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

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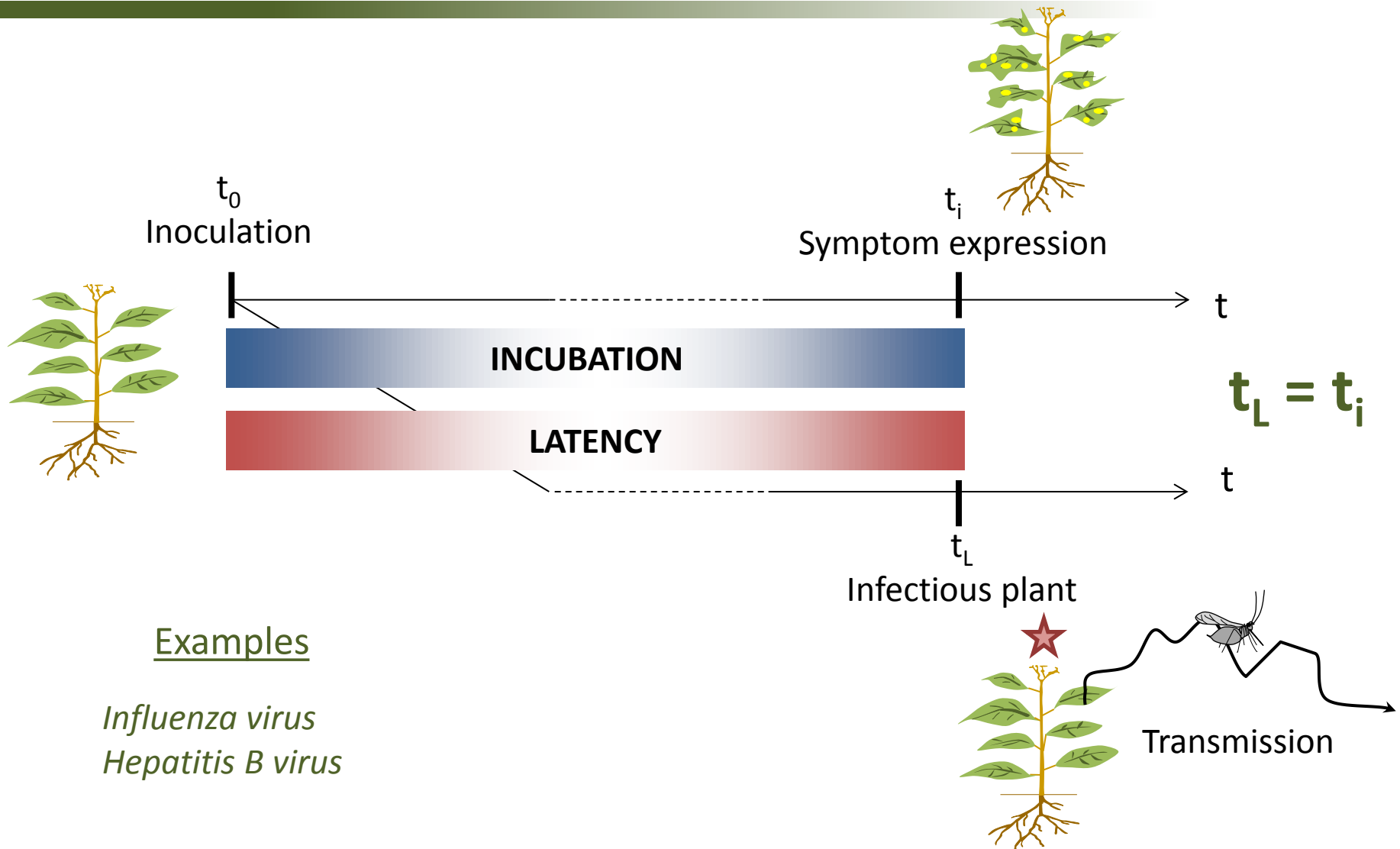
# Assessing the mismatch between incubation and latency for a vector-borne plant disease

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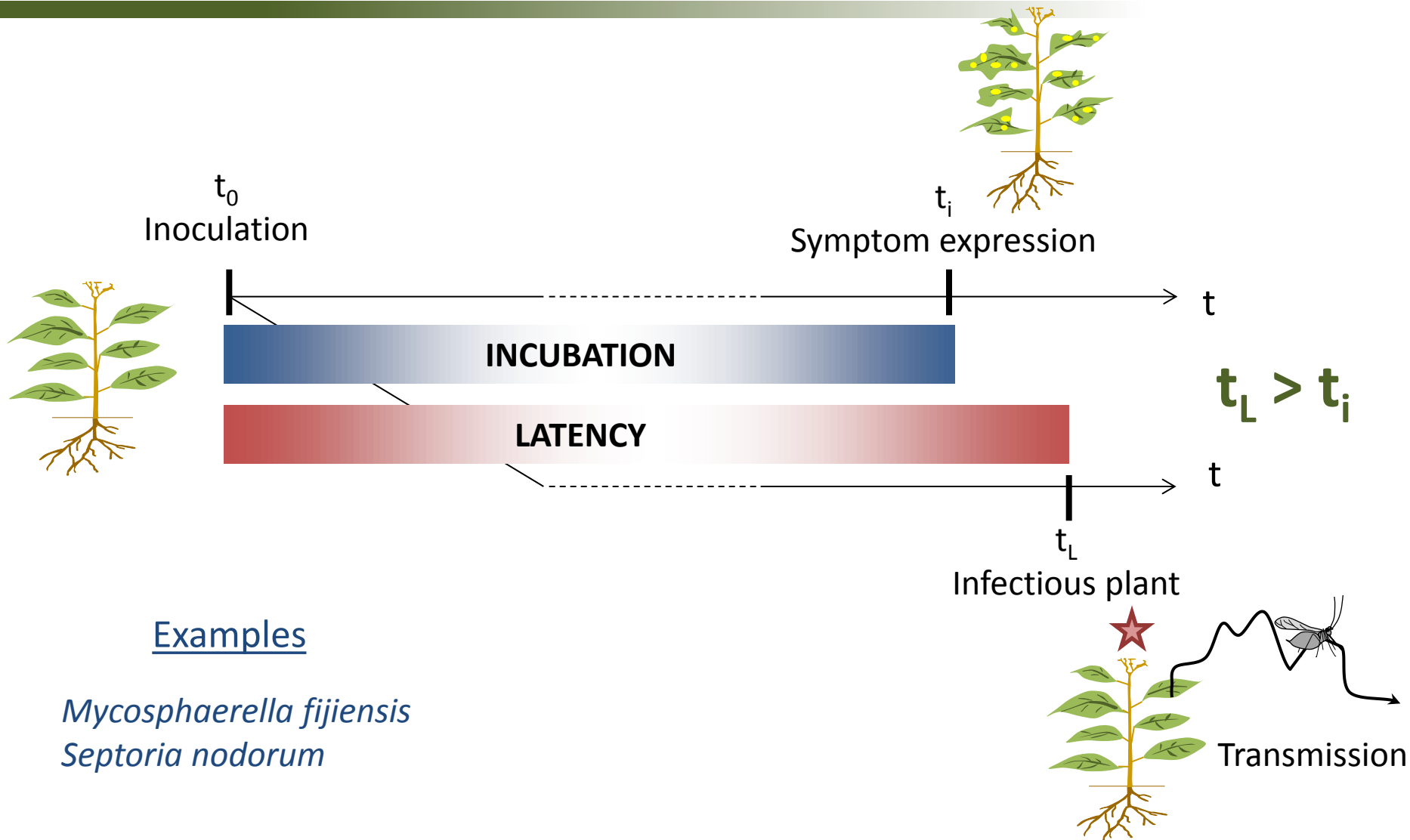
# Latency vs. Incubation



## Examples

*Influenza virus*  
*Hepatitis B virus*

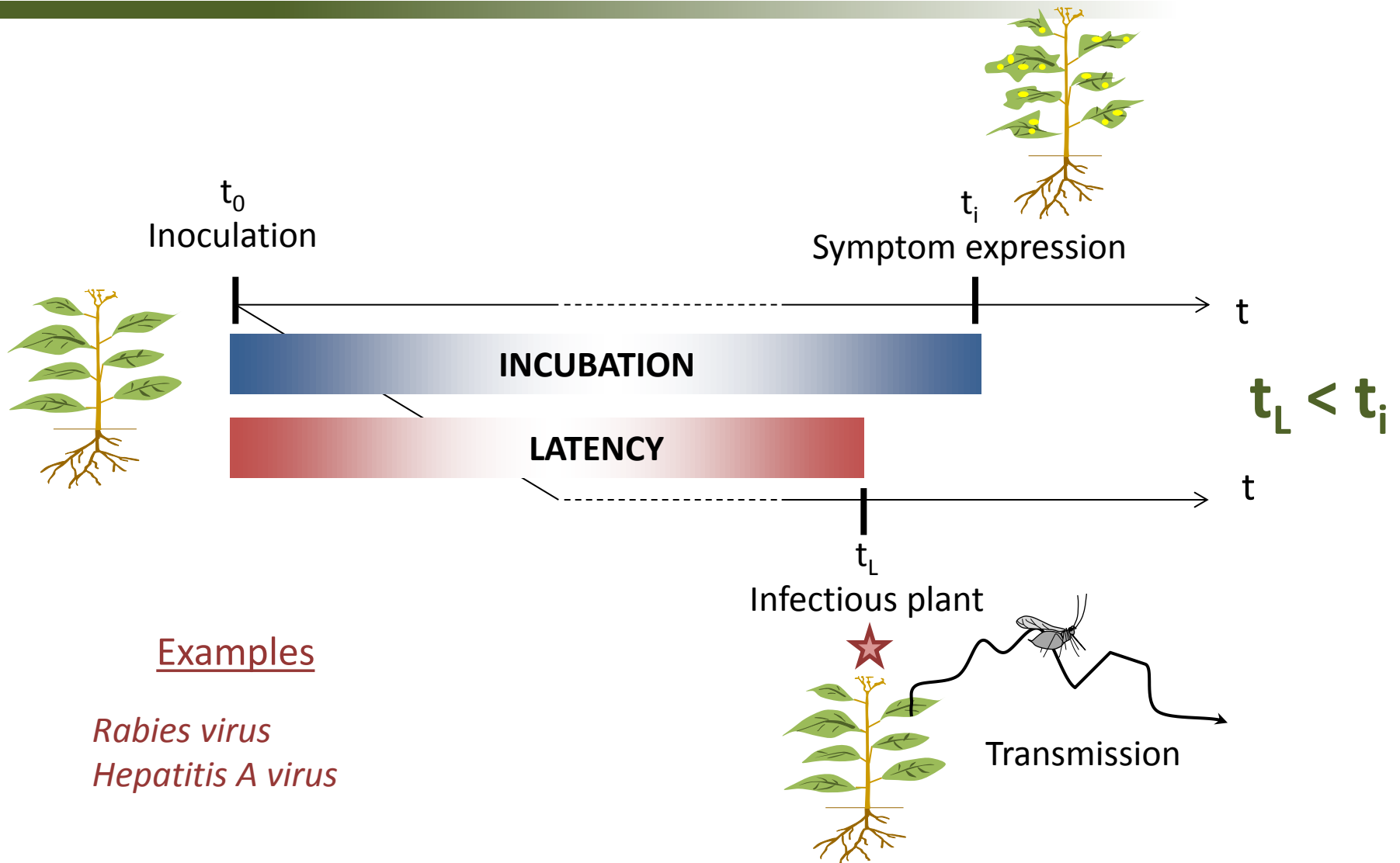
# Latency vs. Incubation



## Examples

*Mycosphaerella fijiensis*  
*Septoria nodorum*

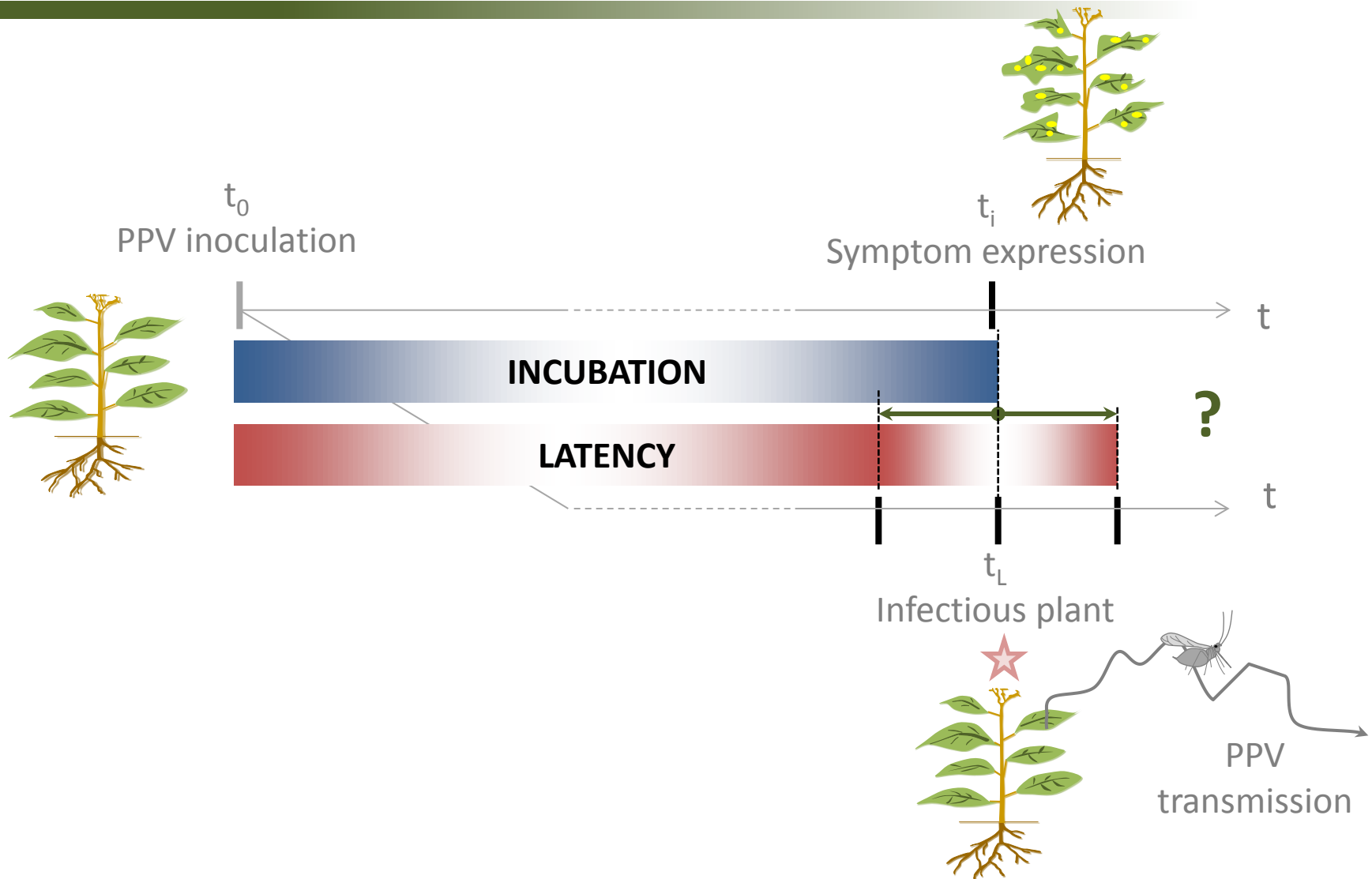
# Latency vs. Incubation



## Examples

*Rabies virus*  
*Hepatitis A virus*

# Latency vs. Incubation



# *Plum pox virus*, the causal agent of sharka disease

<b>Disease</b>	<b>Sharka</b> Most damaging disease on <i>Prunus</i> 10 billions Euros of economic losses worldwide in 30 years
<b>Pathogen</b>	<b><i>Plum pox virus (PPV)</i></b> <i>Potyvirus</i>
<b>Vectors</b>	<b>Aphids:</b> > 20 species <b>Human:</b> transfer of infected material
<b>Hosts of economic interest</b>	<b><i>Prunus</i></b> 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

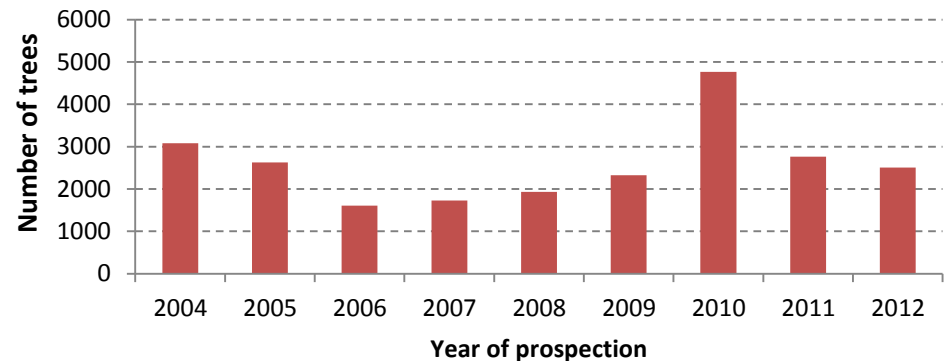


**Infected trees without symptoms  
cannot be detected?**

## Disappointing outcomes:

- Costly strategy
- Still many trees infected each year

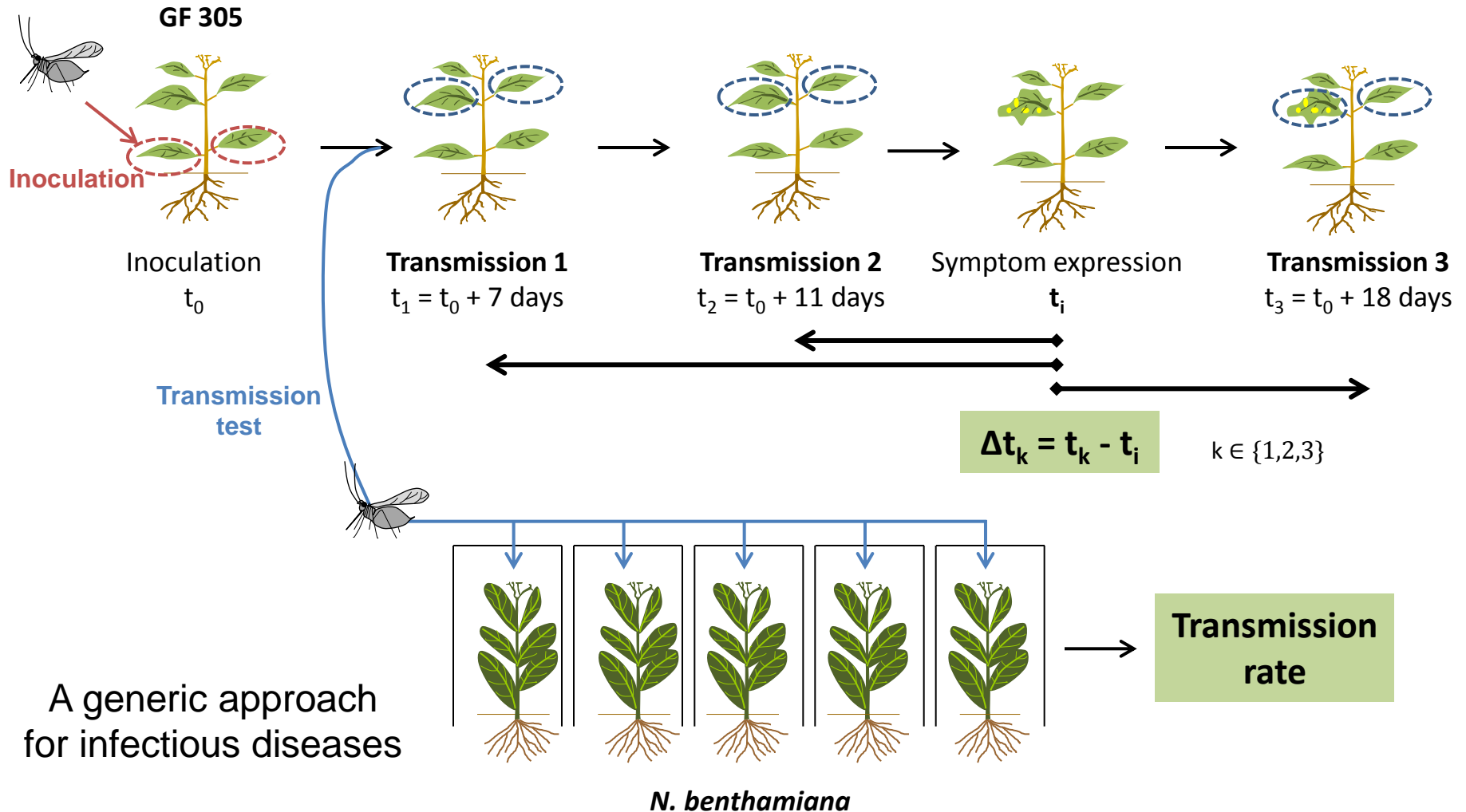
**Symptomatic trees detected in Gard (South of France)**



*(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



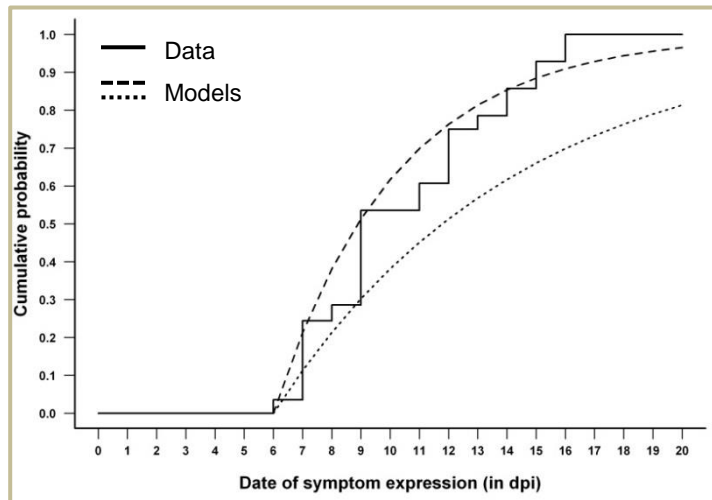
**3**  
Severe  
symptoms



**4**  
Highly severe  
symptoms

# Validation of the protocol by simulation

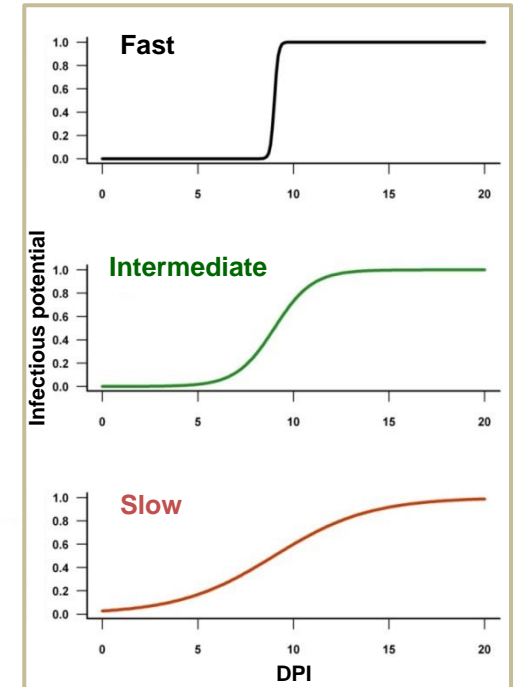
2 symptom expression dynamics to simulate the incubation period



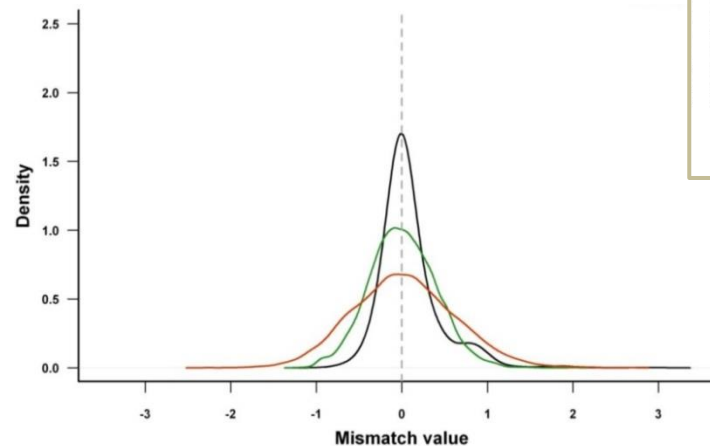
3 scenarios for the mismatch value



3 transition speeds to simulate the latency period



**Unbiased and precise estimate of the mismatch**



# Binomial generalized linear model

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

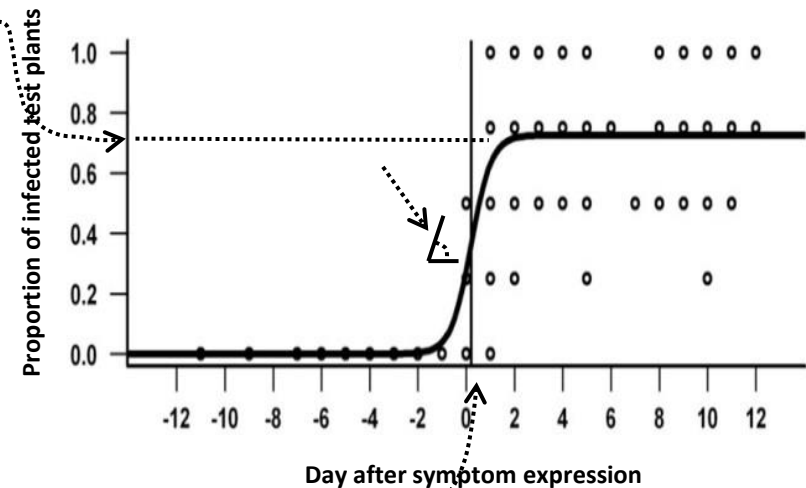
Transmission rate

**Maximum transmission rate (plateau)**

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

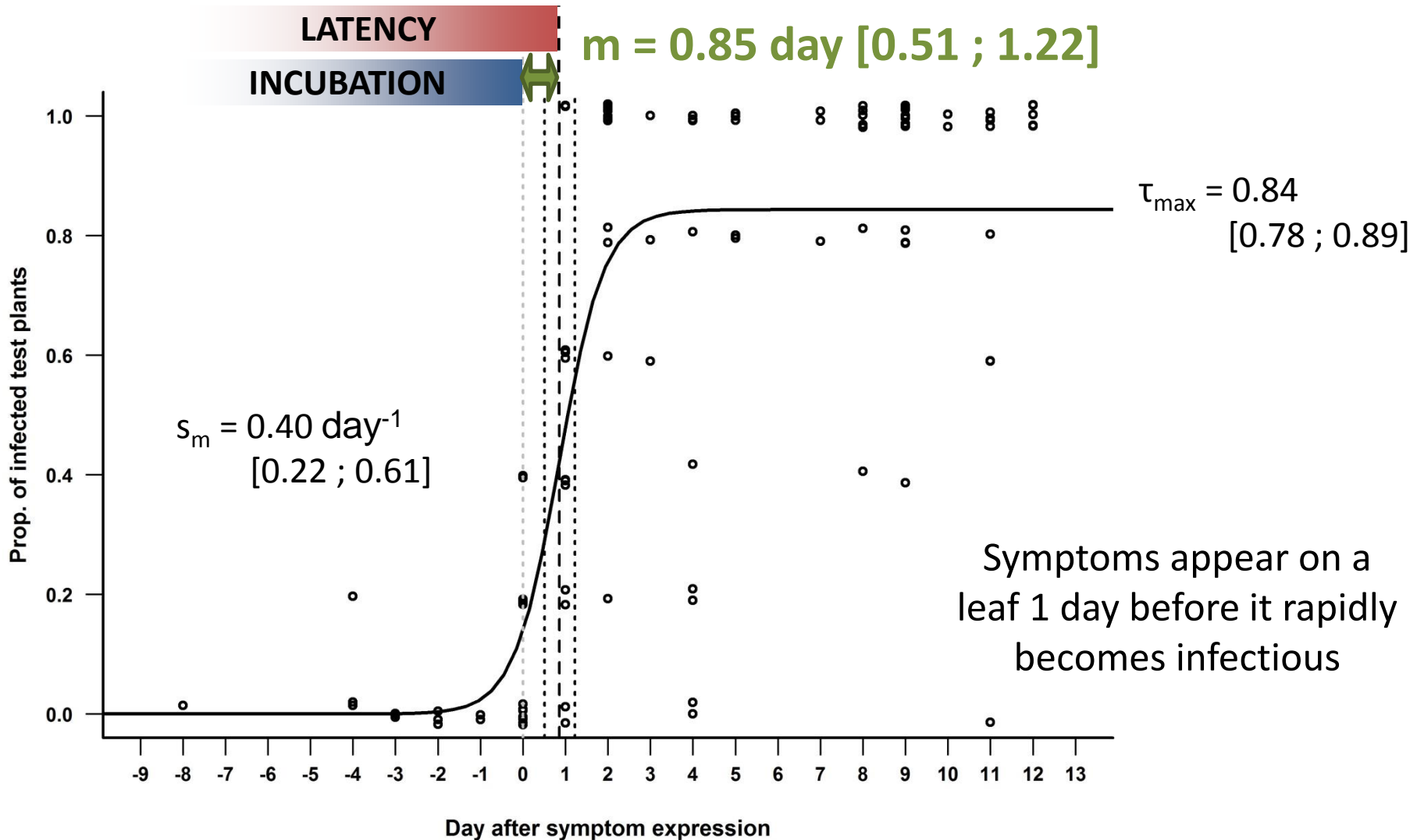
**Transition speed (slope at the inflection point)**

**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



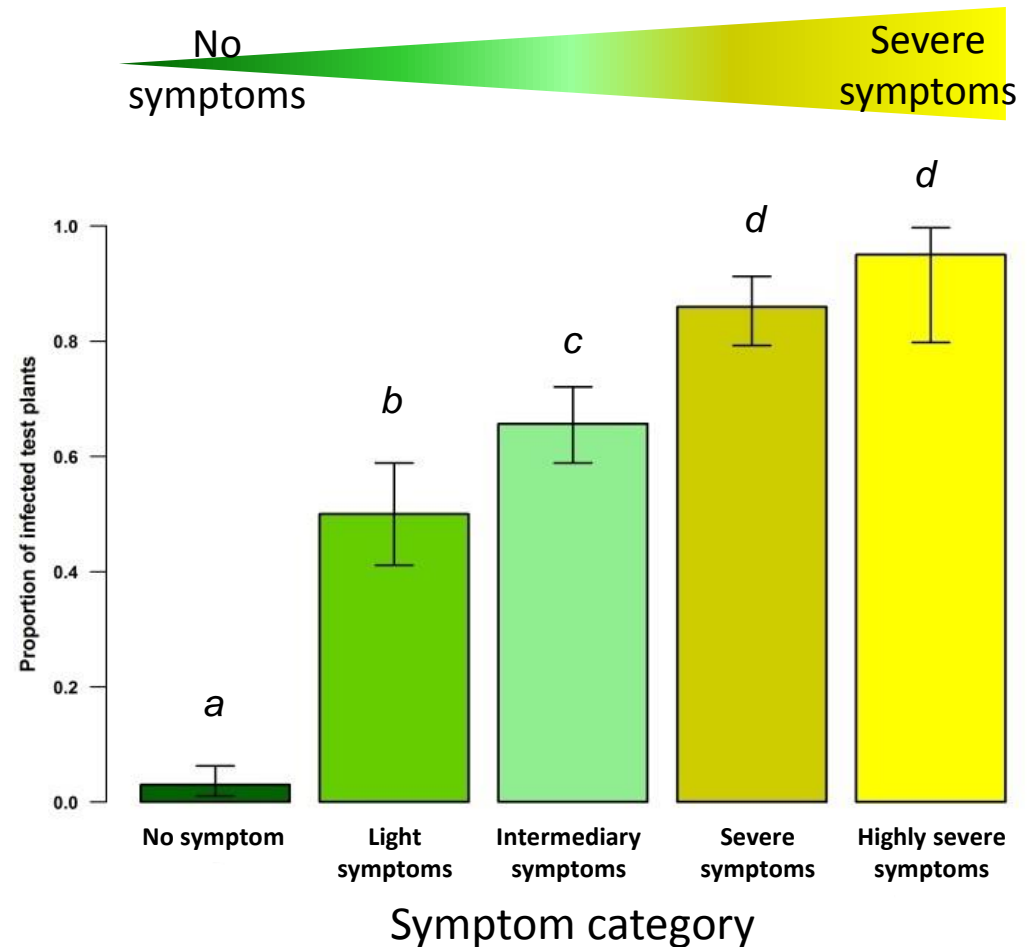
# A correlation with symptom severity

## Binomial generalized linear model:

The more severe the symptoms, the higher the transmission rate

$$R^2_{\text{McF}} = 0.41$$

Vertical bars:  $CI_{95\%}$



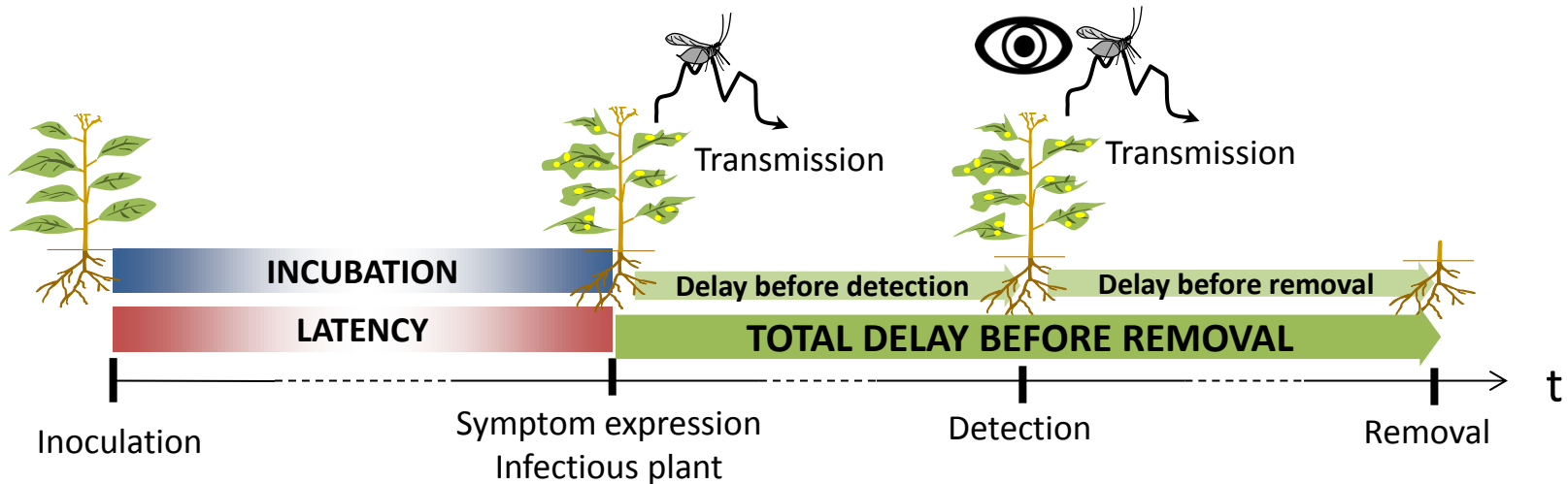
# Conclusions

- ❖ 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

## Acknowledgments:

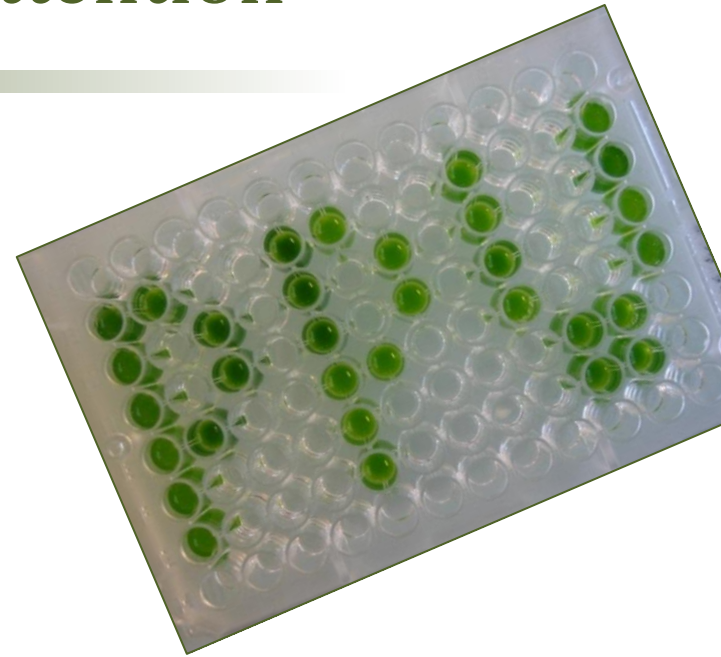
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Sonia Borron  
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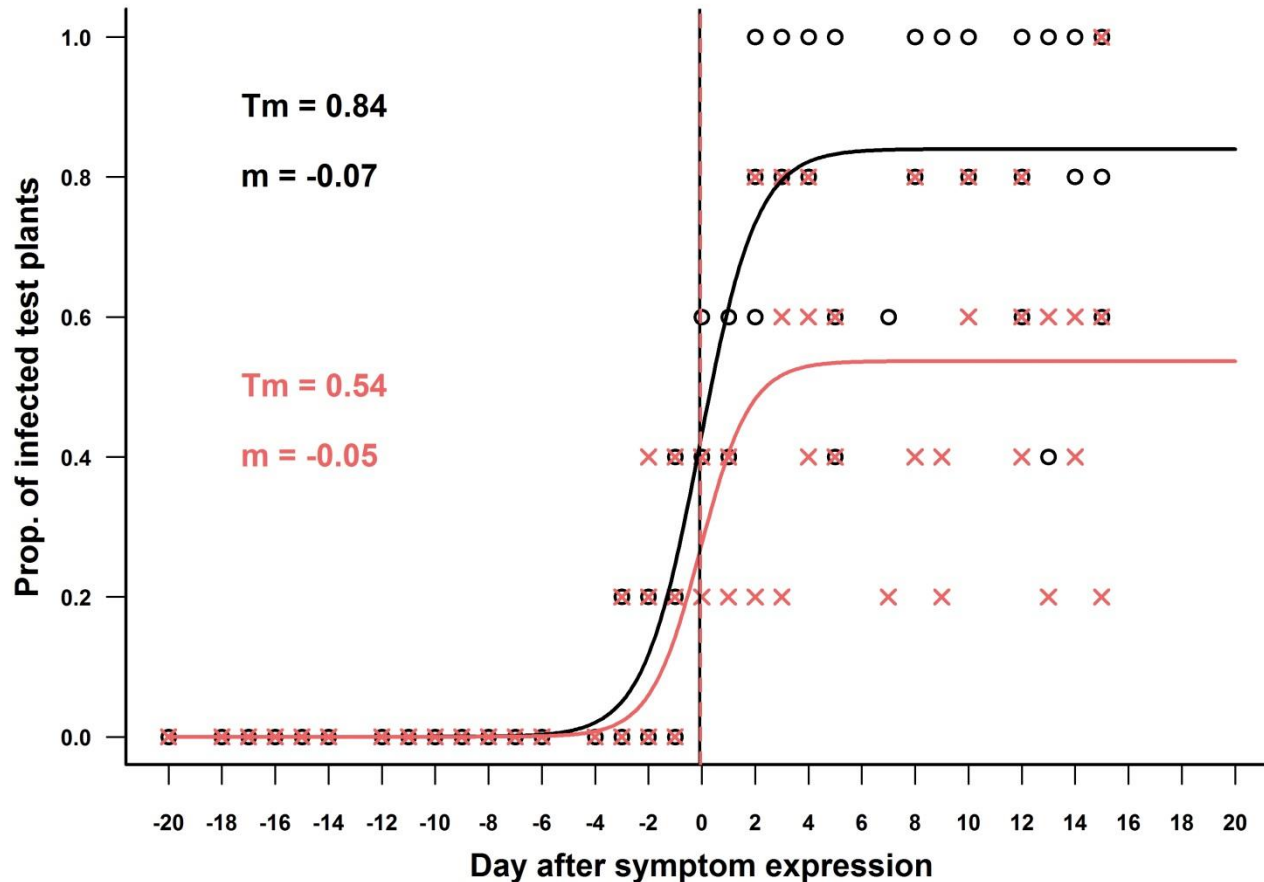
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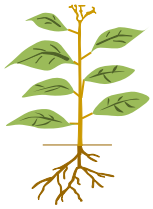
# Bonus: impact of the maximum transmission rate

(simulated experiment)



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

# Bonus: generalization to older trees

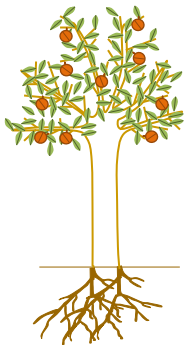
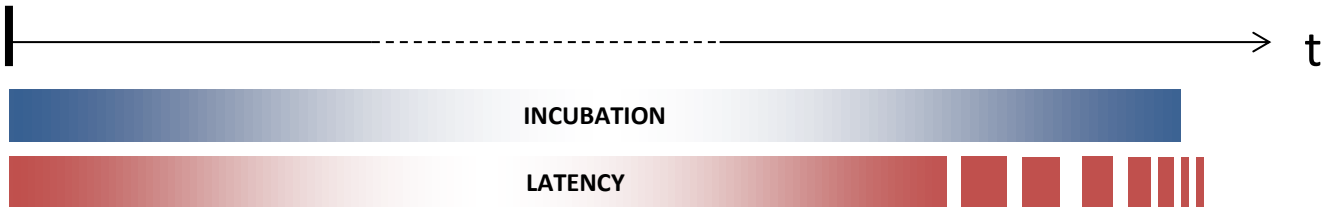


Latency longer than incubation by less than 1 day

INCUBATION

LATENCY

$t_0$   
Inoculation



Latency shorter or approximately equal to incubation?