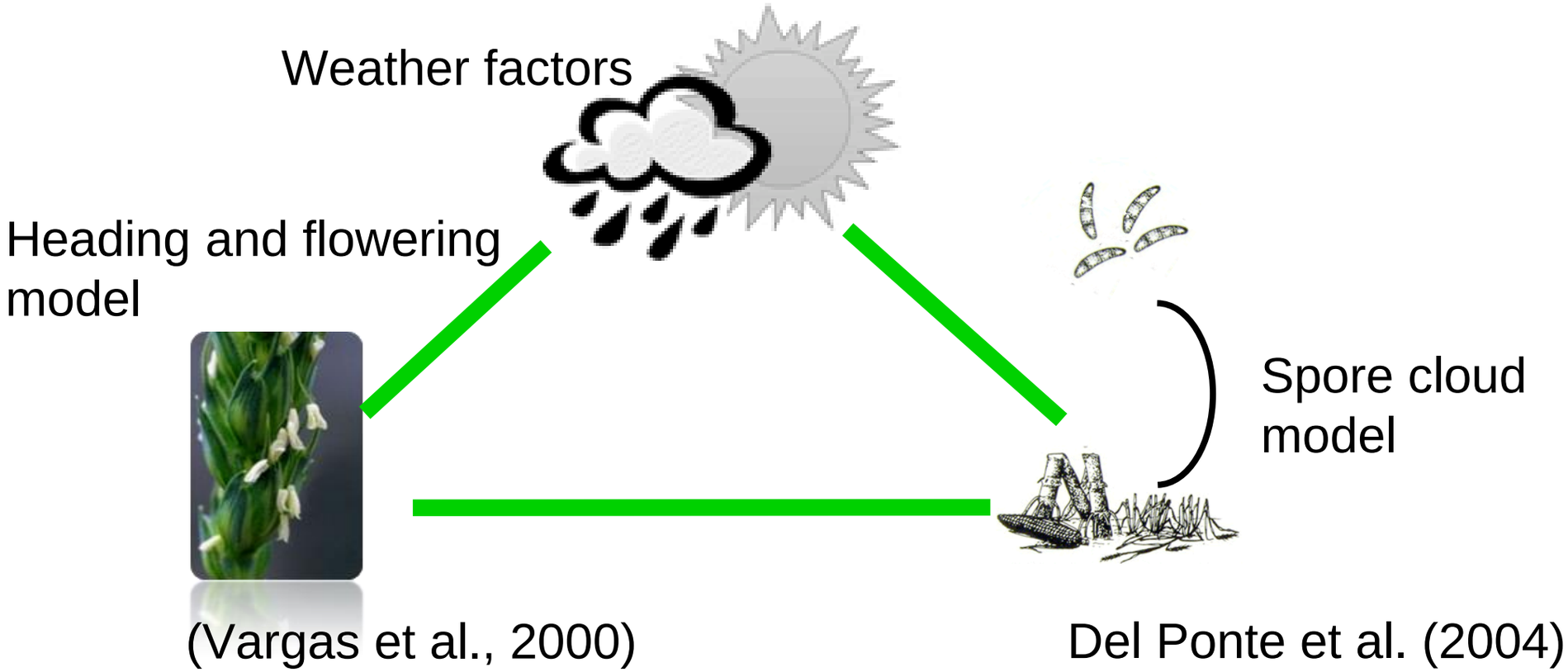
Experiment	lesionAge	lesionNumber	LL	HL	LW	HW	necroticArea	totalArea
2	0	11	1.32	3.92	0.77	2.1	1.0164	8.232
2	1	11	3.65	4.69	2.3	2.78	8.395	13.0382
2	2	11	4.19	4.79	2.4	2.79	10.056	13.3641
2	3	11	5.07	5.25	2.76	2.8	13.9932	14.7
2	7	11	8.95	11.57	2.89	2.95	25.8655	34.1315
2	8	11	10.34	15.43	2.94	3.39	30.3996	52.3077
2	9	11	13.76	17.06	3.18	3.77	43.7568	64.3162

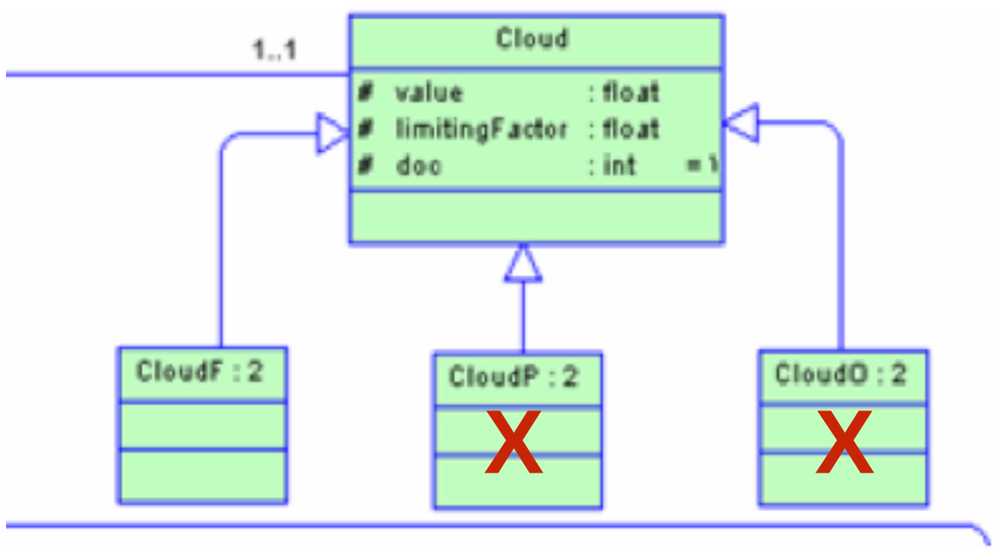
Prates & Fernandes, 2001

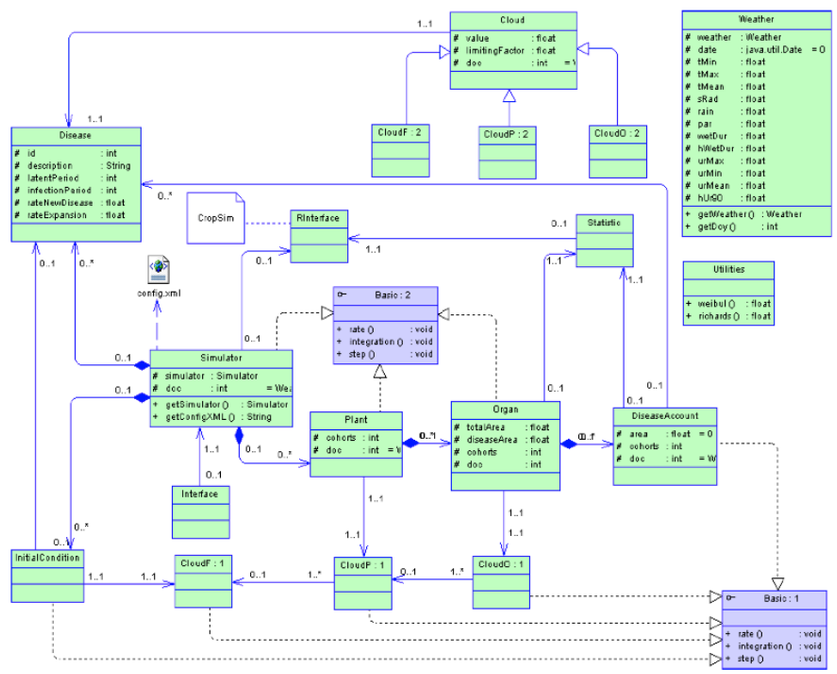
Planetary Boundary Layer (50 m - 1 km)






Weather factors
Heading and flowering model
Spore cloud model
(Vargas et al., 2000)
Del Ponte et al. (2004)


1..1
Cloud
value : float
limitingFactor : float
doc : int
CloudF : 2
CloudP : 2
CloudO : 2


Cloud
Weather
Disease
CropSim
RInterface
Statistic
Utilities
Basic : 2
Simulator
Plant
Organ
DiseaseAccount
Interface
InitialCondition
CloudF : 1
CloudP : 1
CloudO : 1
Basic : 1

Giberela

A Doença | Avaliação de Riscos | Recomendações | Dados Climáticos | O Modelo | Mídias Digitais | Contato

Trigo (Giberela):

Estado: Rio Grande do Sul

Estação: PASSO FUNDO

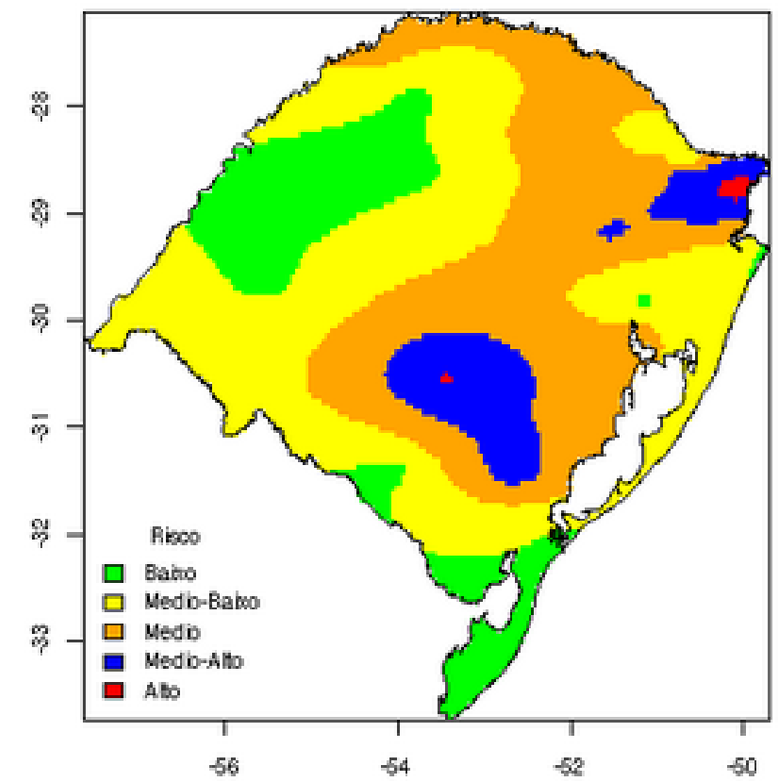
Data do espigamento: 16/09/2011

Visualizar

Espigamento: 16/09/2011
Severidade: 1.58
Risco: **BAIXO**

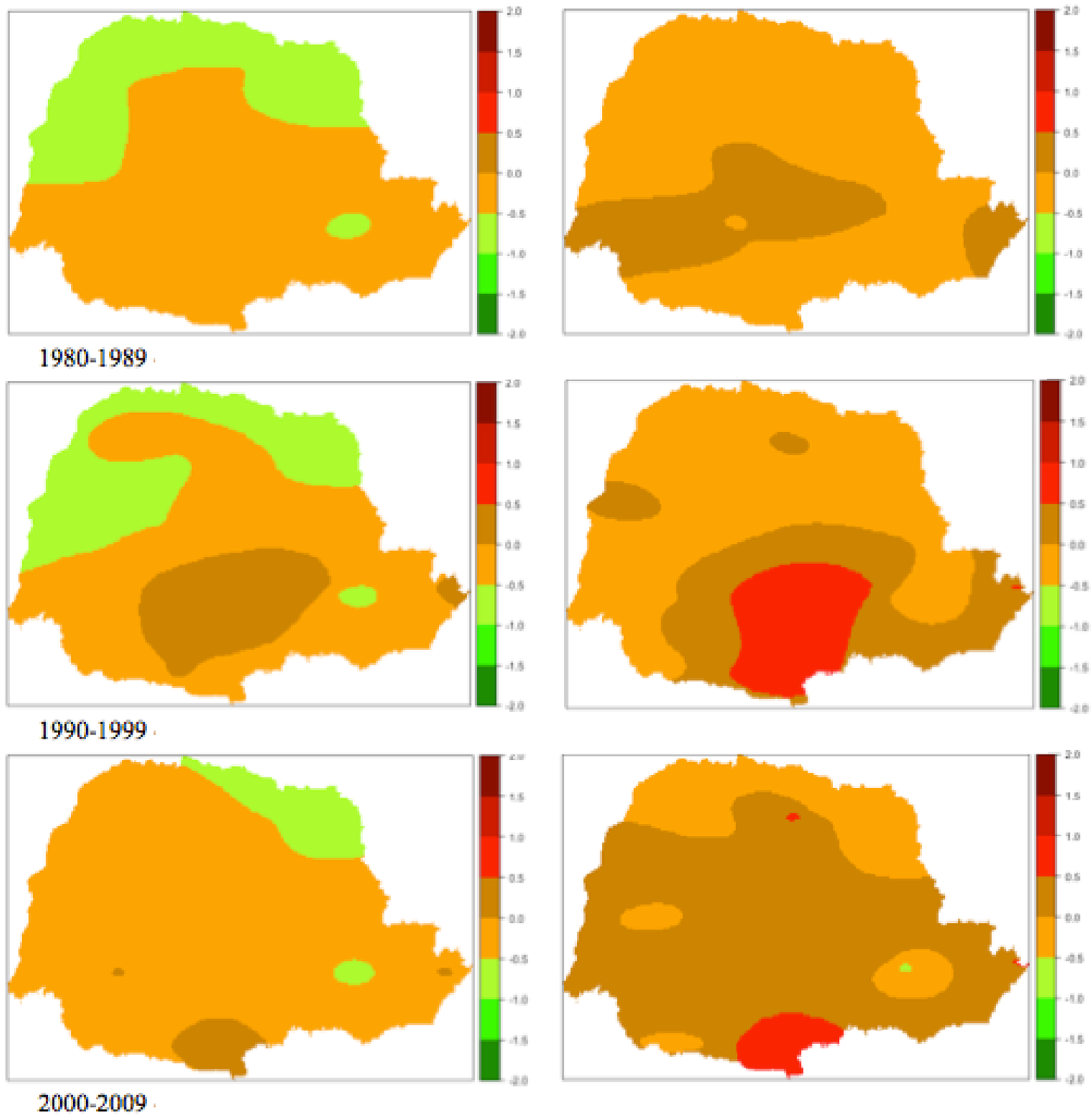
LOW RISK

Regional risk mapping for the selected heading date



Baseline

Projected climate



High

Low

High

Low

High

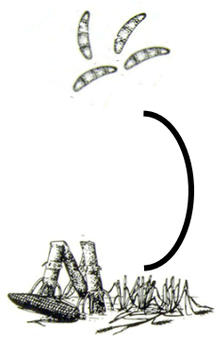
Low

28x5x30=4200

28x5x30x16=67200

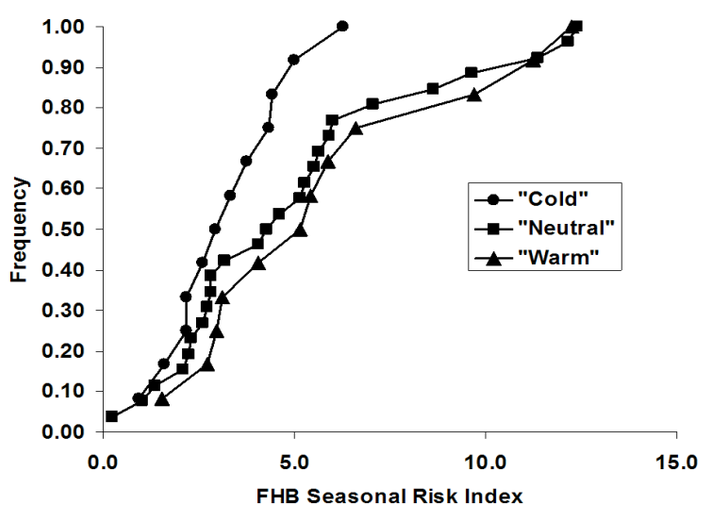
Lazzaretti, A. 2013

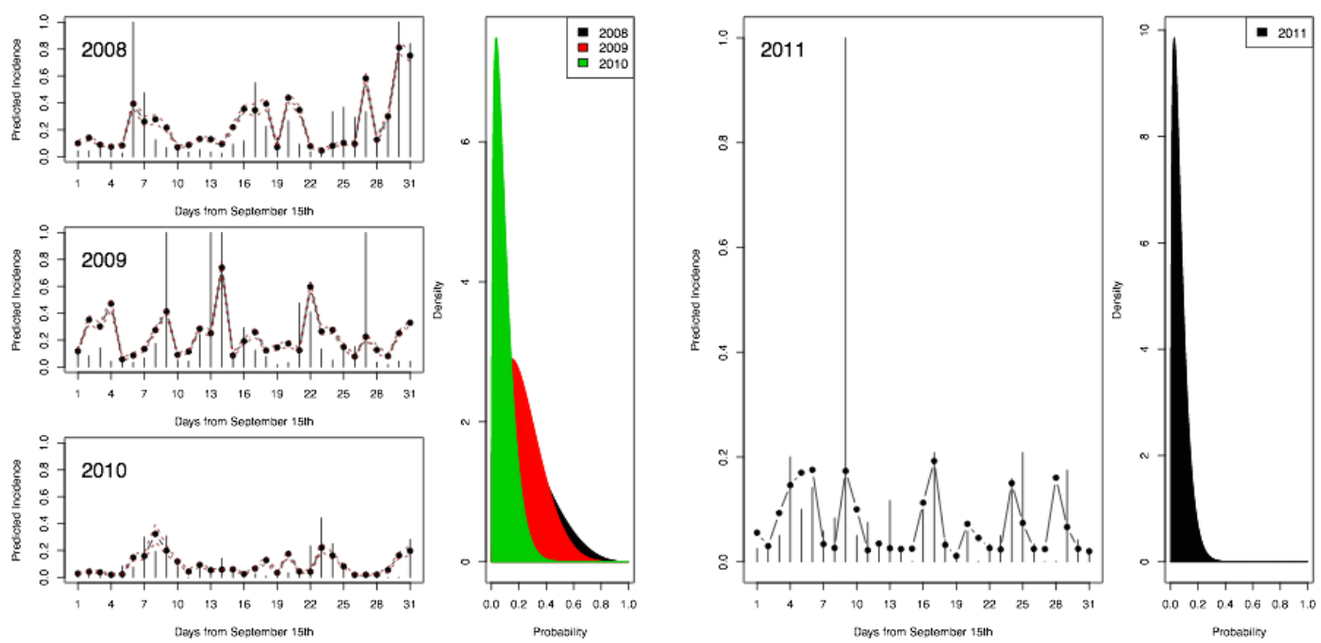
Direct Link



Hierarchical Autoregressive Binary Data Model

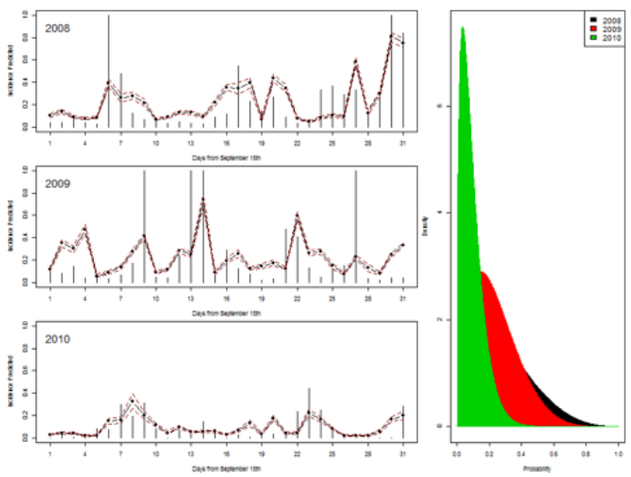
$$
\begin{aligned}
\text{logit}\left\{Pr(Y_{[1,i]}=1)\right\} &= \pi_{[1,i]} \\
\pi_{[1,i]} &= \beta_{0[i]} + \sum_{k=1}^{4} \beta_{k[i]} X_{k[1,i]} + \varepsilon_{[1,i]}, \text{ when } t=1 \\
\text{logit}\left\{Pr(Y_{[t,i]}=1)\right\} &= \pi_{[t,i]} \\
\pi_{[t,i]} &= \beta_{0[i]} + \sum_{k=1}^{4} \beta_{k[i]} X_{k[t,i]} + \phi_{[i]} \pi_{[t-1,i]} + \varepsilon_{[t,i]}, \text{ when } t \geq 2
\end{aligned}
$$





Nicolau and Fernandes, 2012

Inoculum probability distribution



P(disease|A,B,C)~ P(A,B|C,disease)~P(A|C) x P(B|C,dise

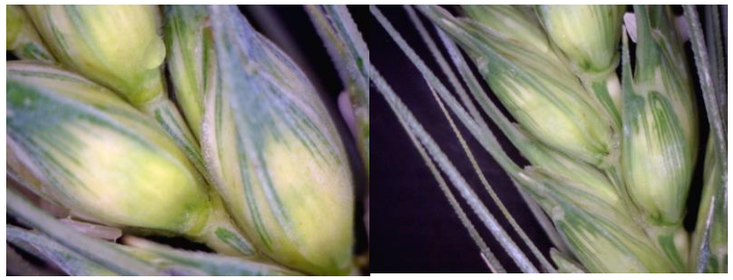
P(B|C,disease)~P(B[I]|C,disease) x P(B[A]|C,disease)

P(B[A]|C,disease) ~ Inoc. probability distr.

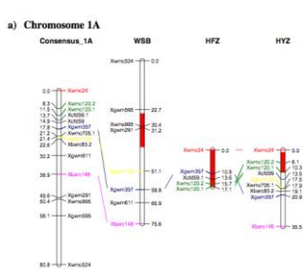
P(B[I]|C,disease) ~ Mixture Process

P(A|C) ~ [const.] Growth Stage (Phenology Mode

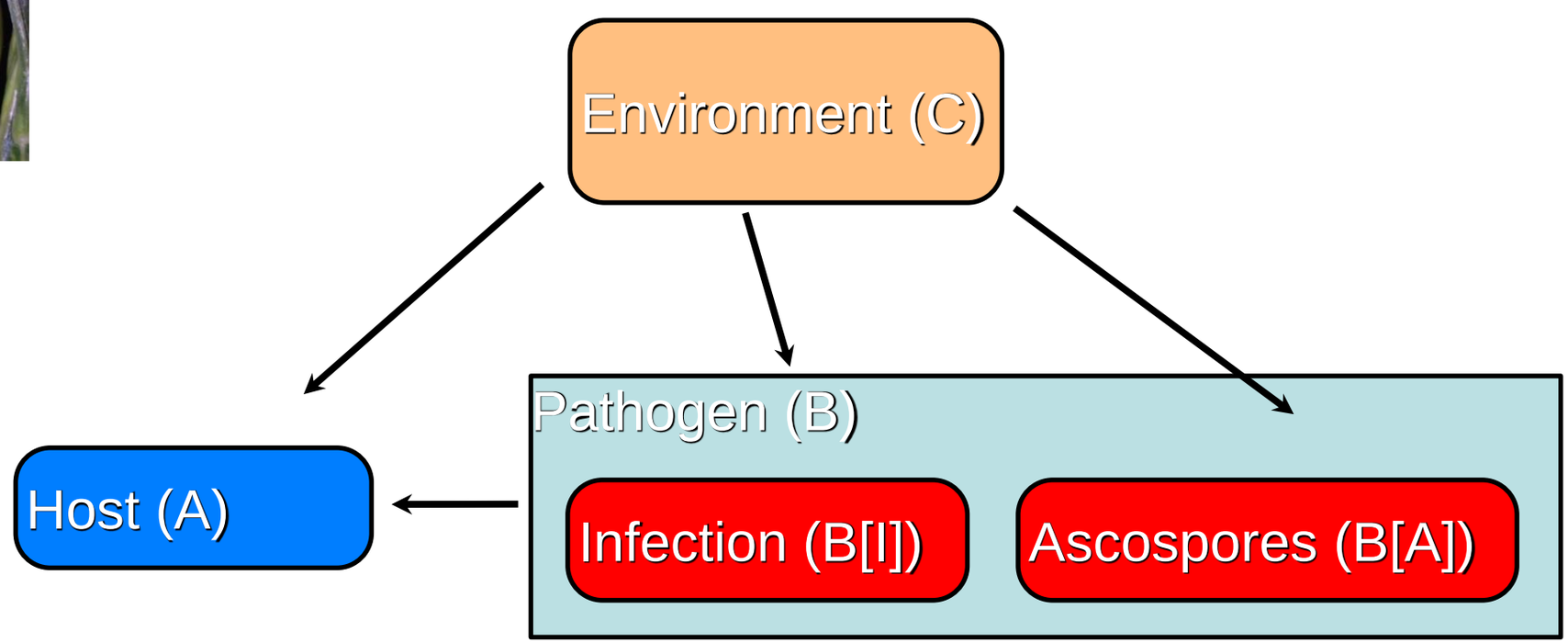
Morphological traits

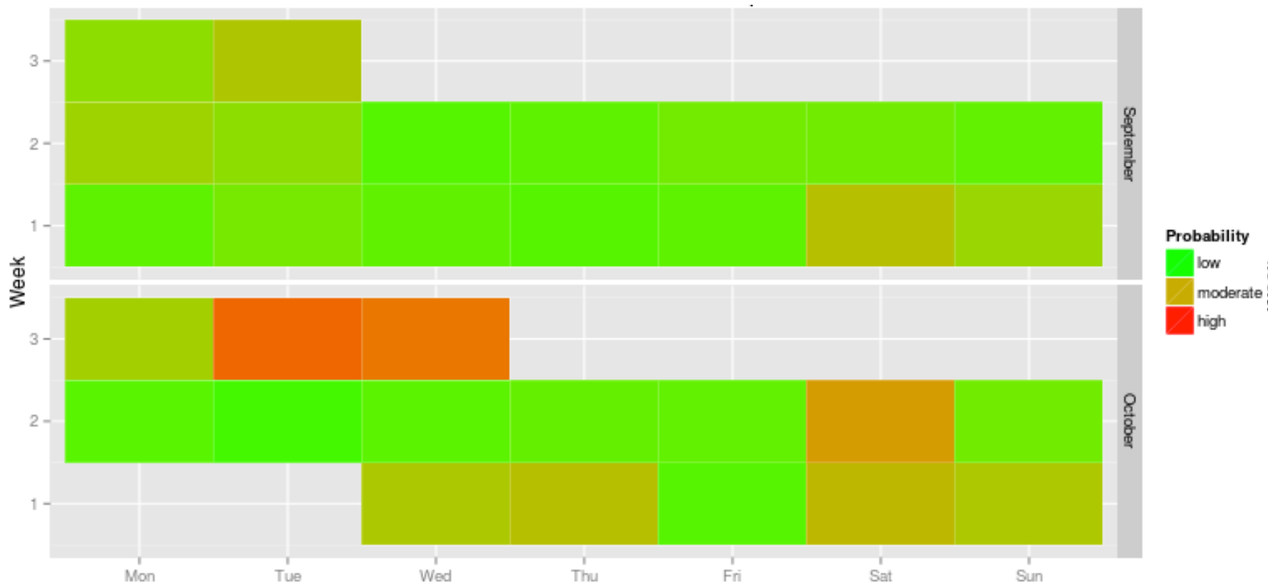


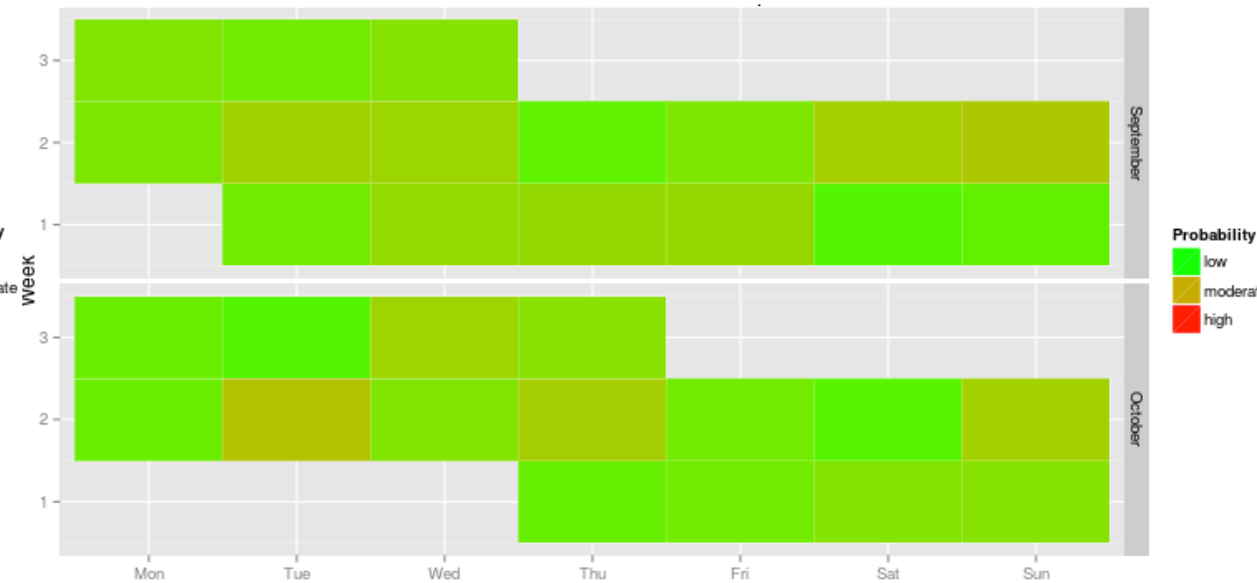
QTL/gene mapping

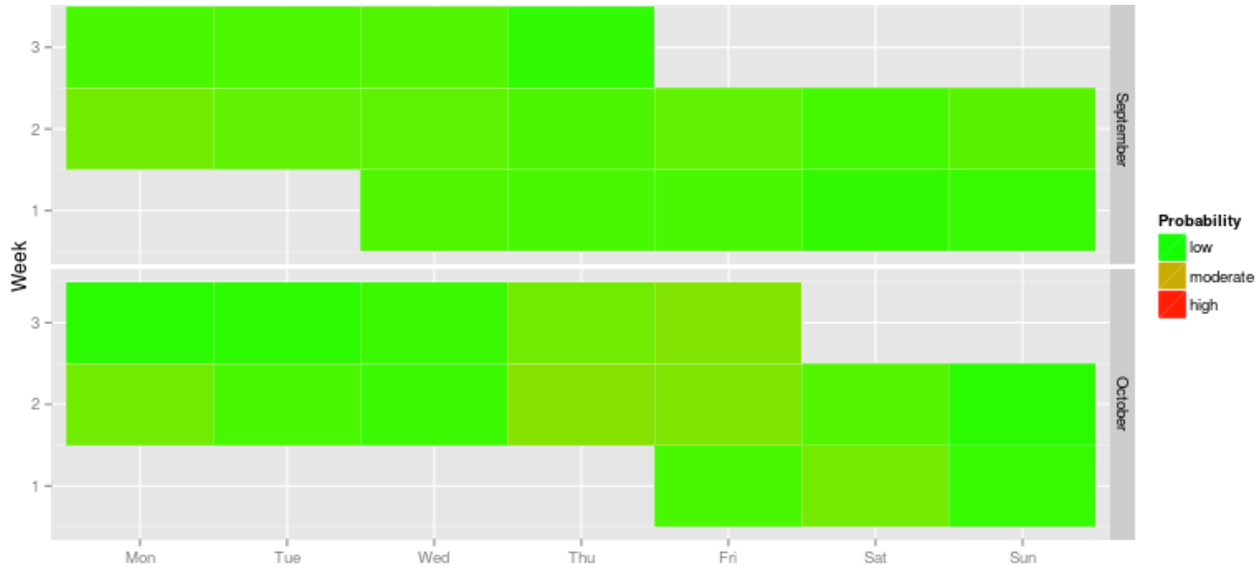


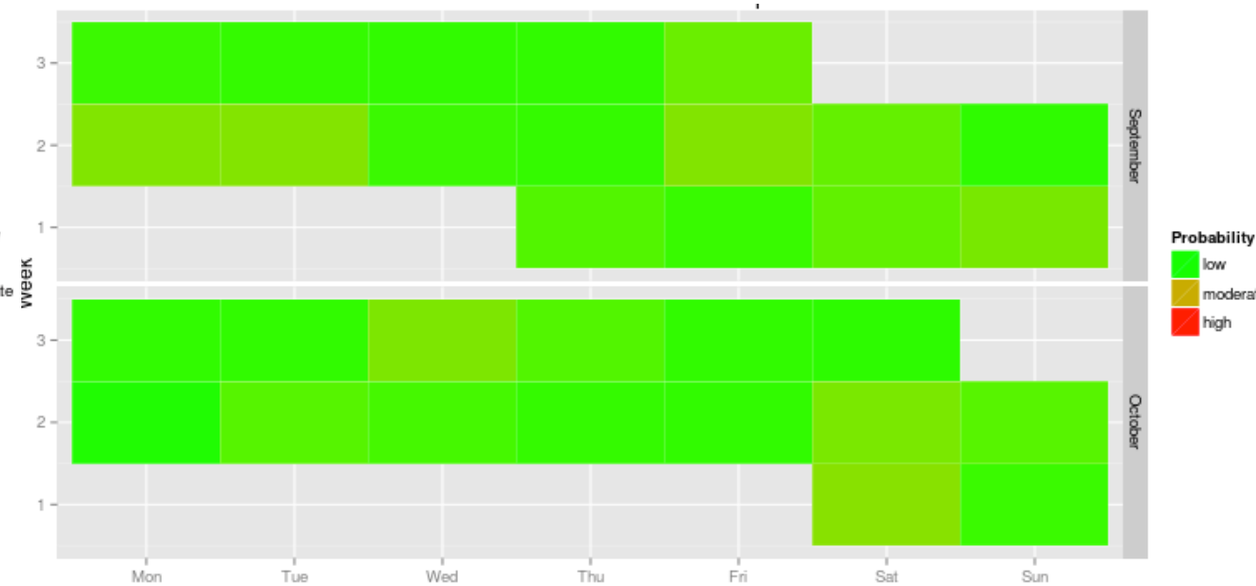
Source: Jin Cai



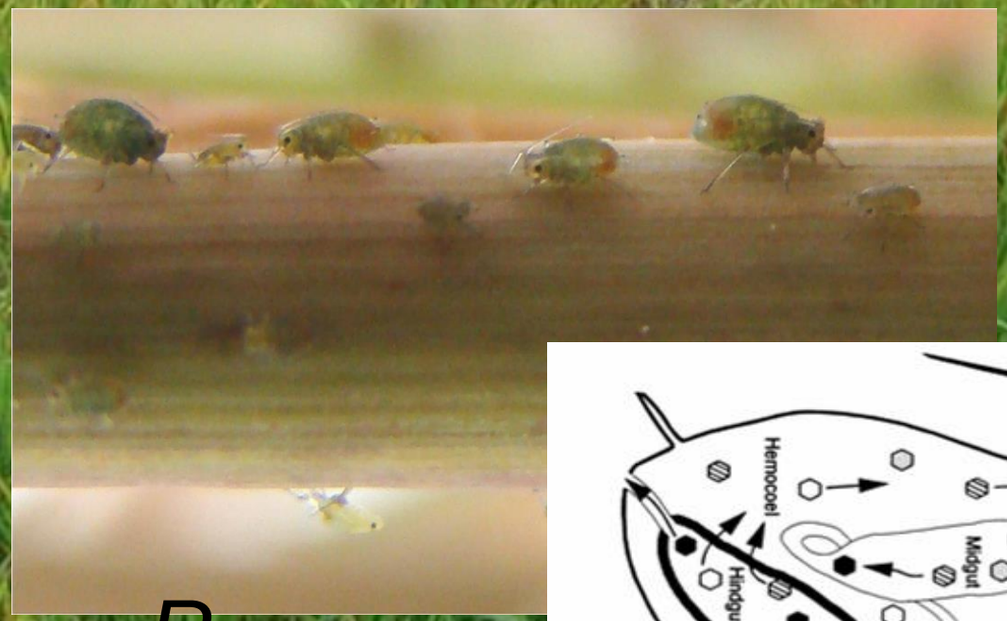

Week
3
2
1
September
October
Mon
Tue
Wed
Thu
Fri
Sat
Sun
Probability
low
moderate
high

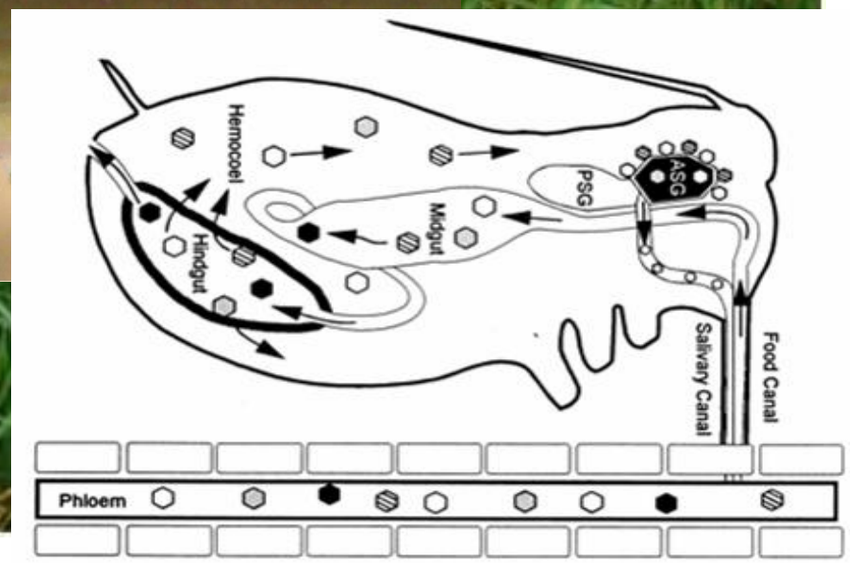

Week
3
2
1
September
October
Mon
Tue
Wed
Thu
Fri
Sat
Sun
Probability
low
high


Week
3
2
1
September
October
Mon
Tue
Wed
Thu
Fri
Sat
Sun
Probability
low
moderate
high


Week
3
2
1
September
October
Mon
Tue
Wed
Thu
Fri
Sat
Sun
Probability
low
high

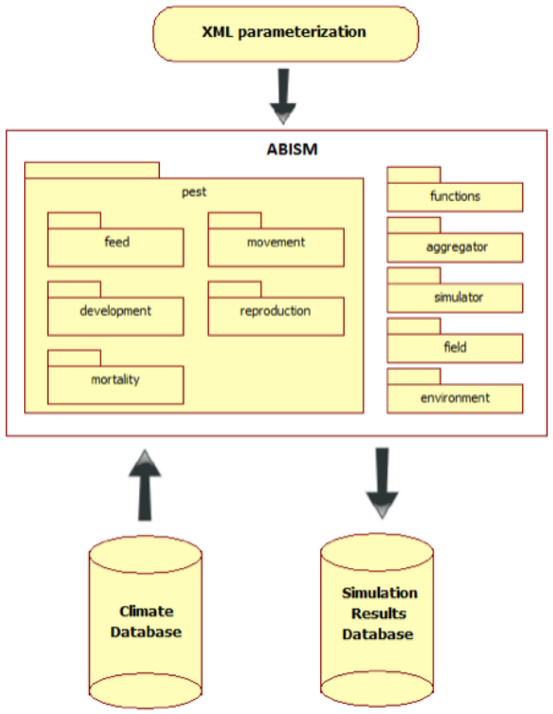
C/BYDV

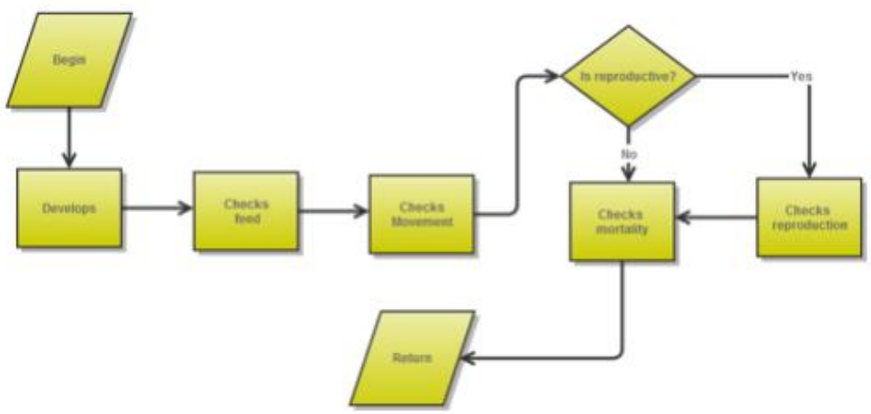


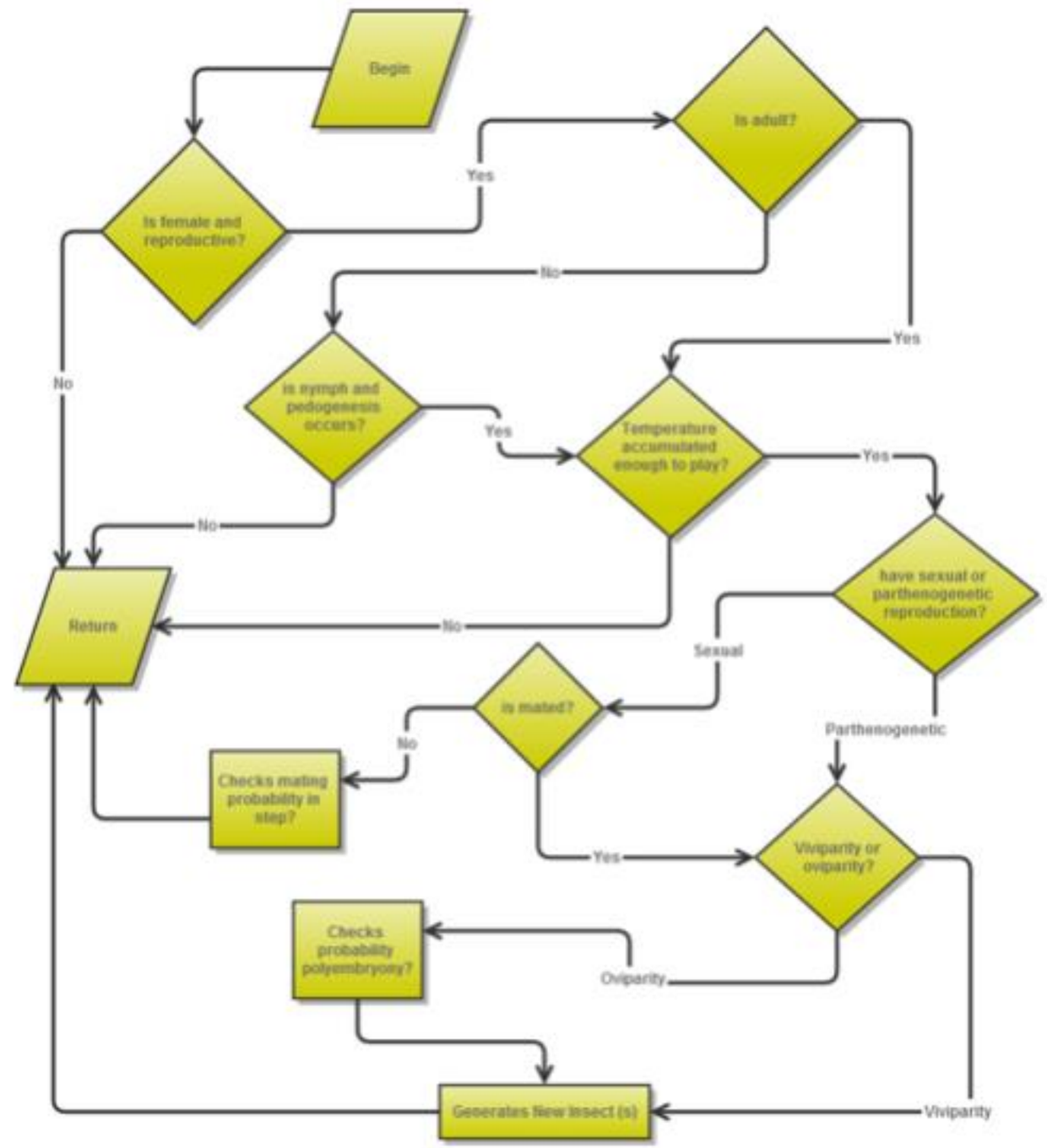

Hemocoel
Hindgut
Midgut
PSG
ASG
Salivary Canal
Food Canal
Phloem

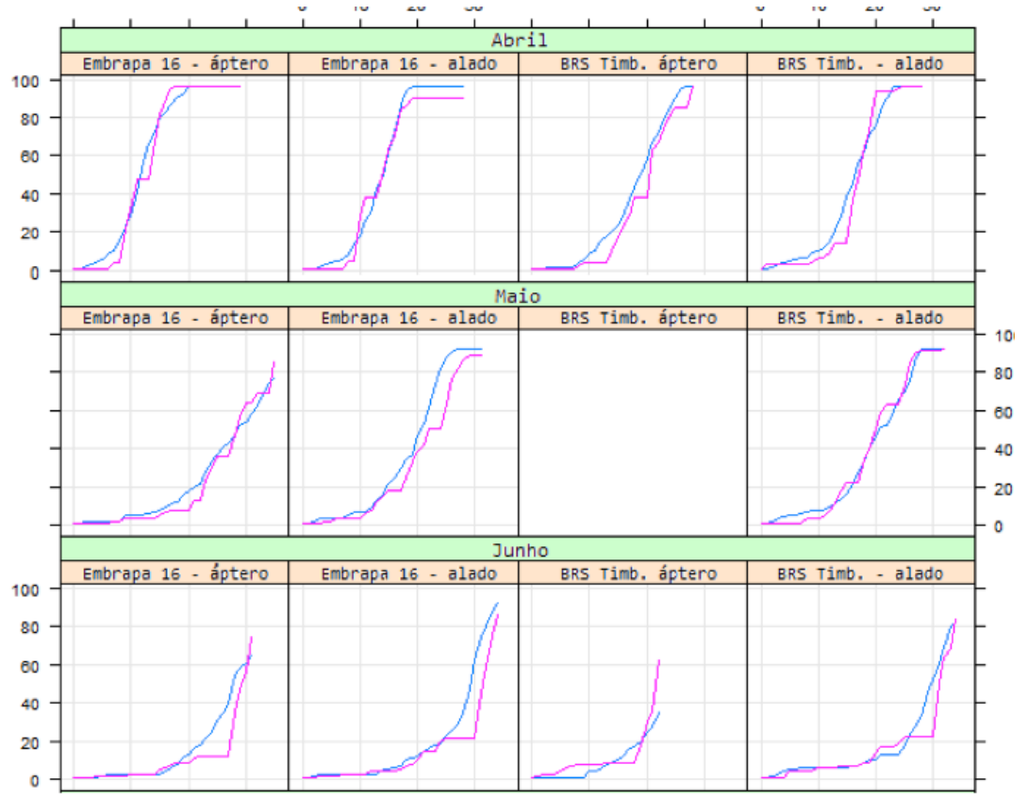
R. pa di

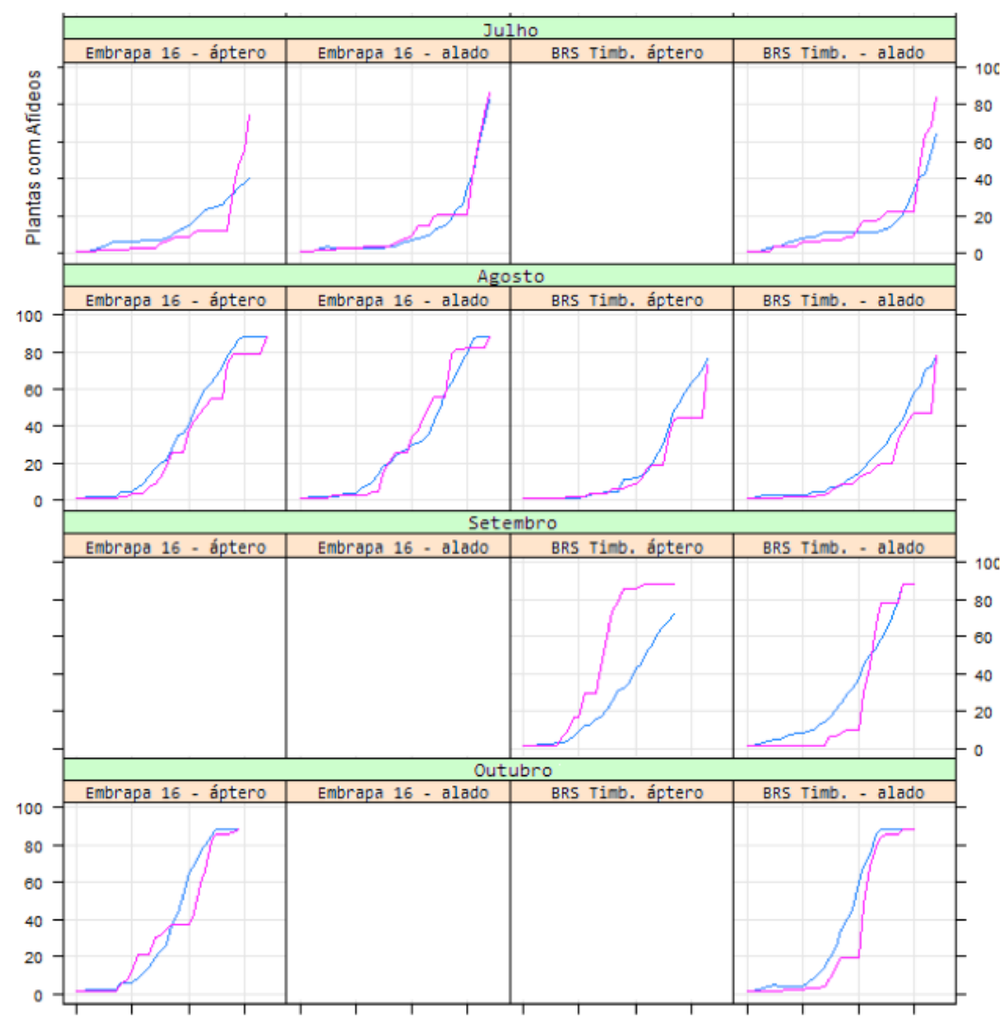
Agent Based Model - Insects








Abril
Maio
Junho
Embrapa 16 - áptero
Embrapa 16 - alado
BRS Timb. áptero
BRS Timb. - alado
0
20
40
60
80
100


Plantas com Afídeos
Julho
Agosto
Setembro
Outubro
Embrapa 16 - áptero
Embrapa 16 - alado
BRS Timb. áptero
BRS Timb. - alado
0
20
40
60
80
100

Dia 12

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.............................................................
.....................................IP......................
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Dia 84

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Dia 101

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Dia 136

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Dia 137

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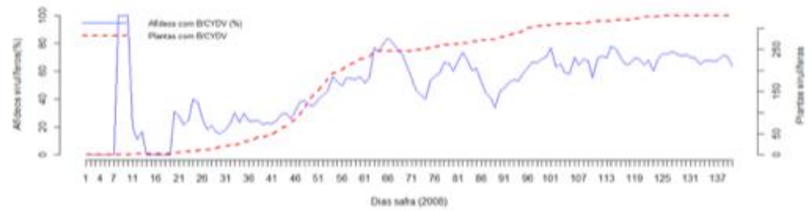
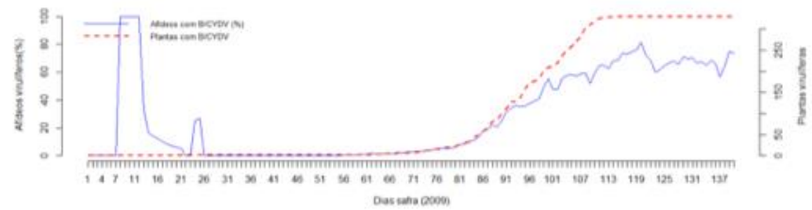
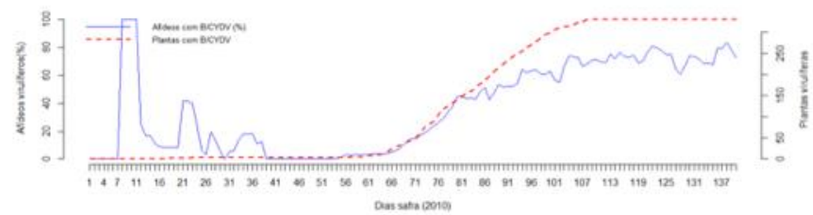
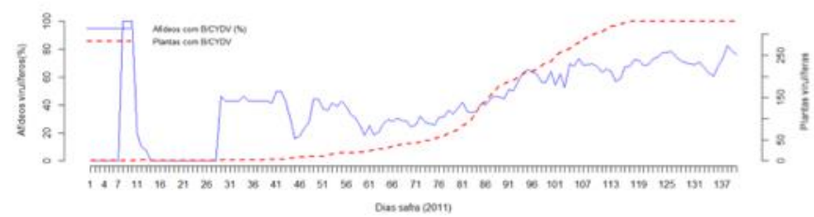
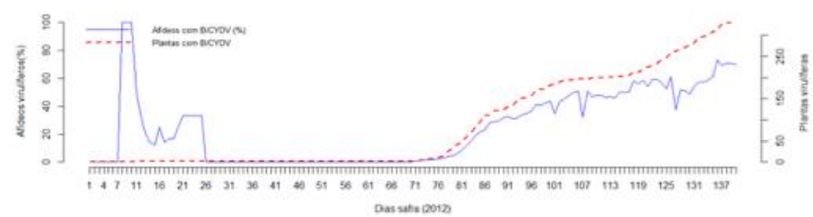


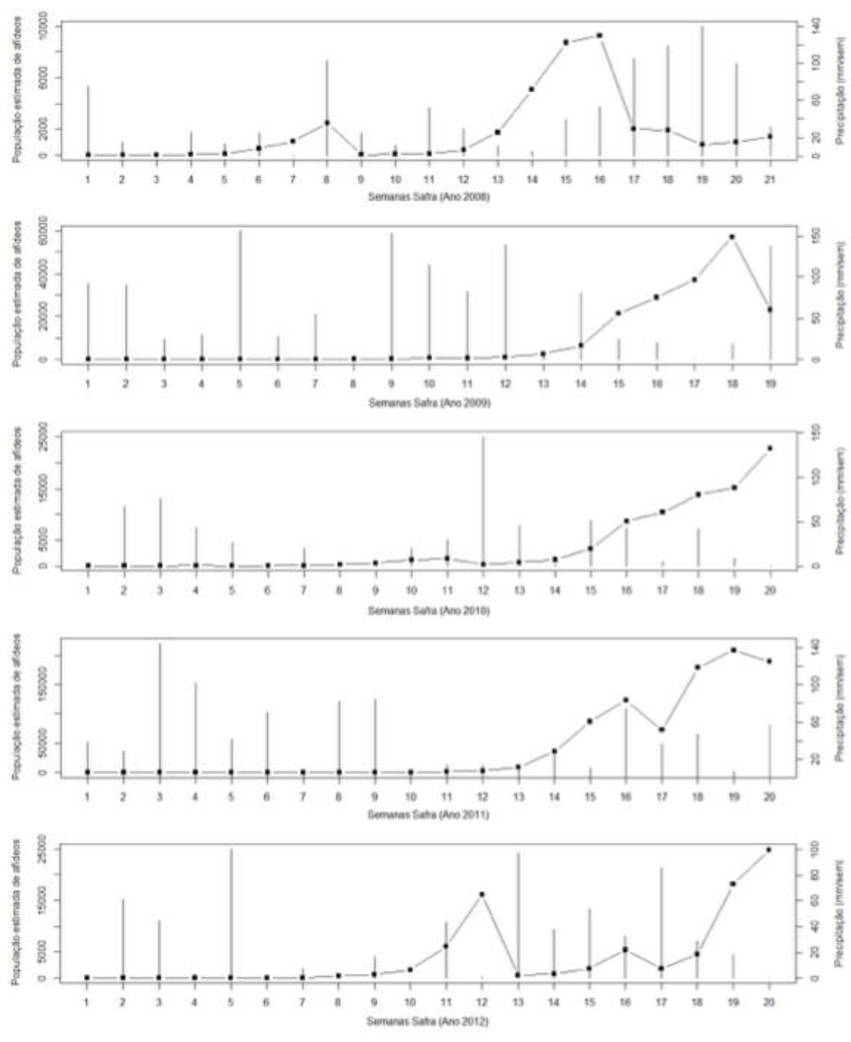




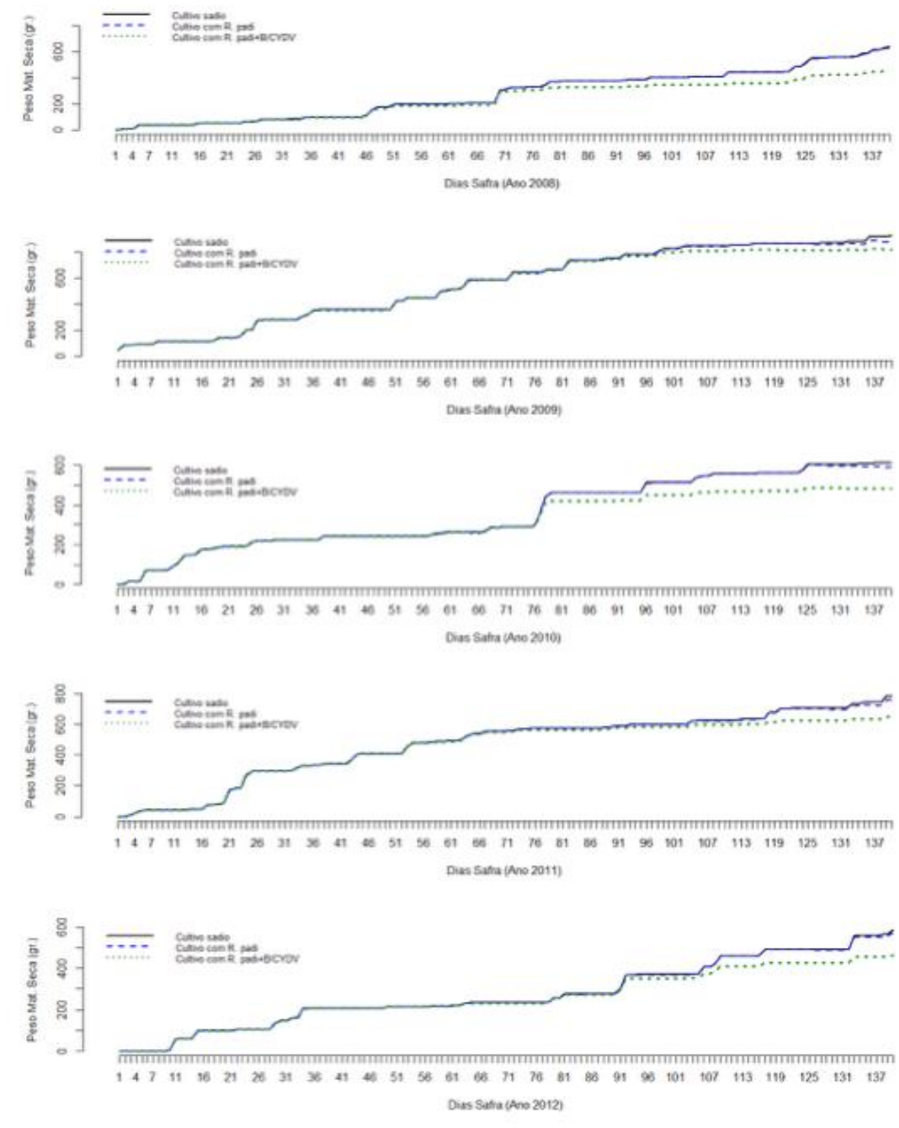


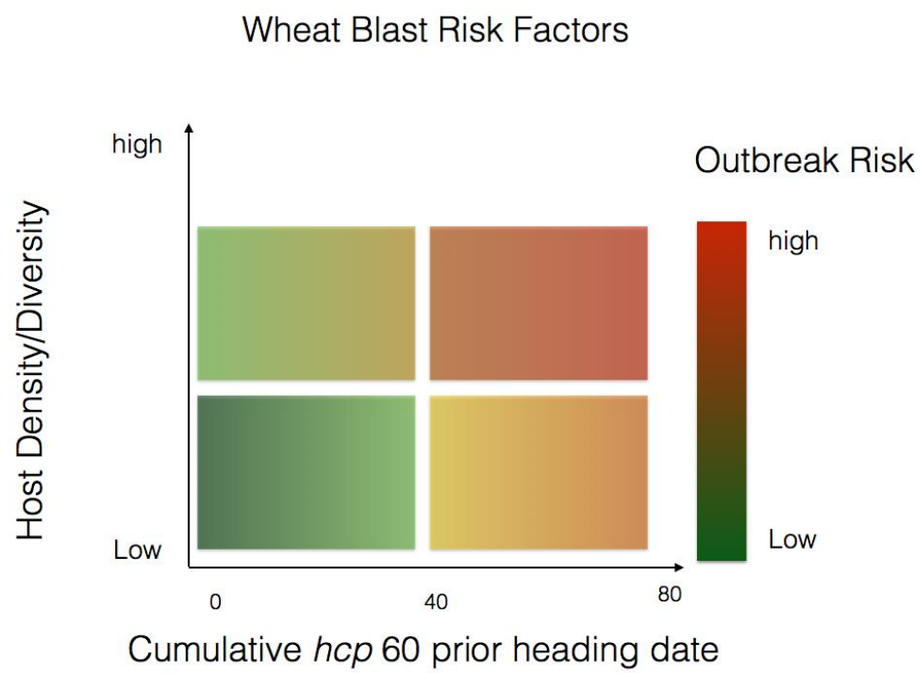


Precipitation Effect

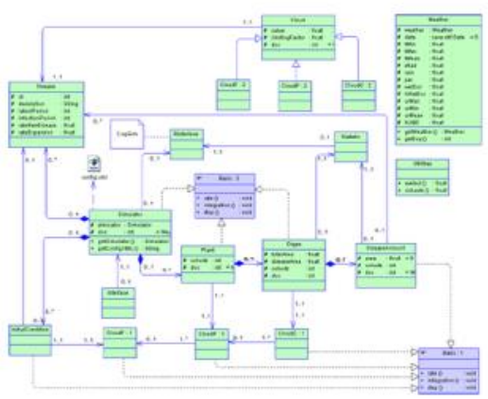


Biomass - host*aphid*virus interaction





What is next……Landscape modeling



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Simulating forage production of Marandu palisade grass (*Brachiaria brizantha*) with the CROPGRO-Perennial Forage model

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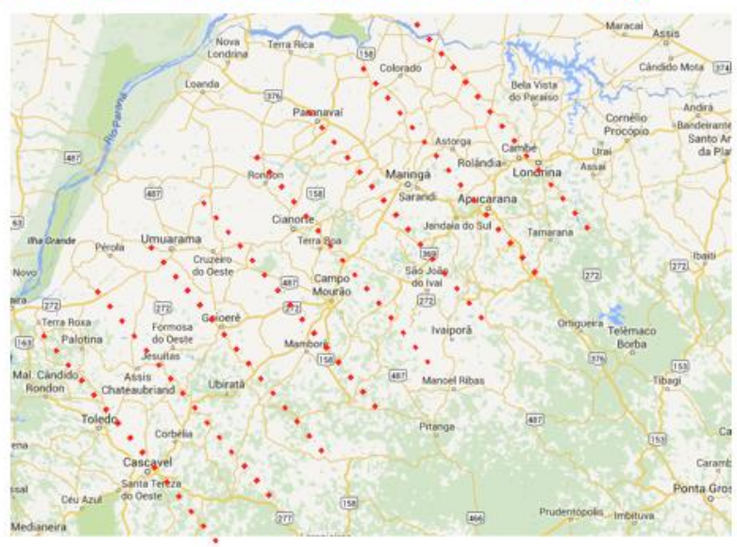
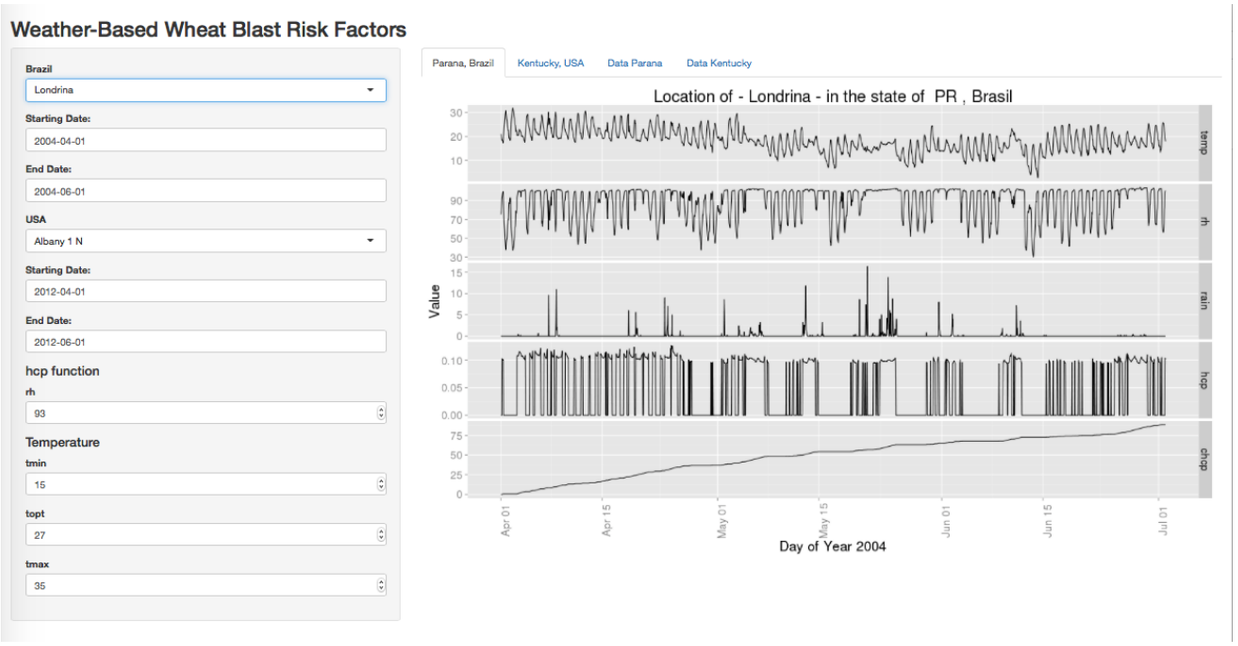
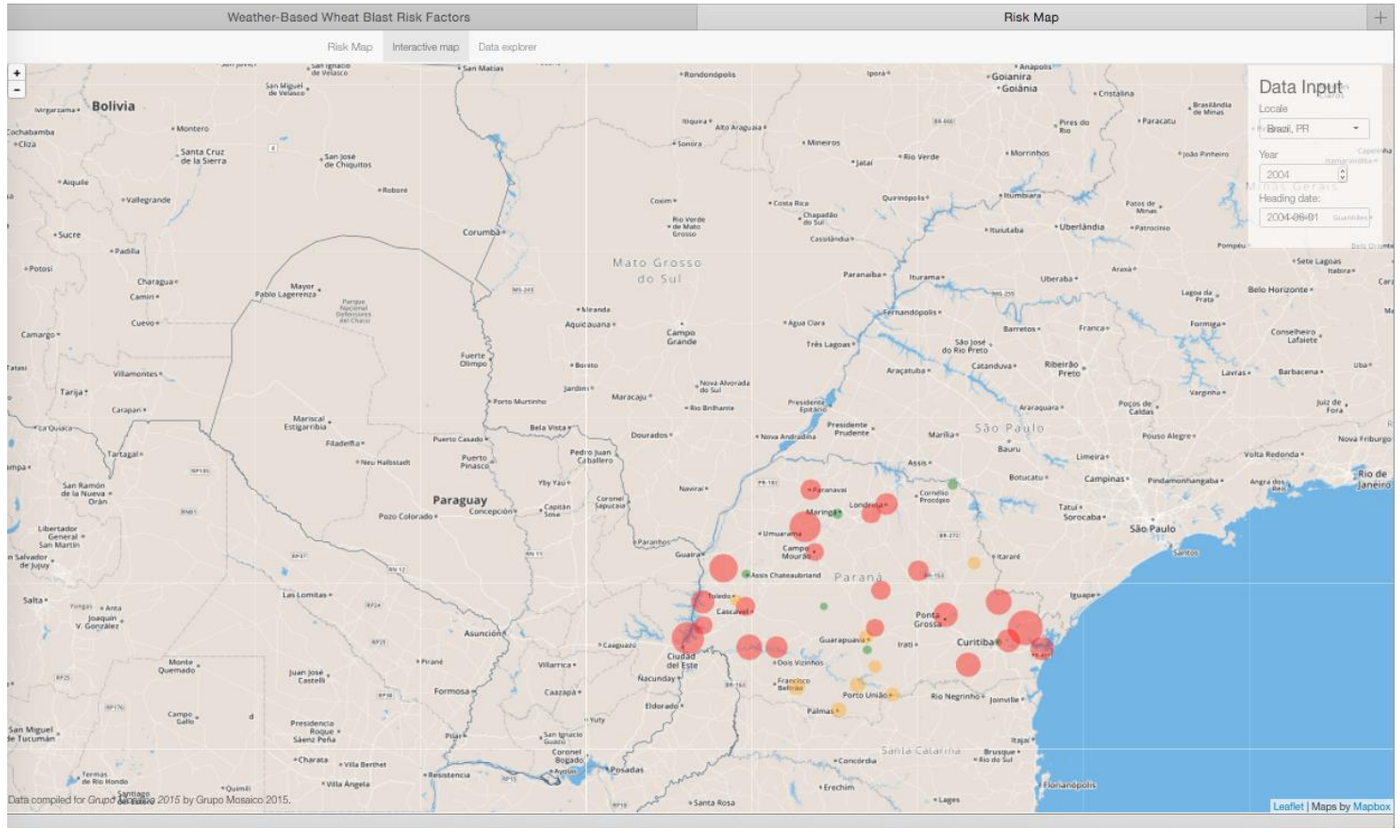
Crop and Pasture Science 65(12) 1335-1348 http://dx.doi.org/10.1071/CP14058
Submitted: 13 February 2014 Accepted: 21 July 2014 Published: 5 November 2014



Compare *Magnaporthe oryzae* conidia density dynamics in time and space.

Data Visualization





Concluding Remarks

- Data quality for model calibration
- Generic and modular approach
- Coupling points
- Integration of different models
- Probabilistic models
- Data visualization

Thank you!

Acknowledgements

Dr. Emerson Del ponte (UFV)
Dr. Willingthon Pavan (UPF)
Dr. Casiane Tibola (Embrapa)
Márcio Nicolau (Embrapa)
Dr Piérri Spolti (Monsanto)
Dr Alexandre Lazzaretti (IFSUL)
Dr Josué Toebe (IFSUL)
Jorge Bavaresco (IFSUL)
Rodrigo Yoiti Tsukahara (FABC)