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

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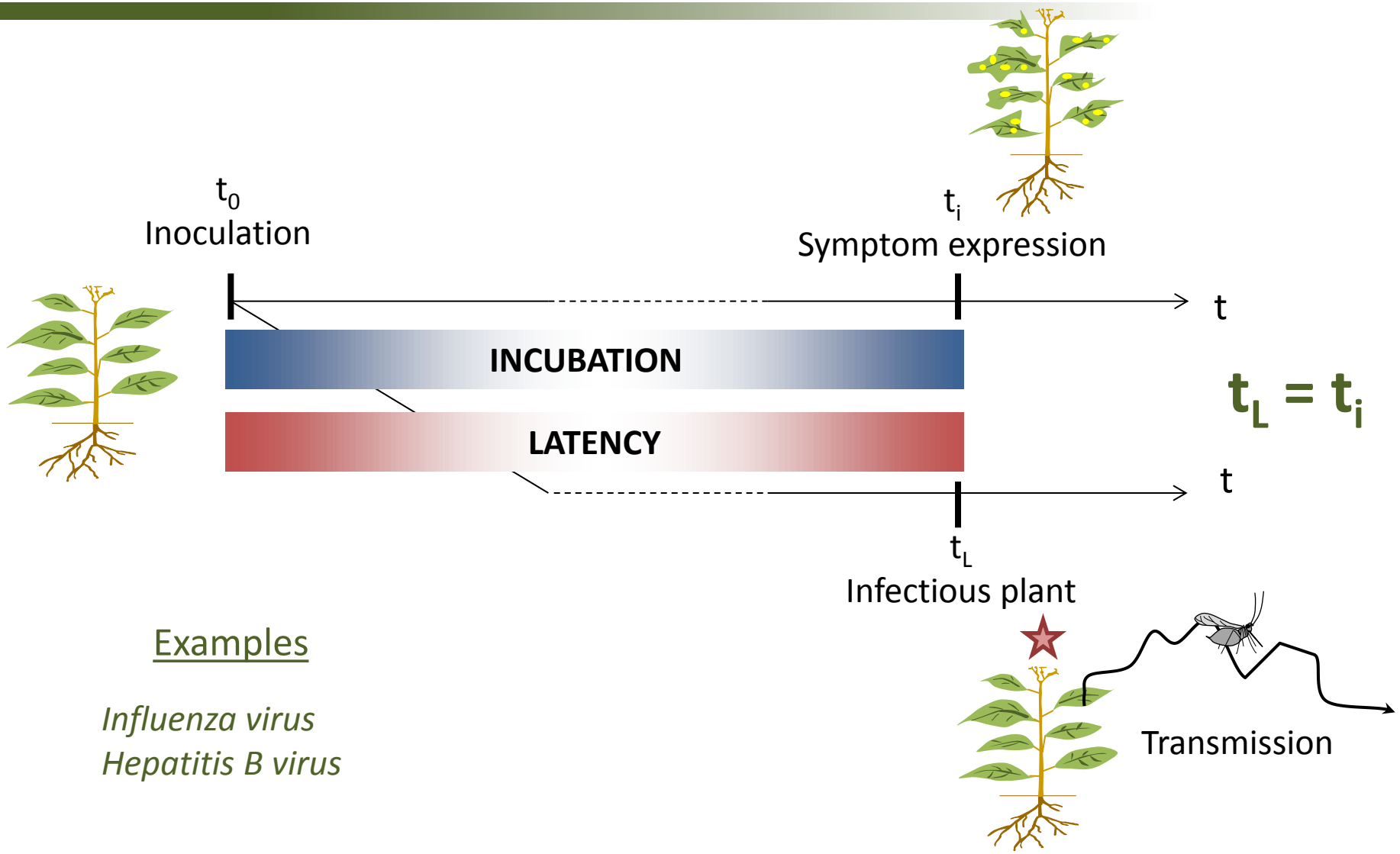
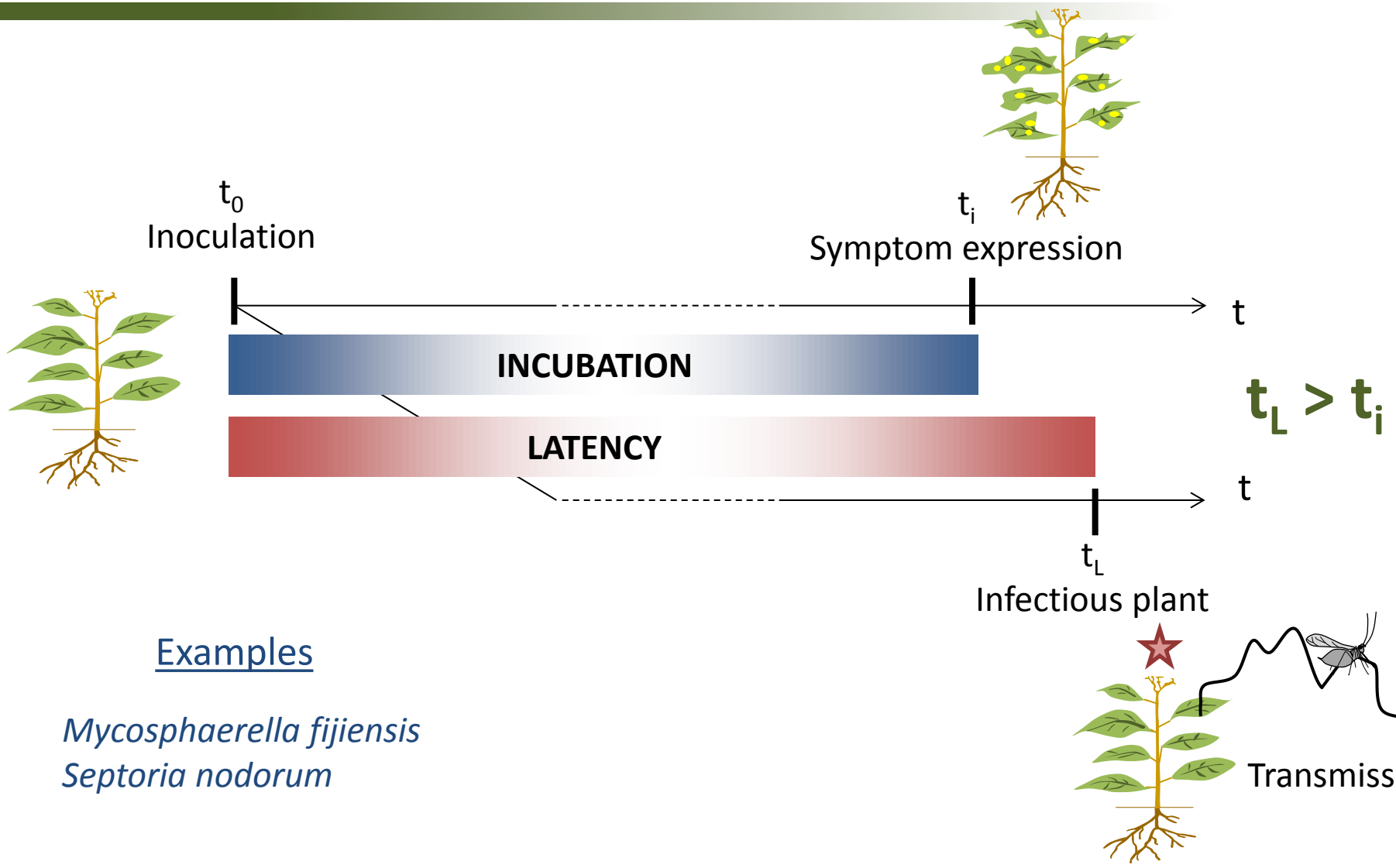
Latency *vs.* Incubation



Examples

Influenza virus
Hepatitis B virus

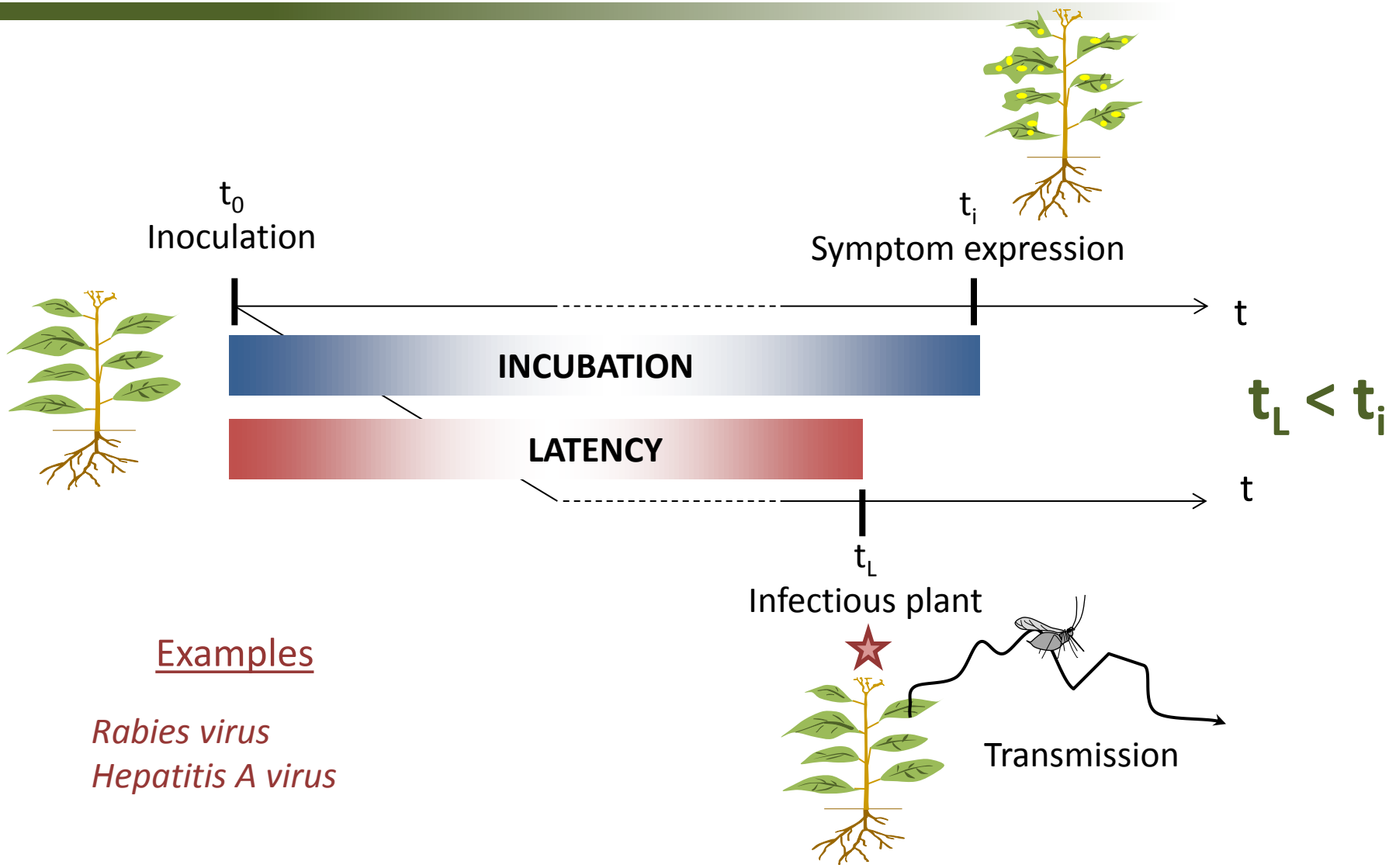
Latency *vs.* Incubation



Examples

Mycosphaerella fijiensis
Septoria nodorum

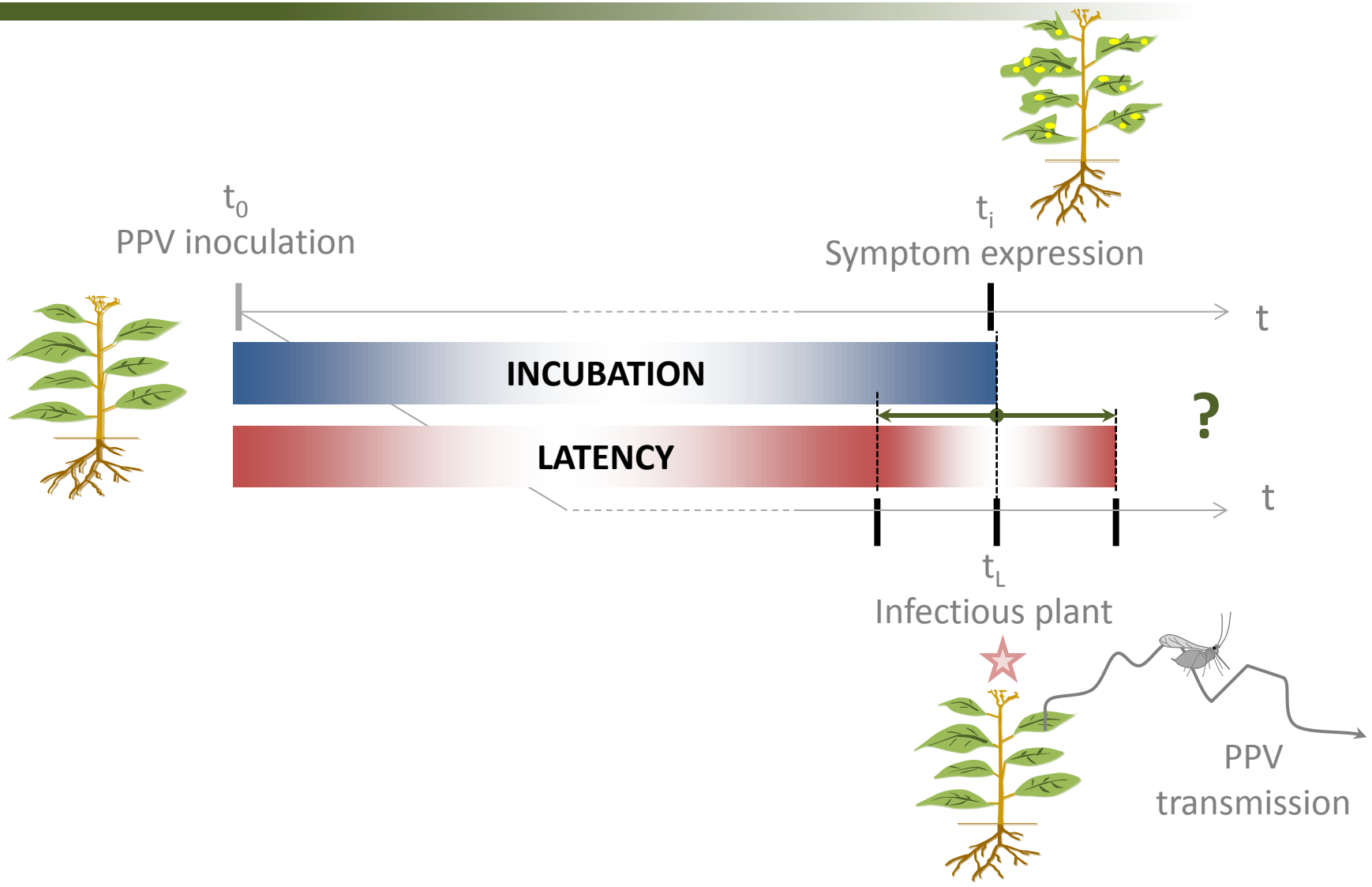
Latency *vs.* Incubation



Examples

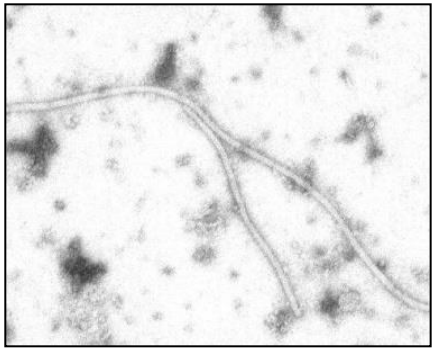
Rabies virus
Hepatitis A virus

Latency *vs.* Incubation



Plum pox virus, the causal agent of sharka disease

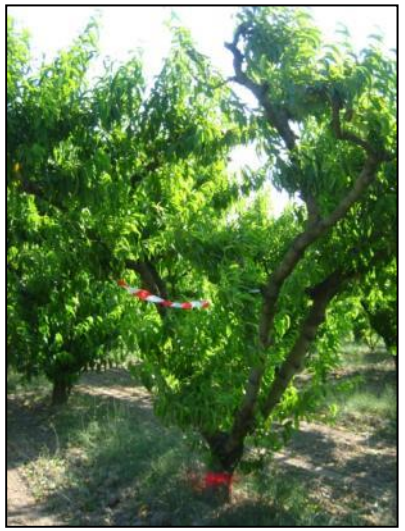
Disease	**Sharka** Most damaging disease on *Prunus* 10 billions Euros of economic losses worldwide in 30 years
Pathogen	***Plum pox virus* (PPV)** *Potyvirus*
Vectors	**Aphids**: > 20 species **Human**: transfer of infected material
Hosts of economic interest	***Prunus*** e.g.: apricot, plum and peach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



Sharka management strategy in France

Since the 1990's

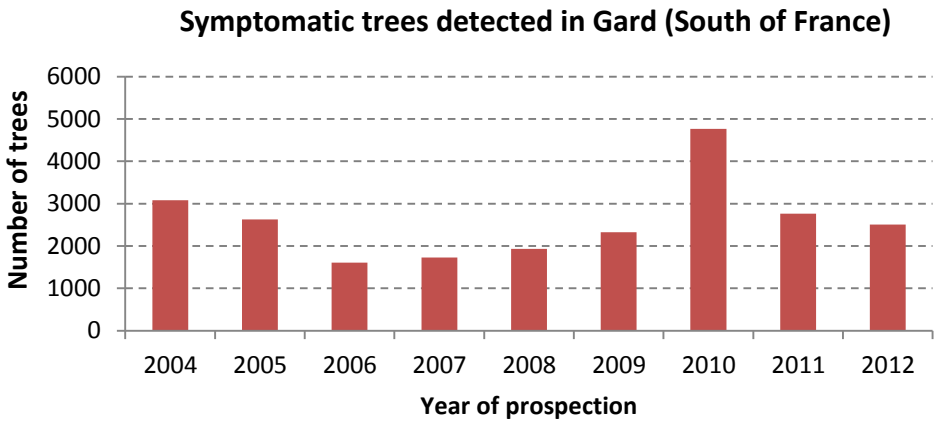
- Frequent visual inspections of the orchards
- Removal of the symptomatic trees (or whole orchards)
- Protection of the nurseries



Infected trees without symptoms cannot be detected?

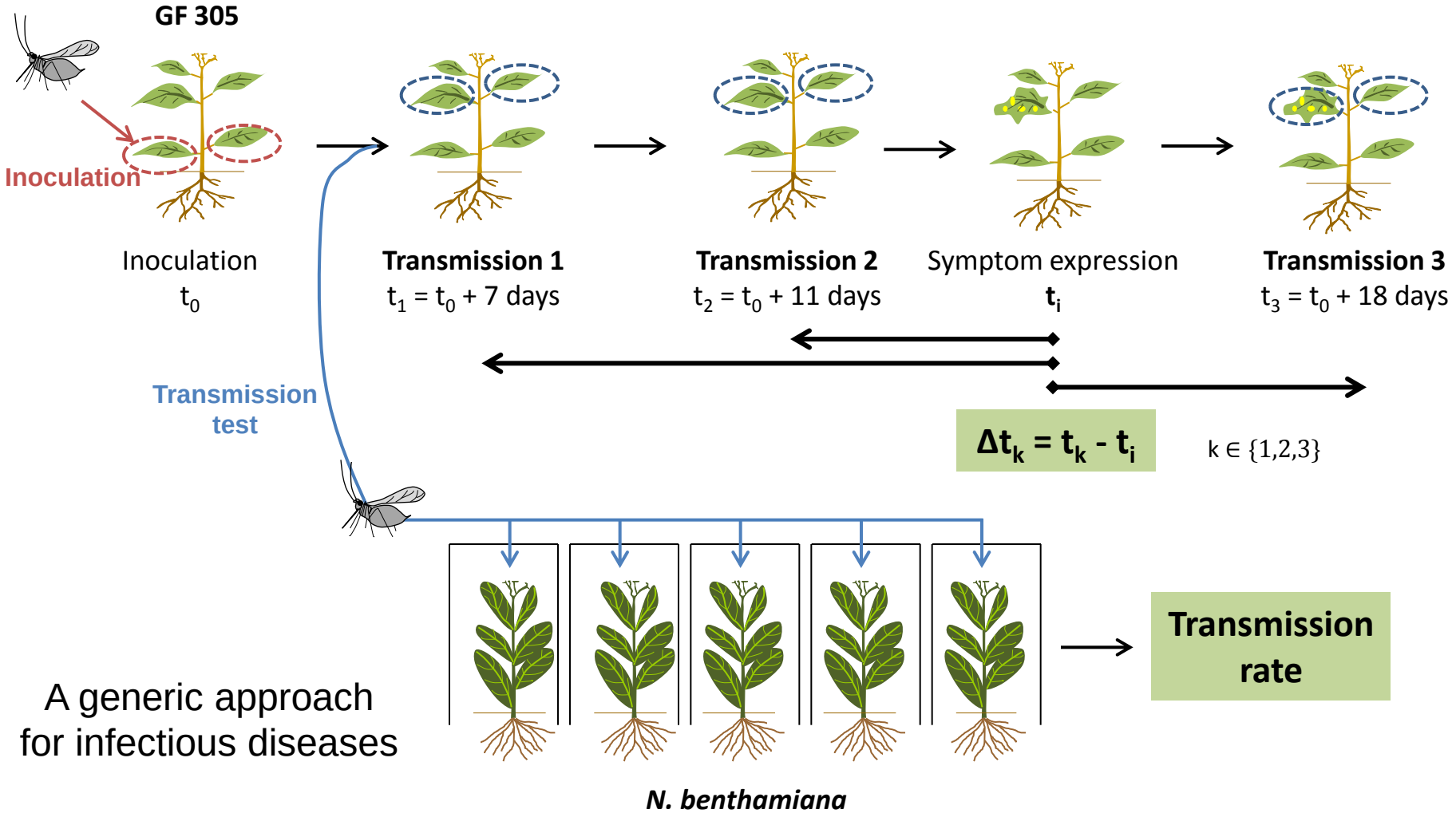
Disappointing outcomes:

- Costly strategy
- Still many trees infected each year



(Data from regional offices of French food agency)

Experimental approach



Symptom monitoring

Definition of 5 classes of leaves:

0

No symptom

1

Light symptoms

2

Intermediary symptoms

3

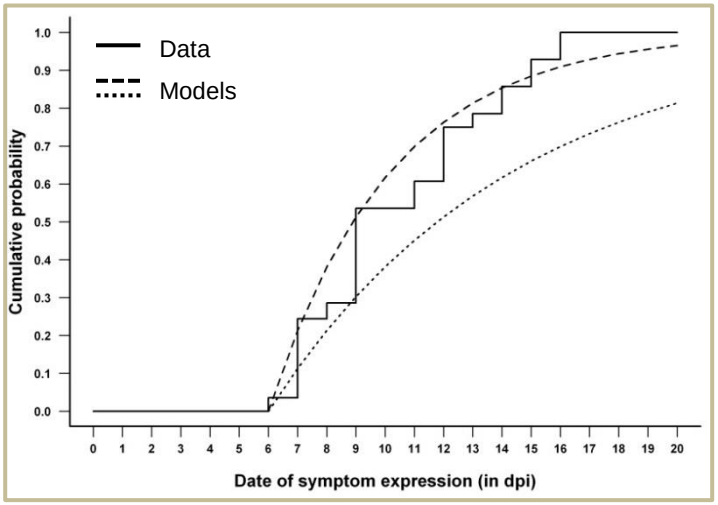
Severe symptoms

4

Highly severe symptoms

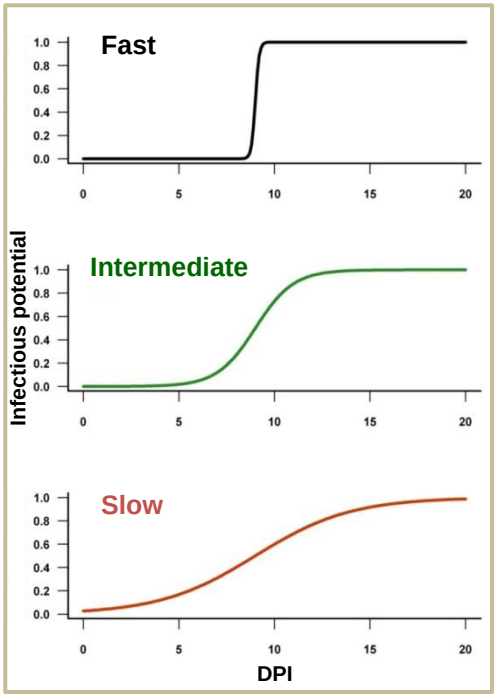
Validation of the protocol by simulation

2 symptom expression dynamics to simulate the incubation period

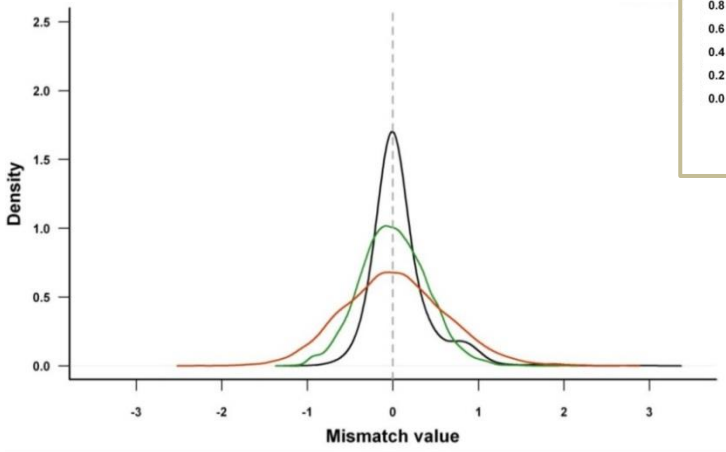


3 scenarios for the mismatch value

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

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

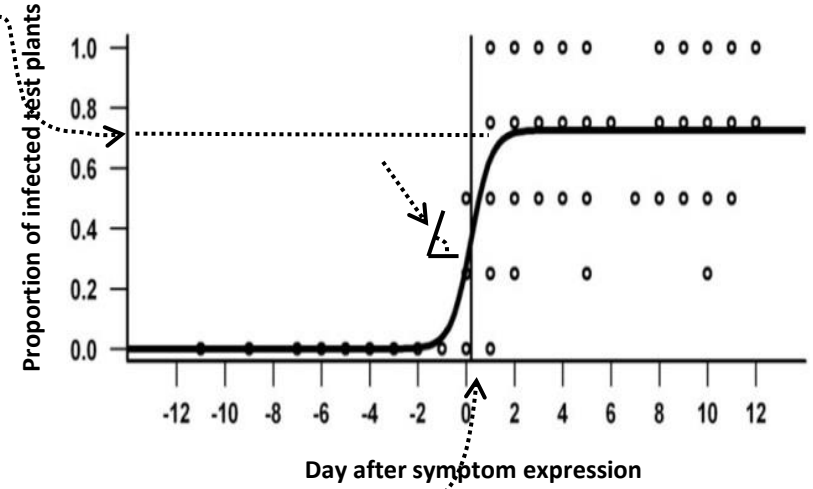
Transmission rate

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

Maximum transmission rate (plateau)

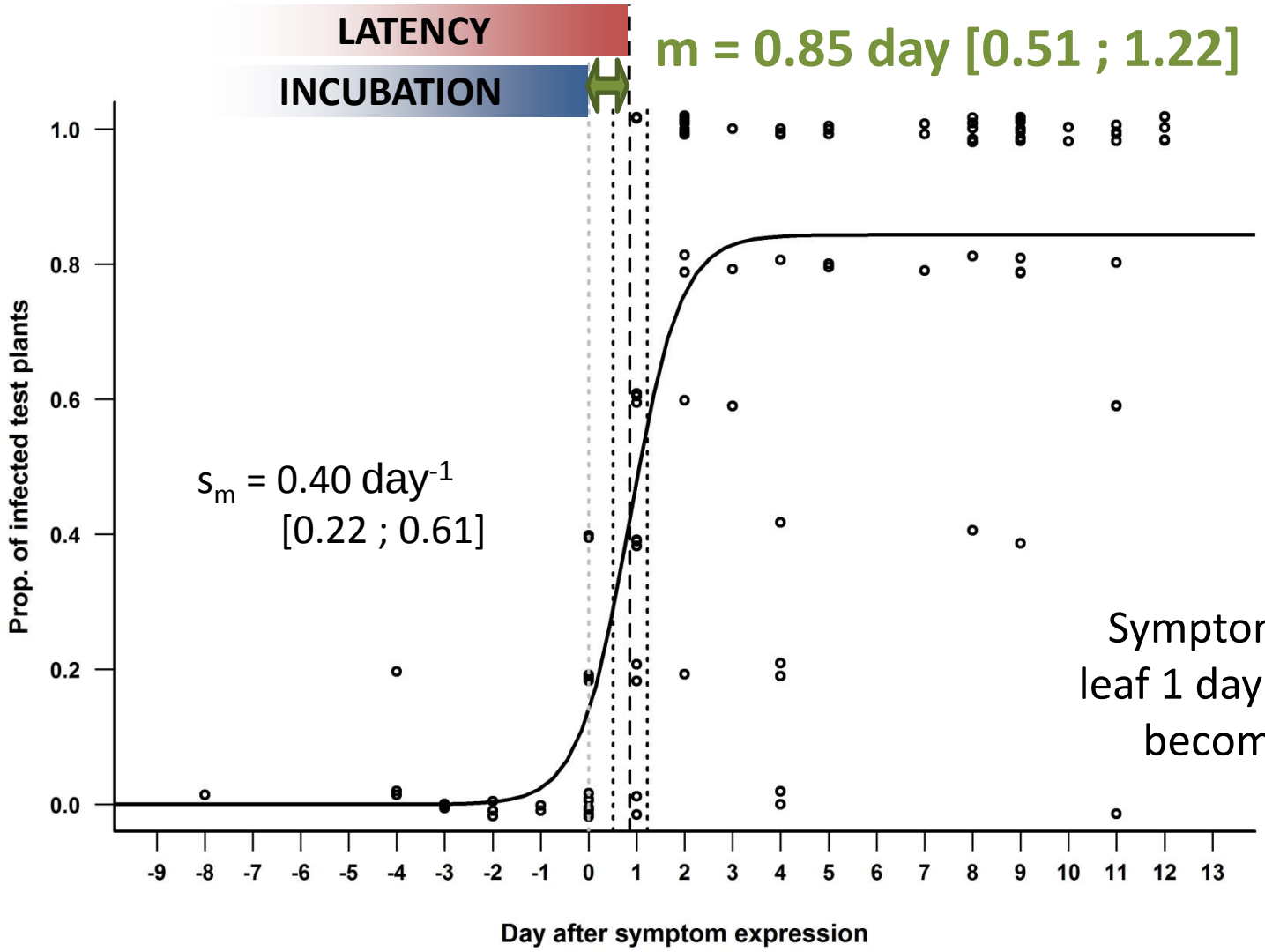
Transition speed (slope at the inflection point)

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

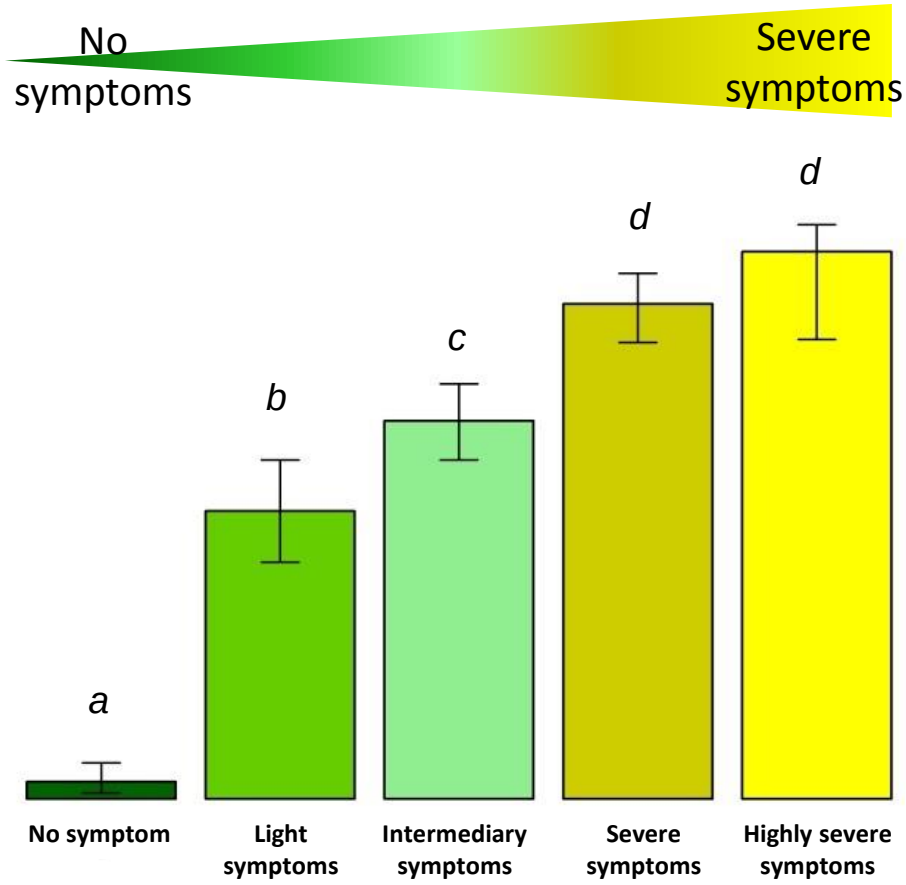


Symptoms appear on a leaf 1 day before it rapidly becomes infectious

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: $CI_{95\%}$

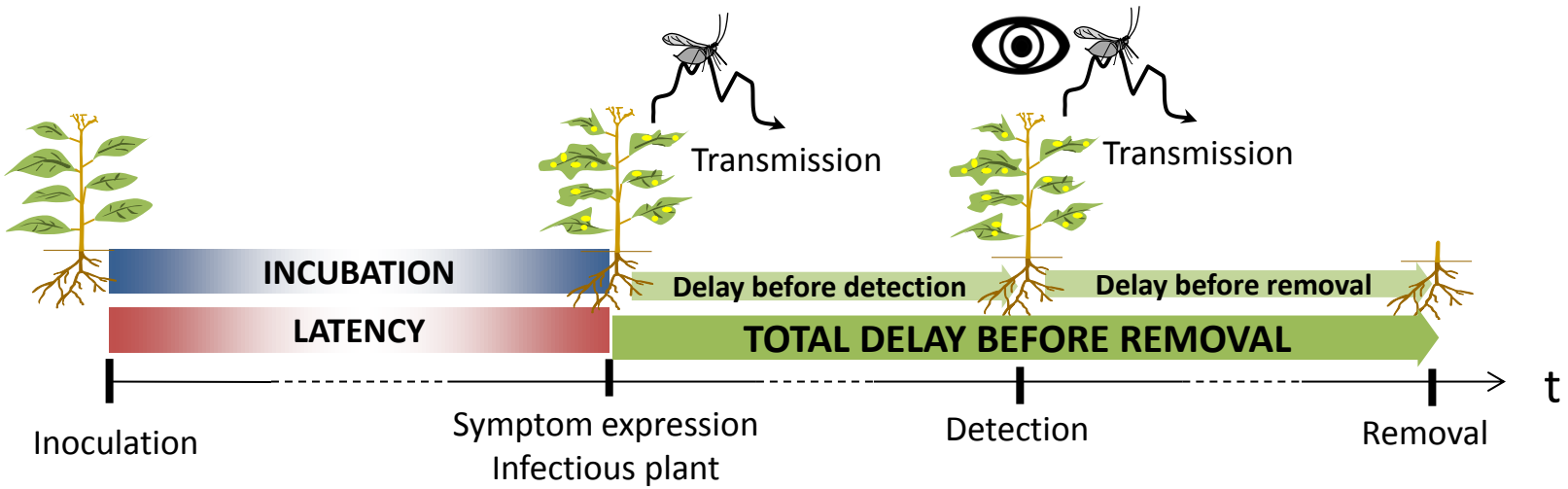
Conclusions

- 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

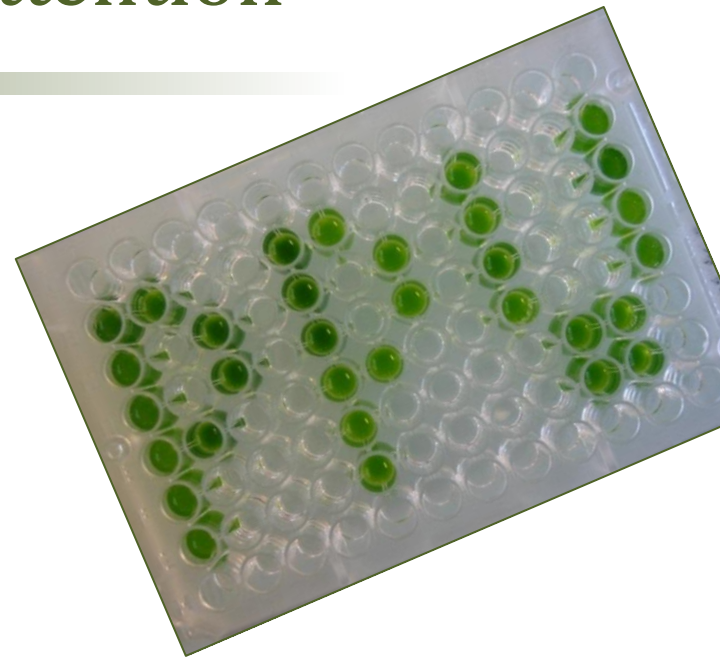
- Modeling the epidemiological impact of the delay between symptom expression and tree removal



- Development of an early diagnosis procedures

  → Detect an infection before symptom expression

Thank you for your attention



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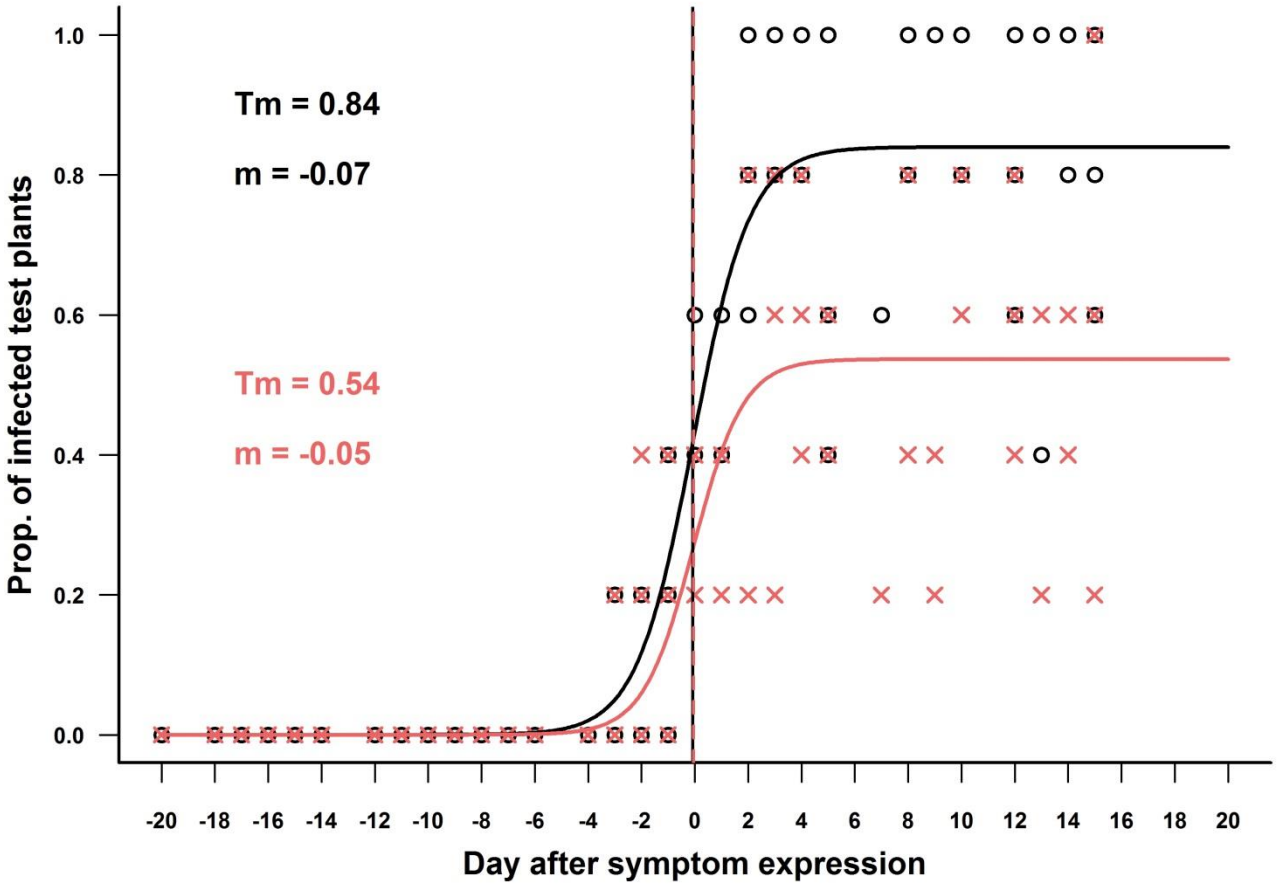
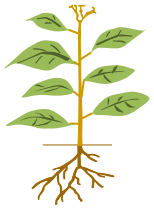
Bonus: impact of the maximum transmission rate

(simulated experiment)

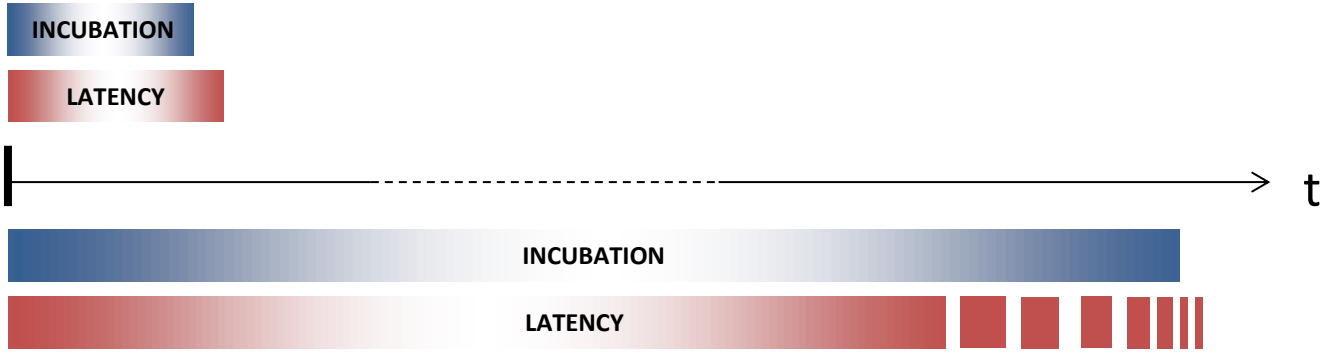


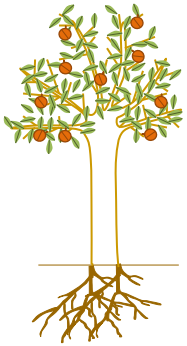
The absissa of the inflection point is a robust estimator of the mismatch between incubation and latency

Bonus: generalization to older trees



Latency longuer than incubation by less than 1 day





Latency shorter or approximately equal to incubation?