Weakly supervised segmentation of leaf symptoms in field conditions

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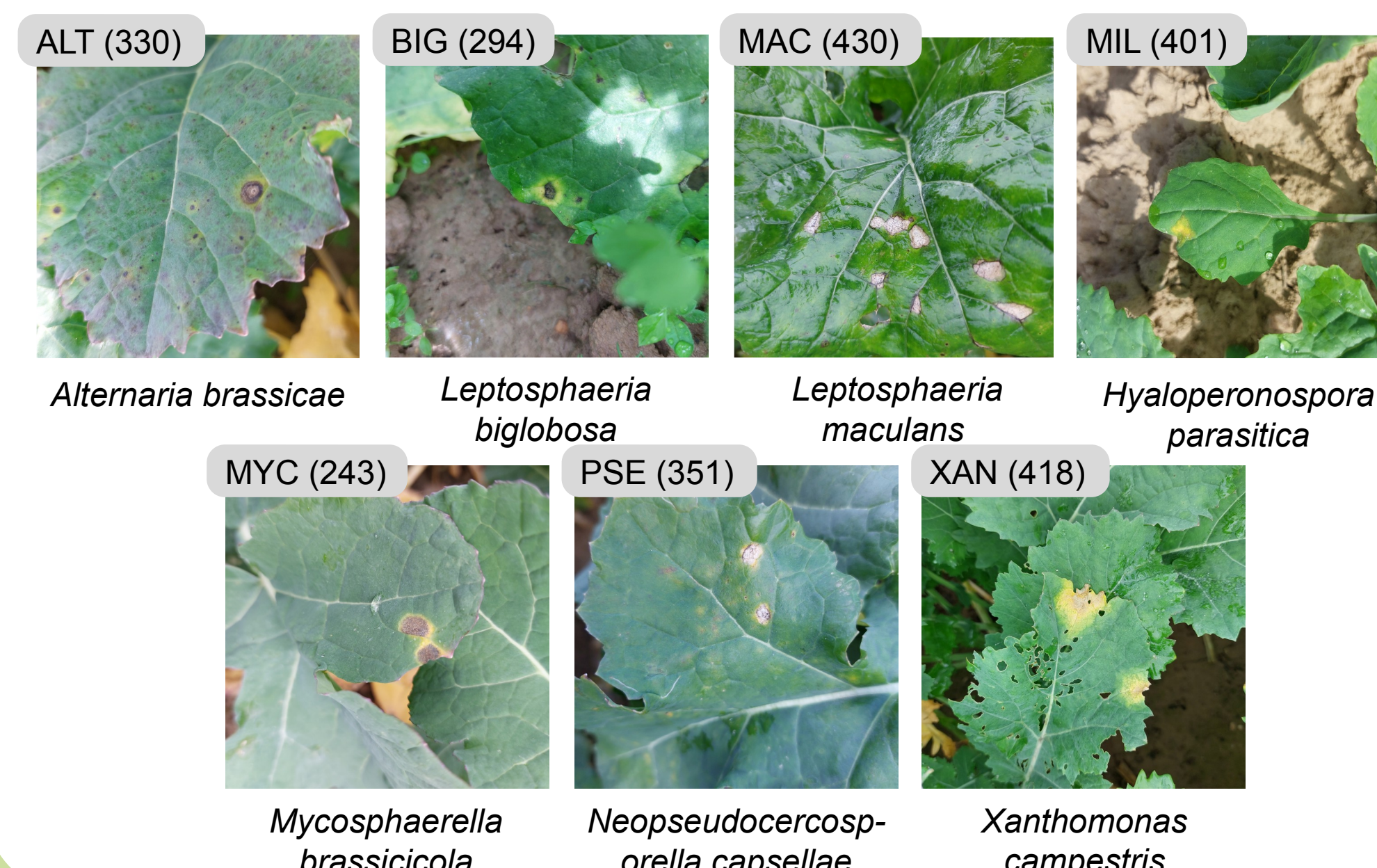[1]IGEPP - UMR INRAE, [2]IROKO - INRIA

Background

Crop diseases can cause significant yield losses. **Deep learning models** for computer vision offers powerful tools to **enhance human observation of plant disease symptoms**, for instance by using **segmentation models** to mark out foliar symptoms. However, the most common and effective architectures rely on a **fully supervised learning** that requires numerous, **costly and often unavailable**, pixel-level annotated images. To overcome this, we focus on **weakly supervised segmentation** [1]. The principle is to **generate segmentation masks** from less informative annotations, such as **image-level labels**, in order to train segmentation models with reduced annotation effort.
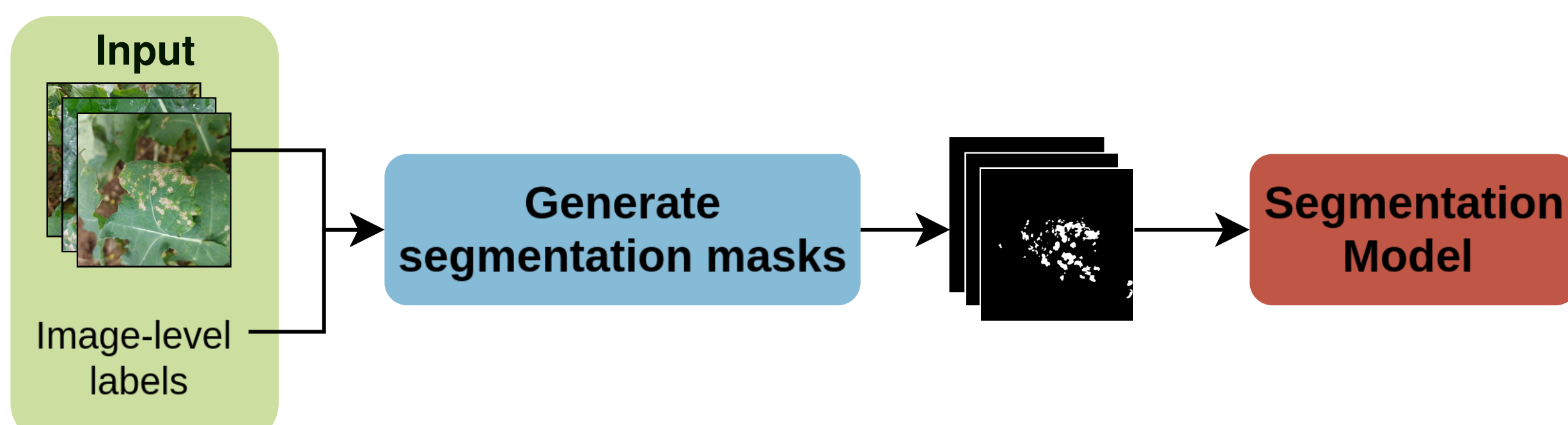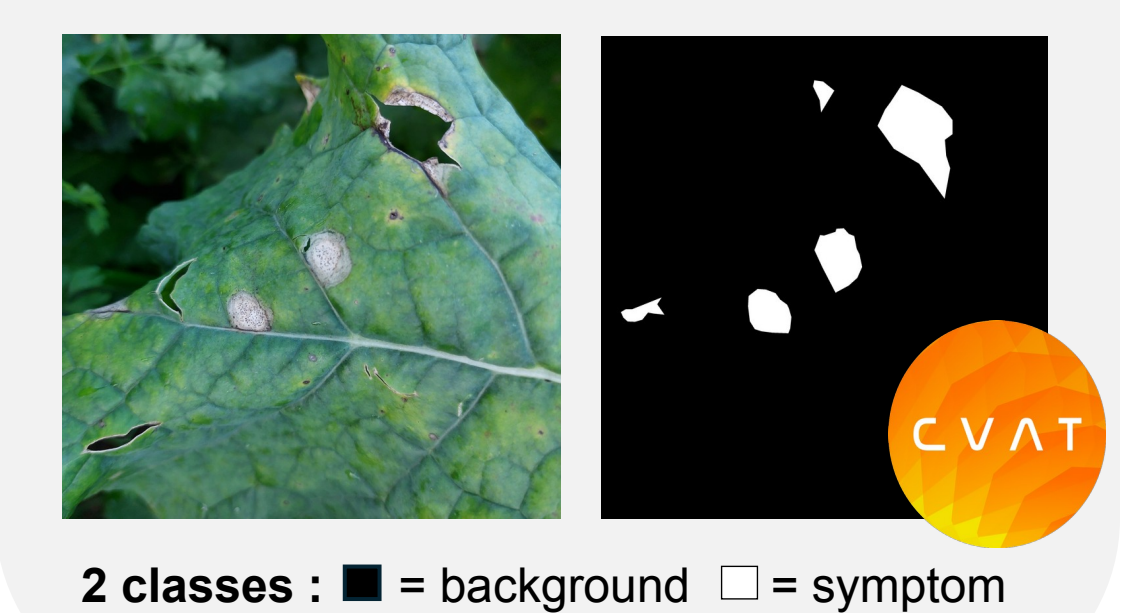

Input

The data are composed of **2540 RGB images** of symptoms caused by **7 pathogens** of **rapeseed** observed in **fields** among multiple growing seasons.
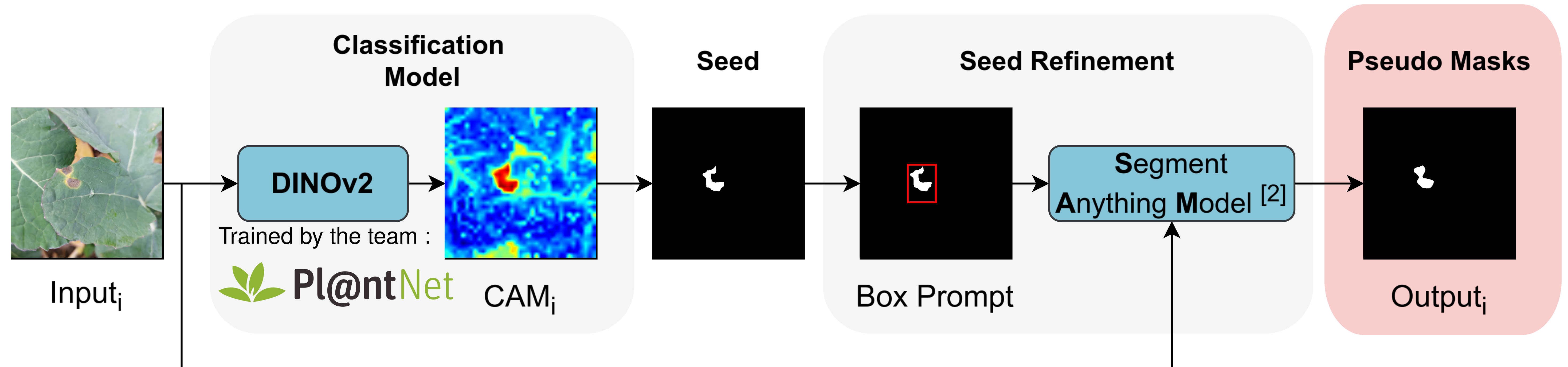

ALT (330) — *Alternaria brassicae*
BIG (294) — *Leptosphaeria biglobosa*
MAC (430) — *Leptosphaeria maculans*
MIL (401) — *Hyaloperonospora parasitica*
MYC (243) — *Mycosphaerella brassicicola*
PSE (351) — *Neopseudocercosporella capsellae*
XAN (418) — *Xanthomonas campestris*

Data annotation

Visible symptoms were manually segmented on **580 images**.

2 classes : ■ = background □ = symptom

Generate Segmentation masks

Input$_i$ → **Classification Model**: DINOv2 (Trained by the team : Pl@ntNet) → CAM$_i$ → **Seed** → **Seed Refinement**: Box Prompt → **Segment Anything Model** [2] → **Pseudo Masks**: Output$_i$
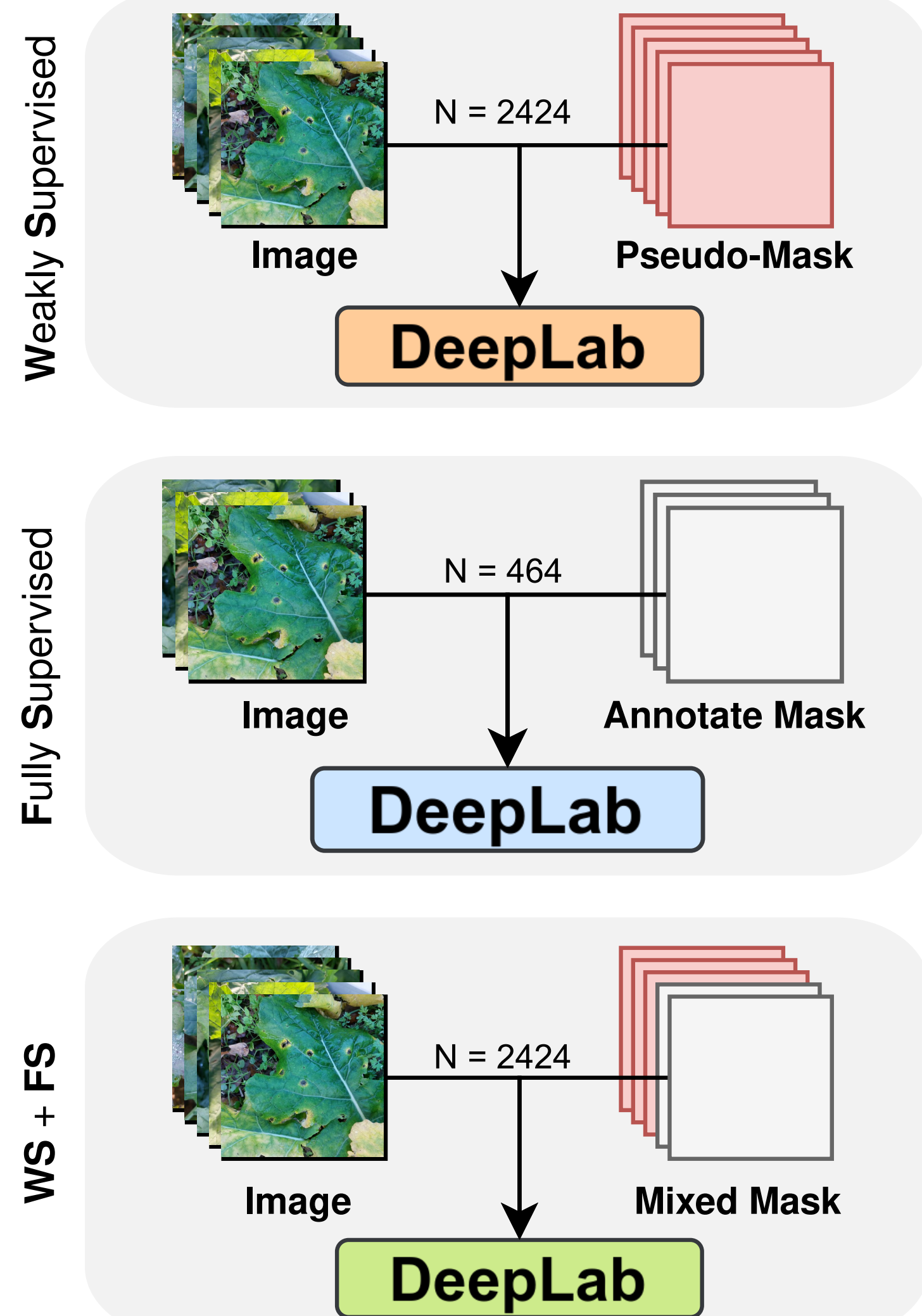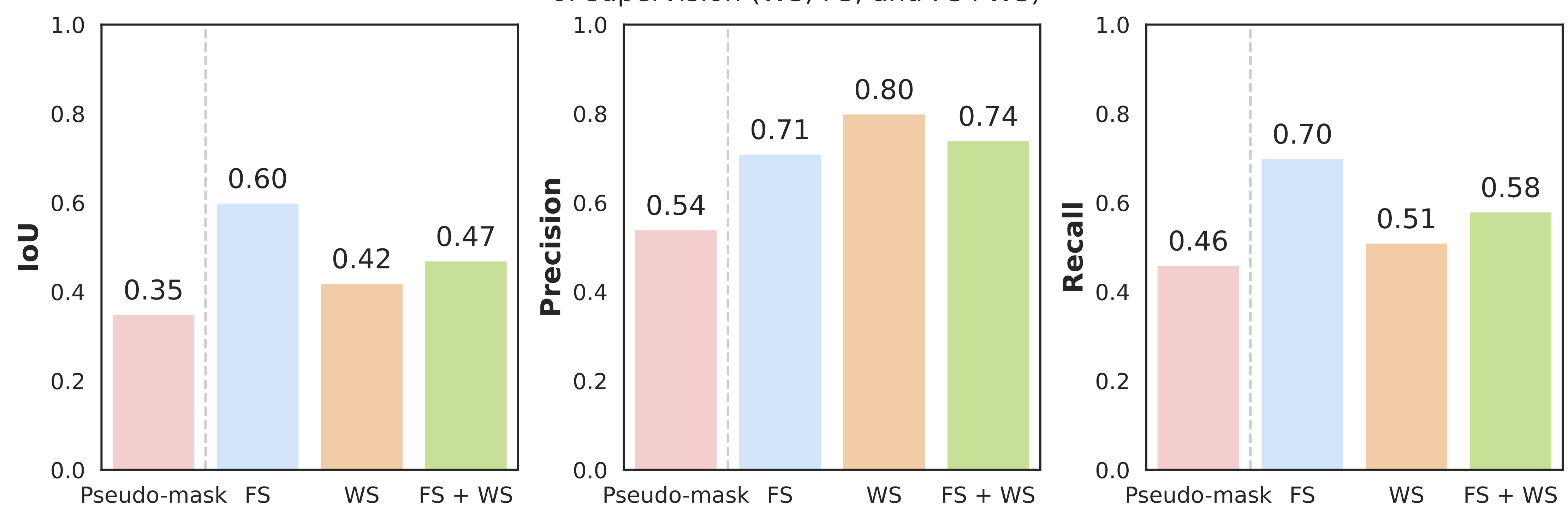
Segmentation Model

3 **segmentation models** were train with differents **degree of supervision**.

TRAIN SET N = **2424** or **464**	TEST SET N = **116**

Weakly Supervised: Image N = 2424 → DeepLab → Pseudo-Mask

Fully Supervised: Image N = 464 → DeepLab → Annotate Mask

WS + FS: Image N = 2424 → DeepLab → Mixed Mask

Evaluation of pseudo-masks and performance of the Segmentation Model under 3 levels of supervision (WS, FS, and FS+WS)

IoU: Pseudo-mask 0.35, FS 0.60, WS 0.42, FS + WS 0.47
Precision: Pseudo-mask 0.54, FS 0.71, WS 0.80, FS + WS 0.74
Recall: Pseudo-mask 0.46, FS 0.70, WS 0.51, FS + WS 0.58

Key message

- The model trained with **pseudo-masks (WS)** achieved a **lower IoU** compared to the DeepLab model trained with **annotated masks (FS)** (0.41 vs. 0.60).
- However, the **IoU improved by 0.05** when DeepLab was trained using a combination of annotated and pseudo-masks (WS + FS).

- The pseudo-masks, being noisy annotations, tend to **"clean" the segmentation** by suppressing some symptoms that are incorrectly labeled but they also **fail to identify new or subtle ones**.

Perspectives

- To enhance the quality of the pseudo-mask, the Seed Refinement step could be improved by **adding a process to segment additional symptoms**.

- Focus on the segmentation of **multiple diseases on a single leaf**, which reflects a current conditions encountered in the field.

- Evaluation of models for estimating **symptom severity indicators**

[1] Chen, Zhaozheng, and Qianru Sun. "Weakly-supervised semantic segmentation with image-level labels: from traditional models to foundation models." ACM Computing Surveys 57.5 (2025): 1-29.
[2] Kirillov, Alexander, et al. "Segment anything." Proceedings of the IEEE/CVF international conference on computer vision. 2023.

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