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# Development of imaging devices and algorithms to quantify Black Rot symptoms in grapevine under semi-controlled conditions: detached leaves in laboratory and growing cuttings in greenhouse



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## Context & Objectives

Black rot (BR), caused by the fungal pathogen *Guignardia bidwellii*, is a historical and extremely harmful disease of grapevines (Fermaud et al., 2024, IOBC-WPRS Bulletin, 171, p.29). In France, where no anti-BR biocontrol product has been registered so far, the risk of BR epidemics may be rising following both i) the reduction in use of synthetic fungicides and ii) a near-future deployment of the grapevine cultivars resistant to powdery and downy mildews, but that are highly susceptible to the pathogen.

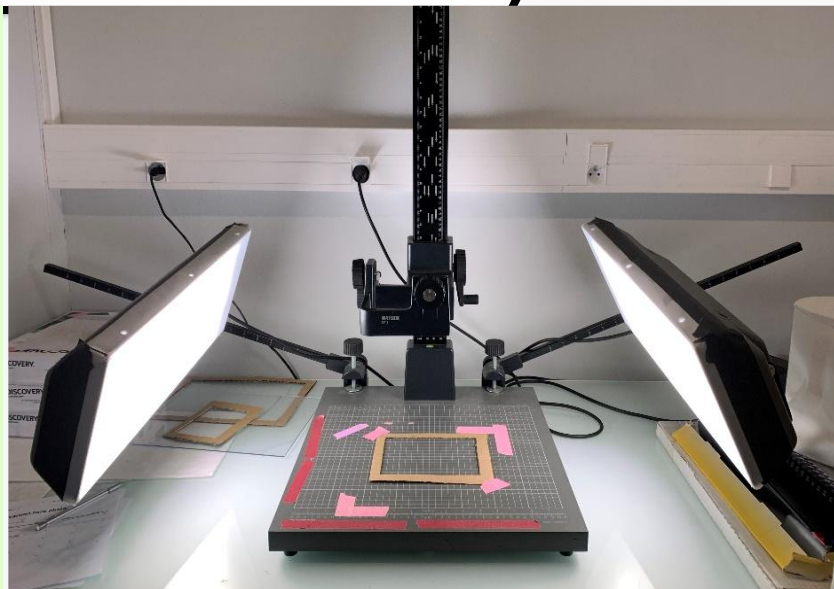
**An acceleration of research is required for high-throughput BR phenotyping in order to promote research for developing biocontrol tools and further studying key epidemiological issues.**

## Image capture devices and database

### Two original image capture devices:

> Lab device: to observe symptoms on **detached symptomatic leaves** assessing BR severity (lesion size, density) and **counting pycnidia** conceptacles containing the asexual spores.

> Greenhouse device: to assess, more precisely and rapidly, BR severity in grapevine growing cuttings, notably in biocontrol bioassays according to Raveau et al (J. Fungi 2024, 10, 471. <https://doi.org/10.3390/jof10070471>).



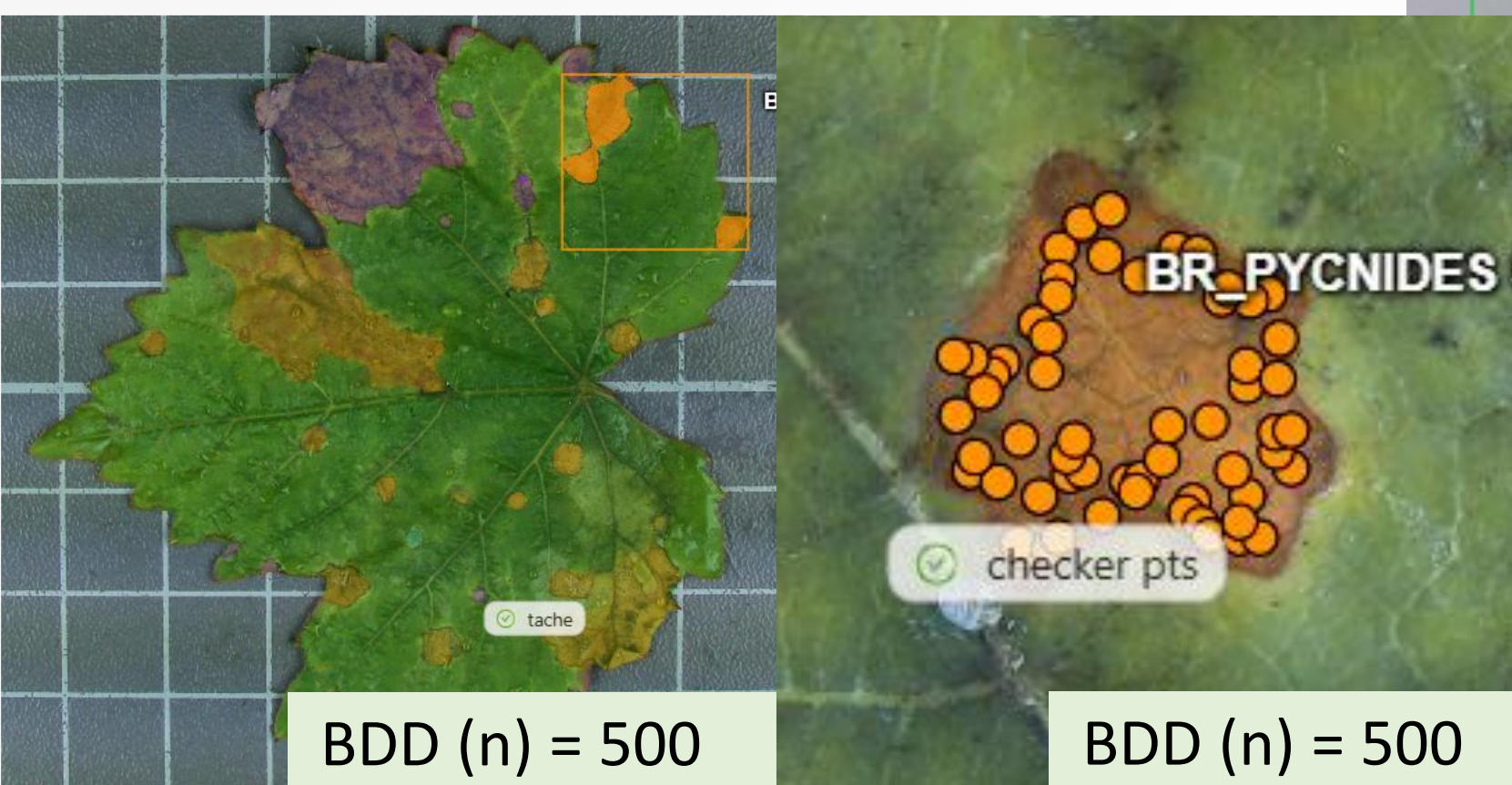
### Three annotated databases:

>> Detached leaves databases:  
 - DL\_DB\_1: approx 500 images at leaf scale  
 - DL\_DB\_2: approx 500 macro-images at infra-symptom scale (pycnidia counting)

>> Young plant database: YP\_DB

- YP\_DB: 184 images from XXX young plant cuttings

**Annotations conducted with CVAT software following a specific annotation protocol designed in this project *AMBRE***

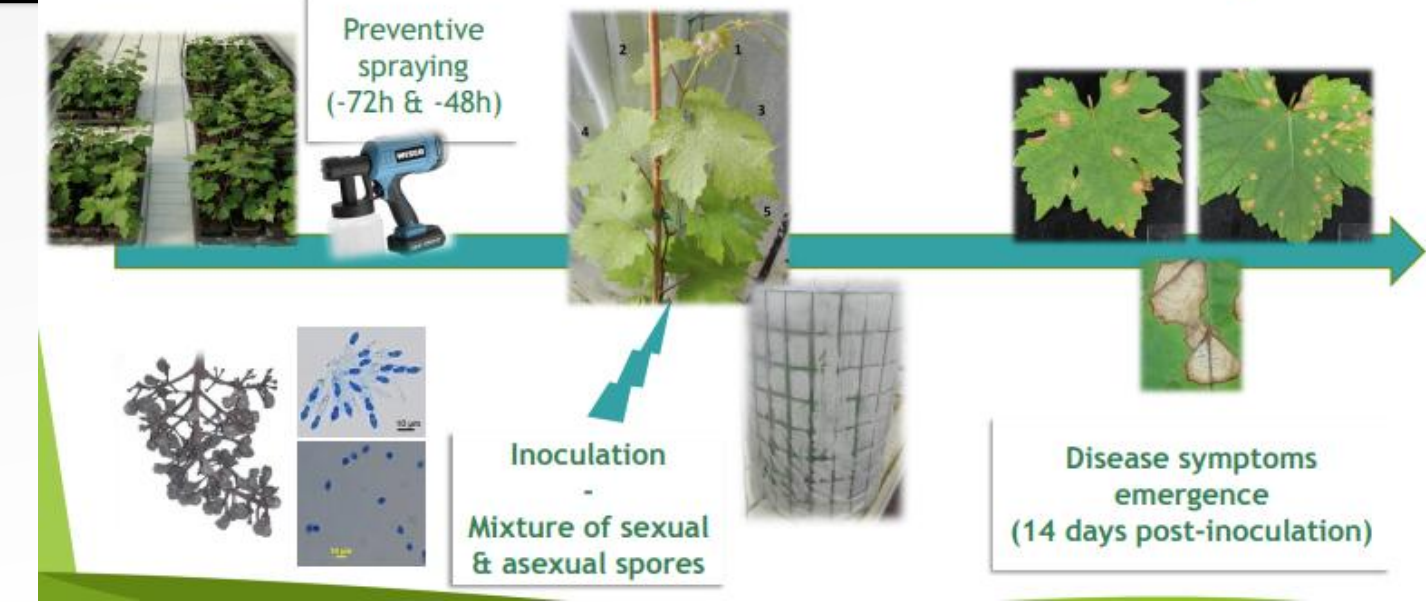


## Materials & Methods

Greenhouse trials were based on artificial BR inoculations (Raveau et al. J. Fungi 2024, 10, 471. <https://doi.org/10.3390/jof10070471>). Studied growing cuttings issued from various biocontrol assays. An image database based on 32 photographs per plant is in progress.



### Greenhouse methodology for Black Rot assays



## Deep learning algorithms

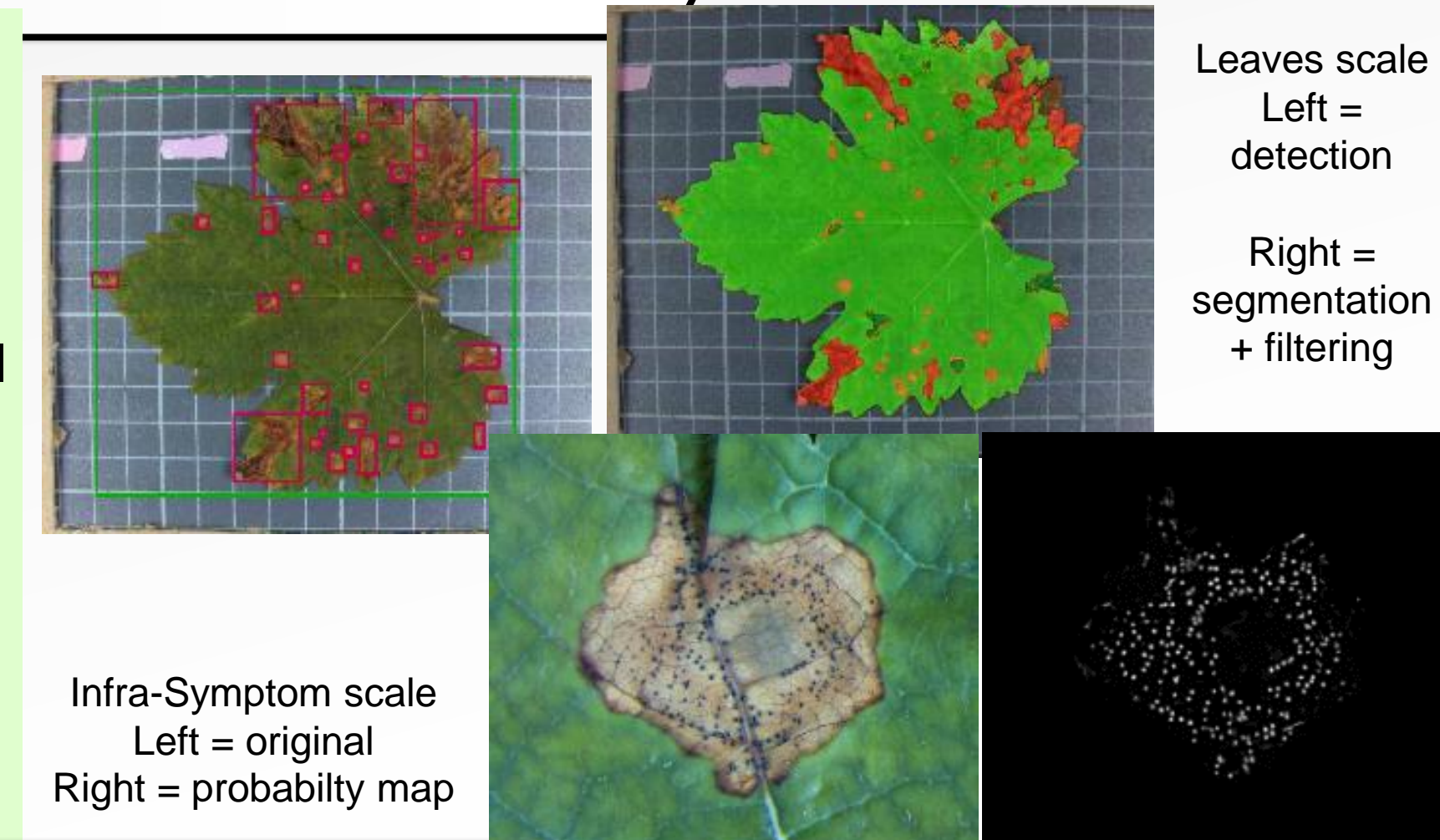
### At leaf scale, YOLO v11s (segmentation instance), with 3 steps:

- Detection, circle the symptoms into square
- Segmentation, detect the precise edges of each spot in a square
- Filtering, remove double detections

### At infra-symptom scale (pycnidia counting), U-Net adapted for small size object :

- Segmentation of the spots to avoid false detection outside spots
- Probability map of the pycnidia locations (+ thresholding)
- Counting the detected pycnidia

### At plant scale, the algorithms are still under development



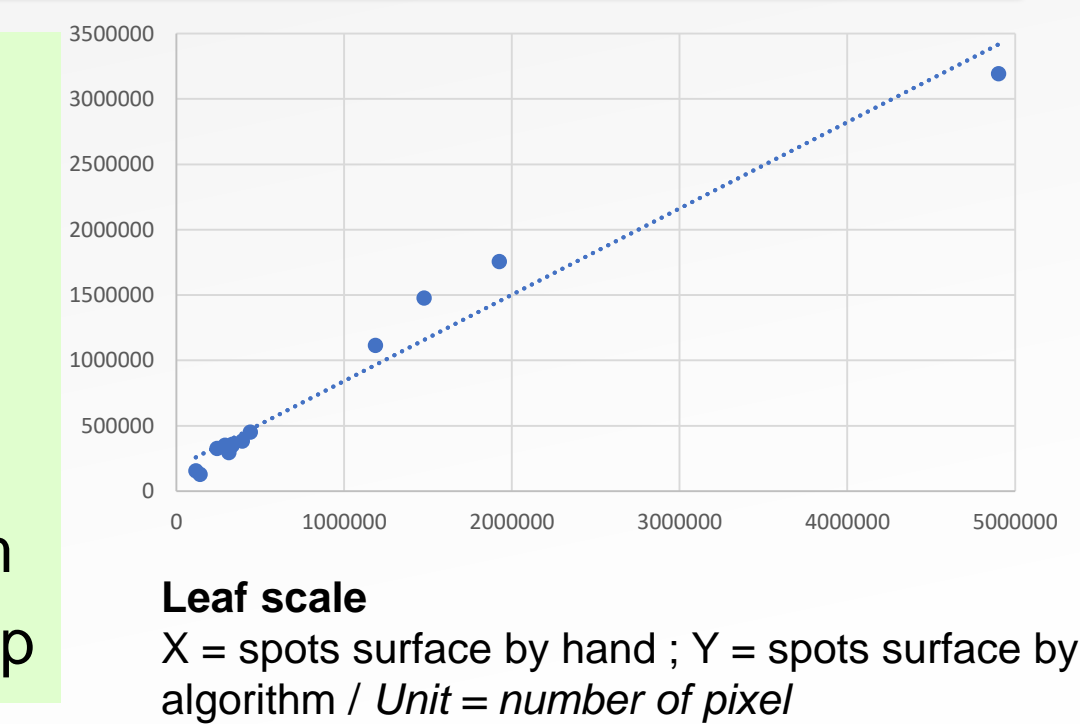
## Results

### Leaf scale:

- $R^2 = 0,97$  spots surface measured by hand VS by algorithm
- Noted a confusion between different spots classes

### Infra-Symptom scale:

- $R^2 = 0,59$  number of pycnidia measured by hand VS by algorithm
- Under-estimation = then to try other thresholds on probability map



## Conclusions and prospects

The **methodology will be further developed and improved** both from the epidemiological/biological as from the deep-learning/AI points of view.

- Possible confounding symptoms with foliar BR symptoms (e.g. biocontrol phytotoxicity) will be more tested/studied
- At the infra-symptom scale (pycnidia counts), there is still room for improvement: better segmentation, thresholds...

As **near-future research development**, we are going to address the vineyard issue with foliar BR detection and severity quantification based on field-images. A first database constitution is currently implemented in both Bordeaux and Cognac vineyard experimental plots (2025/2026).

As a more **long-term prospect**, such innovative methods would support BR biocontrol studies and decision-making for better managing the disease in commercial vineyards.