Assessment of management strategies of sharka epidemics by modeling complemented with experiments

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Assessing sharka management strategies through experiments and modeling

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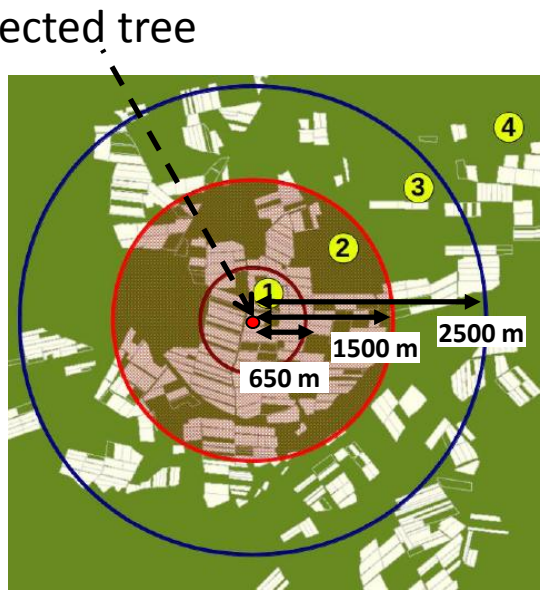
Sharka management strategy in France

Since the 1990's

- Frequent visual inspections of the orchards
- Removal of the symptomatic trees (or whole orchards)
- Protection of the nurseries

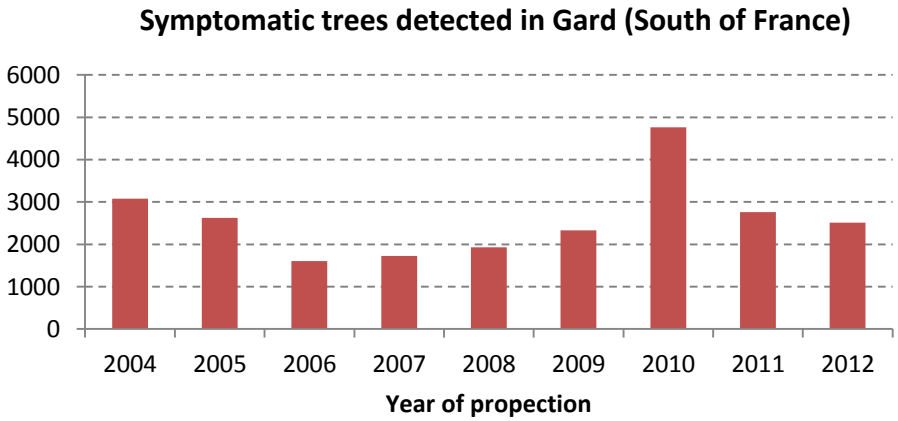
Law published in 2011

- Definition of 4 areas around each infected tree



Disappointing outcome:

- Costly strategy
- Still many trees infected each year



Data from J.Y. Couderc

How to optimize management strategies?

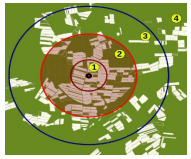
Complex interactions between biological and human processes

Experiments

Large spatial scale → Impossible in the laboratory

Forbidden in the field ← Quarantine pathogen in France

Management strategy



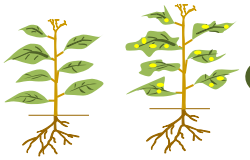
Current strategy

Optimization

Experts' opinions

Modeling

Research project



Step 1

Experiments

Knowledge about biological processes

In silico test

SPATIOTEMPORAL SIMULATION MODEL

Step 2

Proposal of management strategies

Step 3

Identification of key parameters

1

Sensitivity analysis

Step 4

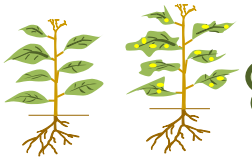
2

OPTIMIZED MANAGEMENT STRATEGIES

Joint simulation of:

- **the epidemic process**
- **the management strategies**

Research project



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OPTIMIZED MANAGEMENT STRATEGIES

Joint simulation of:

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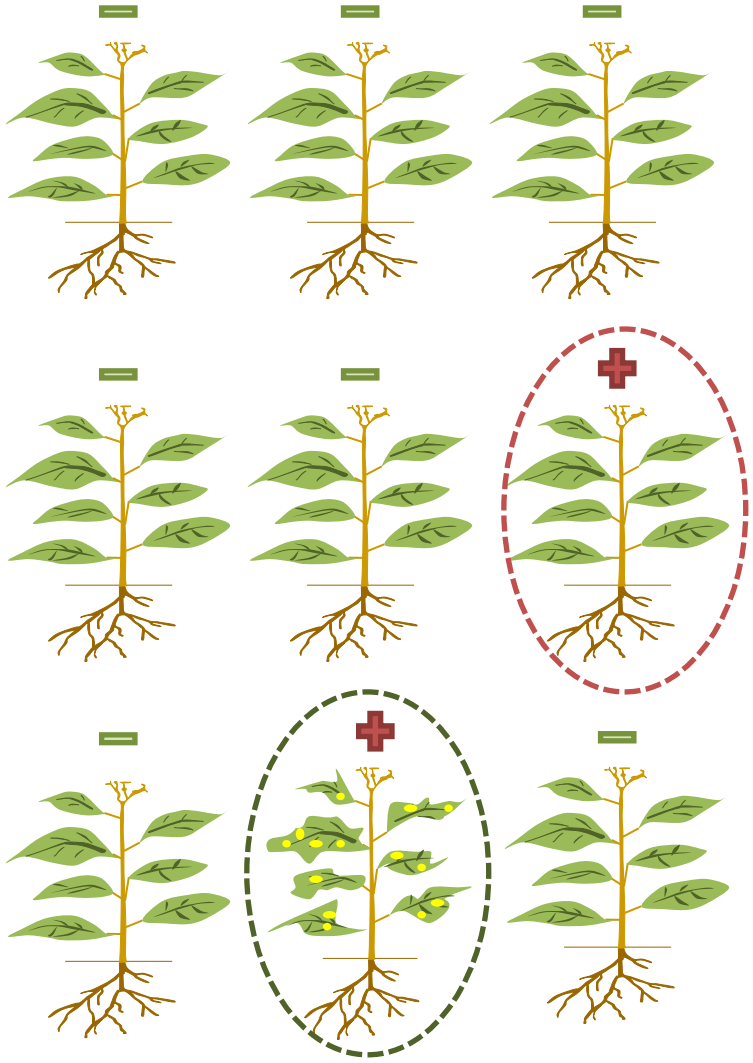
Consequences of symptom-based detection



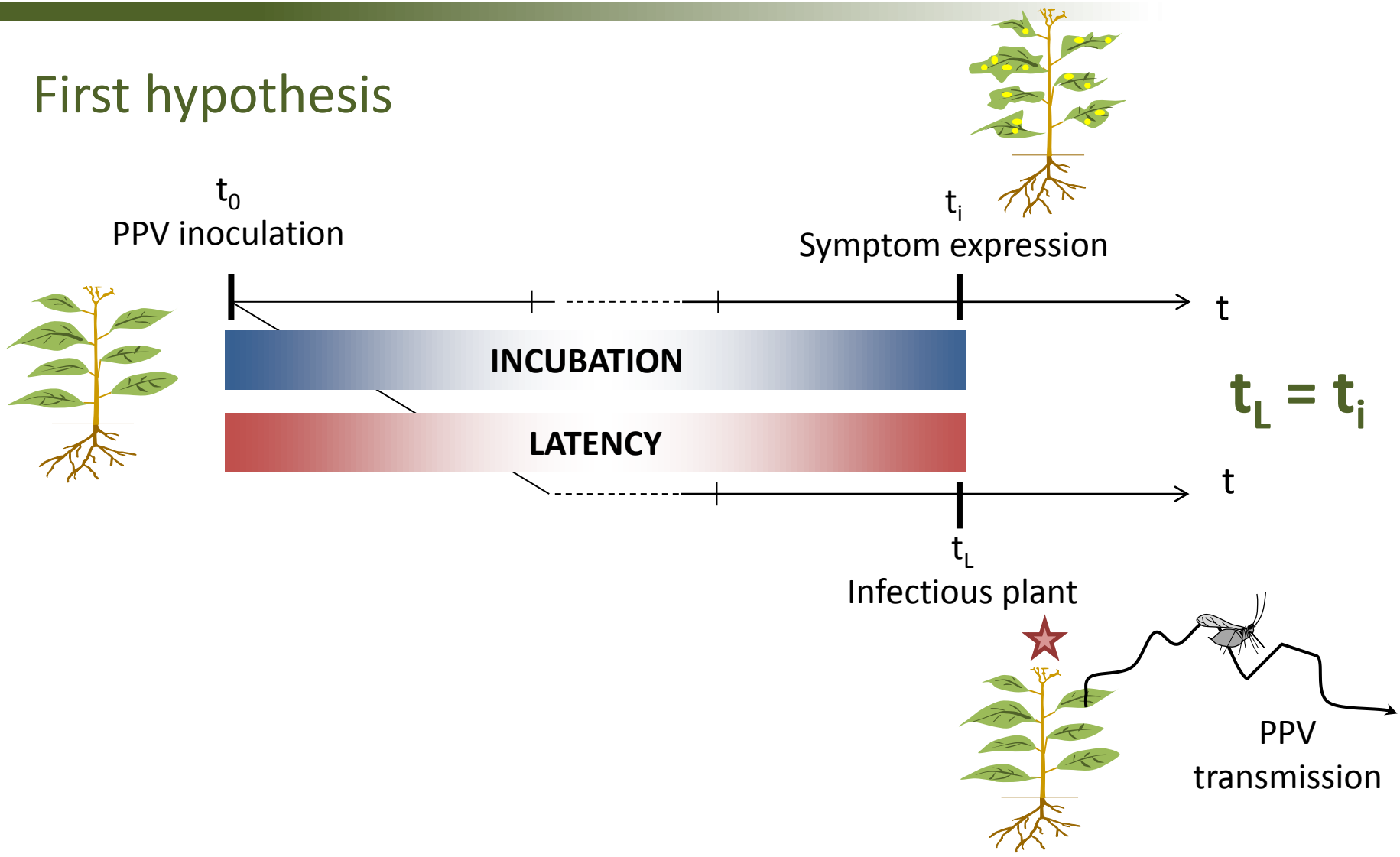
Infected trees without symptoms cannot be detected

Visual inspections allow the detection of symptomatic trees

Infected
Healthy

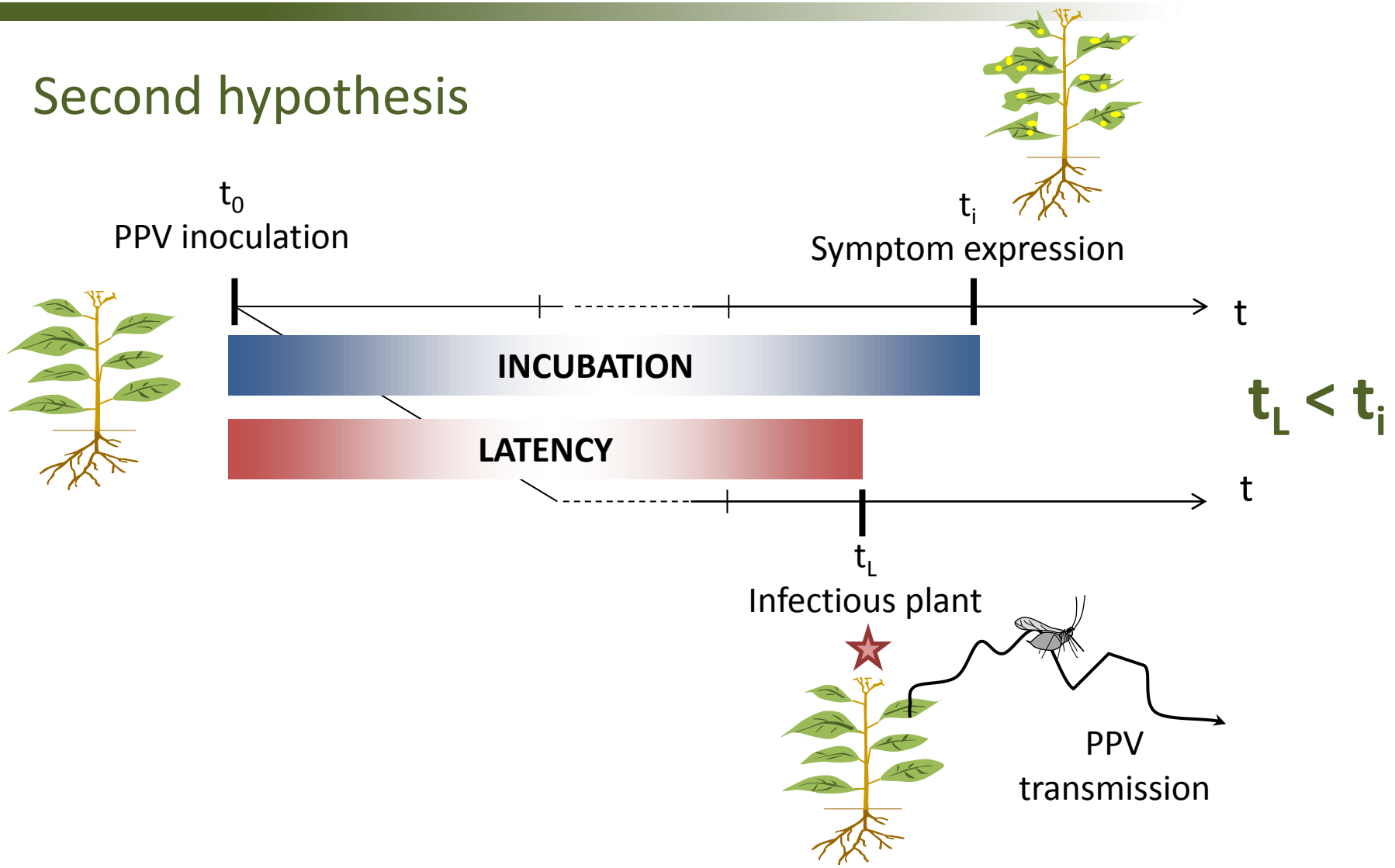
Latency *vs.* Incubation

First hypothesis



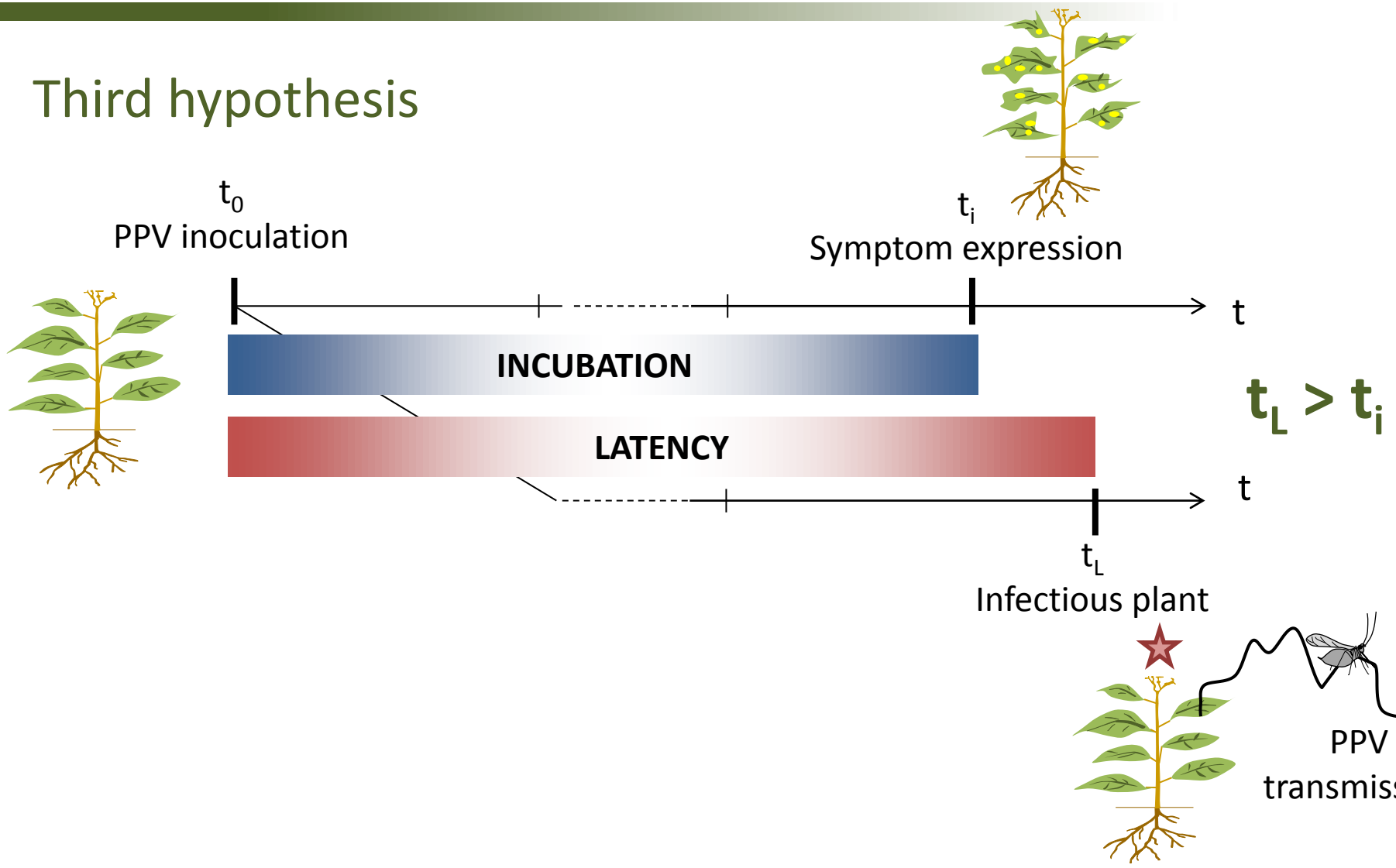
Latency *vs.* Incubation

Second hypothesis

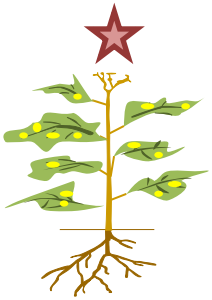


Latency *vs.* Incubation

Third hypothesis



Consequences of these scenarios



Infectious with symptoms

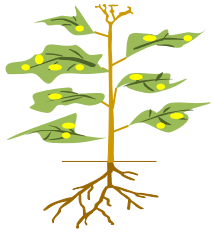
Exemples in literature

Influenza virus
Hepatitis B virus

Infectious without symptom

Virus source trees not detected by visual inspections
→ Need to apply alternative methods

Rabies virus
Hepatitis A virus

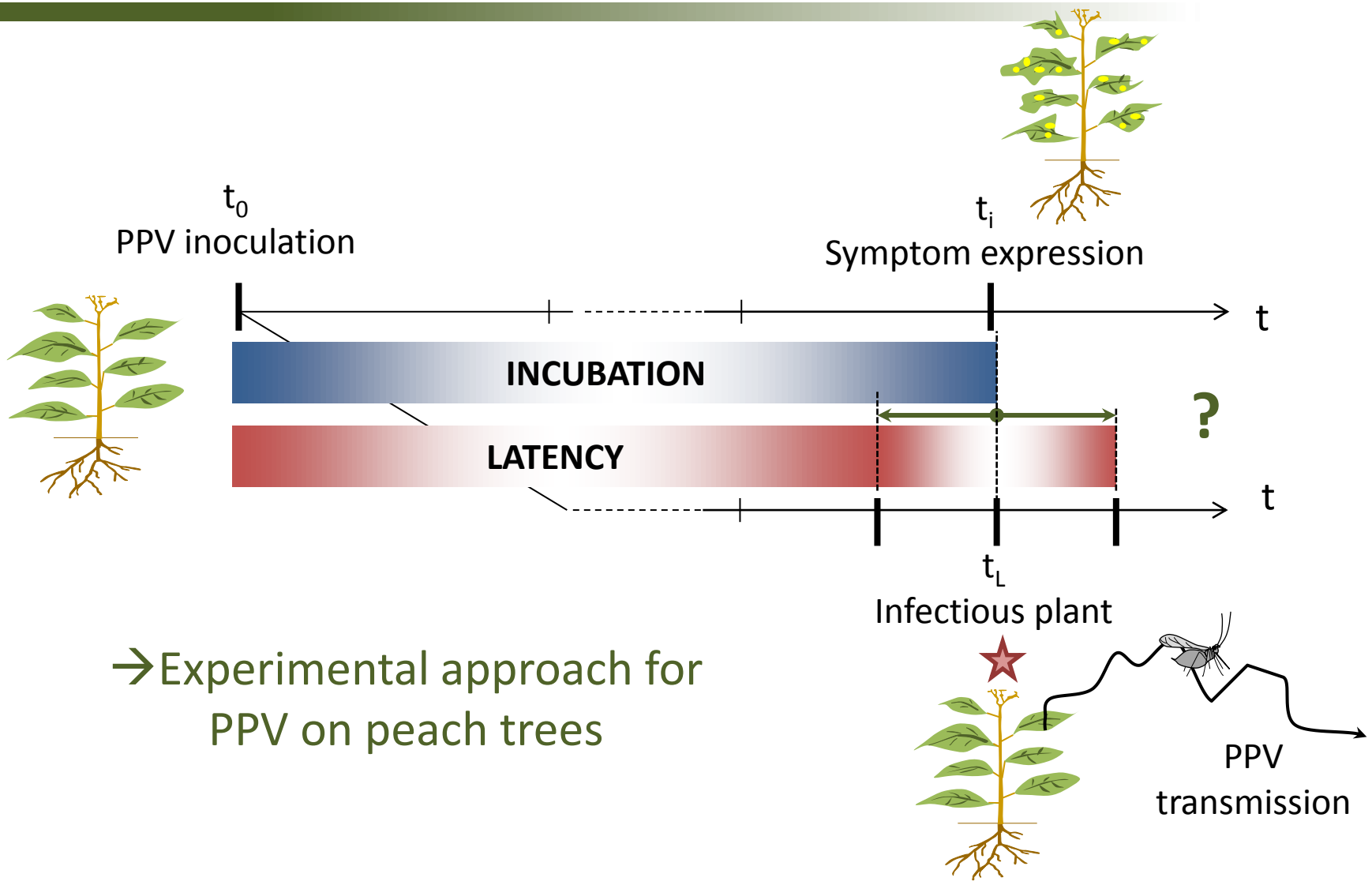


Symptomatic but not infectious

Visual detection possible before the spreading of the disease
→ Visual inspections efficient

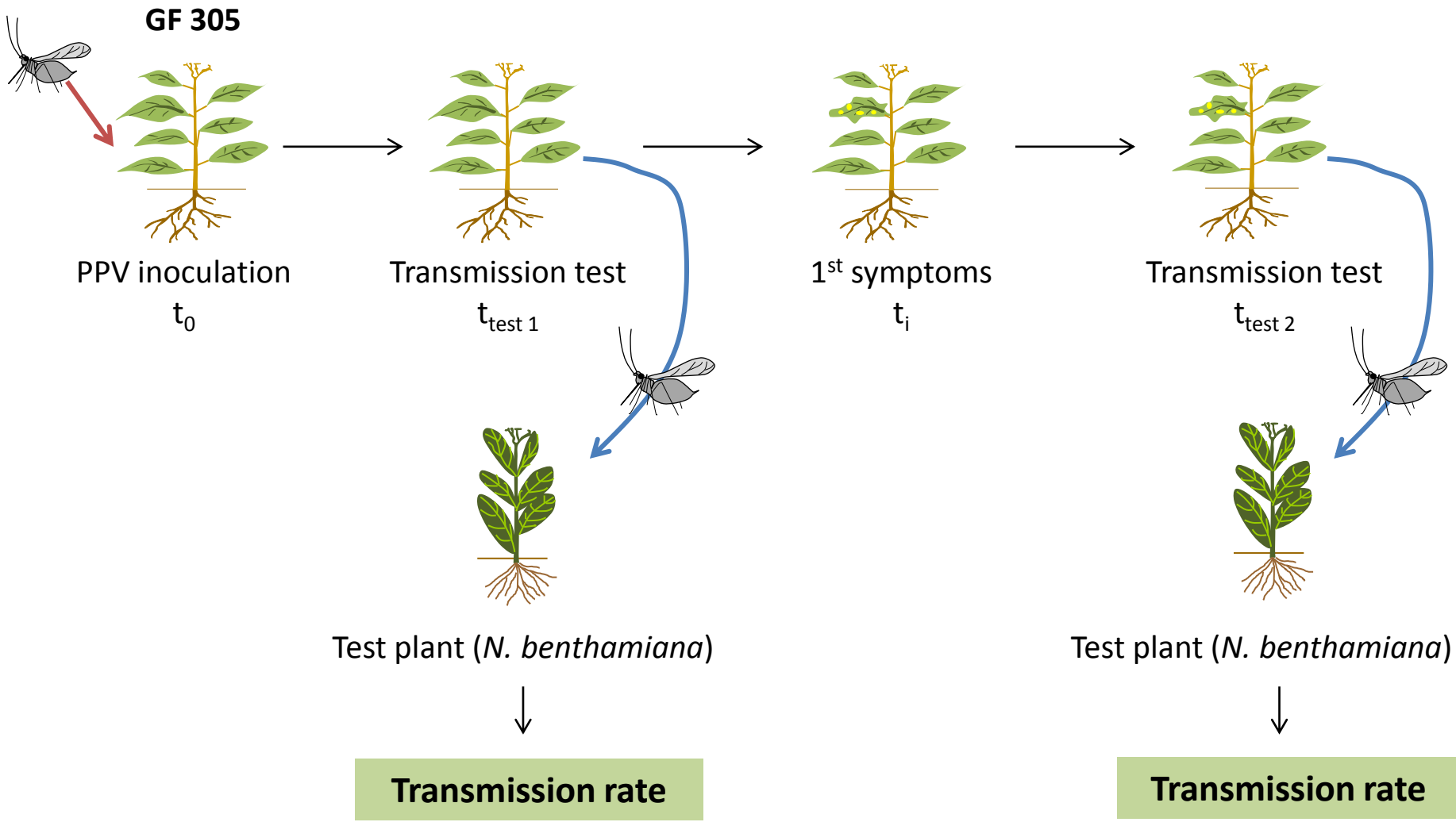
Mycosphaerella fijiensis
Septoria nodorum

Goal: assessment of the potential asynchronism

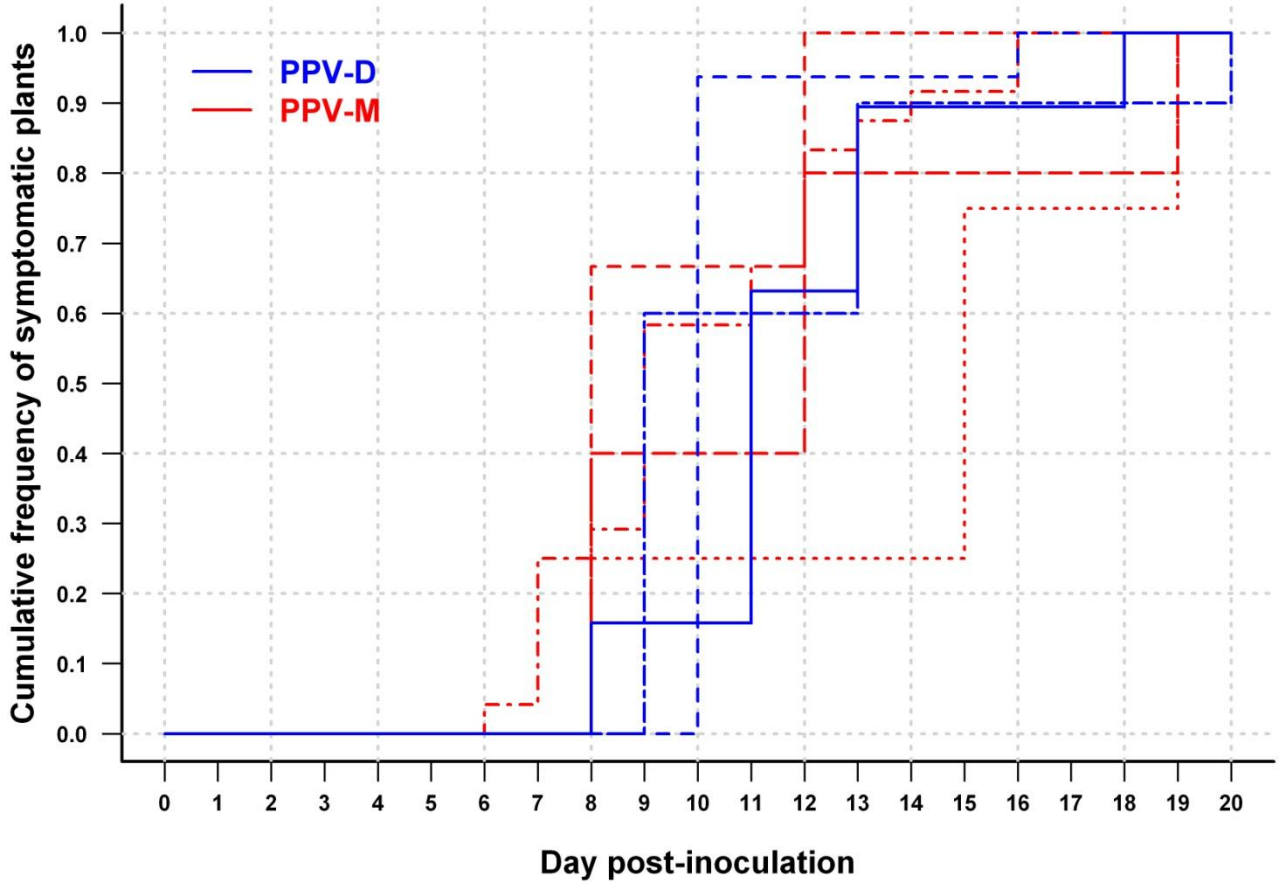


→Experimental approach for PPV on peach trees

Experimental approach



Analysis of inter-plant variation of t_i



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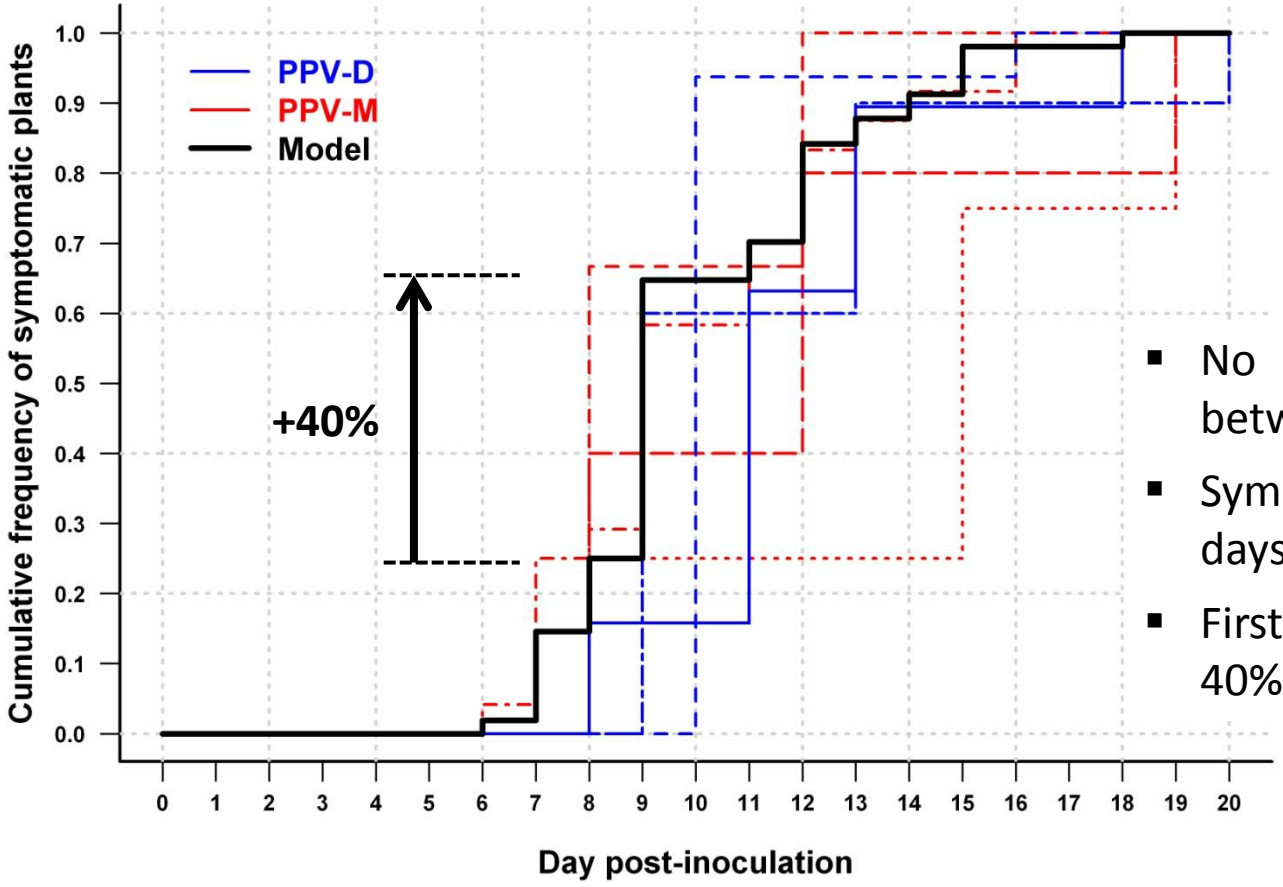
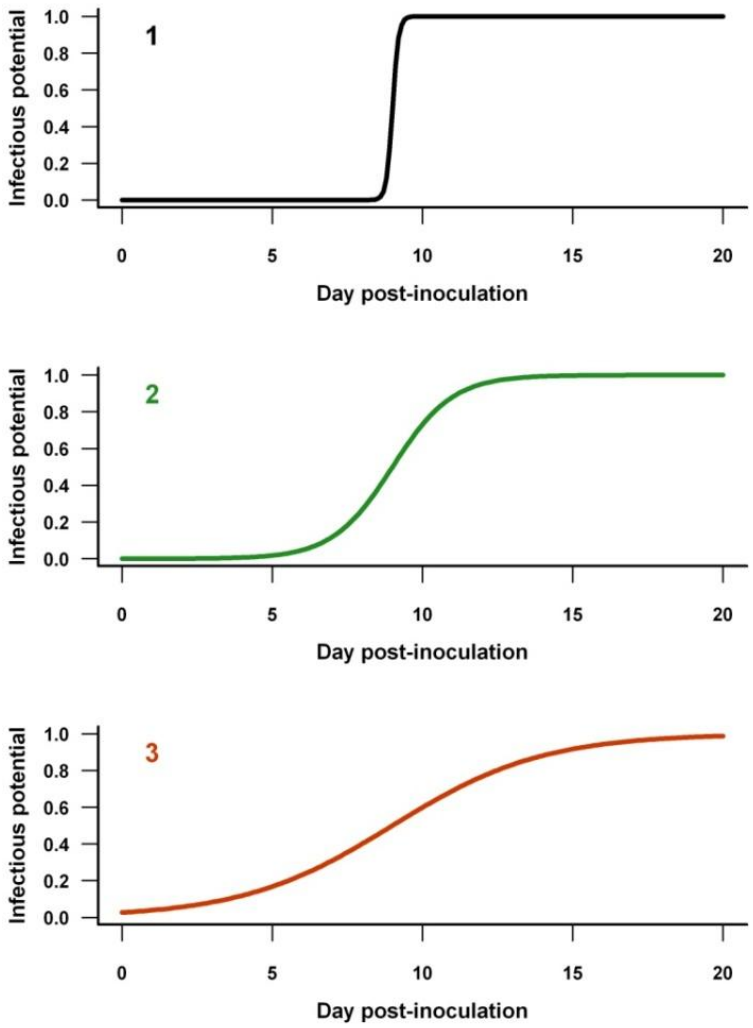


- No significant difference between strains (p = 0.70)
- Symptom expression between days 6 and 18
- First symptoms on day 9 for 40% of the plants

Simulation of inter-plant variation of t_L

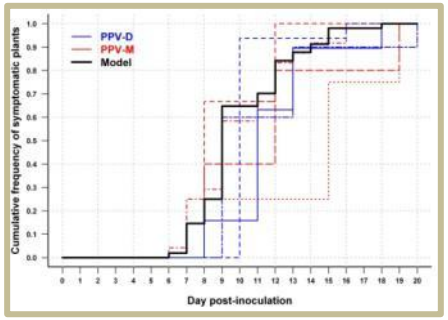
Low variation in the latency duration

High variation in the latency duration

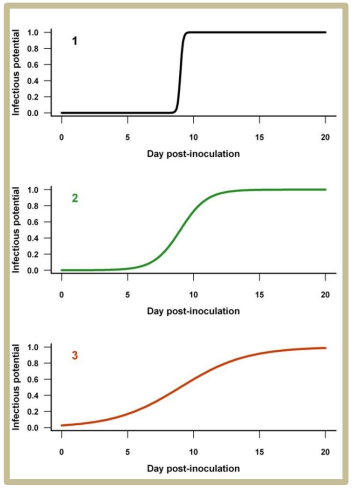


Validation of the protocol by modeling

3 scenarios for the synchronization



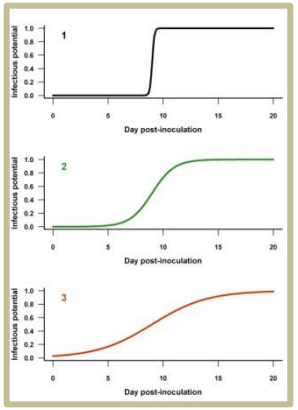
Empirical distribution to simulate the incubation period

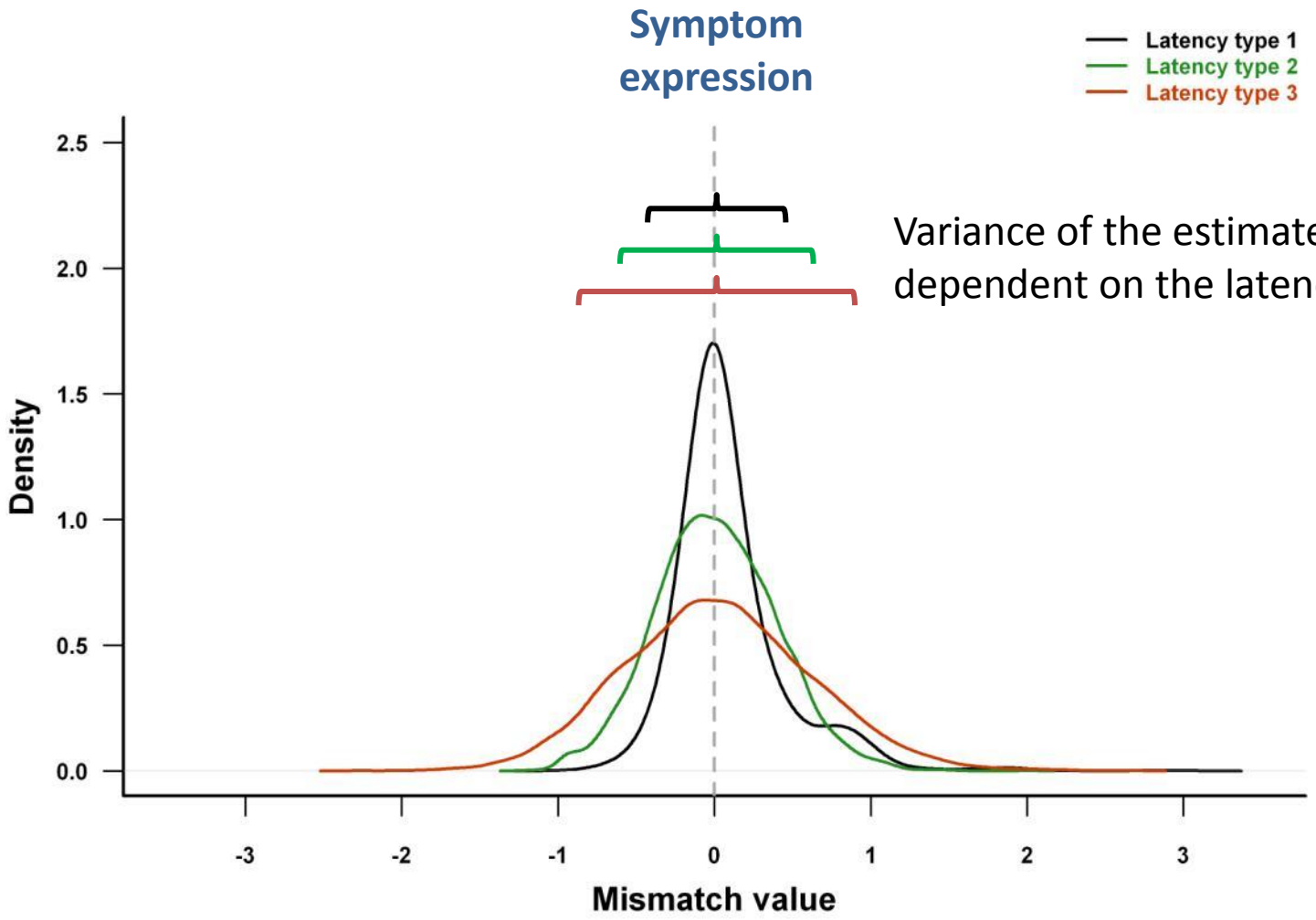


3 theoretical distributions to simulate the latency period

1. Simulation of the number of infected test plants
2. Model fitting & assessment of the mismatch between latency and incubation
3. Assessment of the adequacy between simulated and estimated mismatches

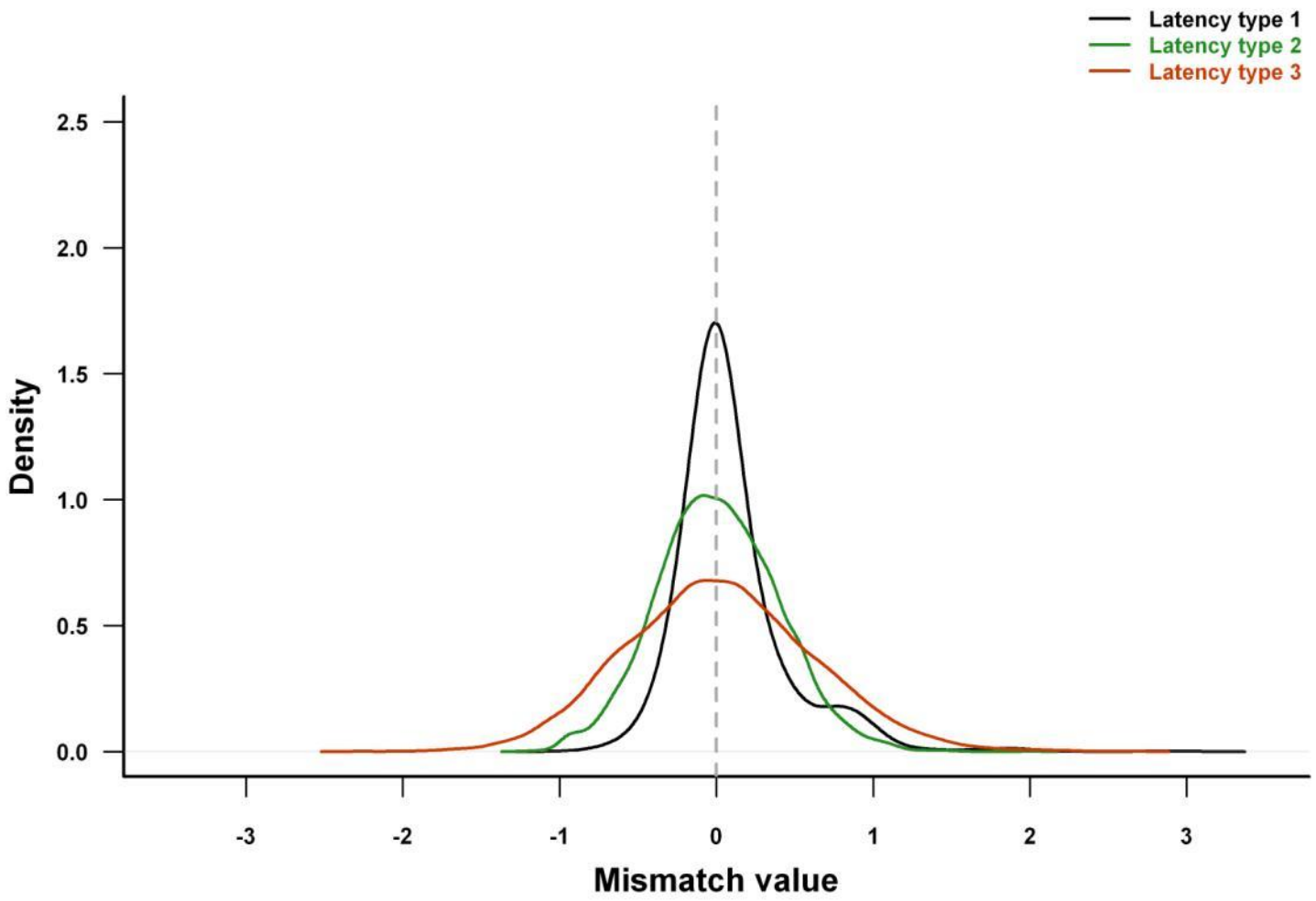
Assessment of the mismatch



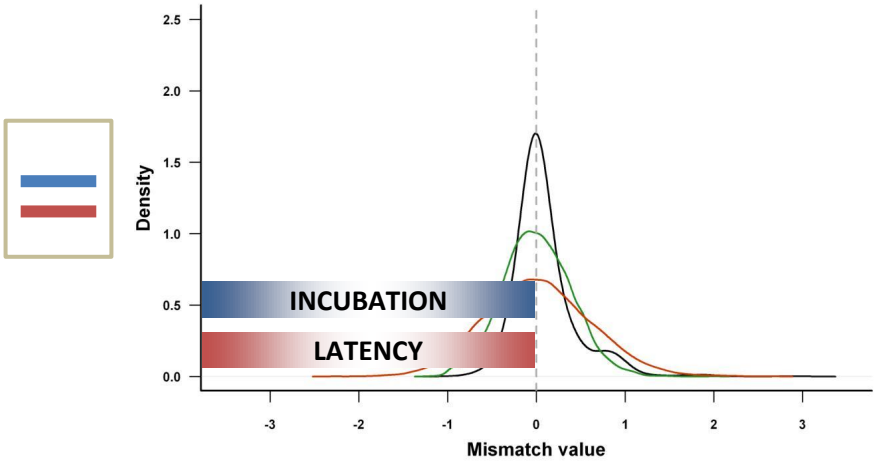


Variance of the estimated mismatch dependent on the latency scenario

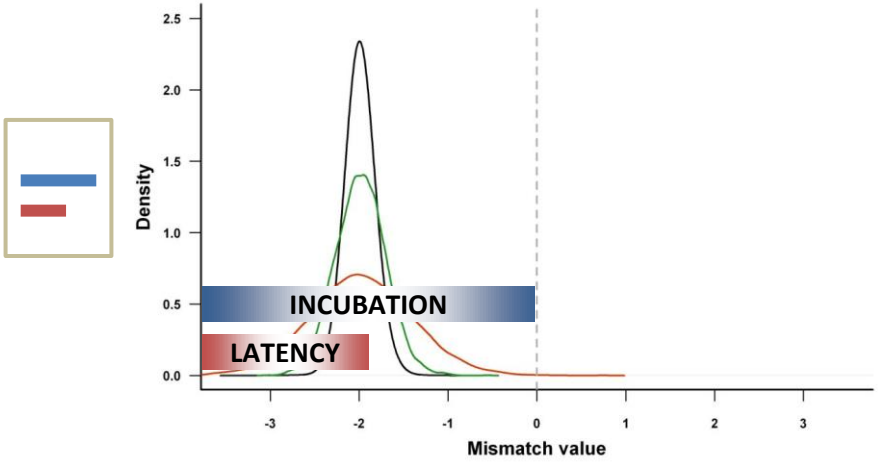
Assessment of the mismatch

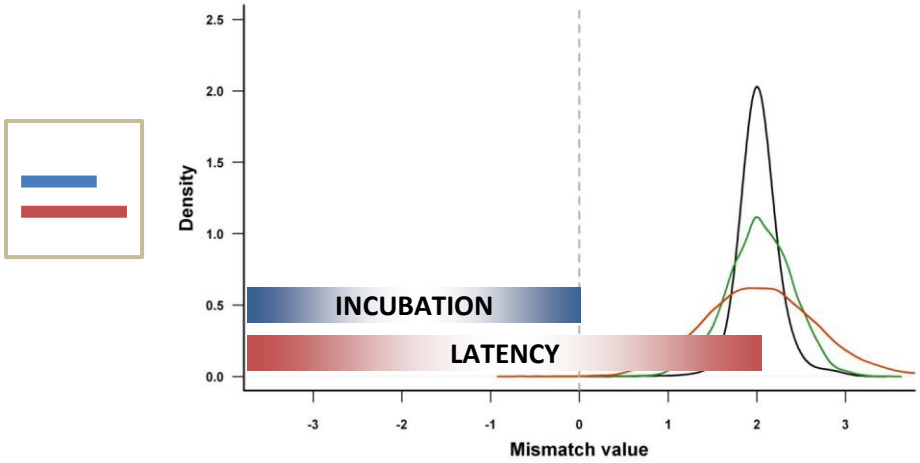


Adequacy between simulated and estimated mismatches



Mismatch between latency and incubation assessed with a precision of 1 day





Conclusions

- Model-based experimental design: a useful approach for assessing several scenarios and designing experiments
- We adopt this approach to acquire new data on latency and incubation periods for PPV
- Knowledge acquired through this experiment will be used to improve:
  - The spatiotemporal model of propagation
  - The proposed management strategies

Thank you for your attention

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