Modelling potato yield losses caused by *P. infestans*. Role of rate of disease, time of infection and temperature

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EuroBlight 2022

May 10, 2022

Ascona, Switzerland

Major modelling approaches

Statistical models:

- Linear/curve fitting to data and extrapolating
- Regression, machine learning methods
- Widely used among scientific disciplines

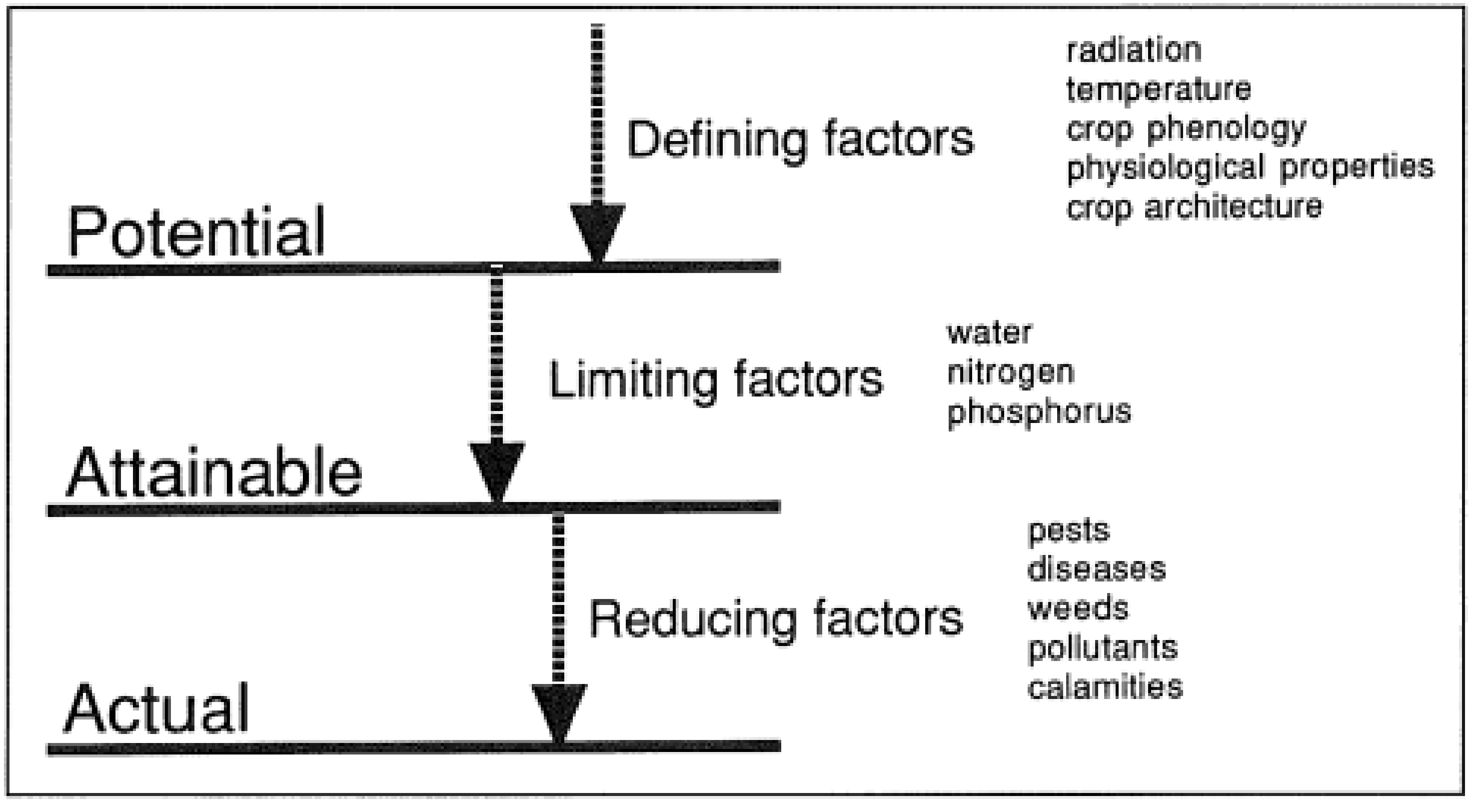
Mechanistic models:

- Reflect the underlying processes of the system
- Include important **nonlinear feedback** loops and delays
- Suitable for both short- and long-term forecasts

➢ Epidemiological modelling

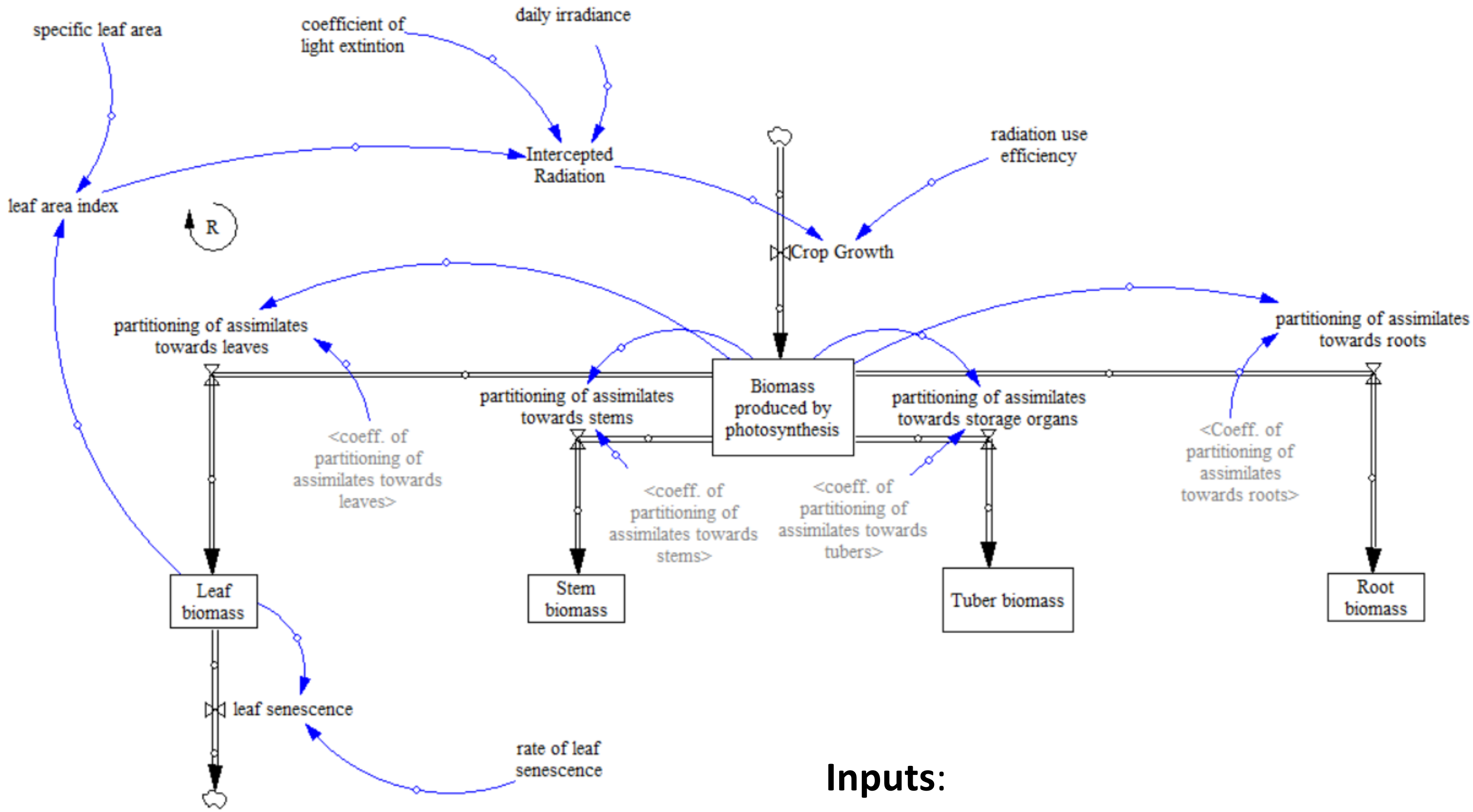
➢ Crop losses modelling

Levels of crop yield



Rossing et al., 1992

Potato growth model



Model assumptions:
- No abiotic limiting conditions (no water, nutrients limitations)

Inputs:
- Daily temperature
- Daily solar radiation
- Radiation Use Efficiency (RUE)
- Length of growing period

Damage mechanisms of crop pest injuries

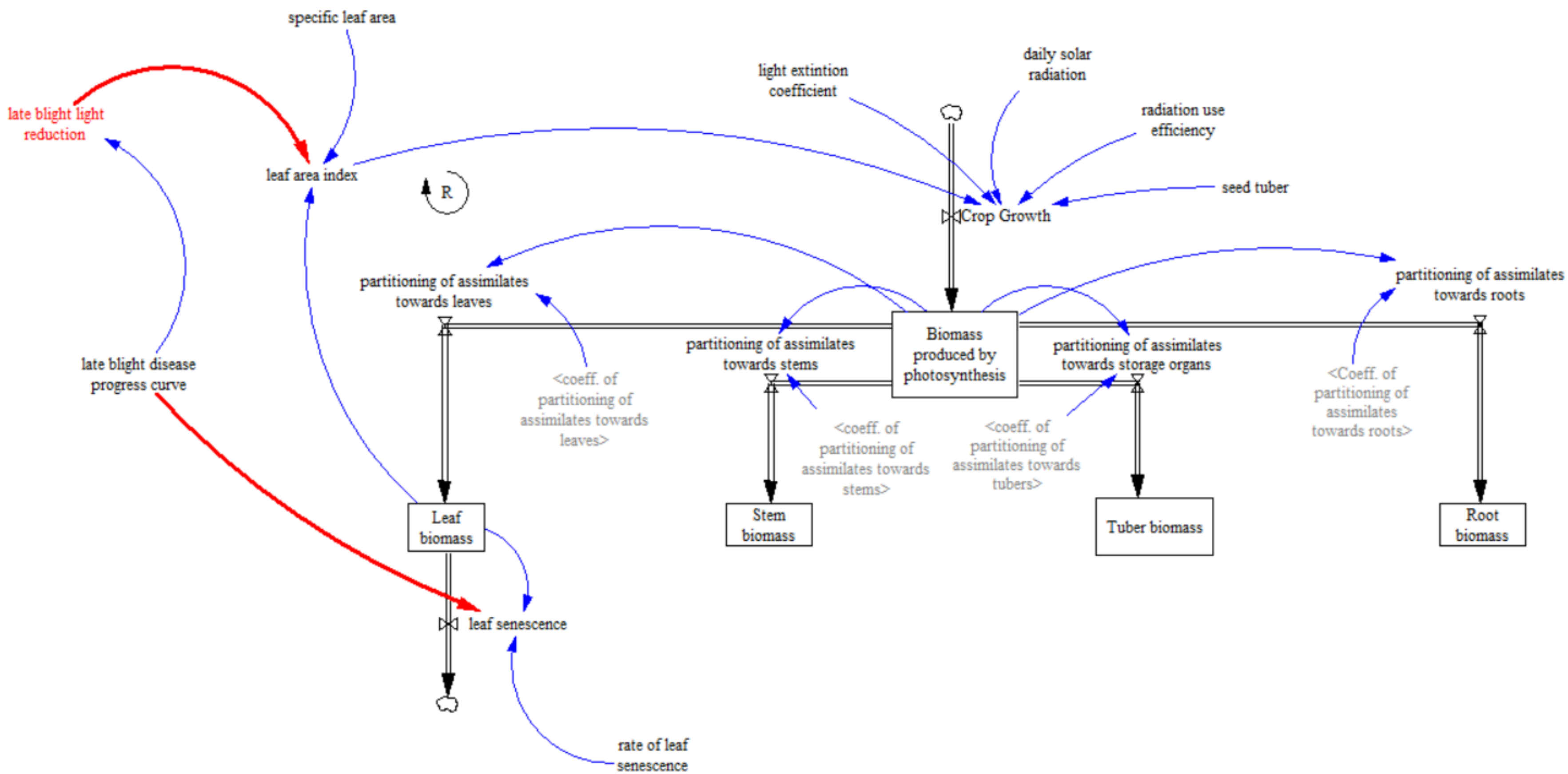
Damage mechanism	Physiological effect	Effect in a crop growth model	Examples of pests
Light stealer	Reduces the intercepted radiation	Reduces the green LAI	Pathogens producing lesions on leaves
Leaf senescence accelerator	Increases leaf senescence, causes defoliation	Reduces leaf biomass by increasing the rate of leaf senescence	Foliar pathogens such as leaf spotting pathogens, downy mildews
Tissue consumer	Reduces the tissue biomass	Outflows from biomasses of the injured organs	Defoliating insects
Stand reducer	Reduces the number and biomass of plants	Reduces biomass of all organs	Damping-off fungi
Photosynthetic Rate reducer	Reduces the rate of carbon uptake	Reduces the RUE	Viruses, root-infecting pests, stem infecting pests, some foliar pathogens
Turgor reducer	Disrupts xylem and phloem transport	Reduces the RUE, accelerates leaf senescence	Vascular, wilt pathogens
Assimilate sapper	Removes soluble assimilates from host	Outflows assimilates from the pool of assimilates	Sucking insects, e.g. aphids, some planthoppers, biotrophic fungi exporting assimilates from host cells

Boote et al., 1983; Savary et al., 2014

P. Infestans - potato interaction

Two damage mechanisms of *P. infestans*:

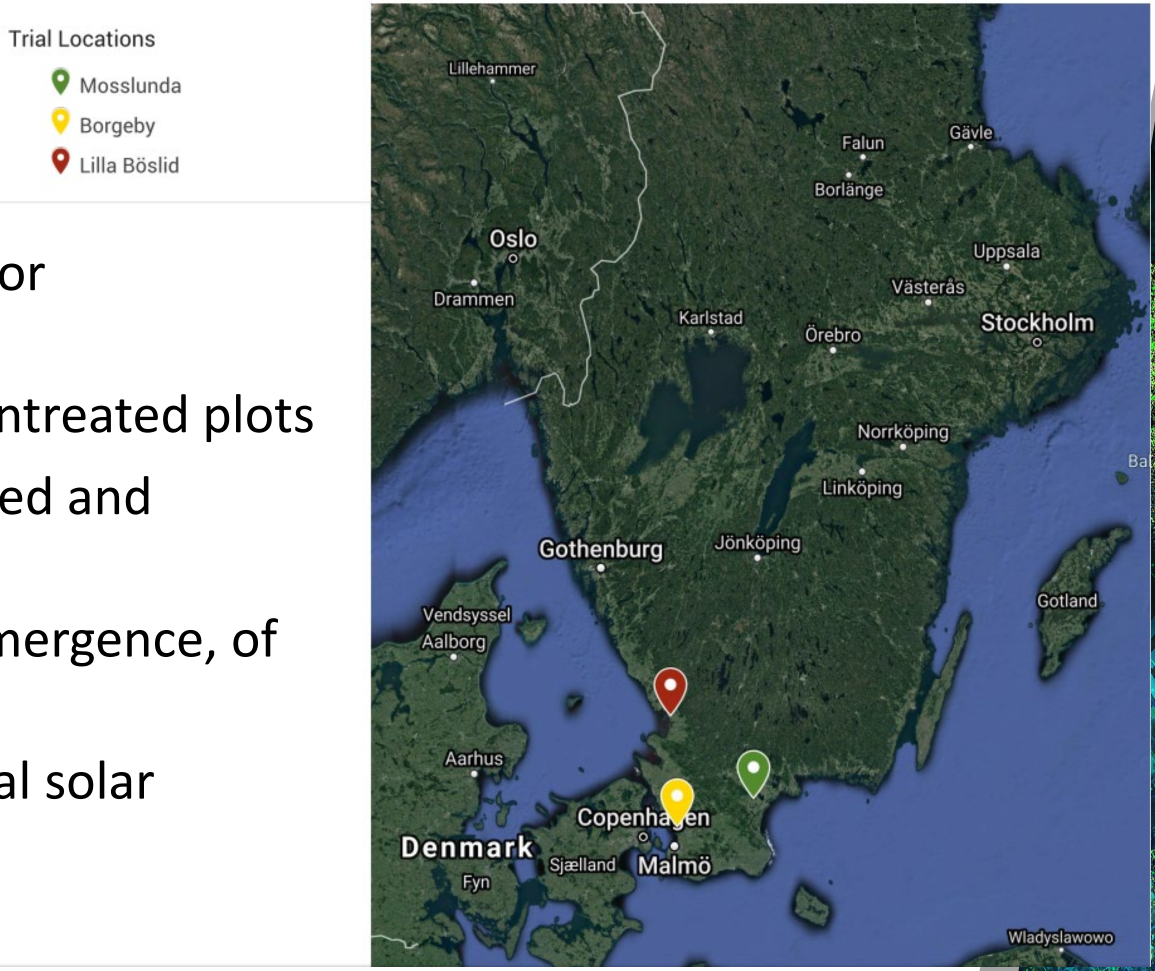
- Reduces the intercepted radiation (light stealer)
- Increases leaf senescence (leaf senescence accelerator)



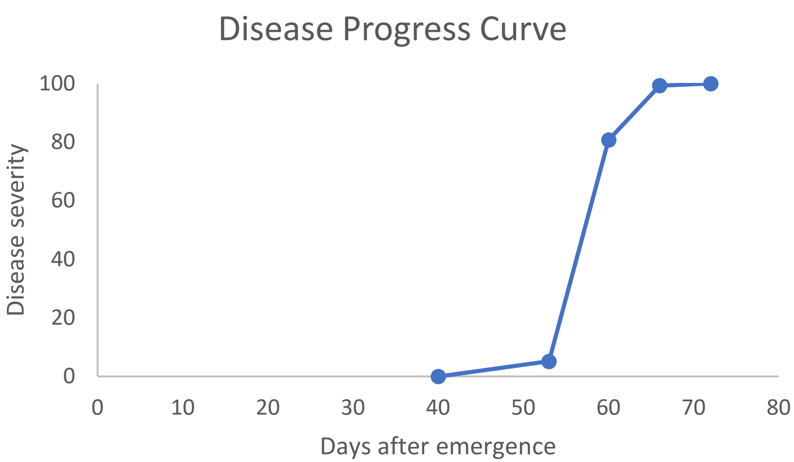
Database for calibration and evaluation

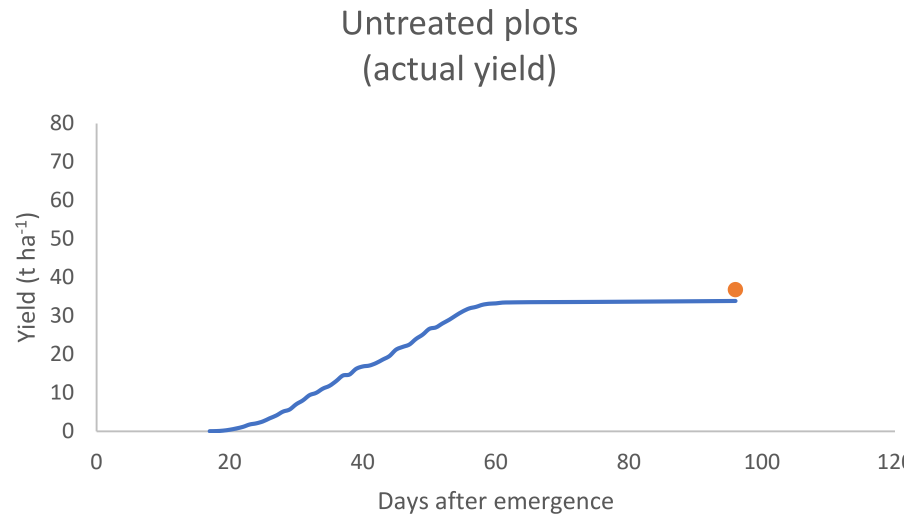
Main inputs:

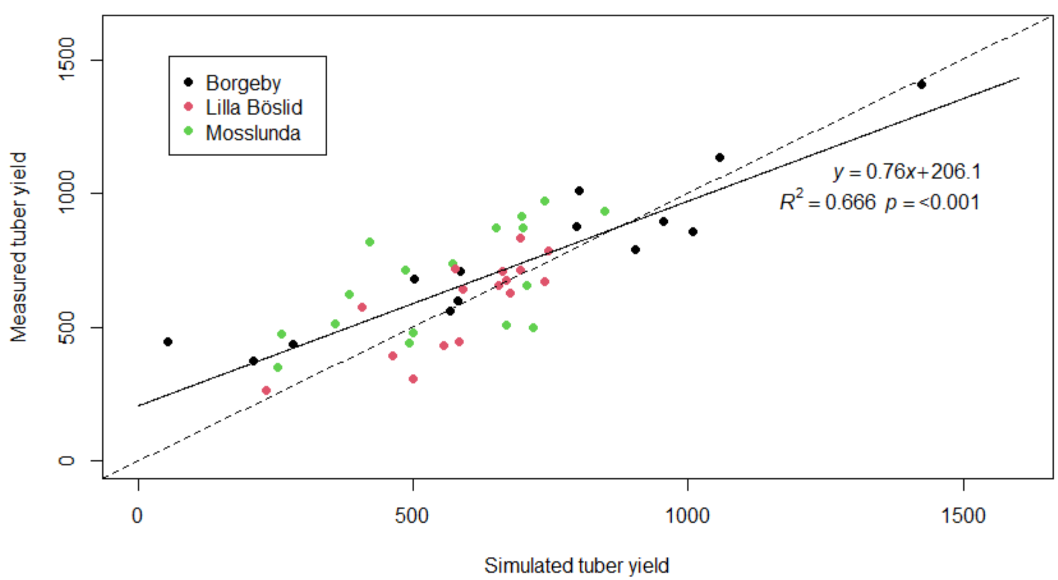
- Period 1993-2017
- Susceptible Bintje cv.
- Several fungicide mixtures for *P. infestans* control
- Disease Progress Curve in untreated plots
- Yield (tonnes/ha) in untreated and treated plots
- Date of planting, of plant emergence, of desiccation, etc.
- Daily temperature and global solar radiation



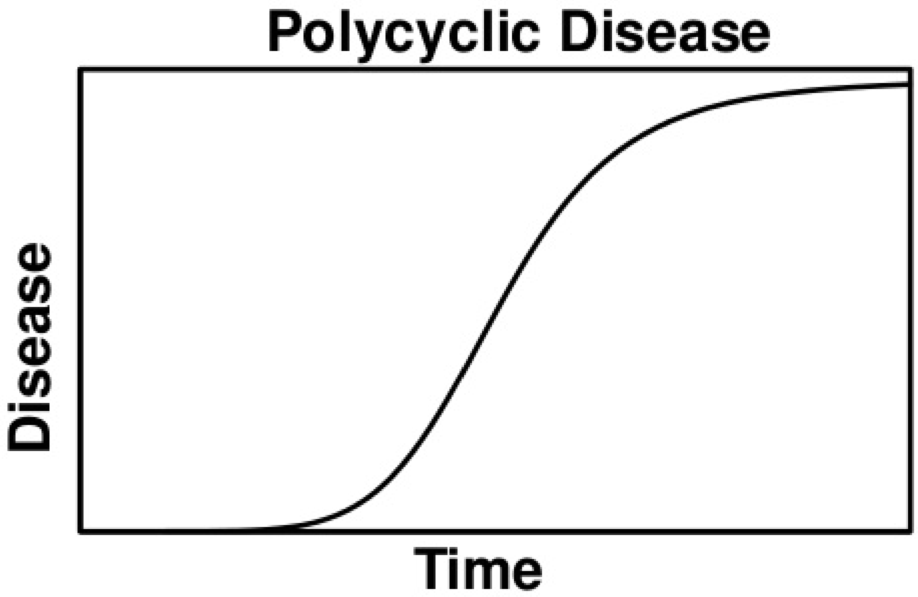
Evaluation of the model (example: Mosslunda 2017)







Disease Progress Curve



Logistic model:

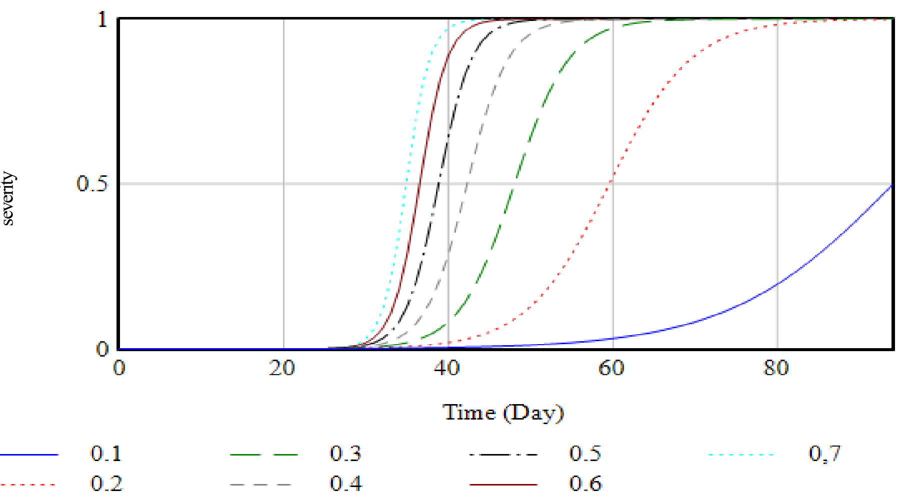
$$y = \frac{1}{1 + \left(\frac{1 - y_0}{y_0}\right) e^{-rt}}$$

y= disease severity (proportion)
r= rate of disease growth (day^{-1})
y_0= disease severity at t=0

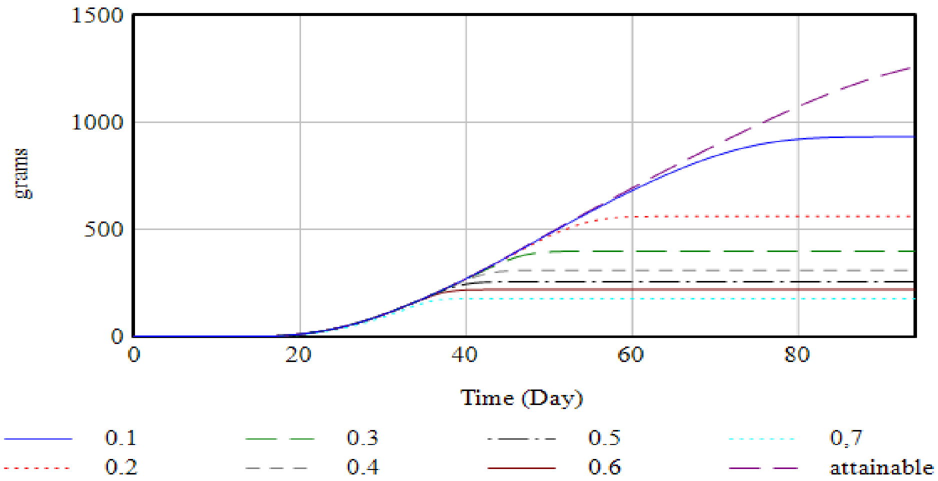
Effect of disease growth rate on yield

Average temperature: 16.6 ° C
Average solar radiation: 17 MJ day^{-1}
Start of the epidemics: 25 days after emergence

Rate of disease

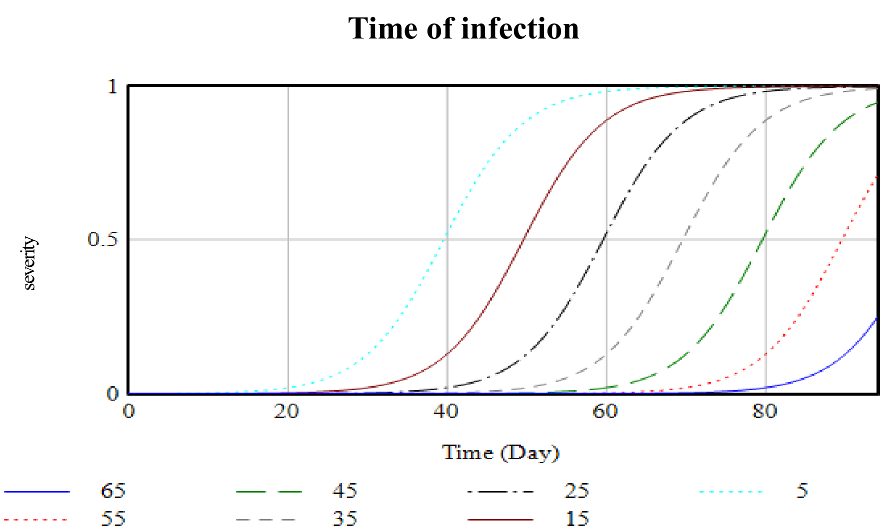


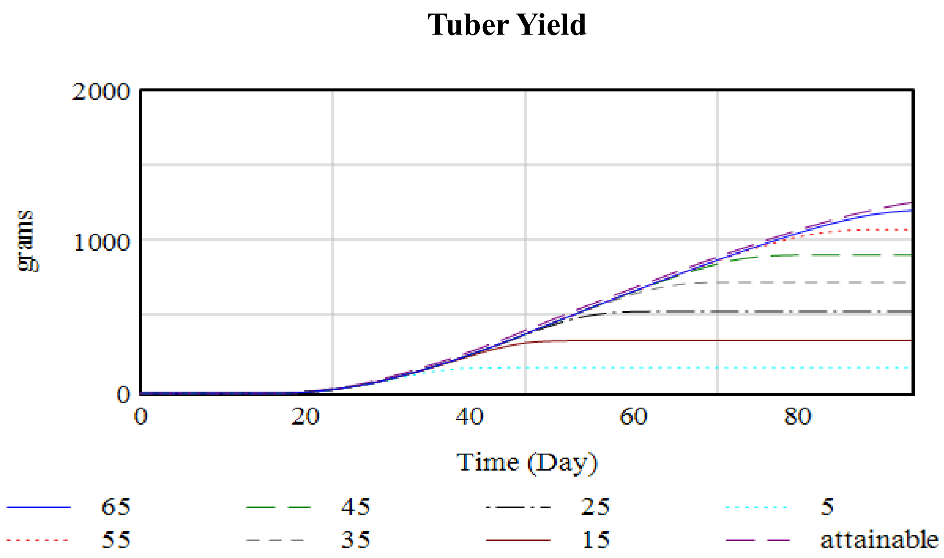
Tuber Yield



Effect of time of infection on yield

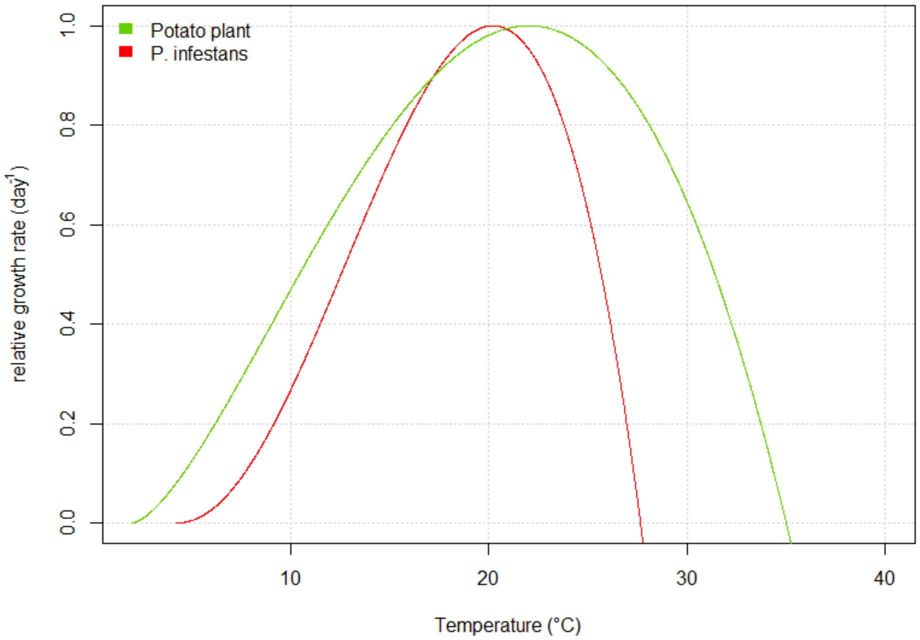
Average temperature: 16.6 ° C
Average solar radiation: 17 MJ day^{-1}
Disease growth rate: 0.2 $days^{-1}$





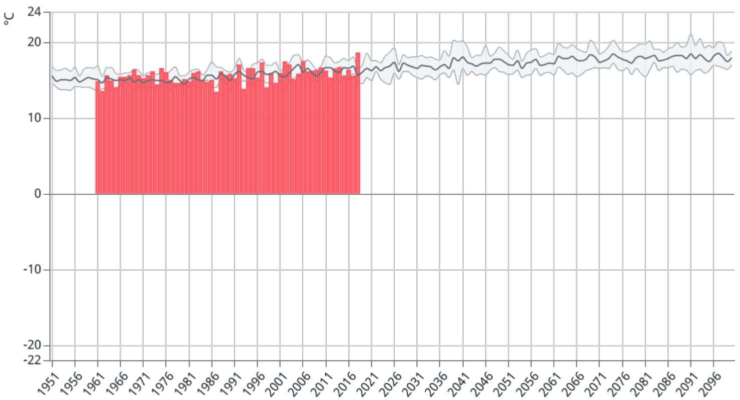
Scenario analysis: effect of temperature on yield loss

Thermal Niche overlap

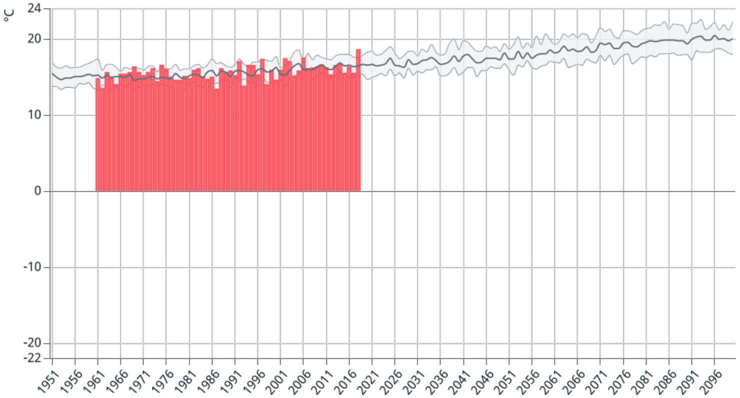


Southern Sweden (Skåne county)
(June-August)

RCP4.5



RCP8.5



Source: SMHI

Future work and directions

- Assessment of different disease management strategies under climate change:
  - Potato cultivars tolerant/resistant (breeding) to high temperatures?
  - Earlier planting
- Introduction of other pathogens (Alternaria ?) for a more integrated yield loss assessment
- Yield loss model coupled with a more detailed, multi-strain epidemiological model

Thank you for listening!

Special thanks to the Swedish Rural Economy and agricultural society for the experimental data

Hushållnings sällskapet

SLU