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

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Integrating disease models to crop models....

**Process-based crop model**

Susceptible host tissue

- Deposition → Infection → Latency → Infectious → removed
- Life span
How to implement?

1. CROPSIM: Wheat Subroutine: Disease

2. Modular and Generic
Equation Based Generic Plant Disease Cycle Model

Pavan & Fernandes, 2009
Models Integration Through a Database

Pavan et. al., 2014
Cereal Rusts

Lesion Counts

Pires, et al., 2009
<disease>
  <description>Wheat Leaf Rust</description>
  <infectionEfficiency>0.17</infectionEfficiency>
  <environmentFavorability>1</environmentFavorability>
  <depositionFrequency>0.05</depositionFrequency>
  <initialInoculum>10</initialInoculum>
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  <vectorSizeCloudH>7</vectorSizeCloudH>
  <vectorSizeCloudD>10</vectorSizeCloudD>
  <maxSporeProduction>3000</maxSporeProduction>
  <cohortAge>{7,15,16,37}</cohortAge>
</disease>

<latentPeriod>6</latentPeriod>
<latentGrowthFunction>gompertz</latentGrowthFunction>
<latentGrowthParameter>{0.0161858,1.563509,0.441721}</latentGrowthParameter>
<br><br>

<infectionPeriod>20</infectionPeriod>
<infectionGrowthFunction>exponential</infectionGrowthFunction>
<infectionGrowthParameter>\{0.01507,1.0104,0.2125\}</infectionGrowthParameter>

---

Organ 7  Organ 8  Organ 9
Soybean Asian Rust
2004/2005 - To present

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<th></th>
<th>January</th>
<th>February</th>
<th>March</th>
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<td>Low</td>
<td>0.31</td>
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<tr>
<td>High</td>
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<td>Moderate</td>
<td>0.72</td>
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Rodrigues et al., 2012
Leaf Spots

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Prates & Fernandes, 2001
Planetary Boundary Layer (50 m - 1 km)
Modeling wheat head blight in Brazil

Heading and flowering model

Spore cloud model

Vargas et al., 2000

Del Ponte et al. (2004)
LOW RISK

Regional risk mapping for the selected heading date
Baseline

Projected climate

High

Low

High

Low

High

Low

High

Low

Baseline

Projected climate

1980-1989

1990-1999

2000-2009

28x5x30=4200

28x5x30x16=67200

Lazzaretti, A. 2013
Hierarchical Autoregressive Binary Data Model

\[
\text{logit}\{\Pr(Y_{1,i} = 1)\} = \pi_{1,i}
\]

\[
\pi_{1,i} = \beta_{0,i} + \sum_{k=1}^{4} \beta_{k,i}X_{k,i} + \epsilon_{1,i}, \quad \text{when } t = 1
\]

\[
\text{logit}\{\Pr(Y_{t,i} = 1)\} = \pi_{t,i}
\]

\[
\pi_{t,i} = \beta_{0,i} + \sum_{k=1}^{4} \beta_{k,i}X_{k,i} + \phi_{0,i}\pi_{t-1,i} + \epsilon_{t,i}, \quad \text{when } t \geq 2
\]
Inoculum probability distribution

\[ P(\text{disease}|A,B,C) \sim P(A,B|C,\text{disease}) \sim P(A|C) \times P(B|C,\text{disease}) \]

\[ P(B|C,\text{disease}) \sim P(B[I]|C,\text{disease}) \times P(B[A]|C,\text{disease}) \]

\[ P(B[A]|C,\text{disease}) \sim \text{Inoc. probability distr.} \]

\[ P(B[I]|C,\text{disease}) \sim \text{Mixture Process} \]

\[ P(A|C) \sim \text{[const.]} \text{ Growth Stage (Phenology Model)} \]

Morphological traits

QTL/gene mapping

Source: Jin Cai
Agent Based Model - Insects
What is next......Landscape modeling

Simulating forage production of Marnodu palisade grass (Brachiaria brizantha) with the CROPSCAPE-Perennial Forage model

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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
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