Assessing the mismatch between incubation and latency for a vector-borne plant disease

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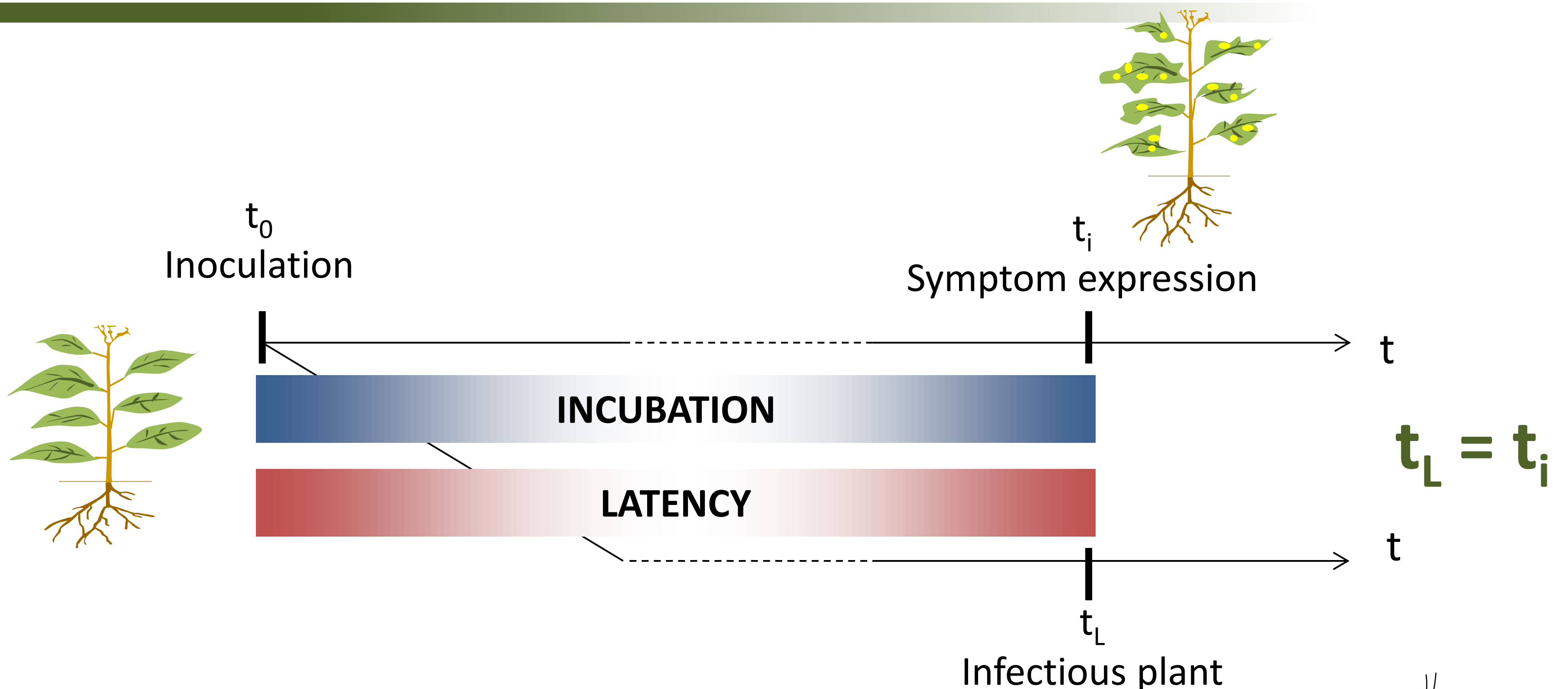
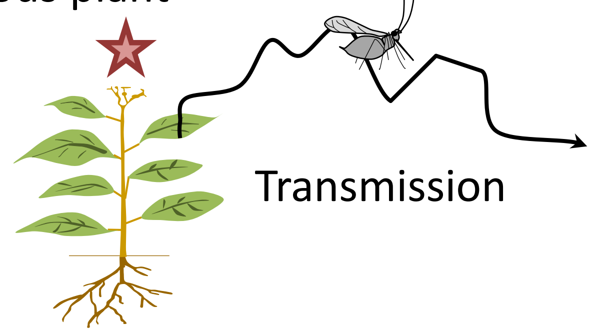
Latency *vs.* Incubation

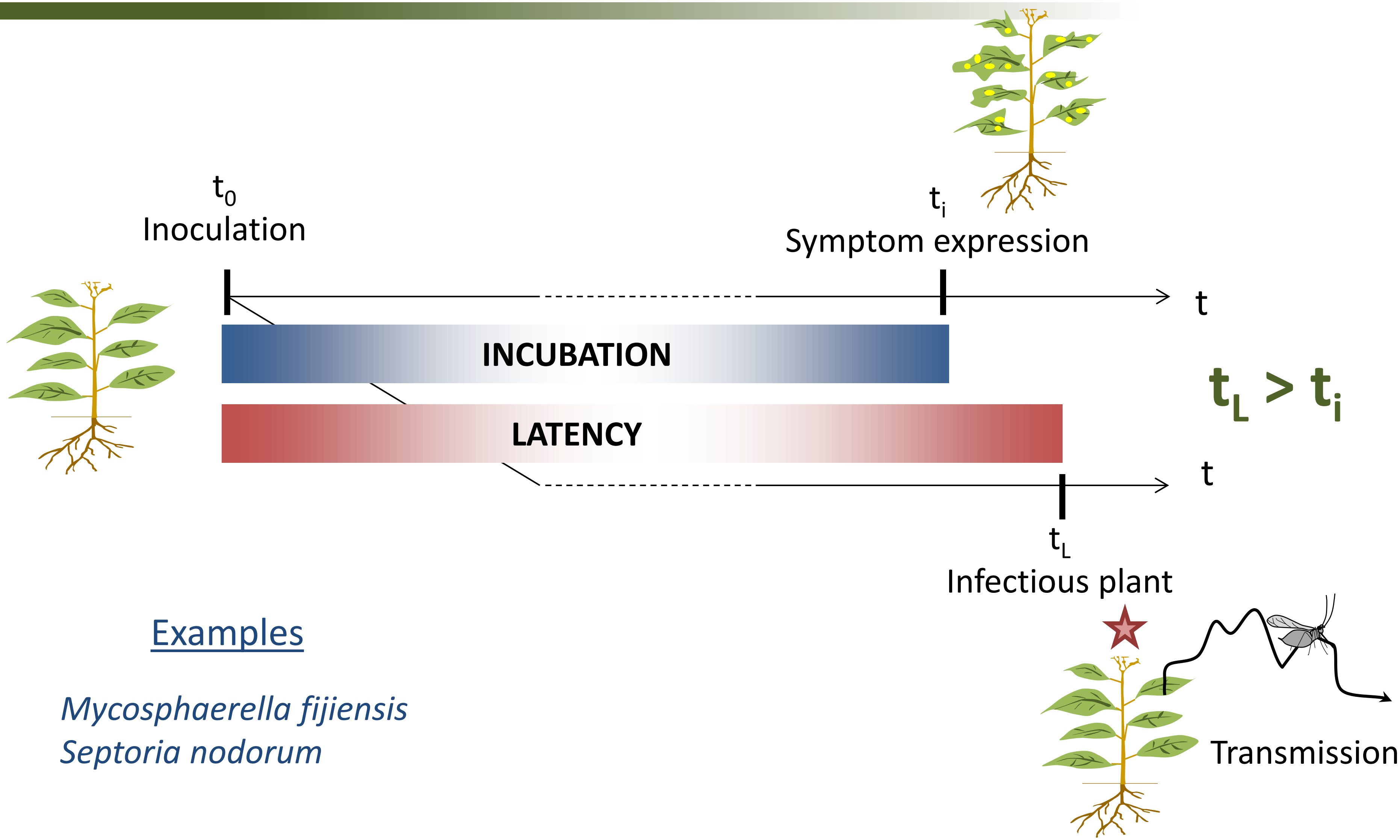




Examples

Influenza virus
Hepatitis B virus

Latency *vs.* Incubation

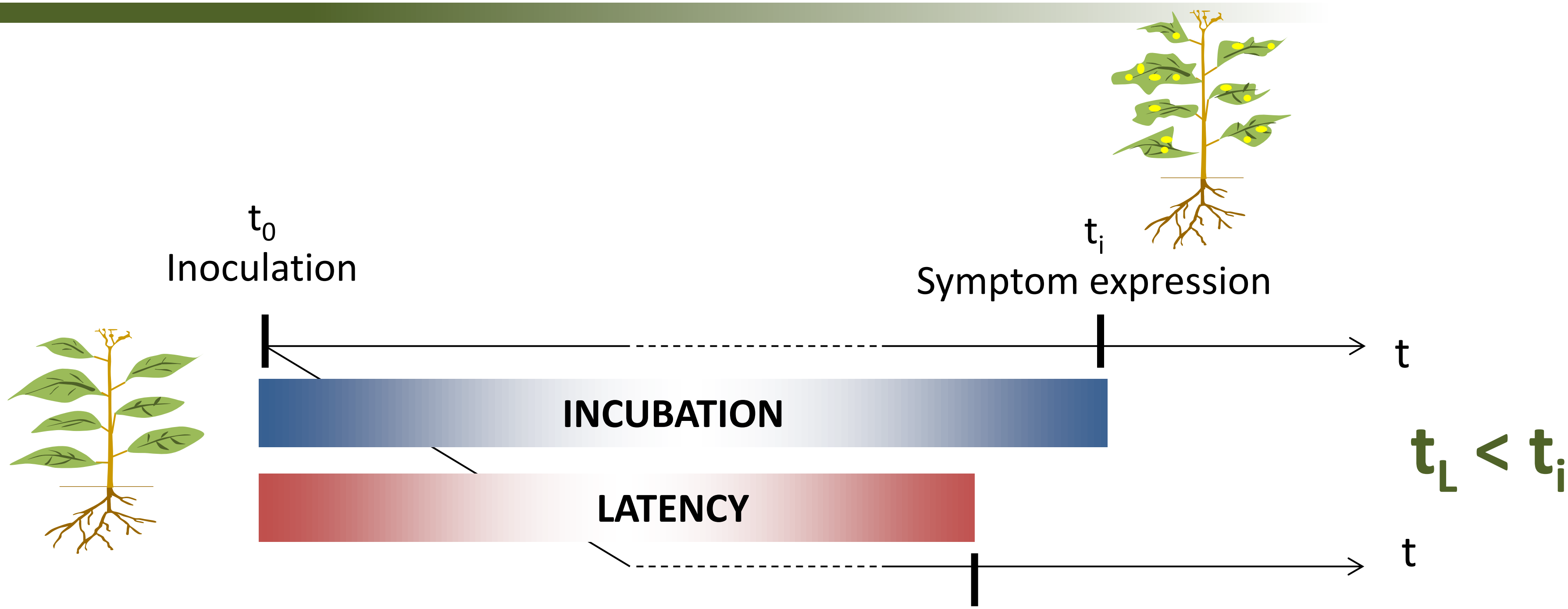


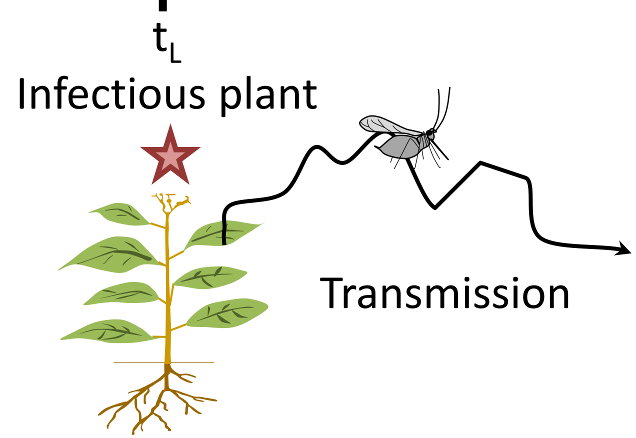
$t_L > t_i$

Examples

Mycosphaerella fijiensis
Septoria nodorum

Latency *vs.* Incubation



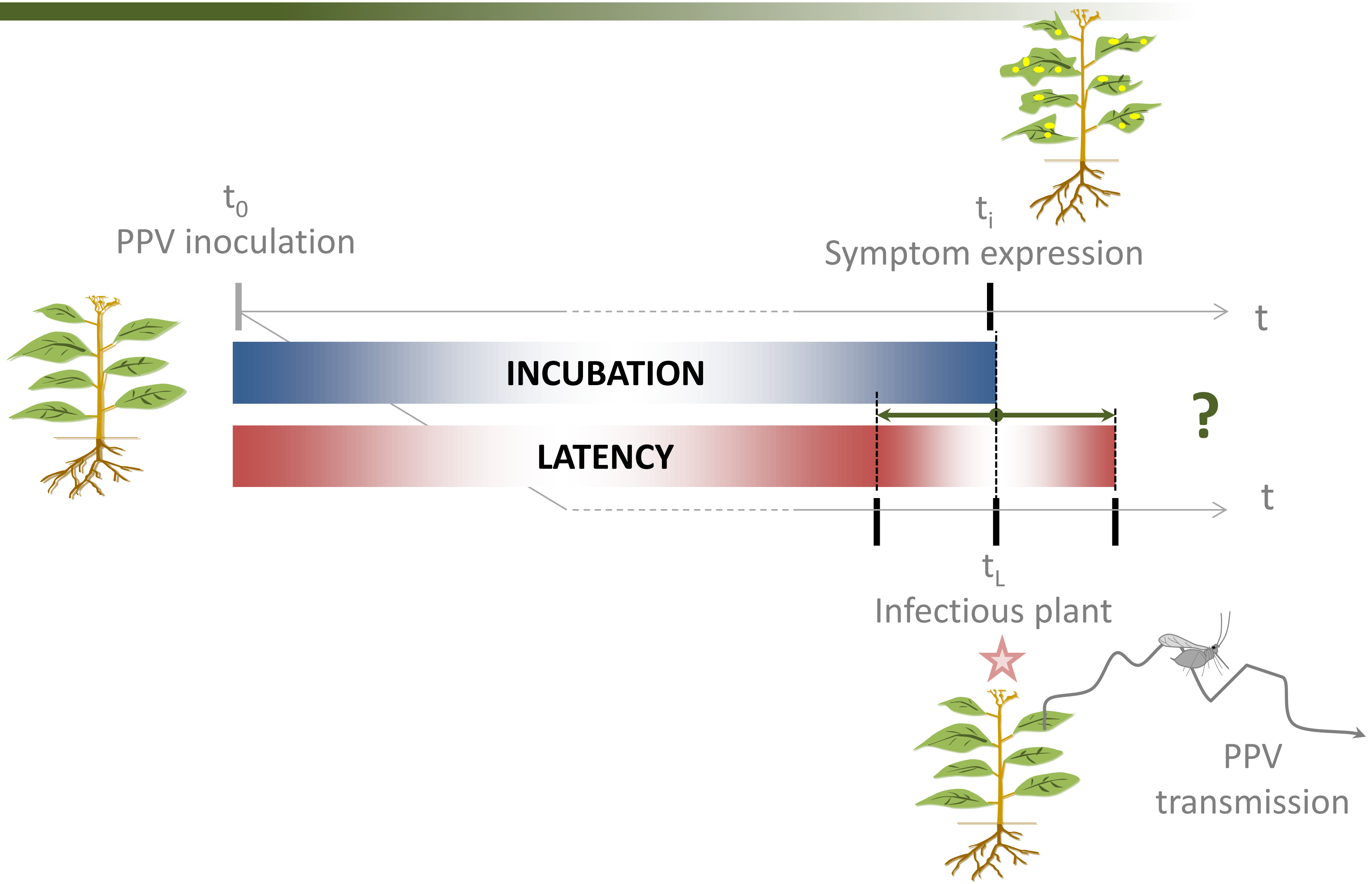


Examples

Rabies virus

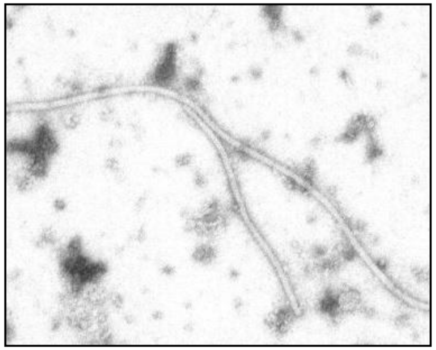
Hepatitis A virus

Latency *vs.* Incubation



Plum pox virus, the causal agent of sharka disease

Disease	**Sharka** Most damaging disease on *Prunus* 10 billions Euros of economic losses worldwide in 30 years
Pathogen	***Plum pox virus* (PPV)** *Potyvirus*
Vectors	**Aphids**: > 20 species **Human**: transfer of infected material
Hosts of economic interest	***Prunus*** e.g.: apricot, plum and peach trees



Sharka management strategy in France

Since the 1990's

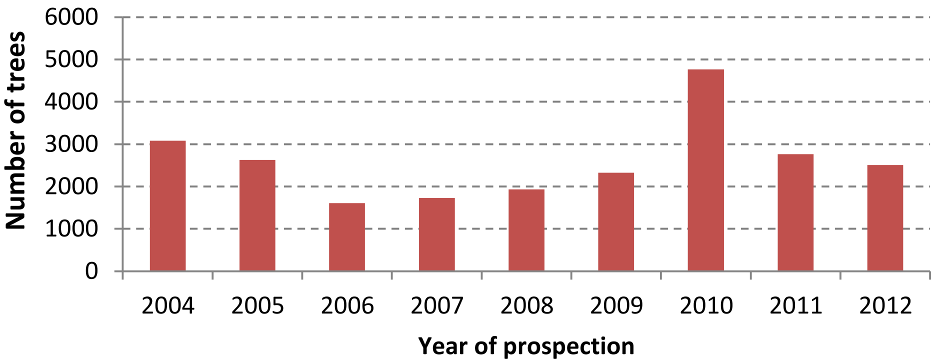
- Frequent visual inspections of the orchards
- Removal of the symptomatic trees (or whole orchards)
- Protection of the nurseries

Infected trees without symptoms cannot be detected?

Disappointing outcomes:

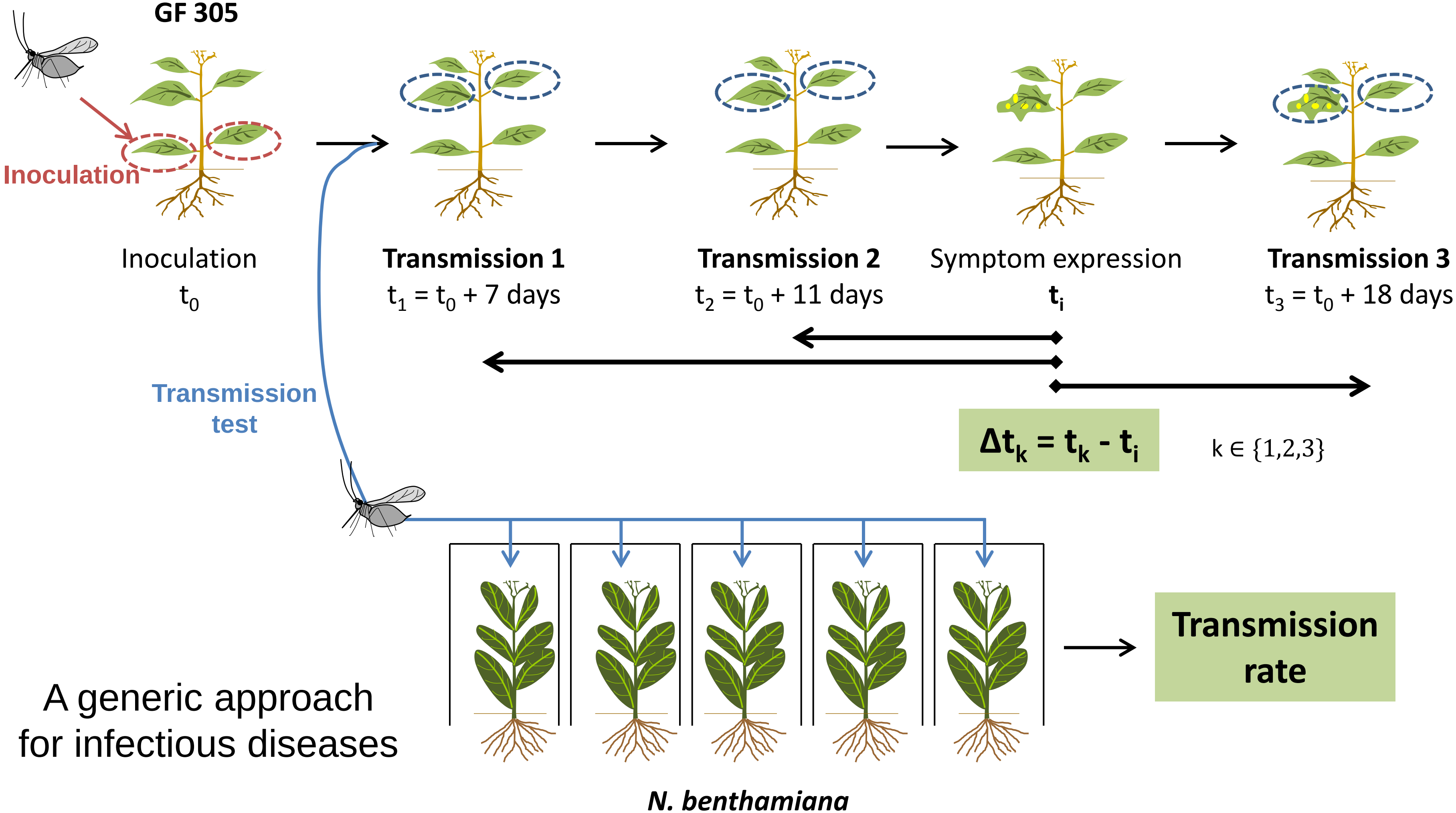
- Costly strategy
- Still many trees infected each year

Symptomatic trees detected in Gard (South of France)



(Data from regional offices of French food agency)

Experimental approach



A generic approach for infectious diseases

Symptom monitoring

Definition of 5 classes of leaves:

0
No symptom

1
Light symptoms

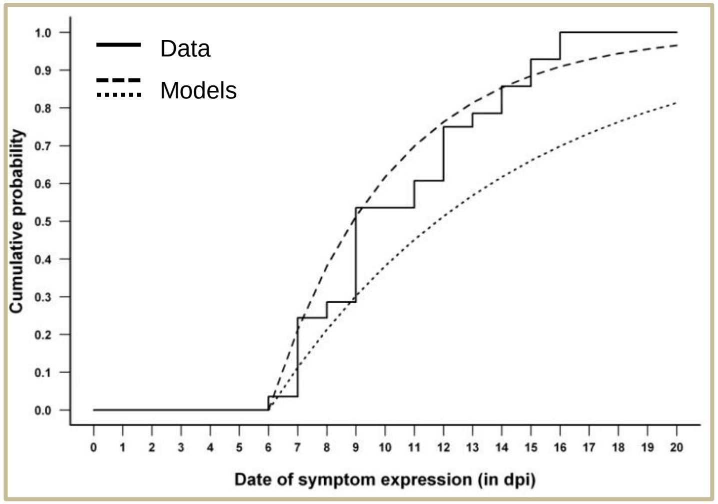
2
Intermediary symptoms

3
Severe symptoms

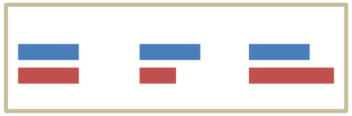
4
Highly severe symptoms

Validation of the protocol by simulation

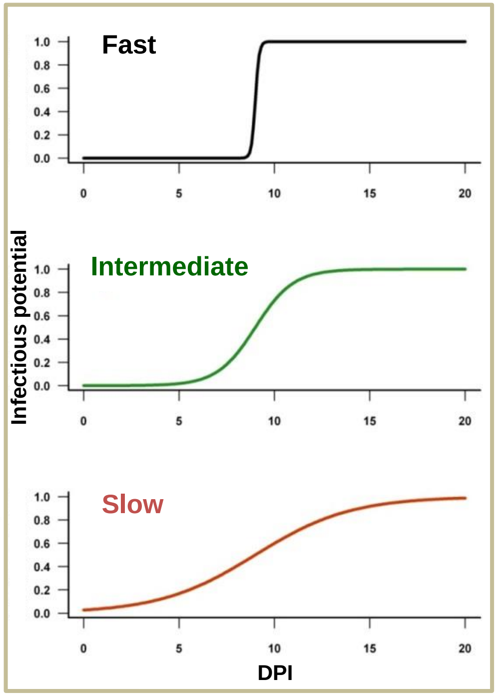
2 symptom expression dynamics to simulate the incubation period

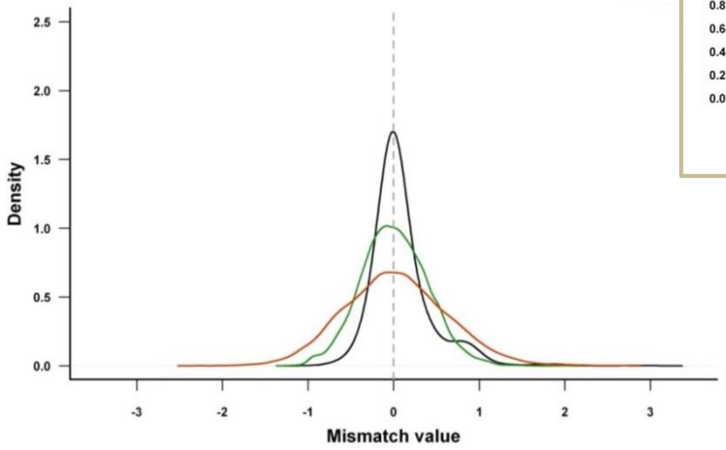


3 scenarios for the mismatch value



3 transition speeds to simulate the latency period





Unbiased and precise estimate of the mismatch

Rimbaud et al., *Acta Horticulturae*, in press.

Binomial generalized linear model

$$N_{infected} \sim B(n_{tested}, \tau)$$

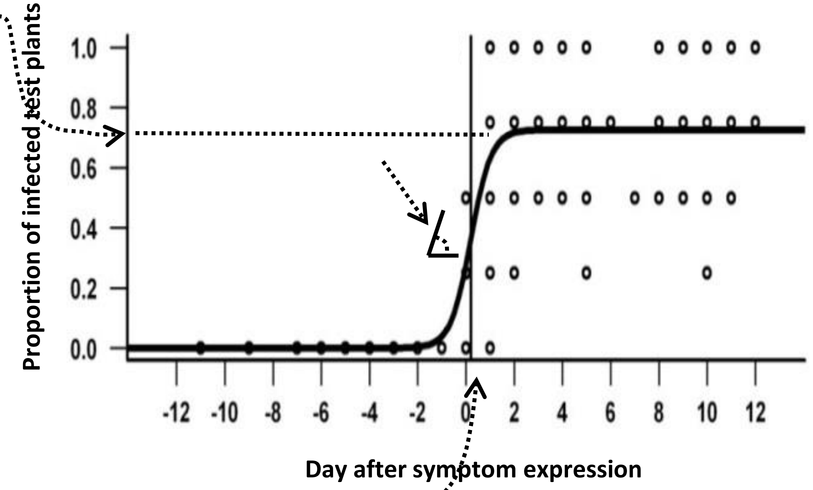
Transmission rate

$$\tau = \frac{\tau_{max}}{1 + e^{-\frac{4.s_m}{\tau_{max}}(\Delta t - m)}}$$

Maximum transmission rate
(plateau)

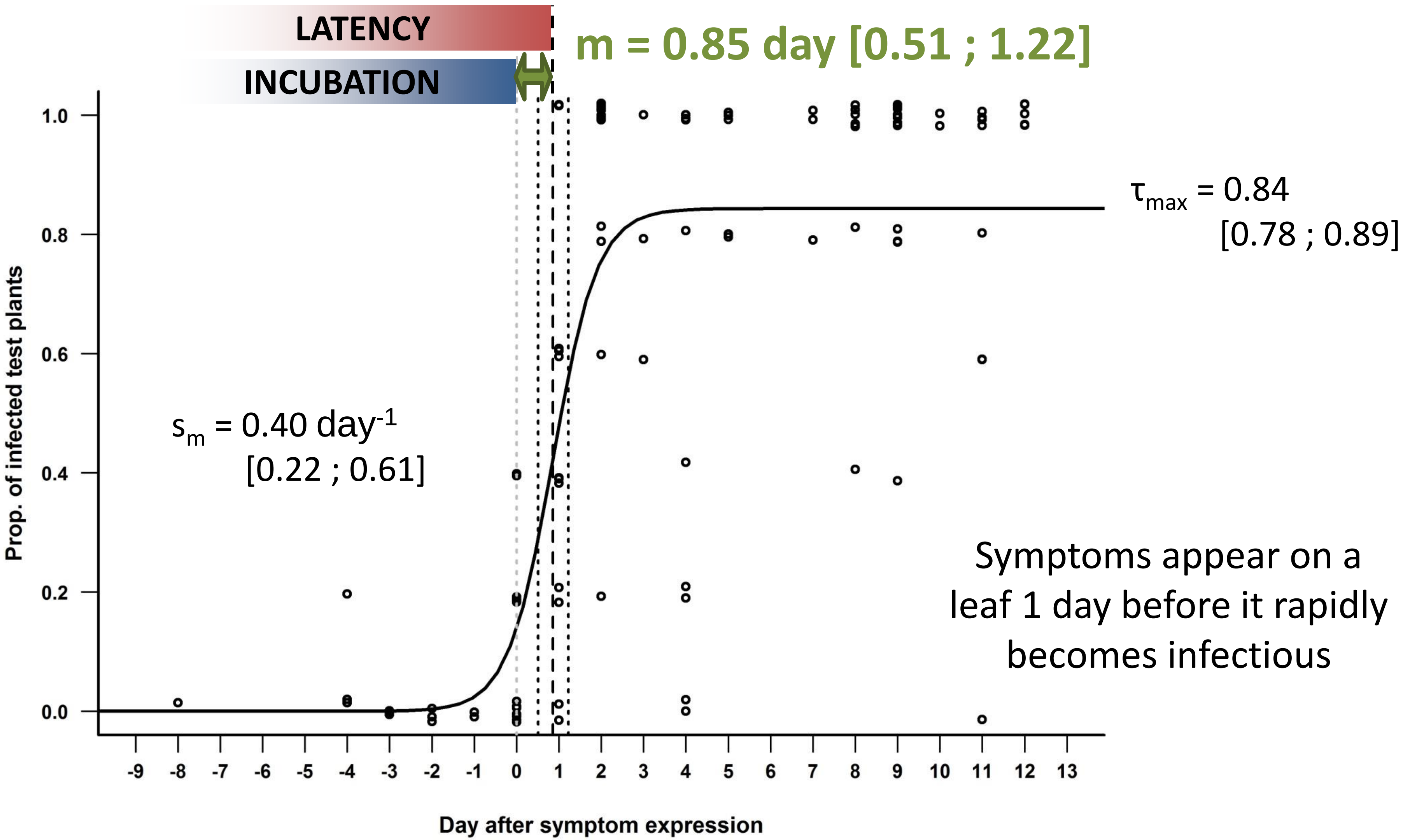
Transition speed
(slope at the inflection point)

Mismatch between incubation and latency
(abscissa of the inflection point)

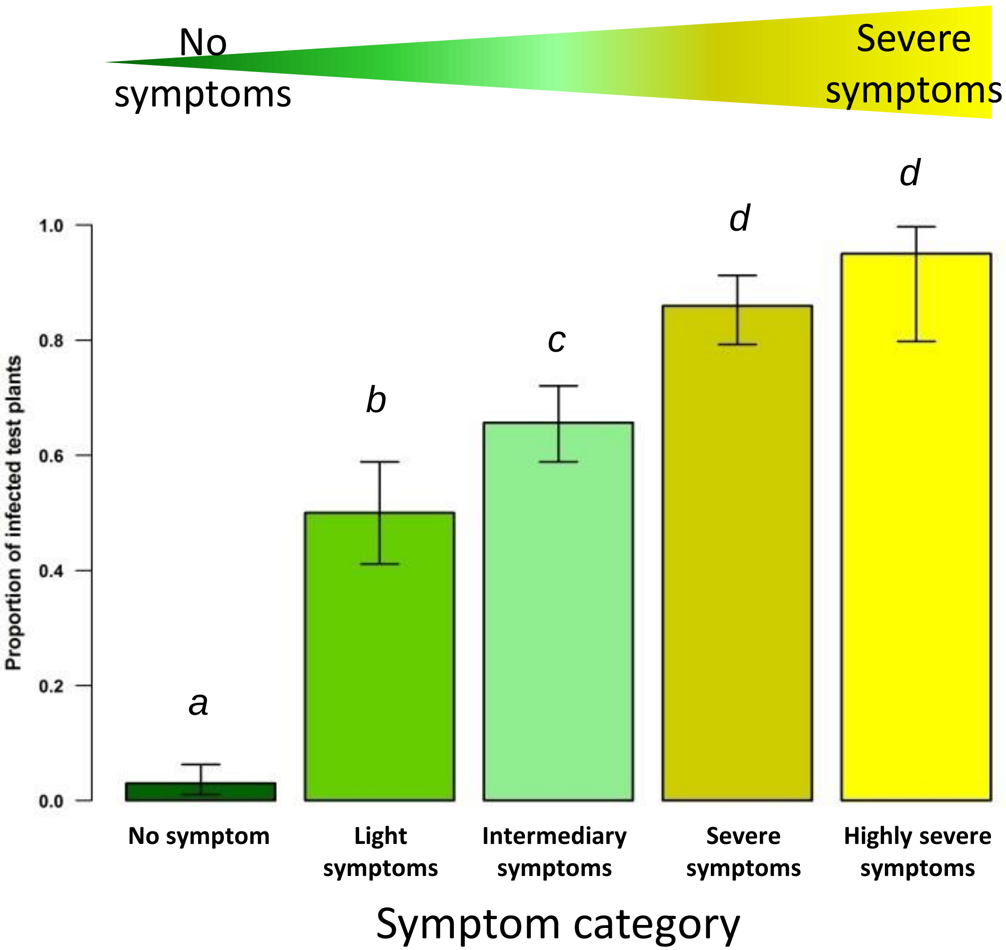


Parameters estimated by maximum likelihood

Result: a 0.85 day mismatch at the leaf scale



A correlation with symptom severity



Binomial generalized linear model:

The more severe the symptoms, the higher the transmission rate

$R^2_{McF} = 0.41$

Vertical bars: $CI_{95\%}$

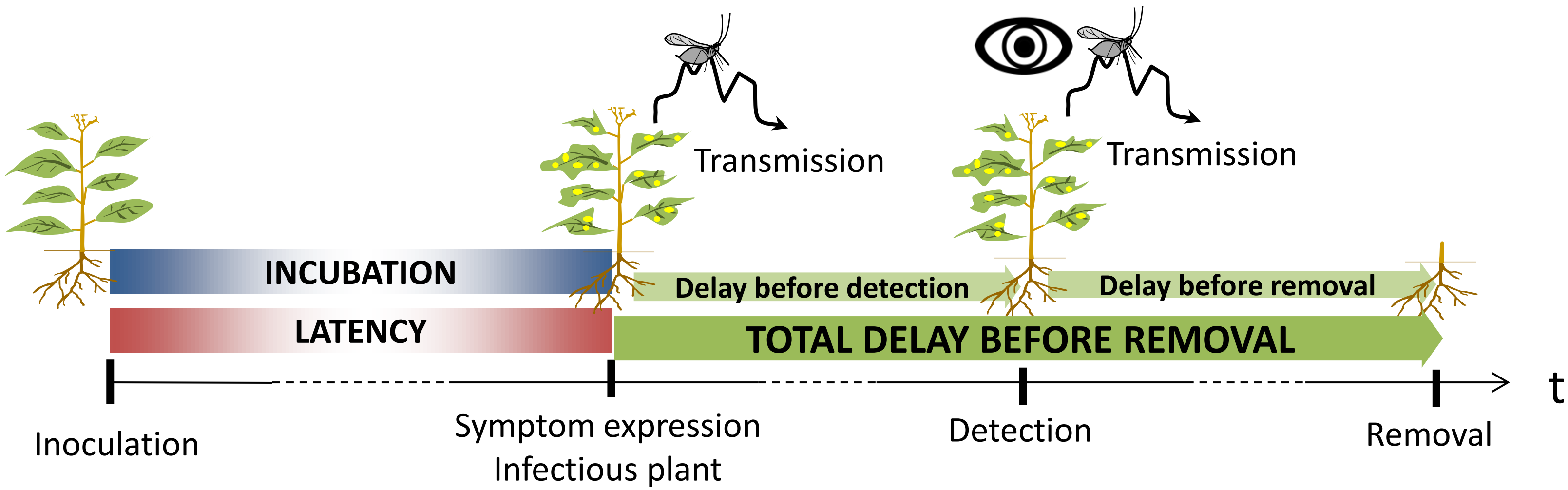
Conclusions

- A generic experimental approach has been developed to assess precisely the mismatch between incubation and latency
- Symptom severity and transmission rate are correlated
  - ✓ As suggested for *Cucumber mosaic virus* on *Cucurbita pepo* (Zitter & Gonsalves, 1990)
    Cauliflower mosaic virus on *Brassica rapa* (Doumayrou et al., 2012)
- Under our experimental conditions, latency and incubation of PPV infection of young peach plants are almost synchronized
  - ✓ Symptomatic plants are efficient sources of PPV (Manachini et al., 2004; Damsteegt et al., 2007; Moreno et al., 2009)
  - ✓ *Beet mosaic virus:* latency shorter than incubation of 1 day in *Beta vulgaris* (Dusi & Peters, 1999)

A strategy based on visual detection of plants infected by PPV could be efficient if symptoms are detected without delay?

Future works

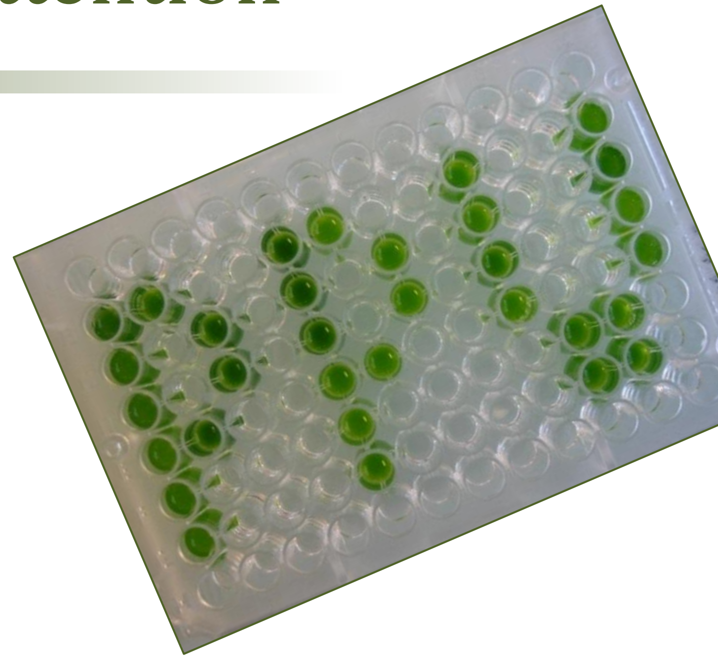
❖ Modeling the epidemiological impact of the delay between symptom expression and tree removal



❖ Development of an early diagnosis procedures

→ Detect an infection before symptom expression

Thank you for your attention



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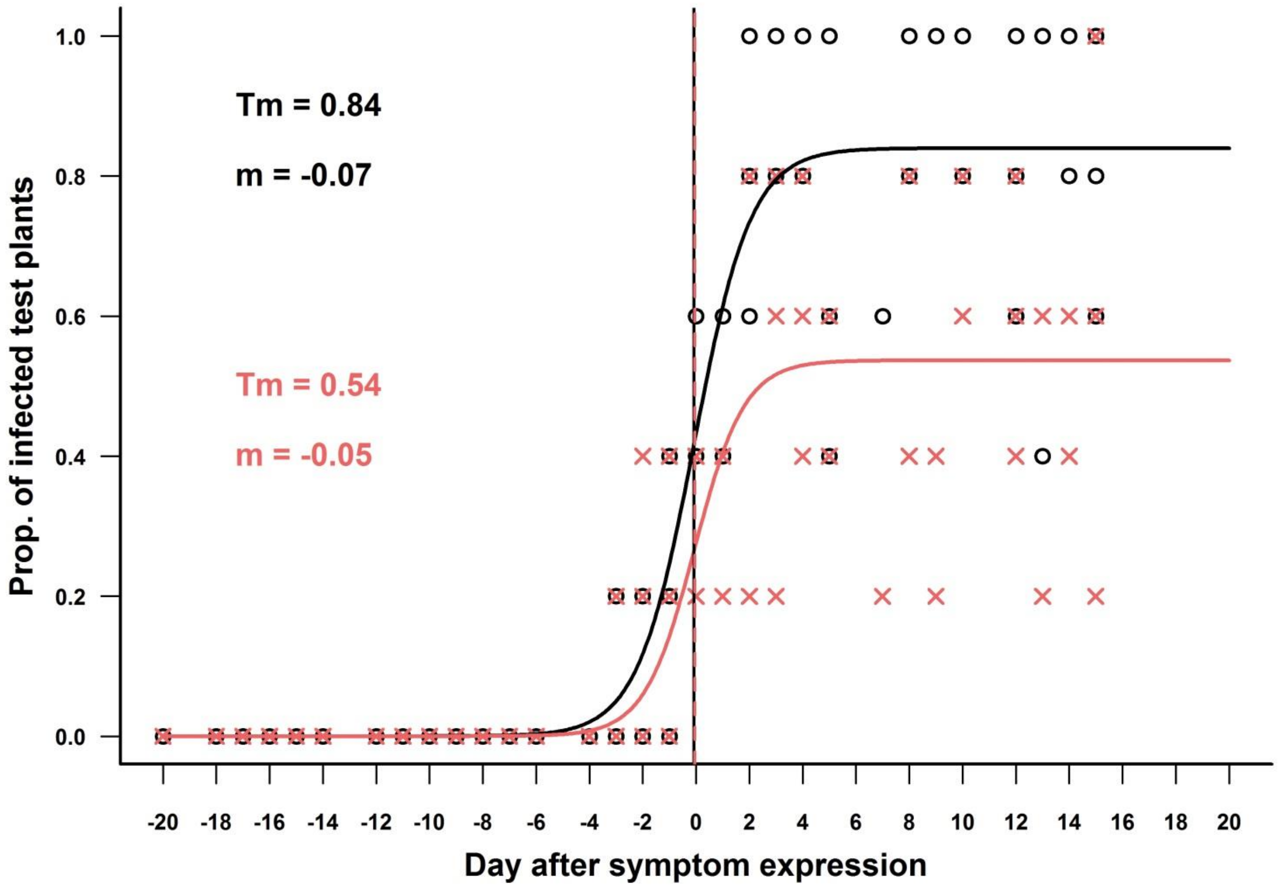
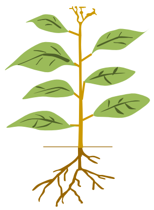
Bonus: impact of the maximum transmission rate

(simulated experiment)



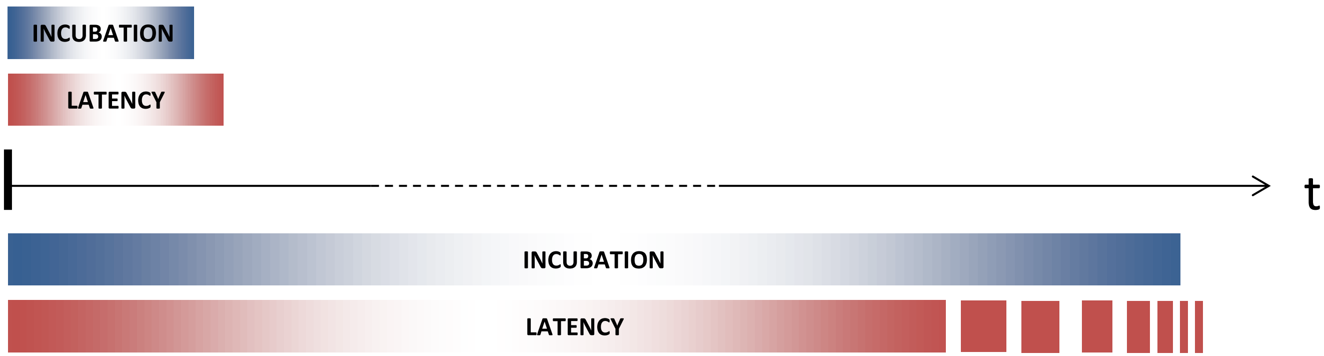
The absissa of the inflection point is a robust estimator of the mismatch between incubation and latency

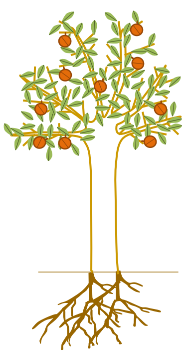
Bonus: generalization to older trees



Latency longuer than incubation by less than 1 day

t_0
Inoculation





Latency shorter or approximately equal to incubation?