



# *Pseudomonas syringae* pv. *actinidiae*: the bacterial canker of kiwifruit

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Costa G.<sup>1</sup> and Spinelli F.<sup>1</sup>

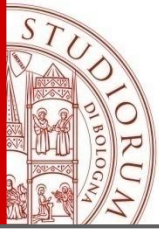
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- 2: Plant & Food Research Ruakura East Street, Hamilton, 3214, New Zealand
- 3: Università di Bologna, Dipartimento di Morfofisiologia Veterinaria e Produzioni Animali, Via Tolara di Sopra, 50 Ozzano Dell'Emilia, Bologna, Italy

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Plant & Food RESEARCH  
RANGAHAU AHUMĀRA KAI





# History of the disease

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- 1984 - Takikawa first isolation on Hayward plants in Japan
- 1989 - First taxonomical classification as a new subspecies *Pseudomonas syringae* pv *actinidiae*
- 1992 - First outbreak in Korea
- 1992 - First isolation in Italy (Latina area)
- 1992 - 2008 Serious outbreak in Italy
- 2008 - First record of infection on *A. chinensis*
- 2009 - Spread of the disease to the major growing areas in Italy and serious economical damages
- 2010 - First occurrence in New Zealand

# The economical impact

- Before Psa



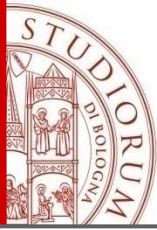
- After Psa



Kiwifruits are economically important crops which are grown in several EU countries (by order of importance in production: Italy, Greece, France, Portugal and Spain). In Japan and Korea, bacterial canker has become one of the **most serious limiting factors for cultivating kiwifruit**. In Italy, it is estimated that the economic due to *P. syringae* pv. *actinidiae* have reached **2,000,000 €**.

# Diffusion in Italy

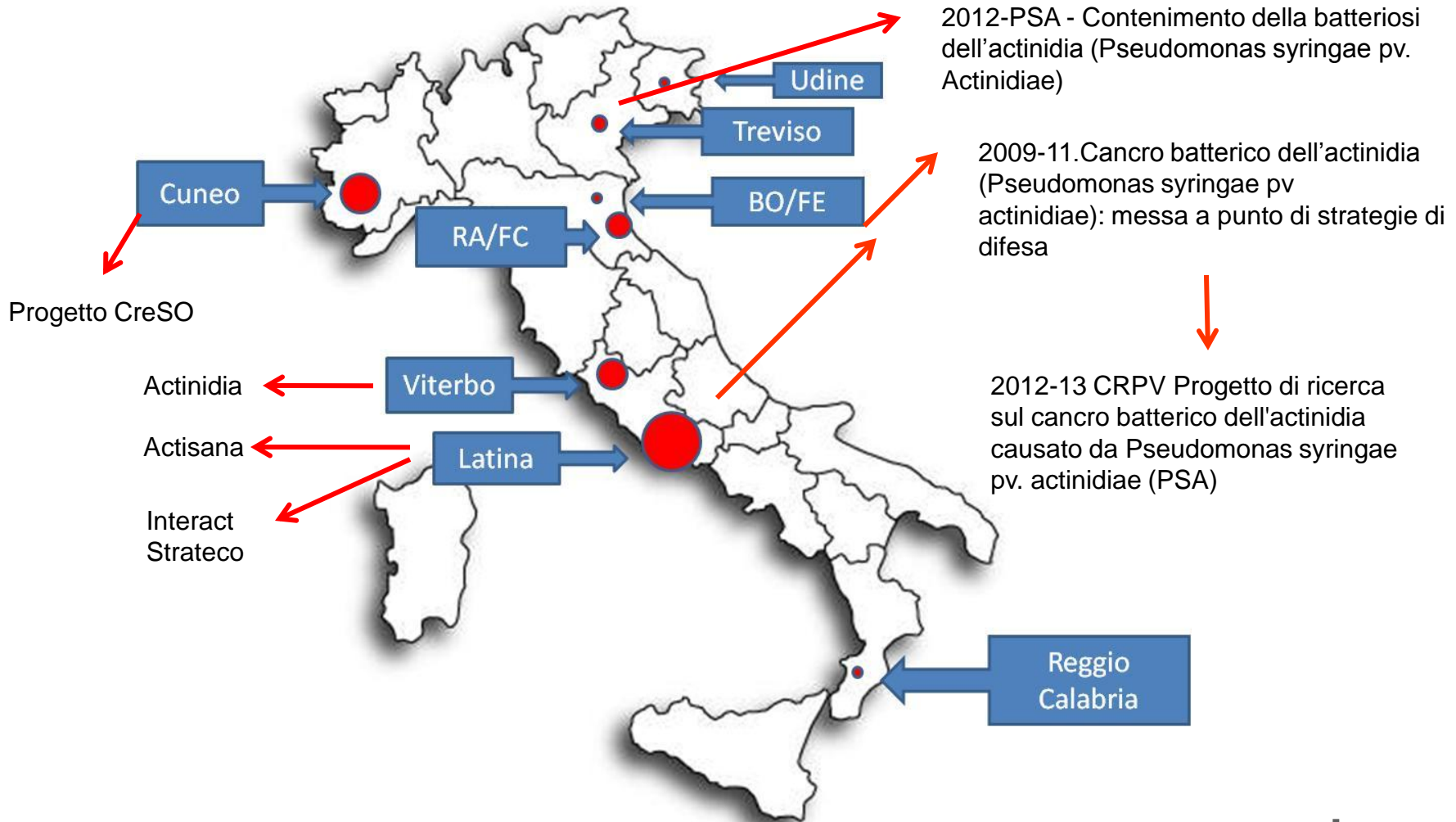




# Unsolved questions

- Epidemiology: how does Psa infect the plant?
- Epidemiology: how does the disease spread?
- Epidemiology: how do the environmental factors affect the disease development?
- Plant-pathogen interactions: which is the bacterial arsenal to hijack plant defences?
- Plant-pathogen interactions: how does the plant react to Psa?
- How can Psa be diagnosed?
- How can the disease be monitored?
- How can the diffusion of Psa be prevented?
- How can the disease be controlled?

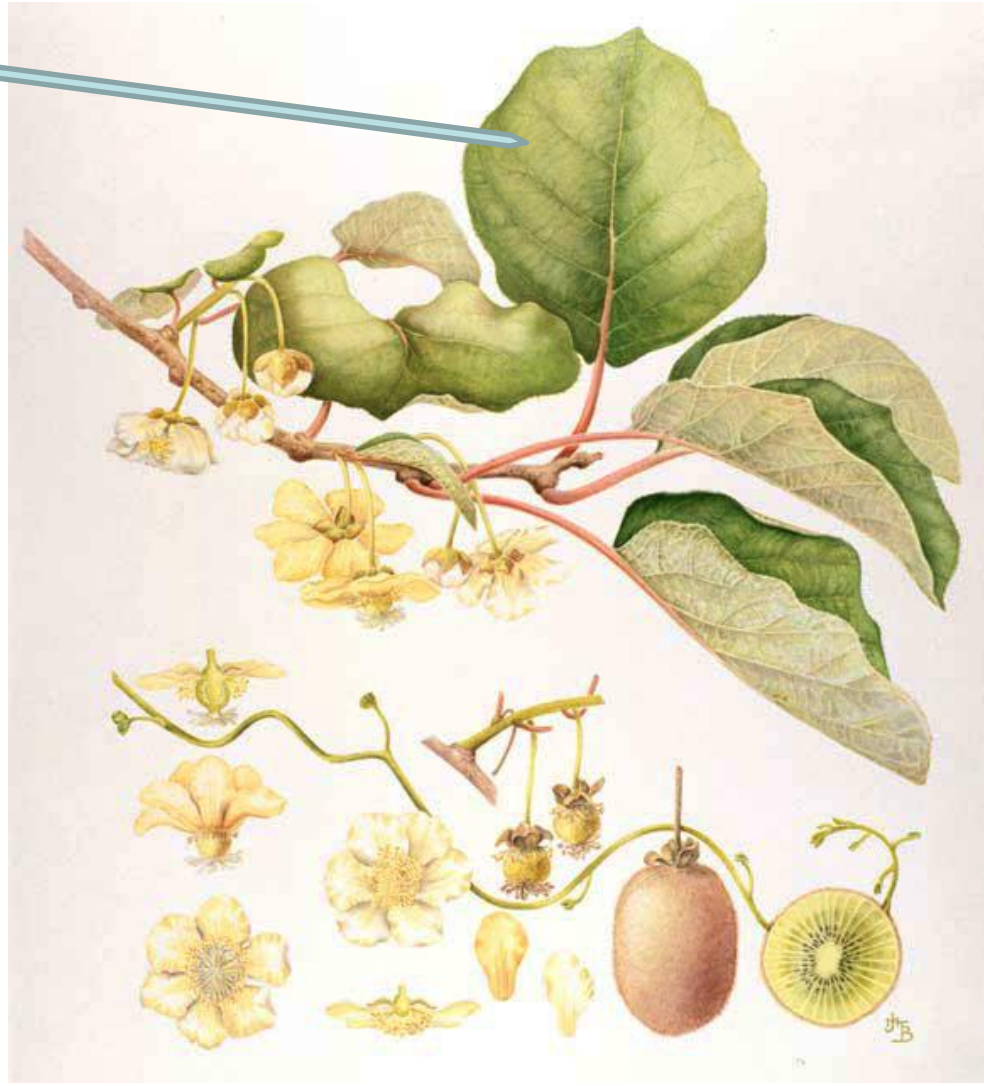
# Italian Projects



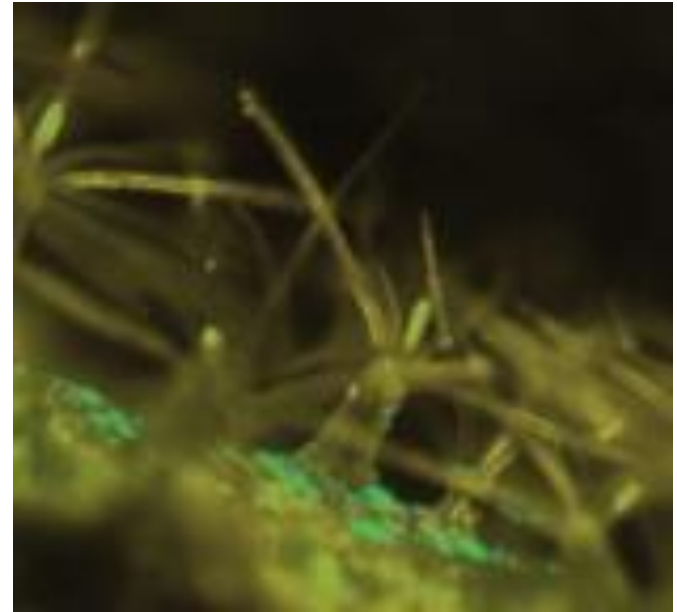
- Epidemiology: how does Psa infect the plant? ←
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- How can the disease be monitored? ←-----
- How can the diffusion of Psa be prevented?
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# Epidemiology

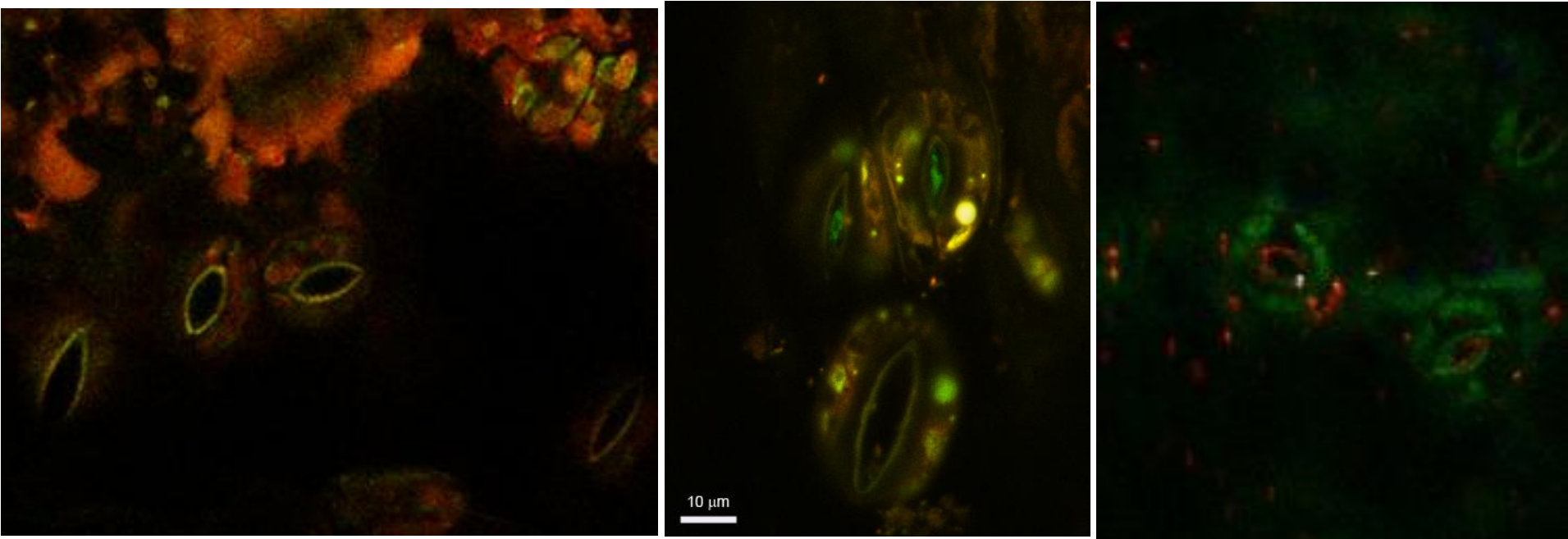
- STOMATA
- BROKEN THRICOMES
- WIND and HAIL DAMAGES
- ...



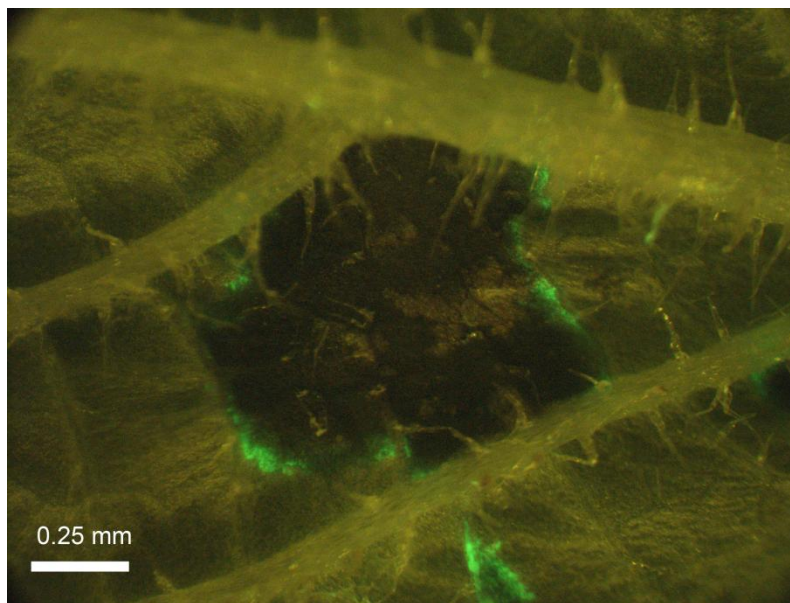
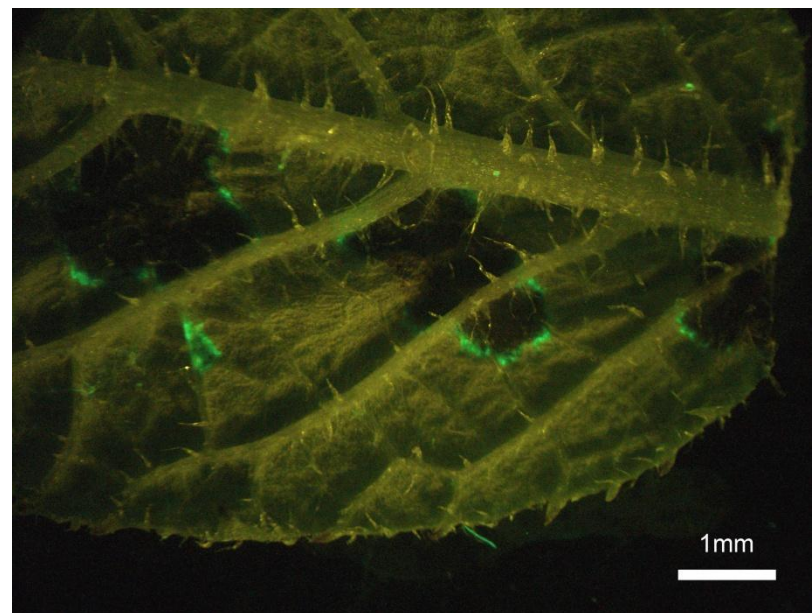
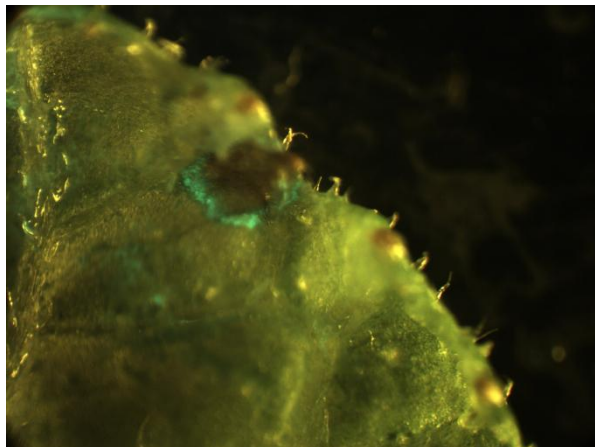
# The role of trichomes



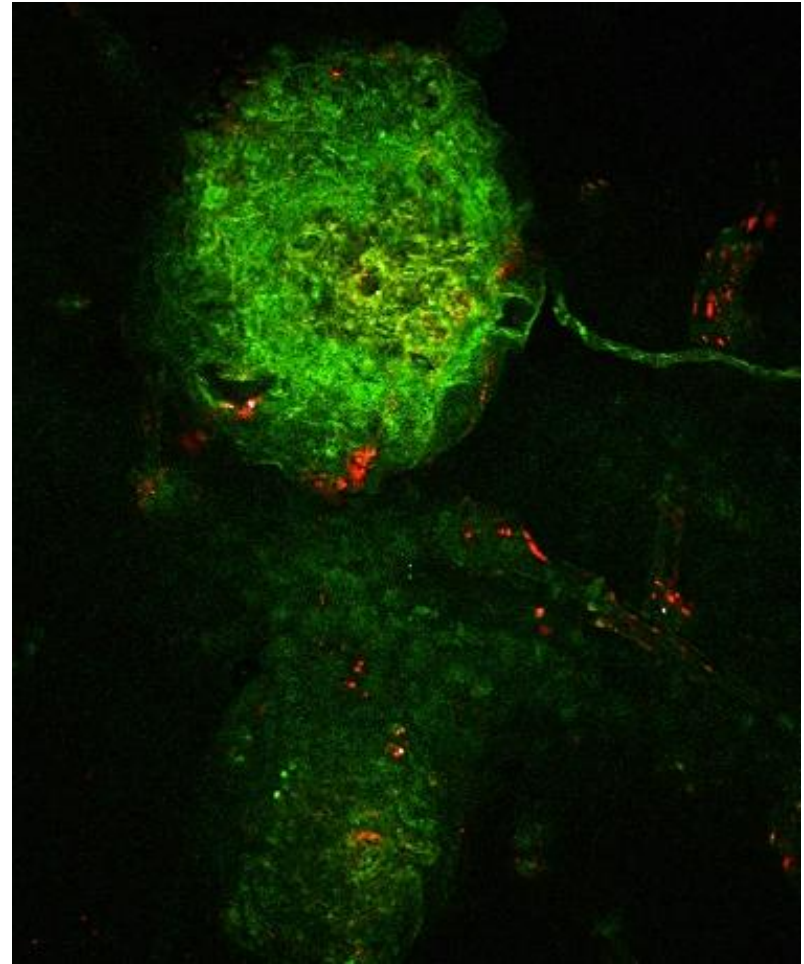
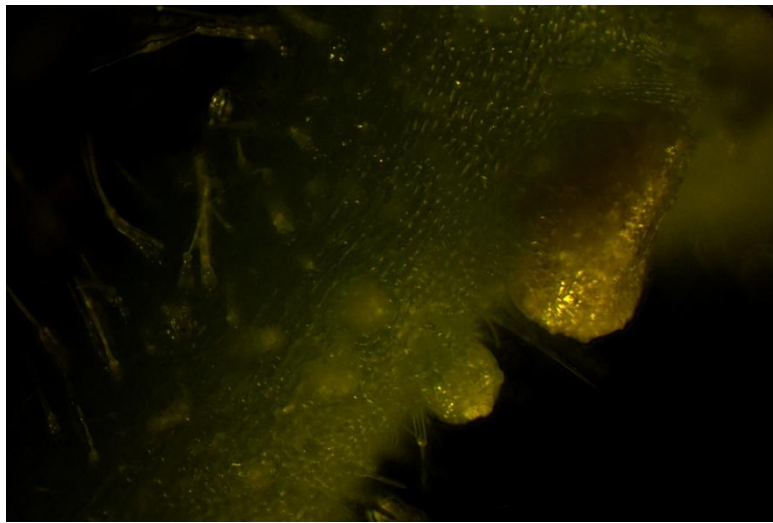
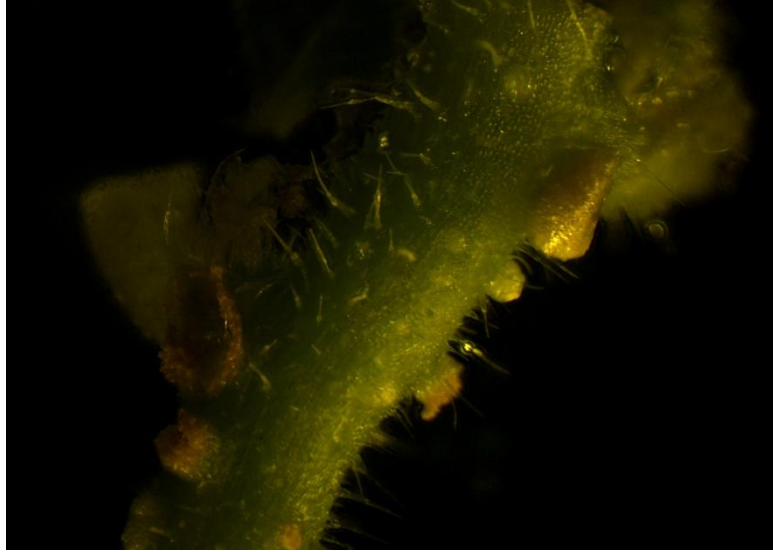
# The role of stomata



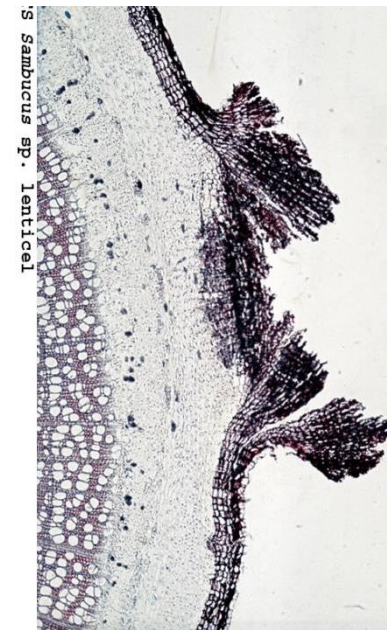
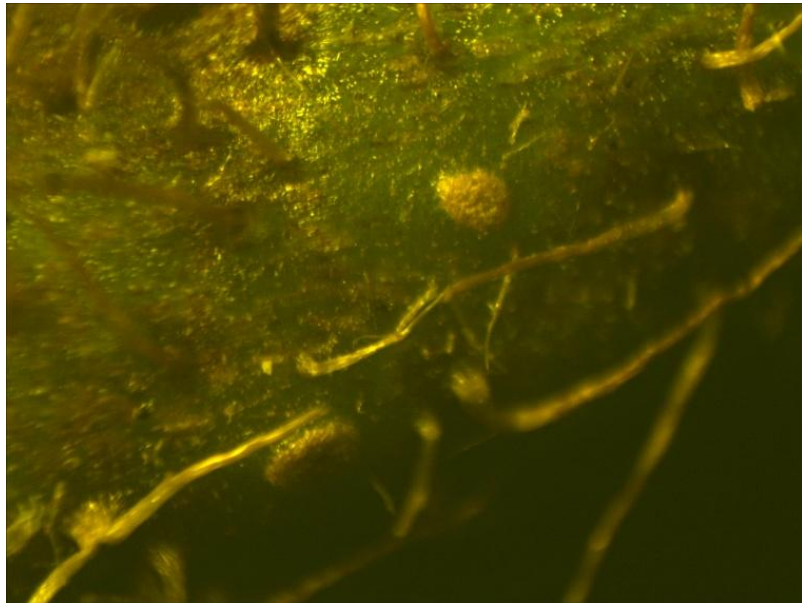
# Leaf spots



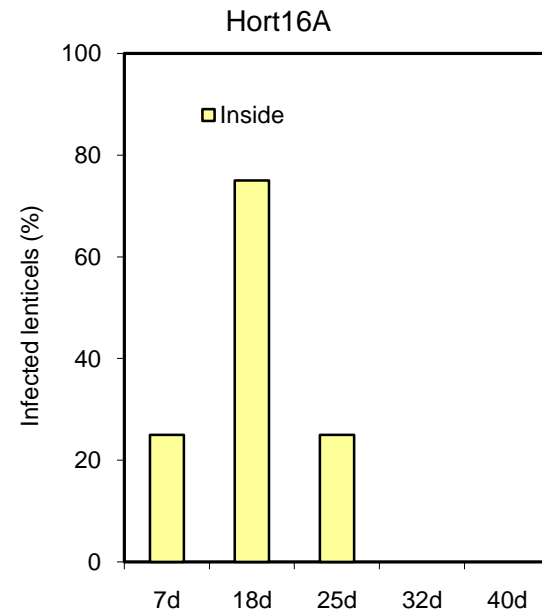
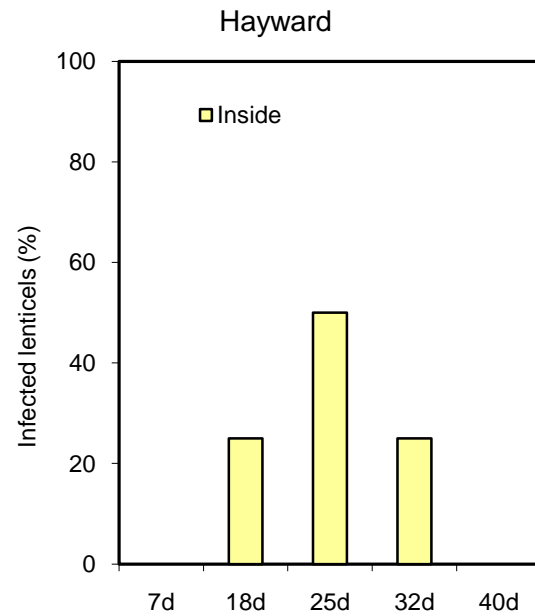
# Lenticels



# Lenticels



Dry Lenticels:  $4 \times 10^8$  cfu  $\text{ml}^{-1}$



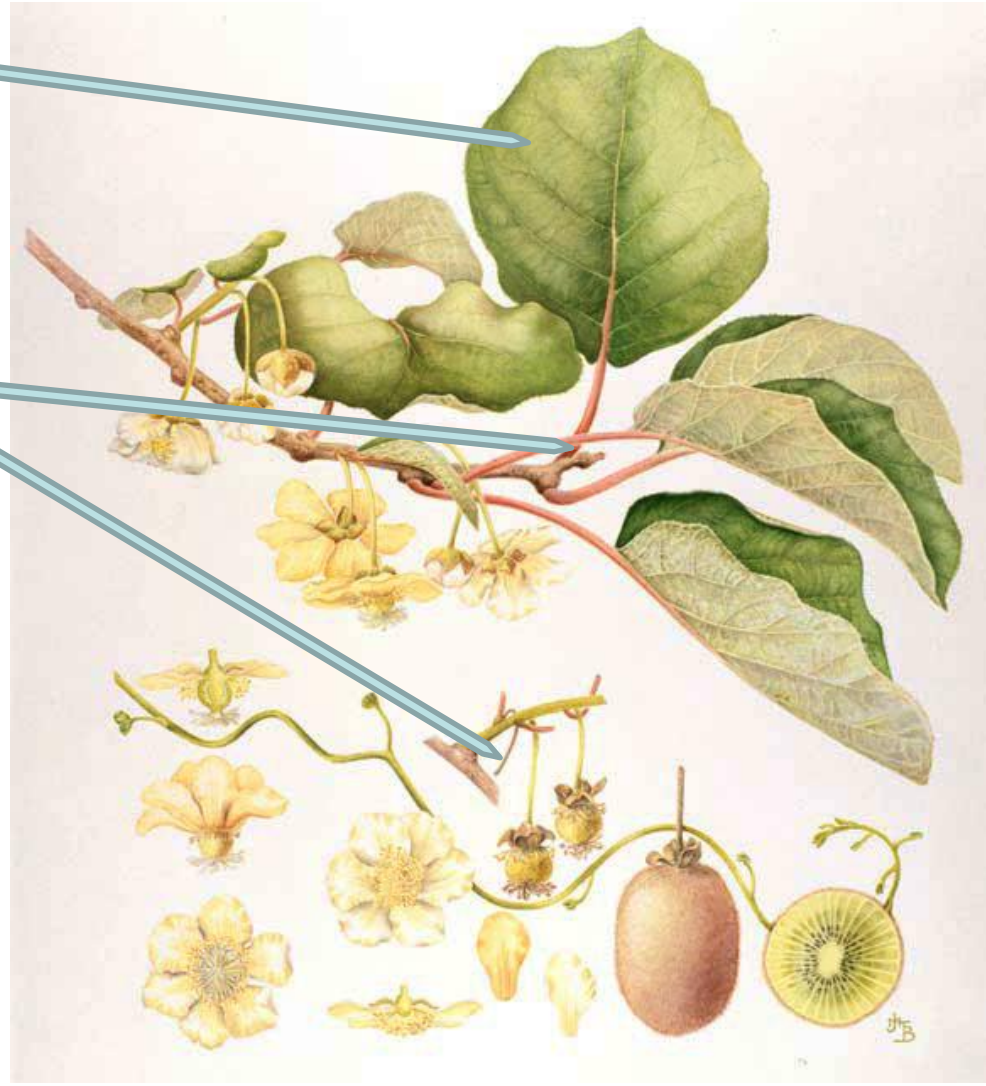
# Epidemiology

- STOMATA
- BROKEN THRICOMES
- WIND and HAIL DAMAGES

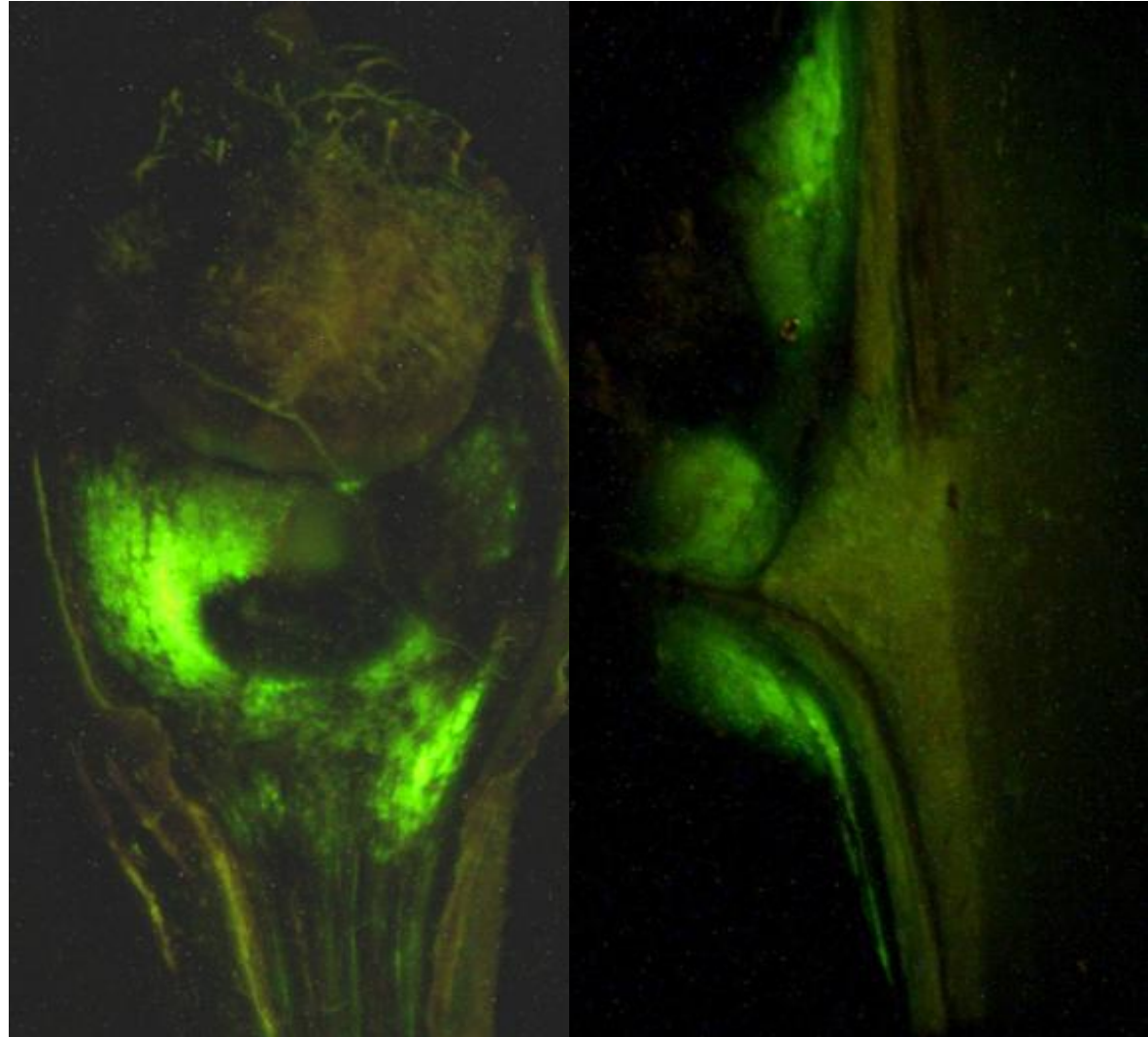
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ABSCISSION LESIONS:

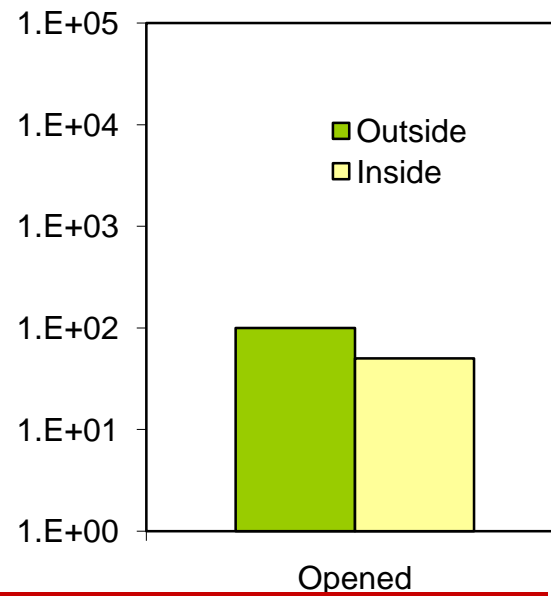
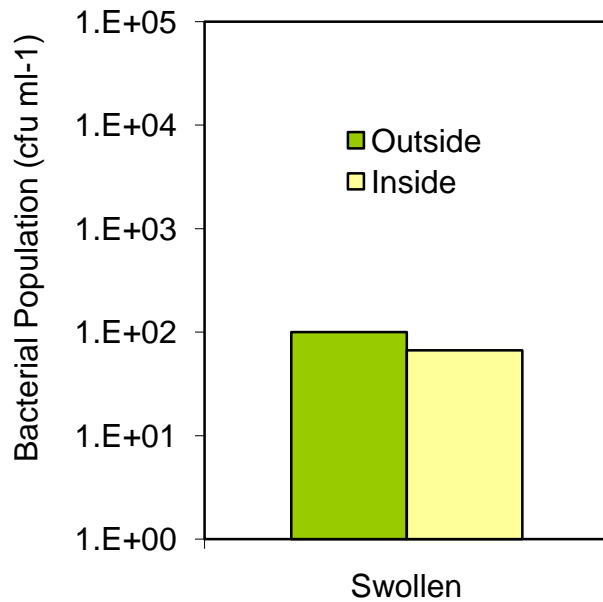
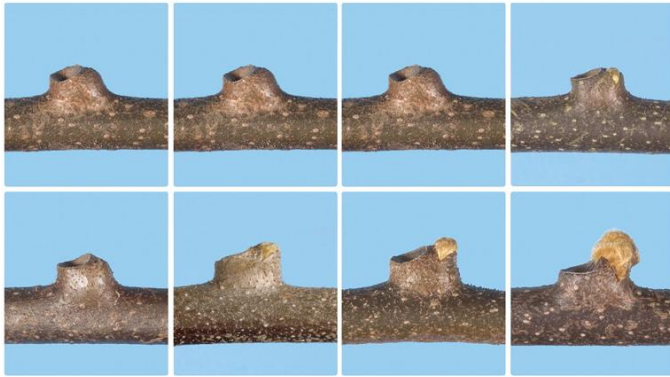
- LEAF SCAR
- FLOWER SCARS



# Leaf abscission scars



# Bud Break



# Epidemiology

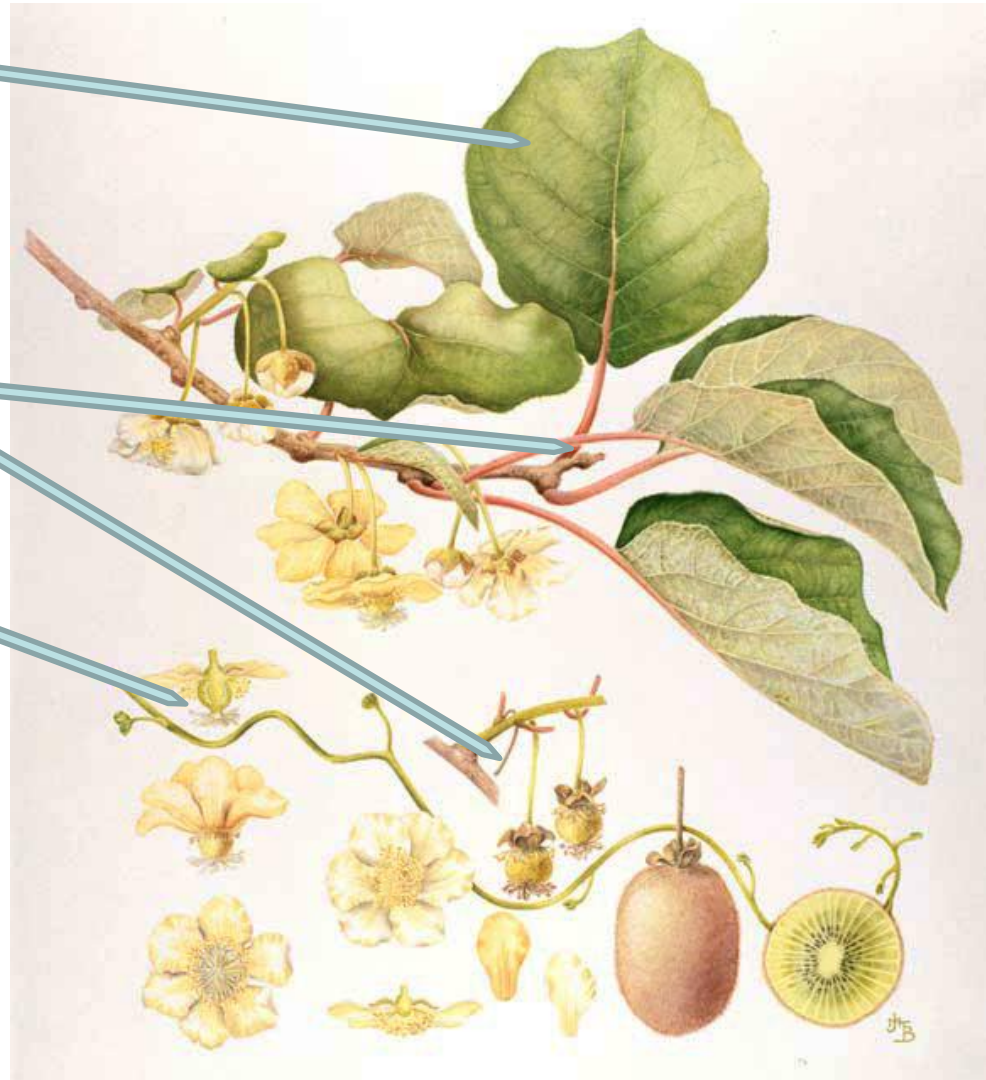
- STOMATA
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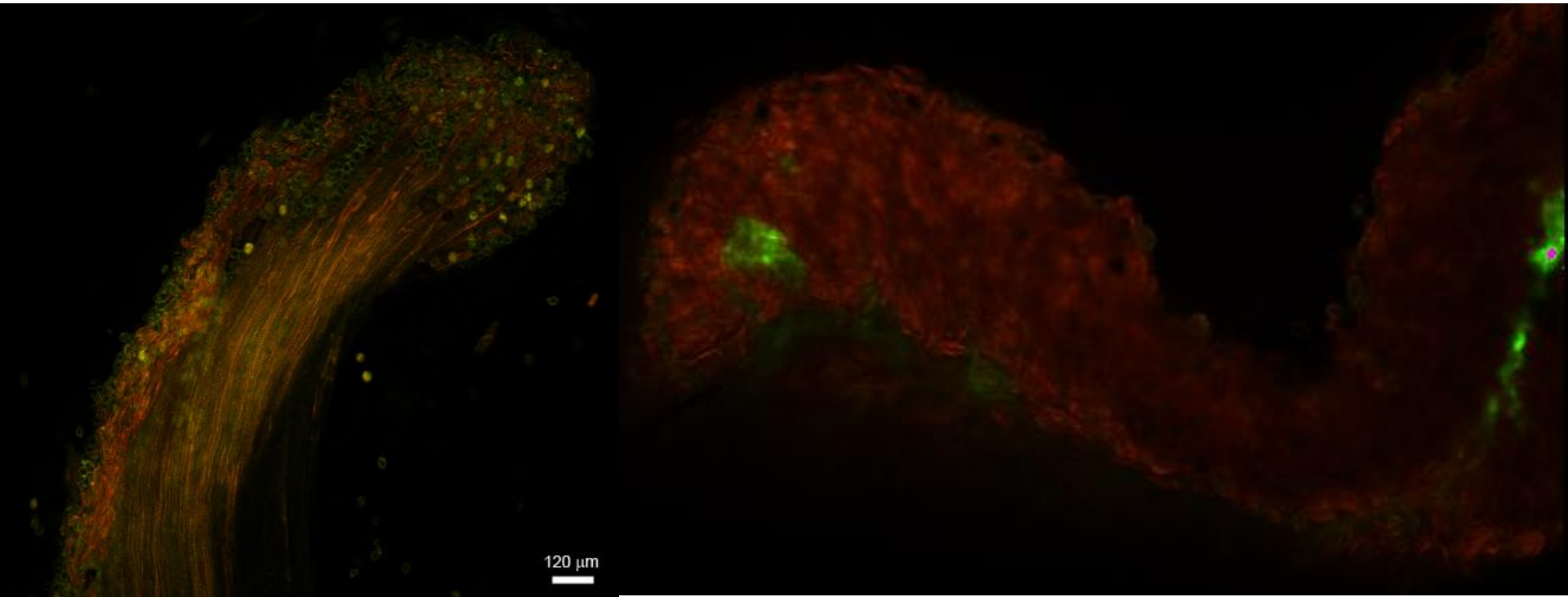
ABSCISSION LESIONS:

- LEAF SCAR
- FLOWER SCARS

FEMALE FLOWERS

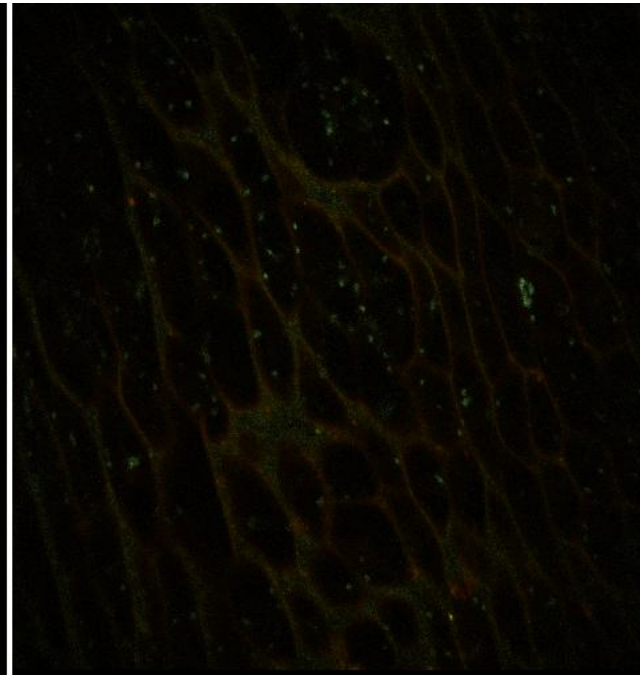
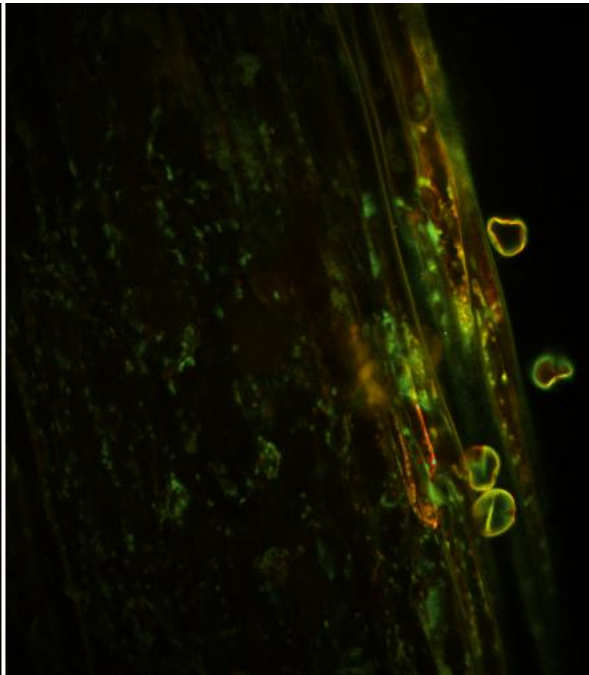
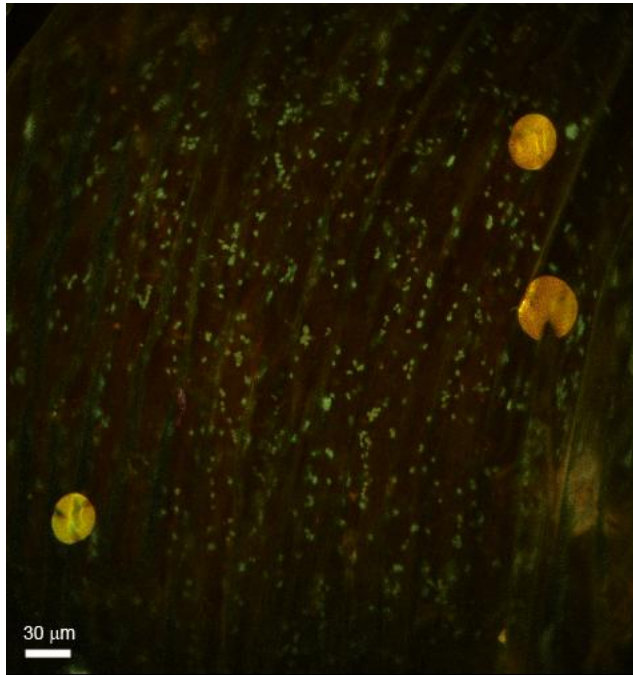


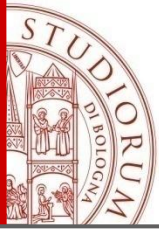
# Female flowers



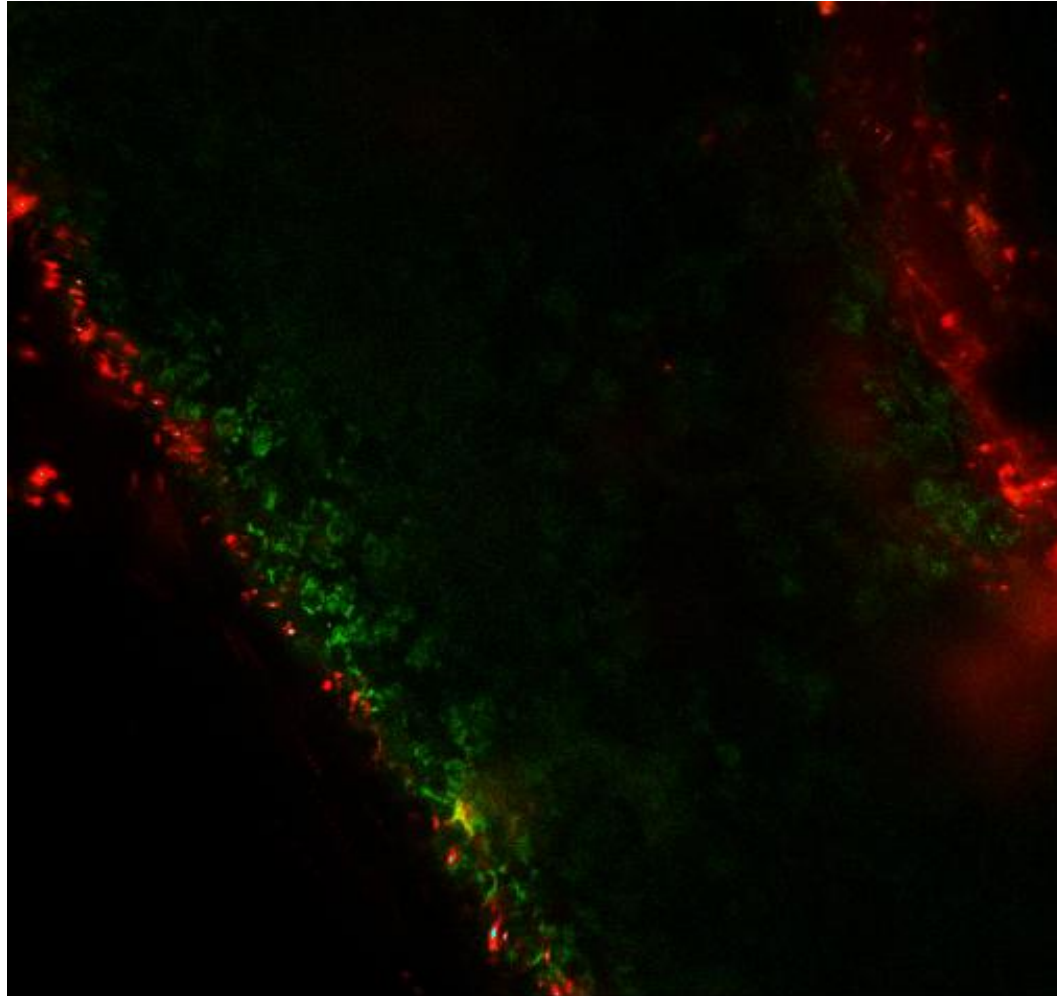
Stigma

# How does it moves on the stigma



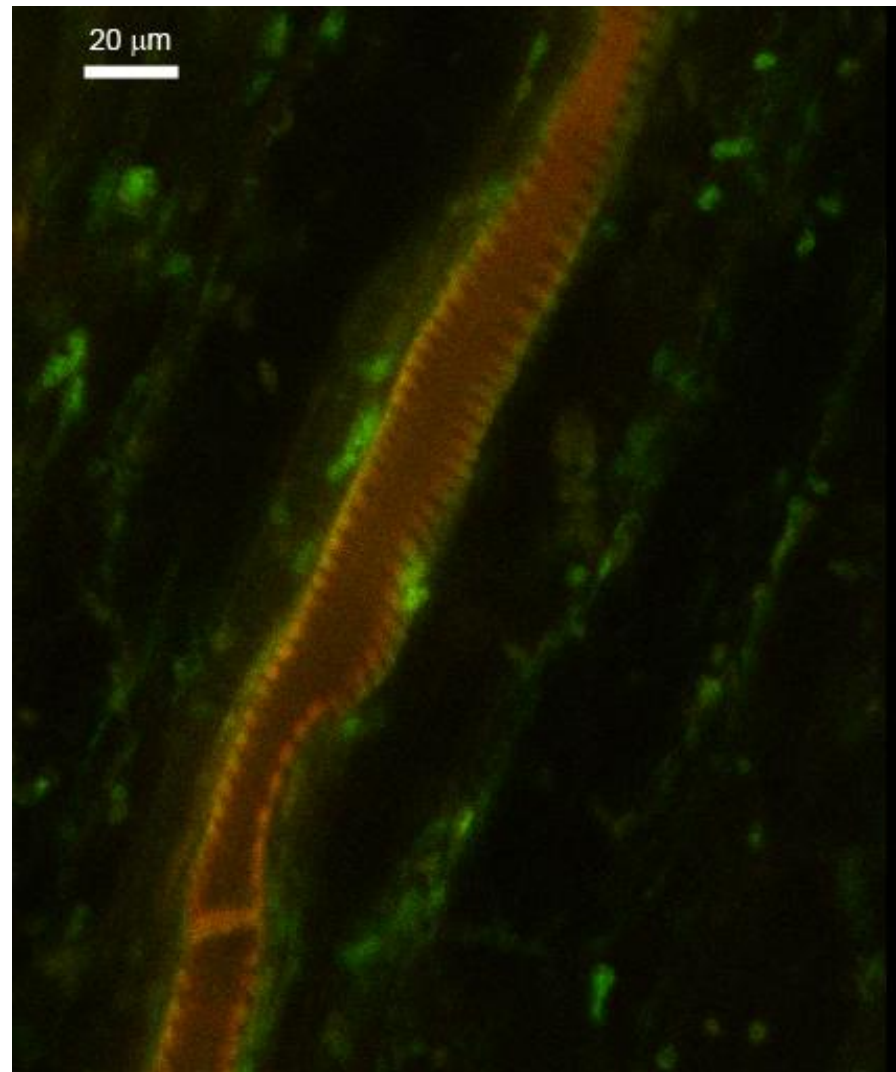
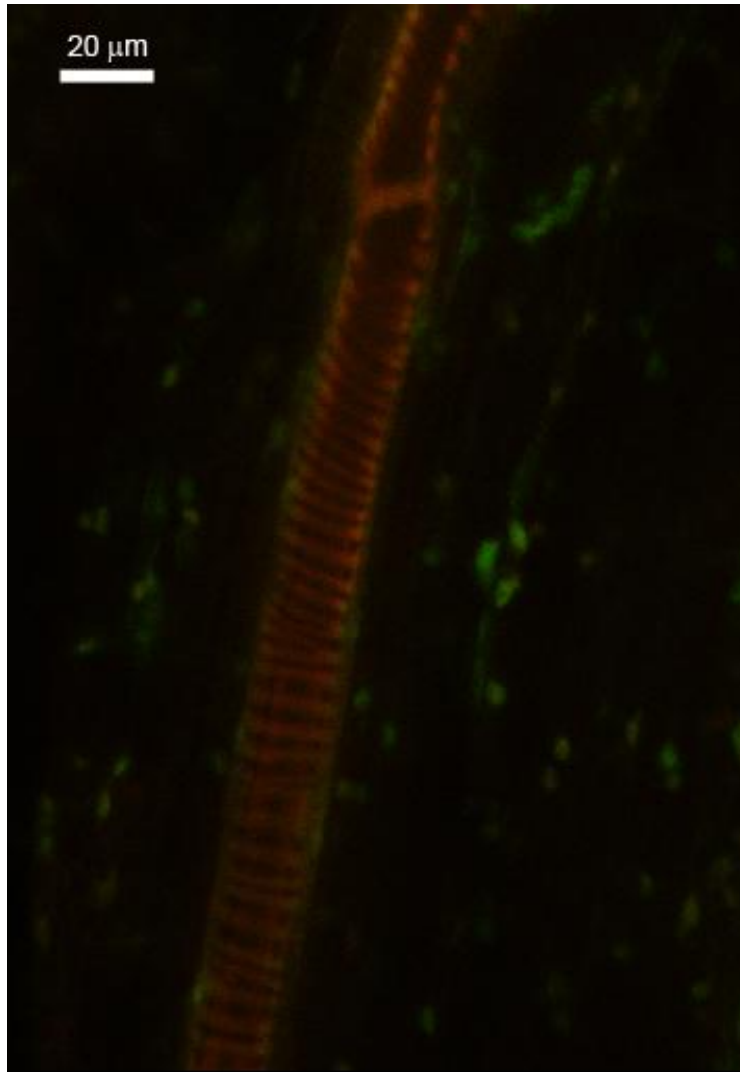


# Simultaneous monitoring of Psa and BCAs

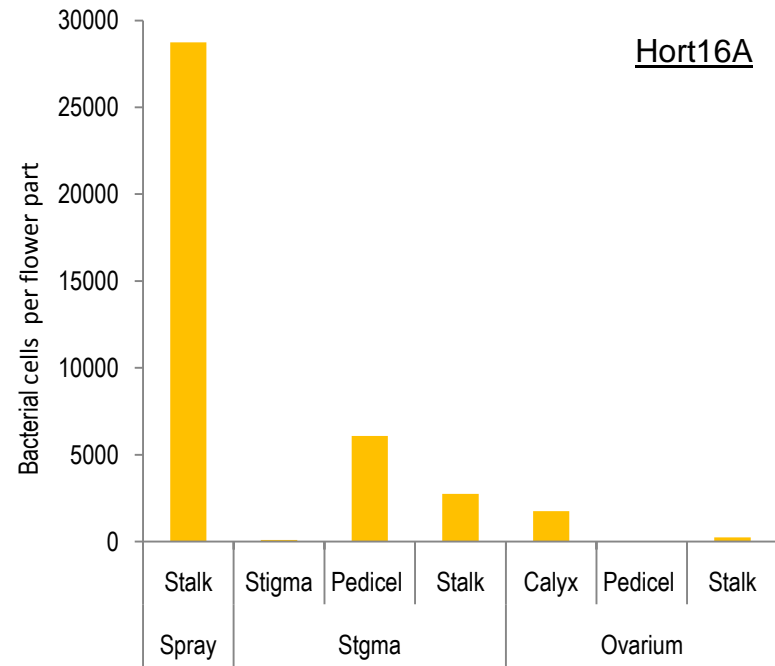
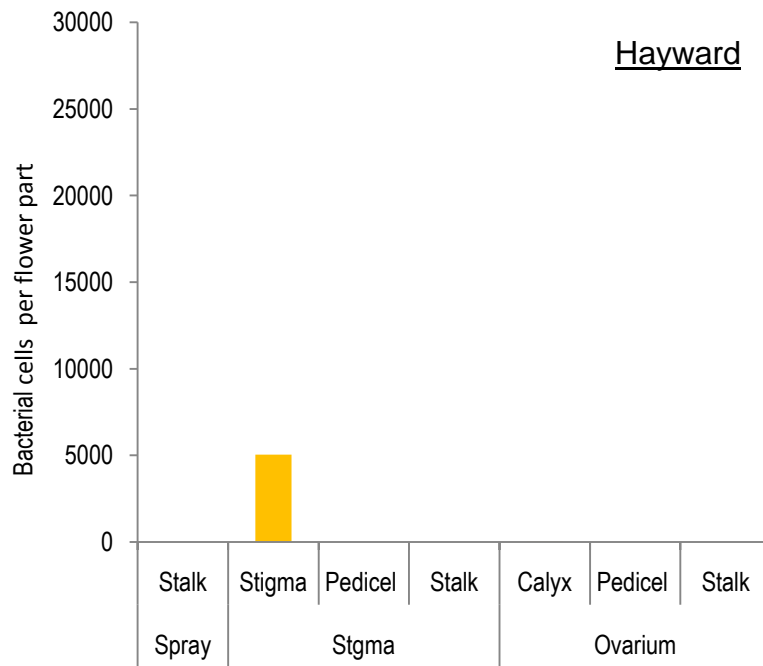


# How does it moves on the stigma?

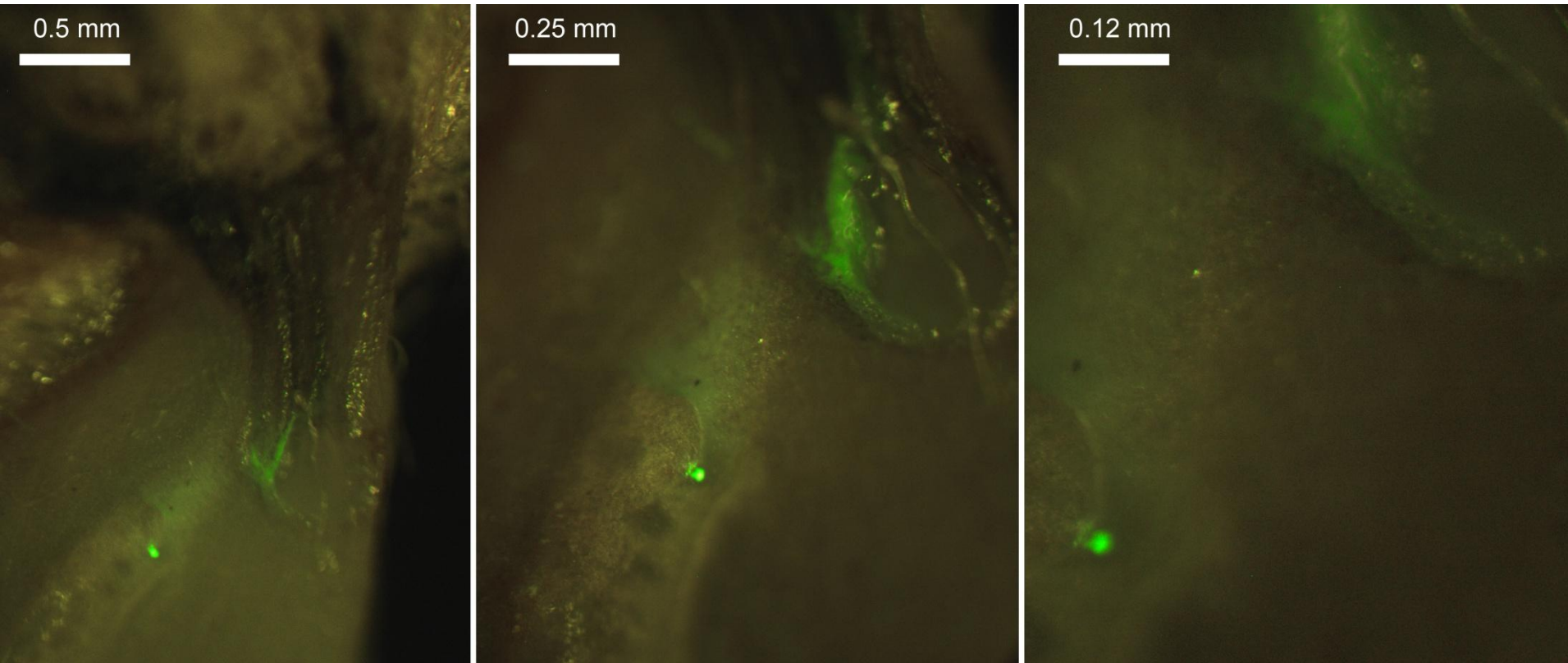
## Tracheids inside the stigmatic pedicel

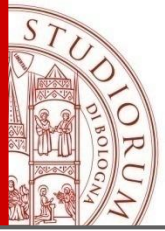


# Can PSA invade the plant *via* flowers?

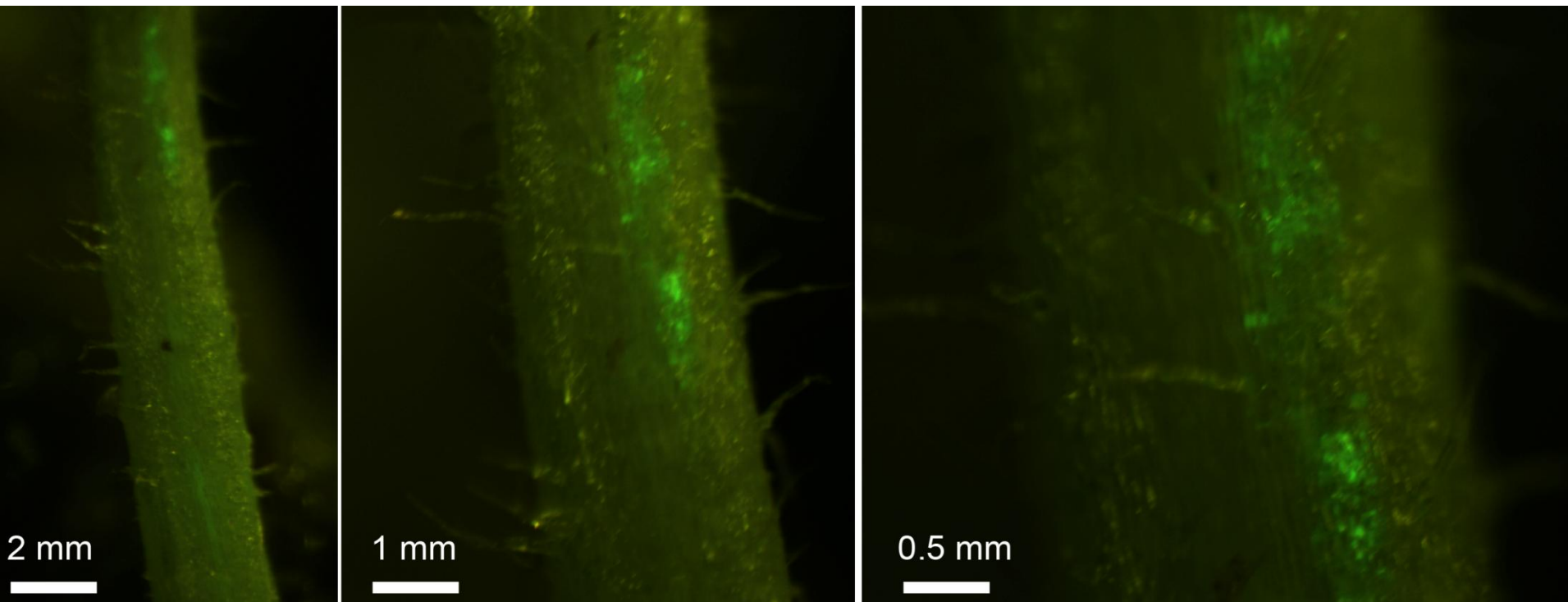


# Can PSA invade the plant *via* flowers?





# Can PSA invade the plant *via* flowers?



# Epidemiology

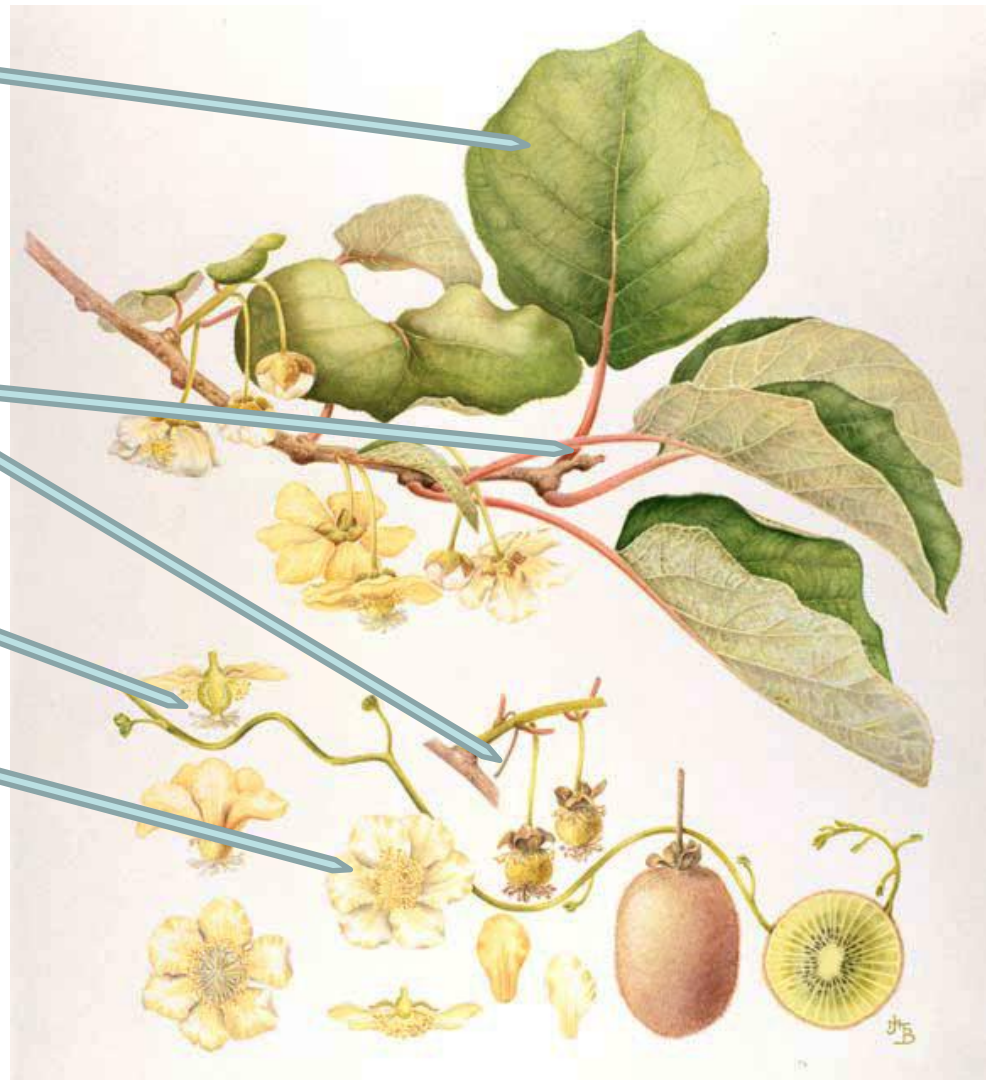
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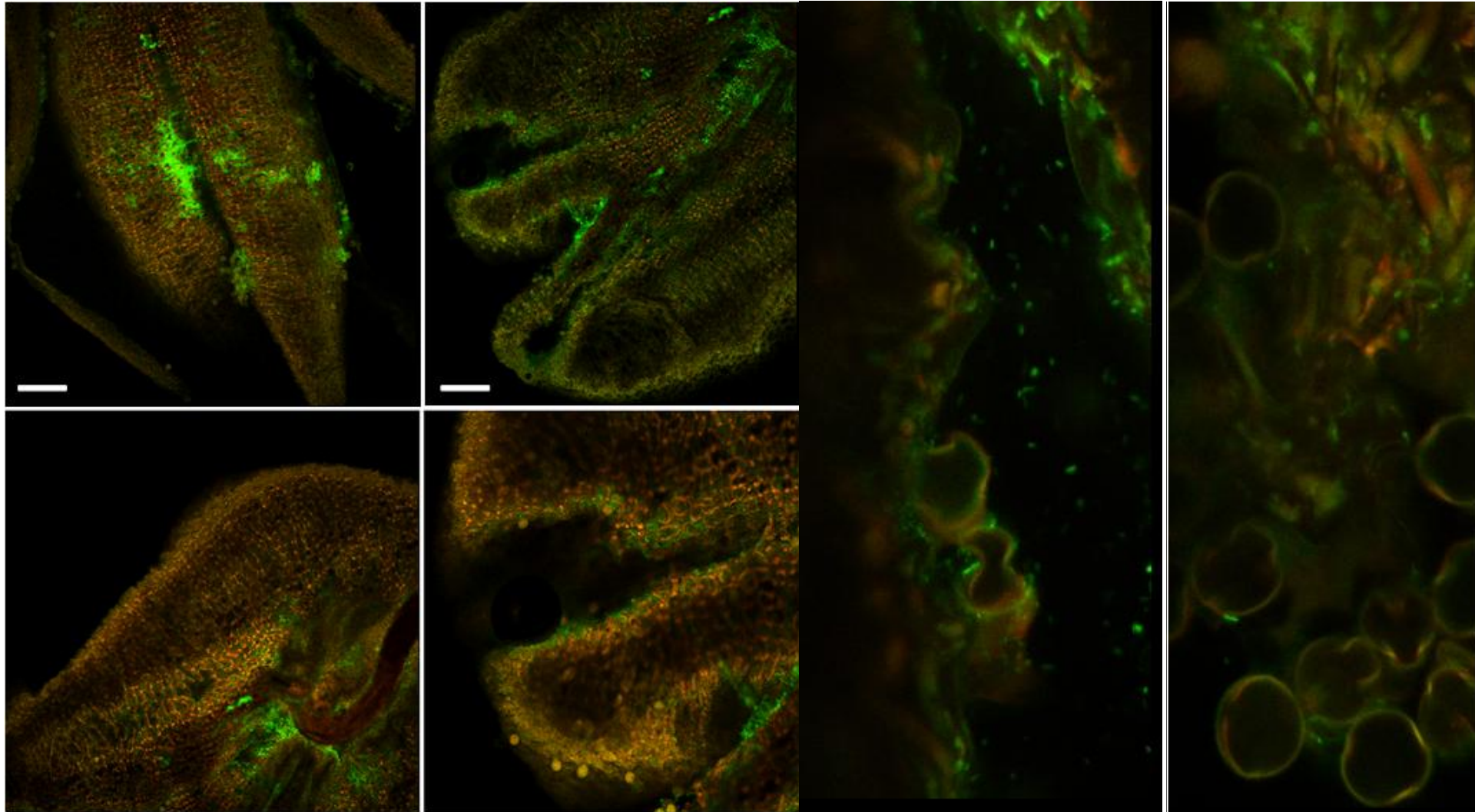
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- FLOWER SCARS

FEMALE FLOWERS

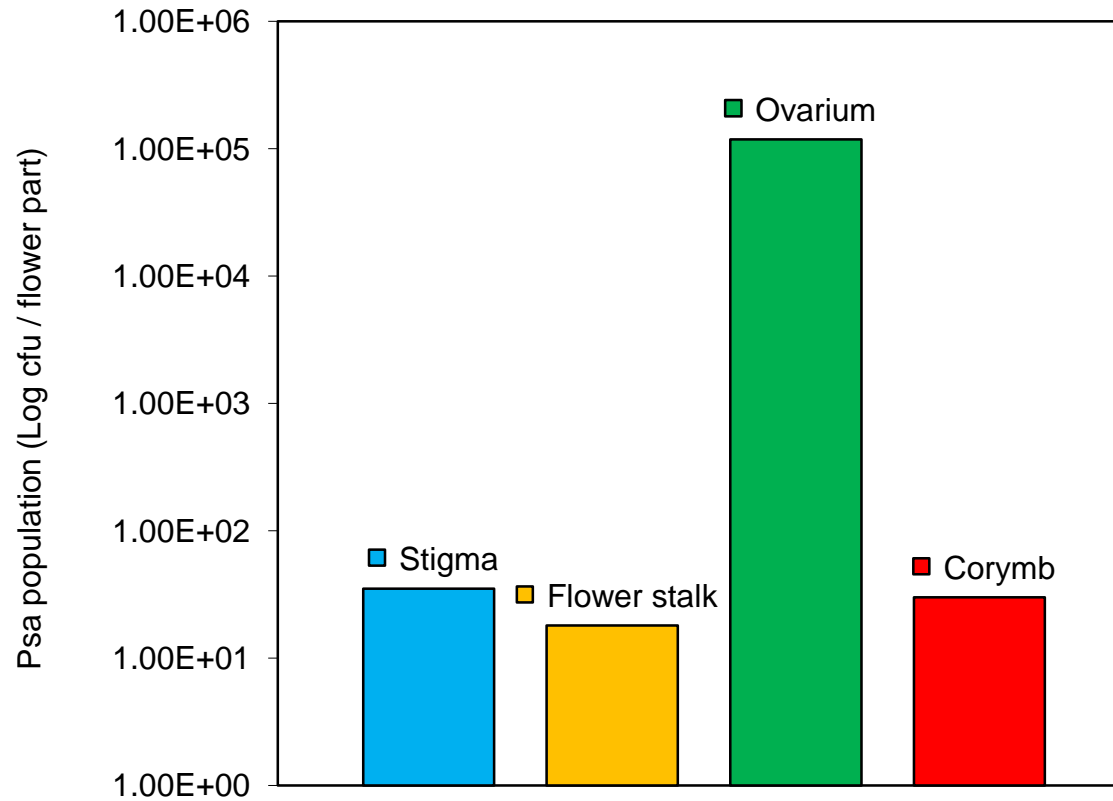
MALE FLOWERS



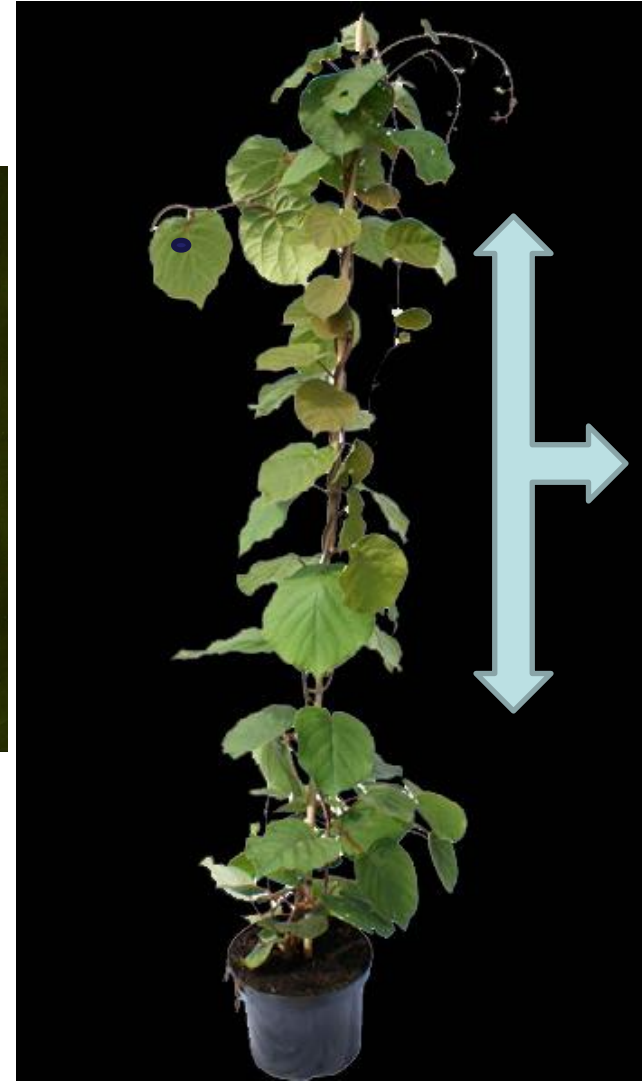
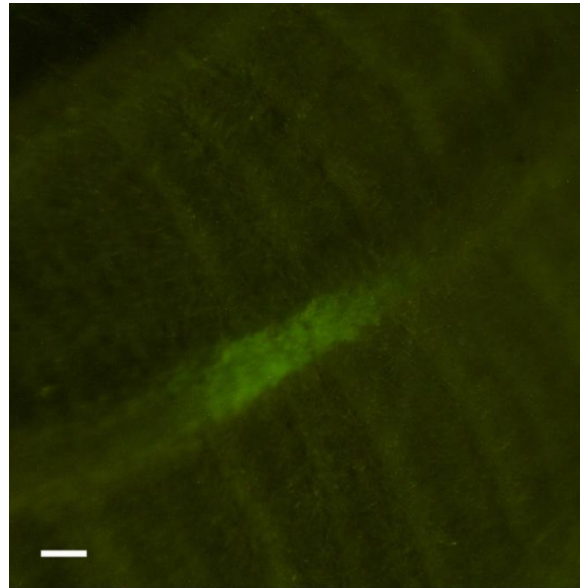
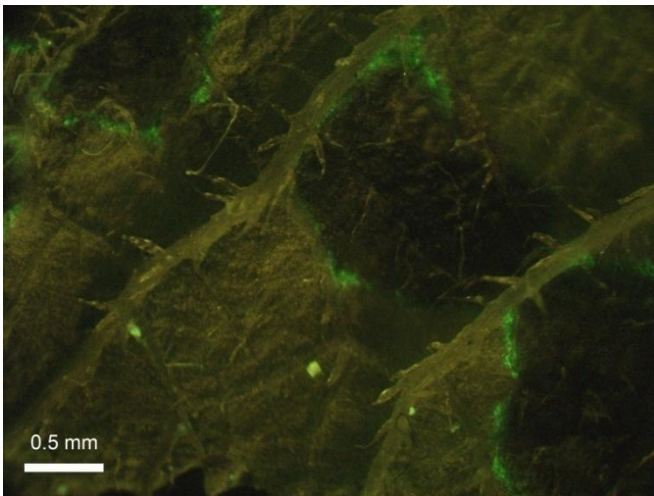
# Male flowers



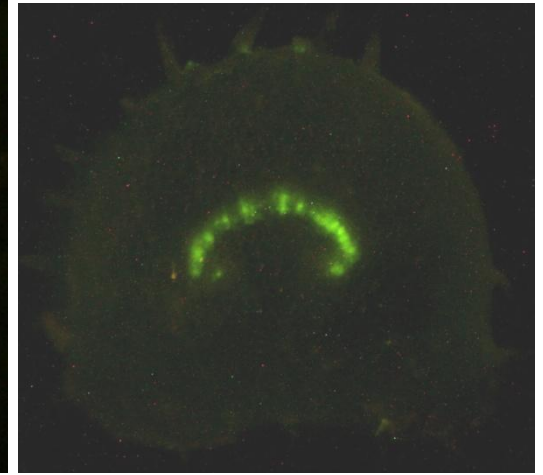
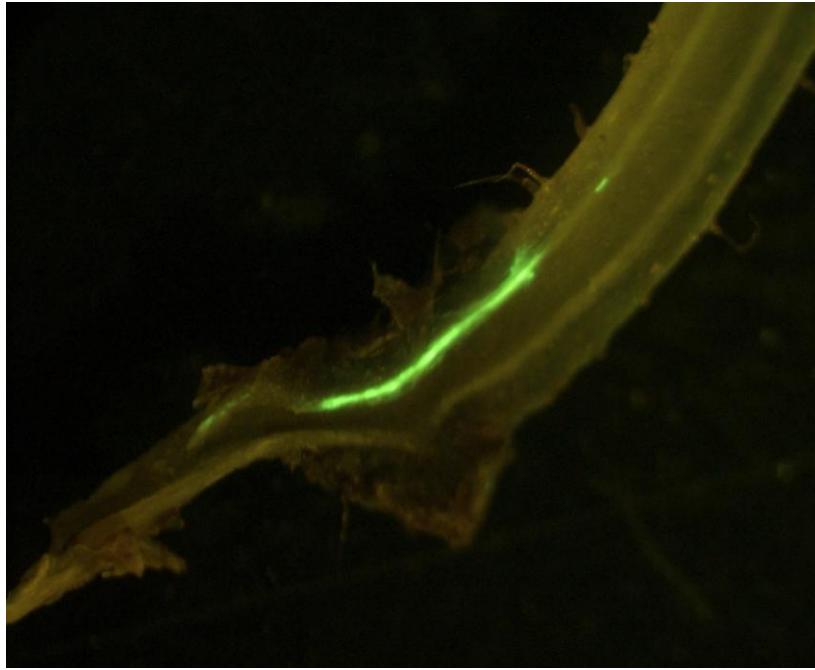
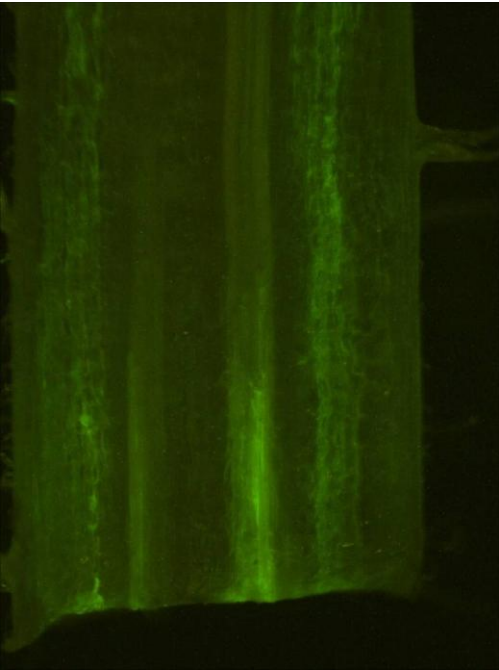
# Can pollen infect flowers?



# How does Psa move in the plant?

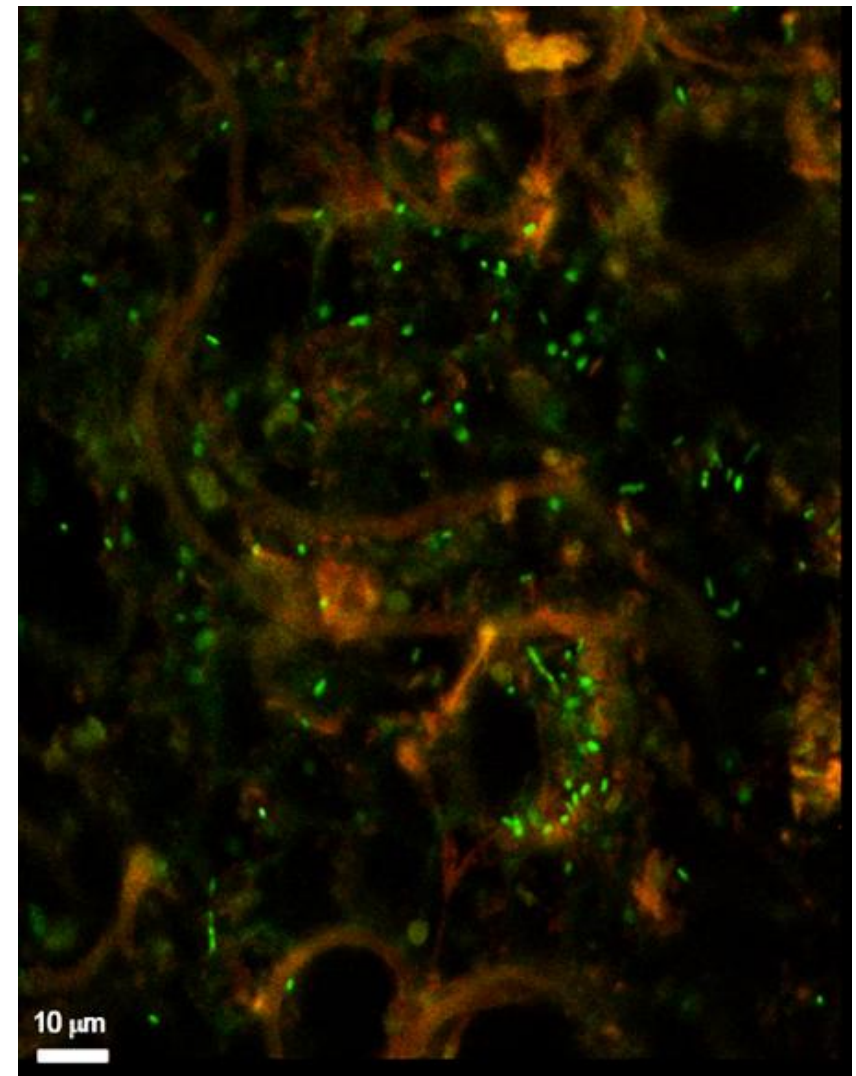
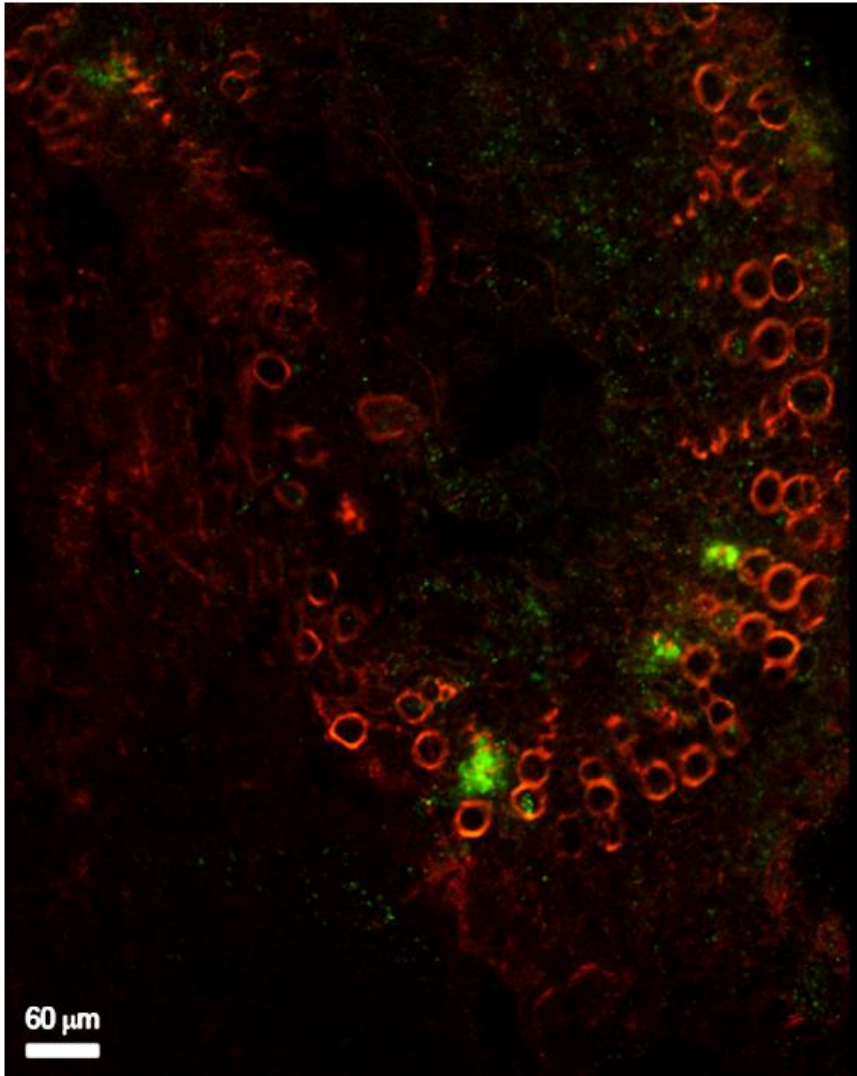


# How does Psa move in the plant?



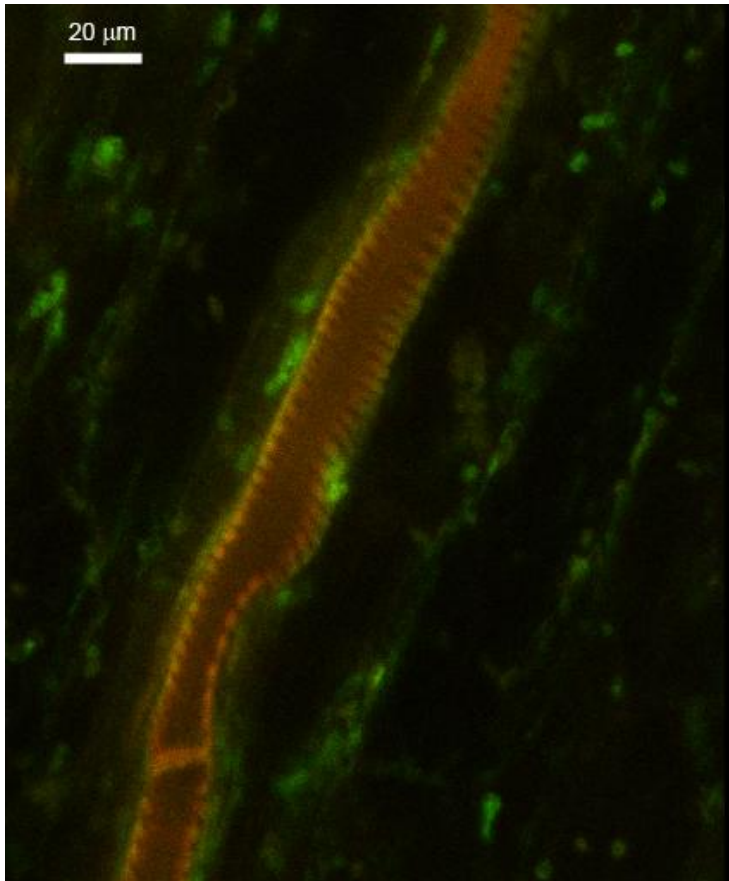
Movement inside xylem vessels

# How does Psa move in the plant?



## How to exploits this information and protocol

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- Target control strategies on the different entry points
- Facilitate the breeding for resistance
- Screen products (i.e. elicitors)
- Elucidate the influence of environmental factors and cultural management

# Psa arsenal to hijack plant defences

OPEN ACCESS Freely available online

 PLOS one

CRA

## *Pseudomonas syringae* pv. *actinidiae* Draft Genomes Comparison Reveal Strain-Specific Features Involved in Adaptation and Virulence to *Actinidia* Species

Simone Marcelletti<sup>1</sup>, Patrizia Ferrante<sup>1</sup>, Milena Petriccione<sup>2</sup>, Giuseppe Firrao<sup>3</sup>, Marco Scortichini<sup>1+</sup>

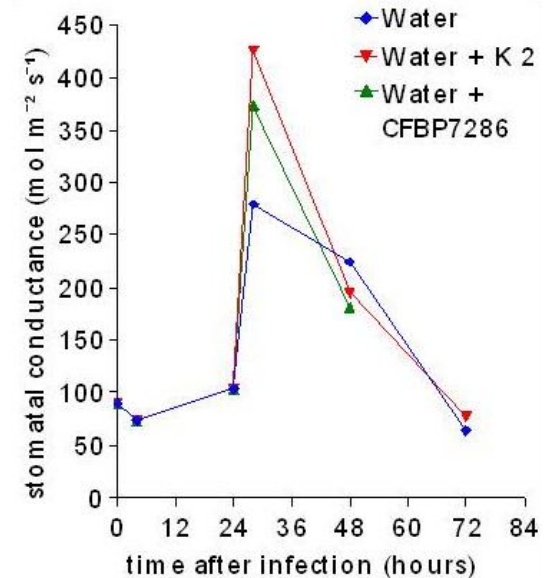
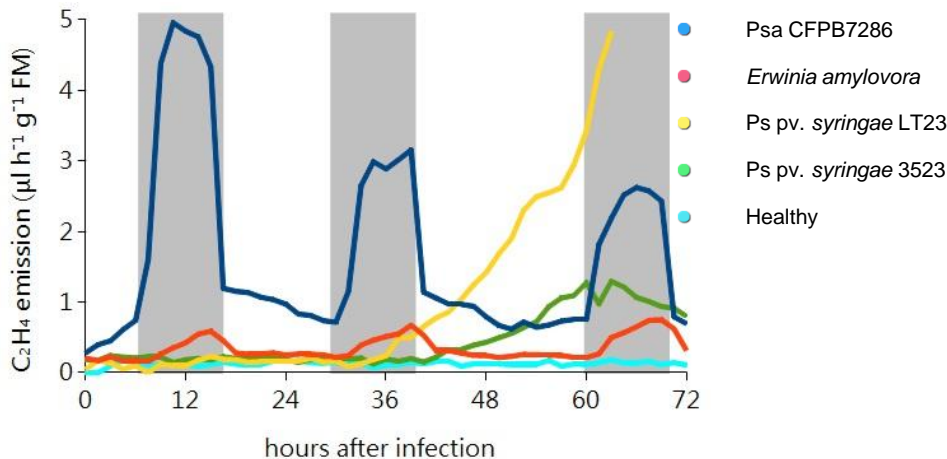
1 Research Centre for Fruit Trees, CRA, Roma, Italy, 2 Research Unit for Fruit Trees, CRA, Caserta, Italy, 3 Department of Agricultural and Environmental Sciences, University of Udine, Udine, Italy

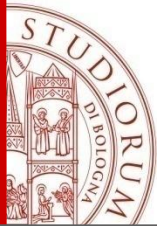
### Abstract

A recent re-emerging bacterial canker disease incited by *Pseudomonas syringae* pv. *actinidiae* (*Psa*) is causing severe economic losses to *Actinidia chinensis* and *A. deliciosa* cultivations in southern Europe, New Zealand, Chile and South Korea. Little is known about the genetic features of this pathovar. We generated genome-wide Illumina sequence data from two *Psa* strains causing outbreaks of bacterial canker on the *A. deliciosa* cv. Hayward in Japan (*J-Psa*, type-strain of the pathovar) and in Italy (*I-Psa*) in 1984 and 1992, respectively as well as from a *Psa* strain (*I2-Psa*) isolated at the beginning of the recent epidemic on *A. chinensis* cv. Hort16A in Italy. All strains were isolated from typical leaf spot symptoms. The phylogenetic relationships revealed that *Psa* is more closely related to *P. s.* pv. *theae* than to *P. avellanae* within genomospecies 8. Comparative genomic analyses revealed both relevant intrapathovar variations and putative pathovar-specific genomic regions in *Psa*. The genomic sequences of *J-Psa* and *I-Psa* were very similar. Conversely, the *I2-Psa* genome encodes four additional effector protein genes, lacks a 50 kb plasmid and the phaseolotoxin gene cluster, *argK-tox* but has acquired a 160 kb plasmid and putative prophage sequences. Several lines of evidence from the analysis of the genome sequences support the hypothesis that this strain did not evolve from the *Psa* population that caused the epidemics in 1984–1992 in Japan and Italy but rather is the product of a recent independent evolution of the pathovar *actinidiae* for infecting *Actinidia* spp. All *Psa* strains share the genetic potential for copper resistance, antibiotic detoxification, high affinity iron acquisition and

# Psa arsenal to hijack plant defences

1. genes involved in the catabolism of aromatic plant compound With possible antimicrobial effects
2. Genes interfering with NO metabolism
3. copA e copB genes involved in copper resistance
4. Psa induce ET emission in *Actinidia* spp. and unbalance the defence signalling pathways
5. Psa may induce stomata opening in *A. chinensis*





# Molecular diagnosis on Pollen, Leaves and shoots

## LITTERATURE:

- Koh YJ, Nou IS. 2002. DNA markers for identification of *Pseudomonas syringae* pv. *actinidiae*. Mol Cells. 13:309-14.
- Rees-George J, Vanneste JL, Cornish DA, Pushparajah PS, Yu J, Templeton MD, Everett KR 2010. Detection of *Pseudomonas syringae* pv. *actinidiae* using polymerase chain reaction (PCR) primers based on the 16S–23S rDNA intertranscribed spacer region and comparison with PCR primers based on other gene regions. Plant Pathology 59: 453-464.

*Phytopathol. Mediterr.* (2011) 50, 462–472

**CRA**

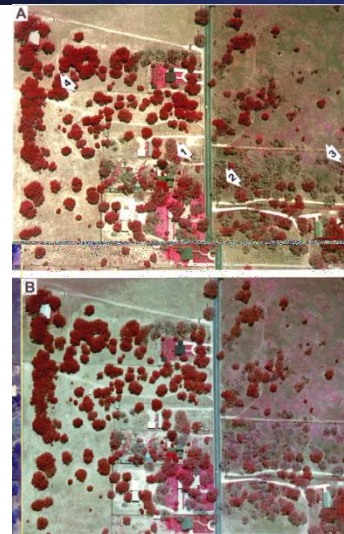
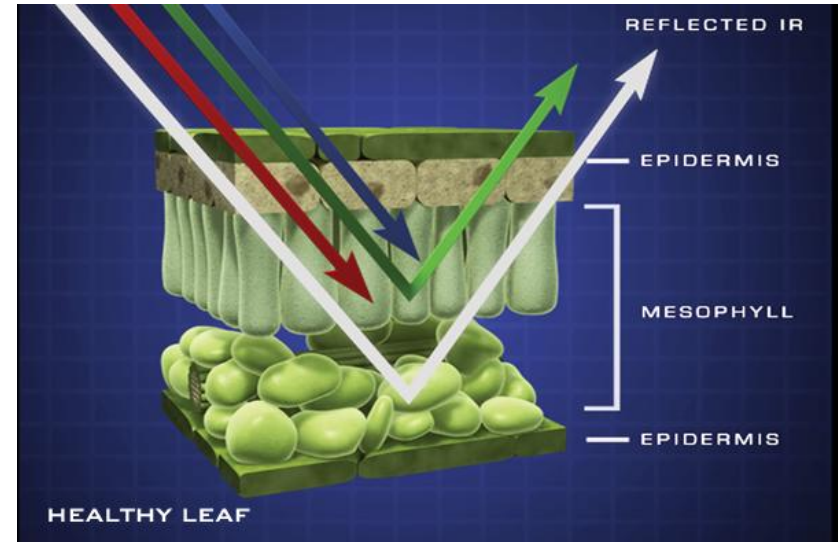
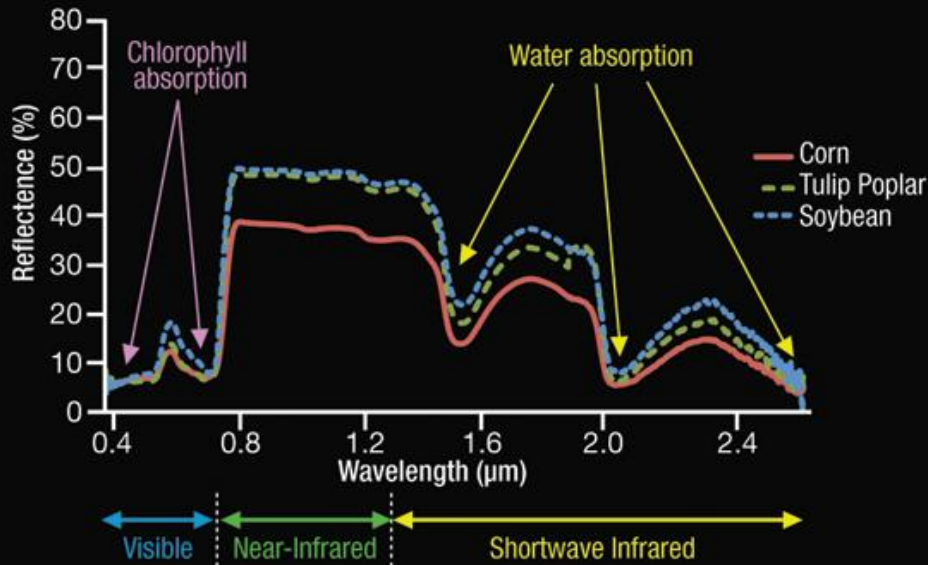


## **Detection of *Pseudomonas syringae* pv. *actinidiae*, causal agent of bacterial canker of kiwifruit, from symptomless fruits and twigs, and from pollen**

ANGELA GALLELLI, SILVIA TALOCCI, ALESSIA L'AURORA and STEFANIA LORETI

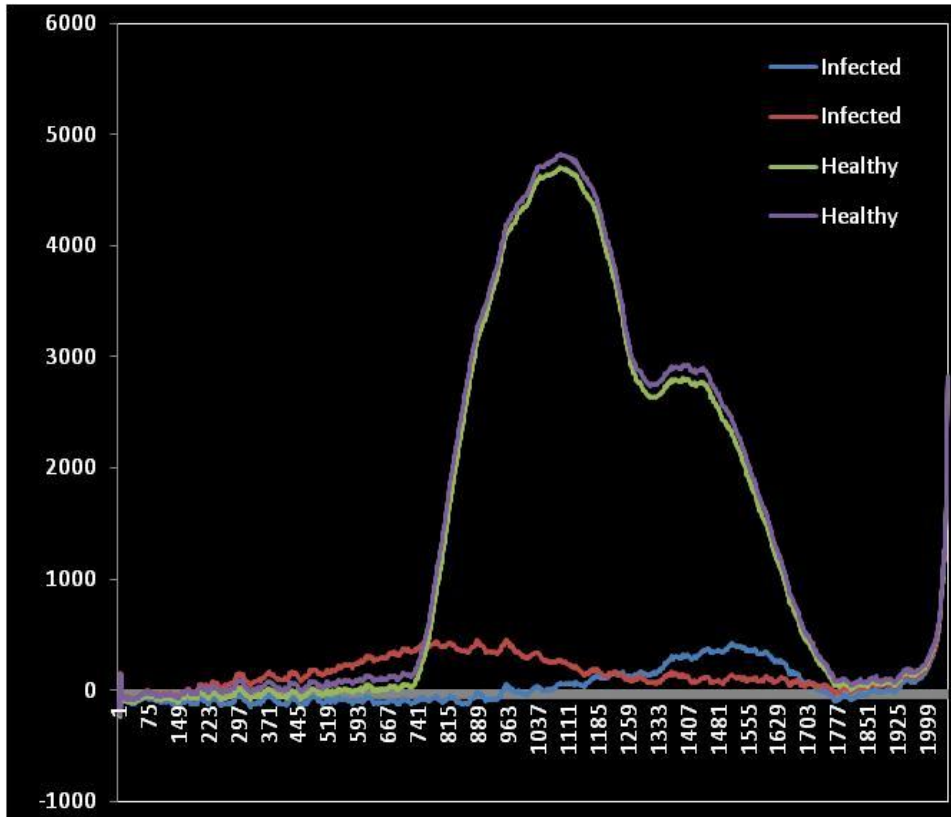
C.R.A. - Centro di Ricerca per la Patologia Vegetale, Via C.G. Bertero, 22, 00156 Roma, Italy

# Near-infrared and other important wavelengths



**UNIBO**

# Portable DA-meter



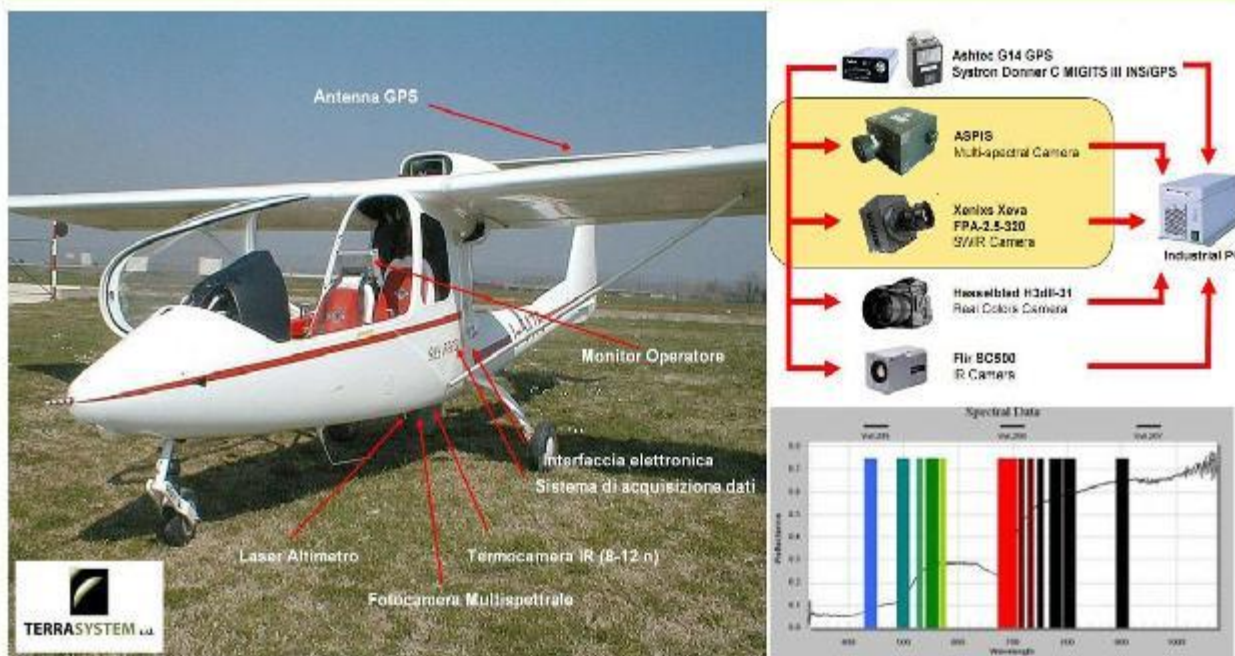
UNIBO



# Remote sensing



## Sistema di telerilevamento ASPIS



ASPIS multispectral camera system

12 bands 400 - 1000 nm  
 1 RGB image  
 1 SWIR band  
 1 TIR band

Camera	Ground width-height (m)	GSD (m)
Real colours	500 x 380	0.10 x 0.10
False colours	500 x 250	0.25 x 0.25
Thermal IR	350 x 250	1 x 1

Università della Tuscia.  
 G.M. Balestra