

Next generation Crop-Pest Model: A case study on Blackleg disease (*Leptosphaeria maculans*) and canola (*Brassica napus*)



Background

- Yield loss = seasonal conditions + pest damage
- Crop management decisions: Attainable yield = $f(\text{environment})$
- Pest management decisions: Threshold

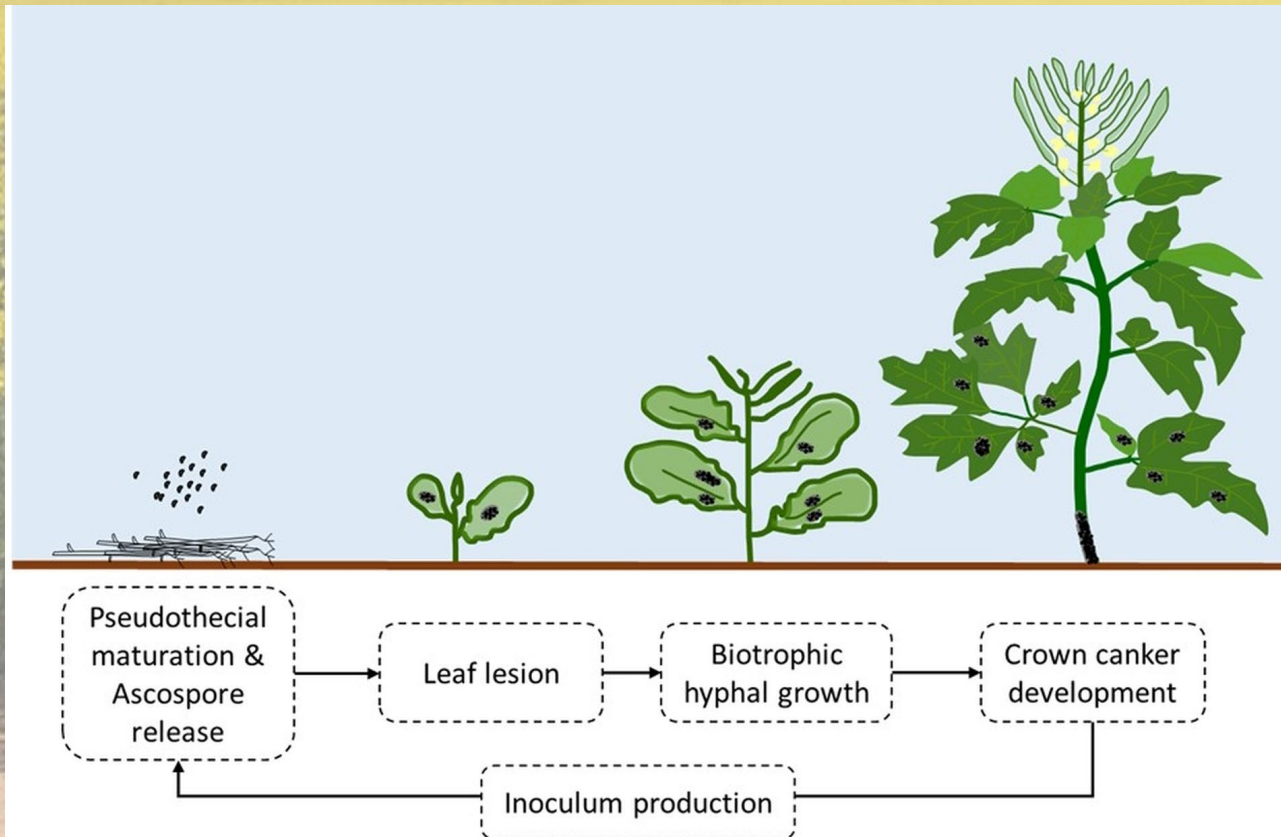
➤ Crop-pest linked models

- ❑ population-based
- ❑ yet to account for the agro-ecological response of the pest

∴ Next gen integrated crop – pest model

- *process-based*
- *pest-host interaction = $f(\text{environment} \times \text{genotype} \times \text{management})$*

Modelling the lifecycle of Blackleg in APSIM



- ▼ 🔄 LifeCycle
 - ▶ 🔄 Pseudothecia
 - ▶ 🔄 MaturePseudothecia
 - ▶ 🔄 Ascospores
 - ▶ 🔄 Germination
 - ▶ 🔄 LeafSpot
 - ▶ 🔄 Biotrophic
 - ▶ 🔄 InfectiveStem
- ▶ 🐛 Infestation
- ▶ 📁 Results
- ▶ 🌻 Canola



Inoculum Development
(Pseudothecial maturation
and Ascospore release)

LifeCycle

Pseudothecia

Development

GrowthRate

MoistTest

TTResponse

Mortality

Migration

Reproduction

ProgenyDestinationPhase

MaturePseudothecia

Reproduction

Release

CurrentCohort

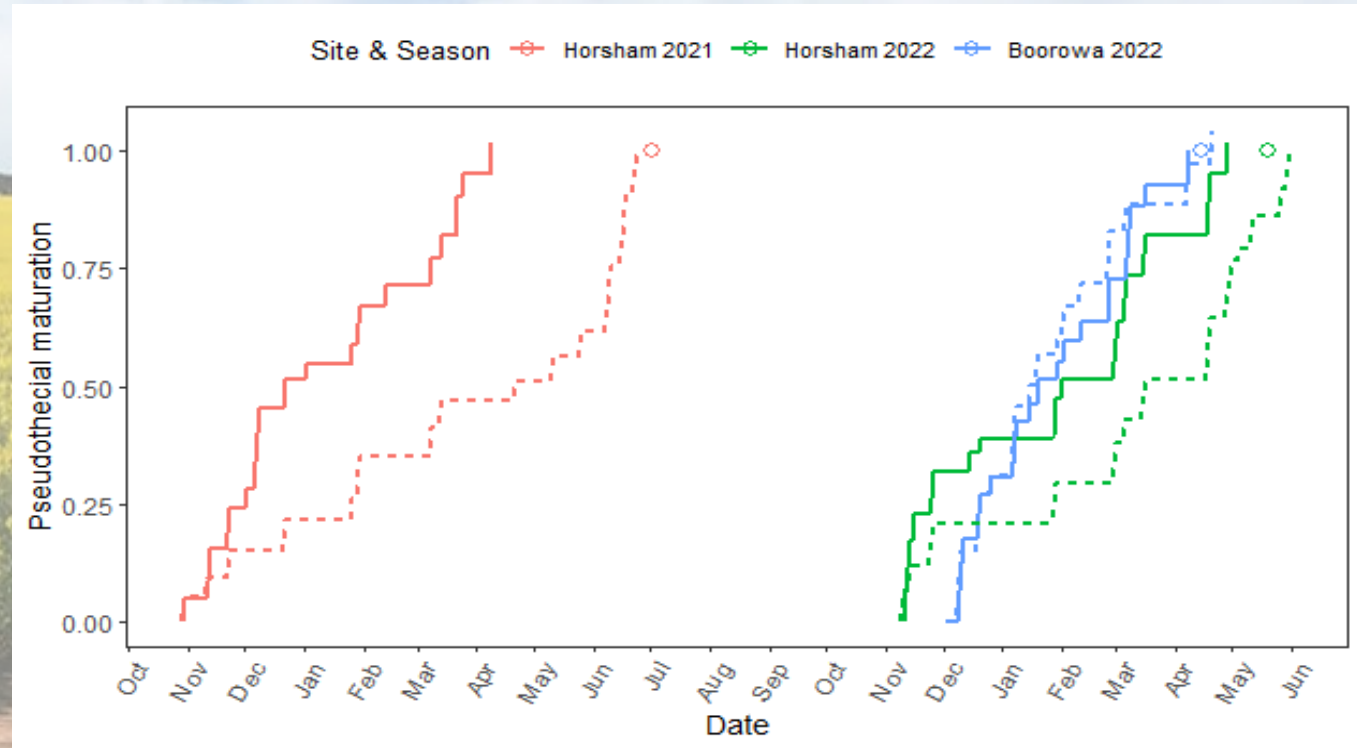
Migration

Development

ProgenyDestinationPhase

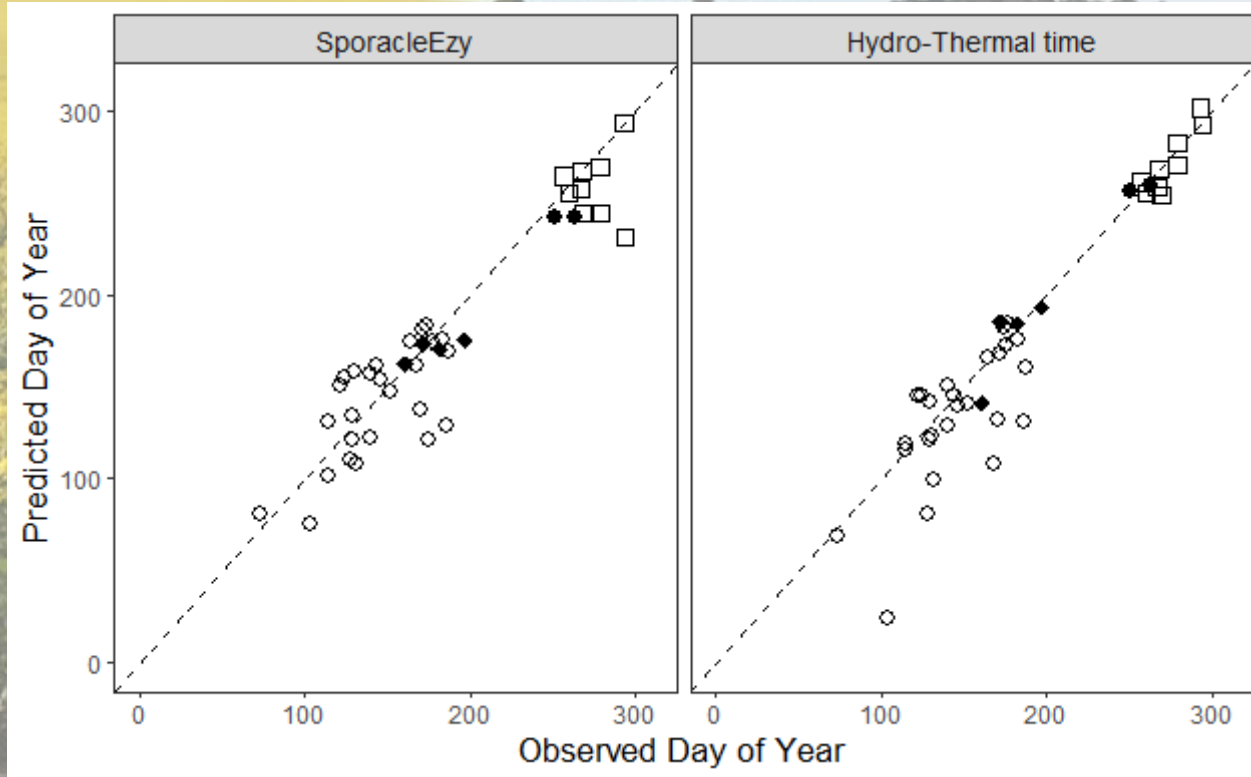
Mortality

Ascospores



Stepwise development of *L. maculans* pseudothecia on standing stubble at Horsham, VIC in 2021 and 2022 and at Boorowa, NSW in 2022 using the rainfall threshold $\geq 1\text{mm}$ + target thermal time value of $196^\circ\text{C}\text{-day}$ (solid line), and rain $>$ soil evaporation + target thermal time value of $196^\circ\text{C}\text{-day}$ (dashed line). The date when the development reaches 1 is the predicted onset of pseudothecial maturation. The observed dates for the two sites and years are represented by a dot (o).

Model testing against independent datasets and Comparison with the existing predictive model



A regression analysis of the observed versus predicted dates of the onset of pseudothecial maturation and ascospore release in Australia (○), Canada (◆), France (●), and the UK (□) using the Sporacle Ezy and Hydro-thermal time modelling approach (rain > soil evaporation).

Table 1. Performance evaluation of Sporacle Ezy and Hydro-thermal time modelling approach in predicting the onset of pseudothecial maturation and ascospore release using the regression- and deviation-based statistics.

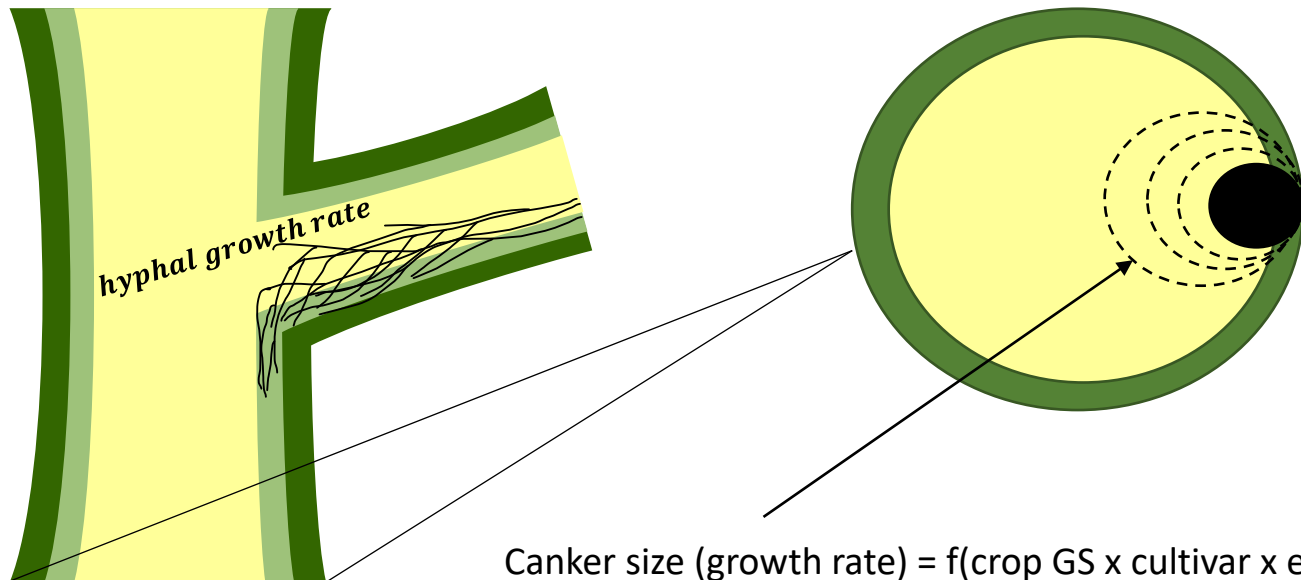
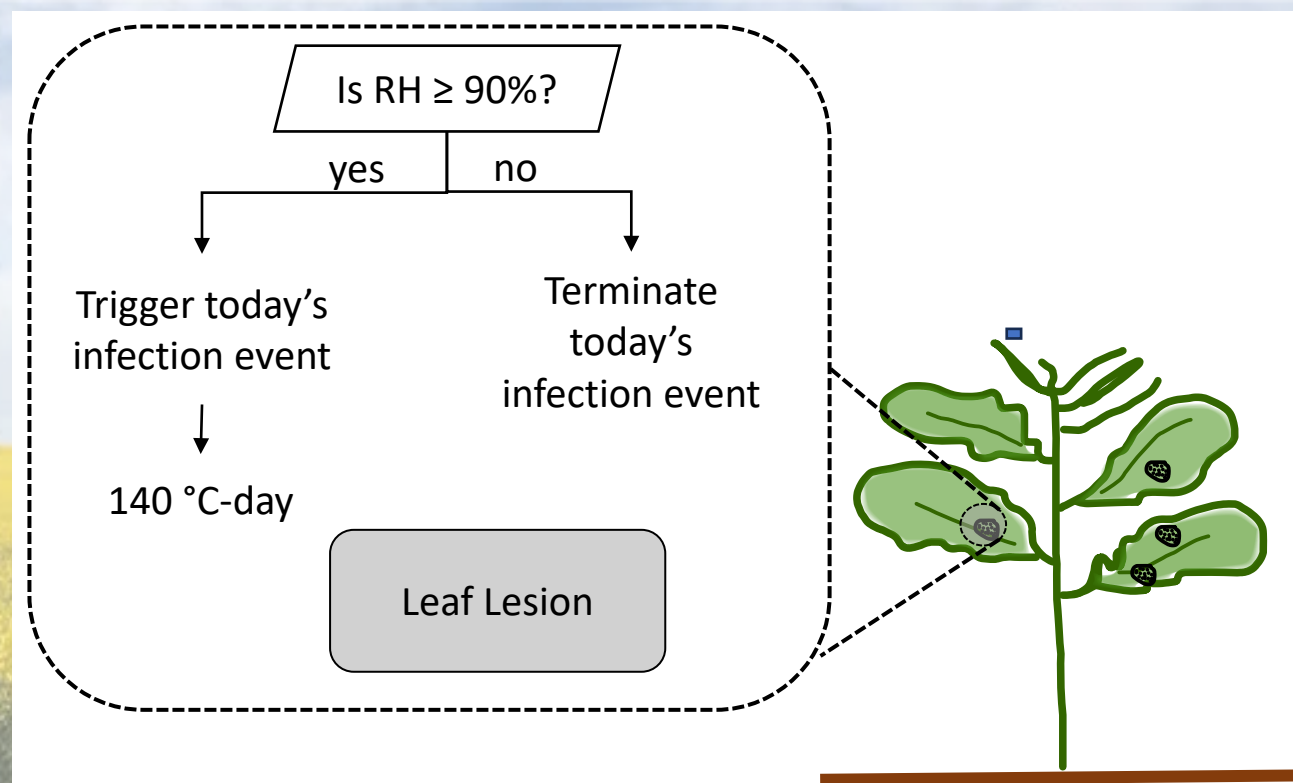
Model	R ²	S.E.	slope	RMSD	RSR ^a	NSE ^b	PBIAS ^c
Sporacle Ezy	0.87	20	0.87	42	0.38	0.85	4.18
Hydro-thermal time	0.90	21	1.05	42	0.38	0.85	4.60

^a 0.00 ≤ RSR ≤ 0.50 (Very Good), 0.50 < RSR ≤ 0.60 (Good), 0.60 < RSR ≤ 0.70 (Satisfactory);

^b 0.75 < NSE ≤ 1.00 (Very Good), 0.65 < NSE ≤ 0.75 (Good), 0.50 < NSE ≤ 0.65 (Satisfactory);

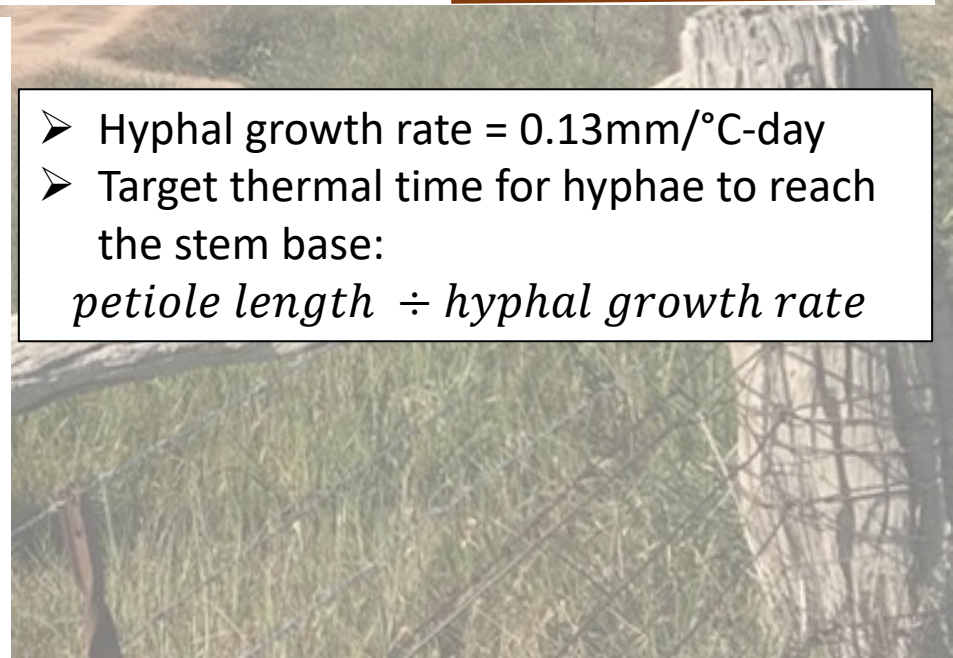
^c (+) PBIAS = model underestimation, (-) PBIAS = model overestimation

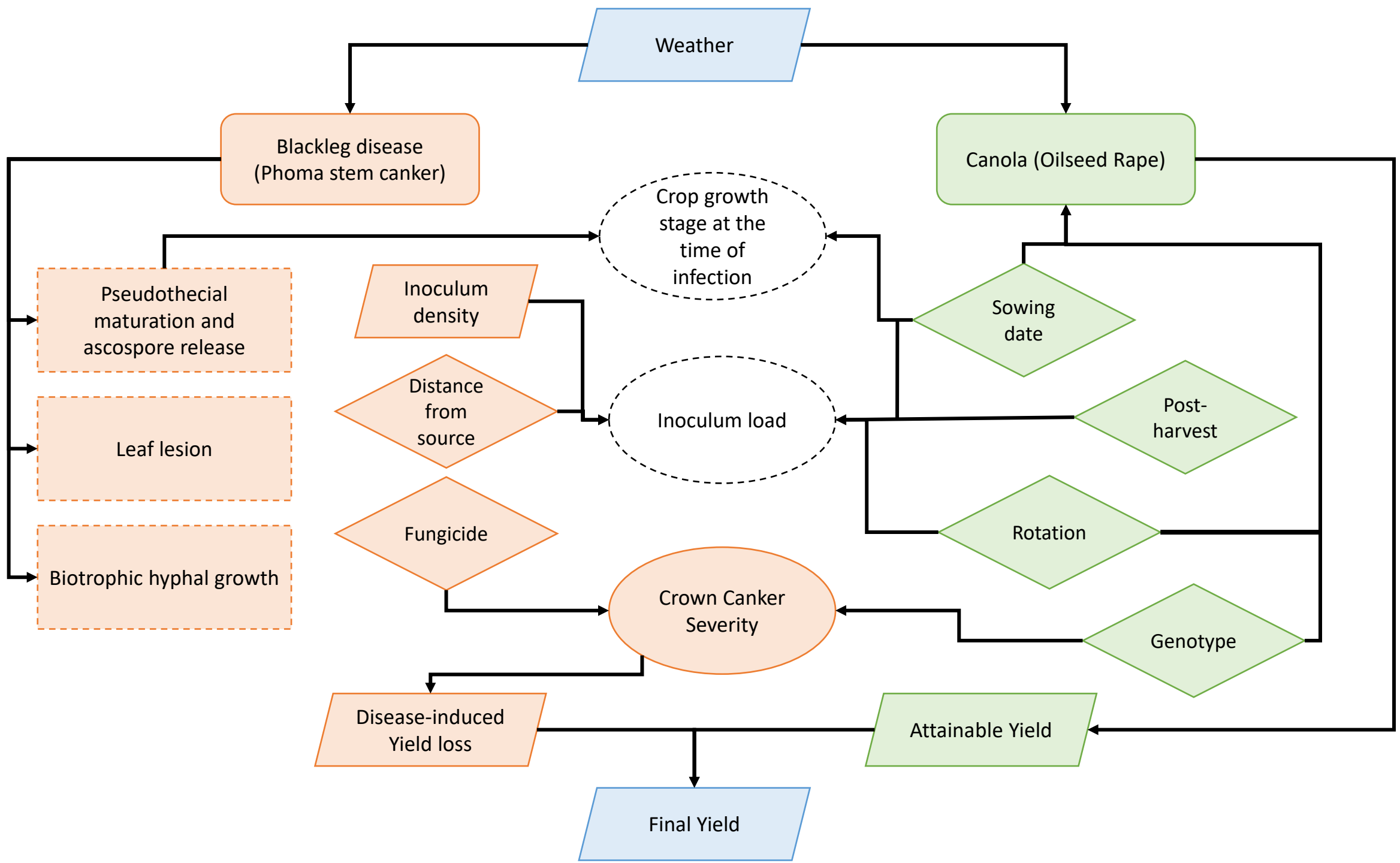
Disease progression



Canker size (growth rate) = $f(\text{crop GS} \times \text{cultivar} \times \text{environment})$

- Hyphal growth rate = $0.13\text{mm}/^{\circ}\text{C-day}$
- Target thermal time for hyphae to reach the stem base:
 $\text{petiole length} \div \text{hyphal growth rate}$





Future work

- Infection Model refinement
- G x E x M simulation

Concluding remarks

- ❖ Improved knowledge on crop-pest modelling = advancement of existing farming systems models
- ❖ Broad application of the modelling approach