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**High throughput phenotyping of interactions between plants and microorganisms, associated devices.  
Phenotyping Platform for Plant and Plant Micro organisms Interactions (4PMI, INRA Dijon)**

Christophe Salon

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Christophe Salon. High throughput phenotyping of interactions between plants and microorganisms, associated devices. Phenotyping Platform for Plant and Plant Micro organisms Interactions (4PMI, INRA Dijon). Scientific Workshop on the effects of biotic and abiotic stresses in legumes: the AB-STRESS and BIOTECISOJASUR projects, Mar 2016, Balcarce, Argentina. hal-02739422

**HAL Id: hal-02739422**

**<https://hal.inrae.fr/hal-02739422v1>**

Submitted on 2 Jun 2020

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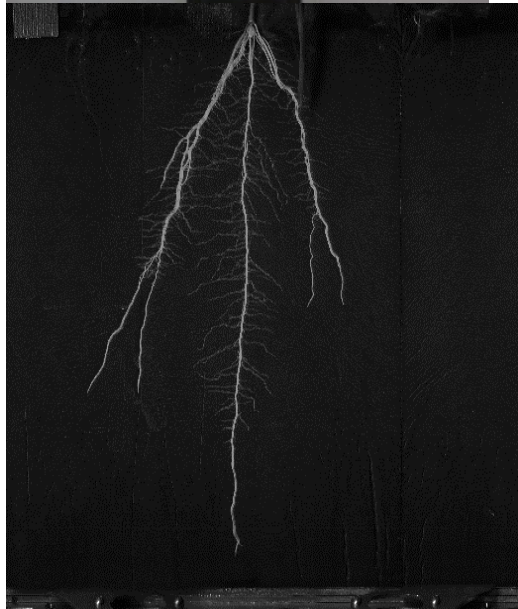


**High throughput phenotyping of interactions between plants and microorganisms, associated devices**  
**Phenotyping Platform for Plant and Plant Microorganisms Interactions**  
**(4PMI, INRA Dijon)**

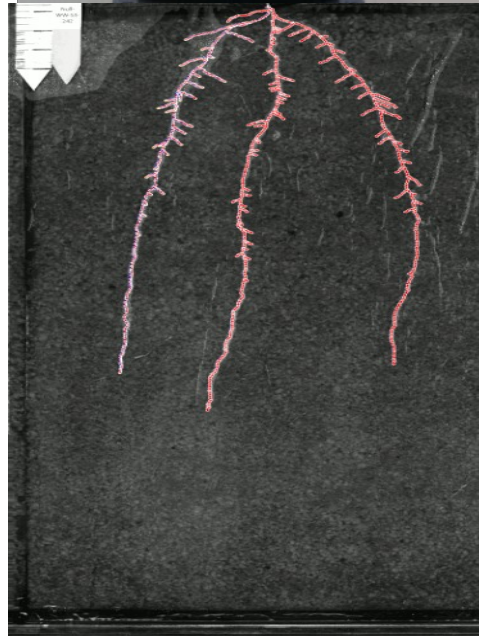
Christophe Salon

UMR 1347-AgroSup/INRA/uB, 17 rue Sully - BP 86510 - 21065 Dijon - France

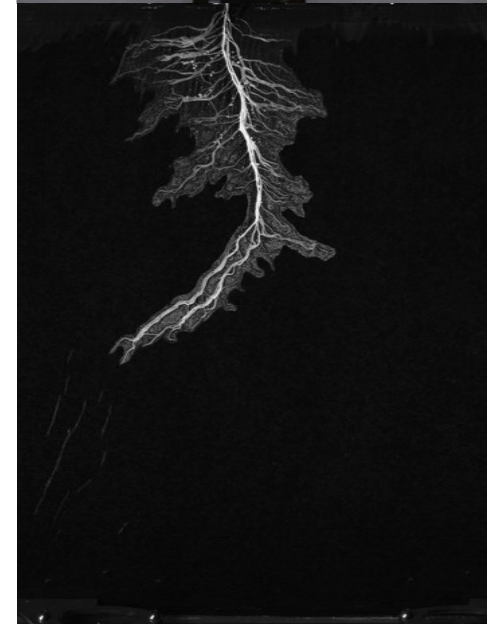
# Achievements: Shoot phenotyping



Maize

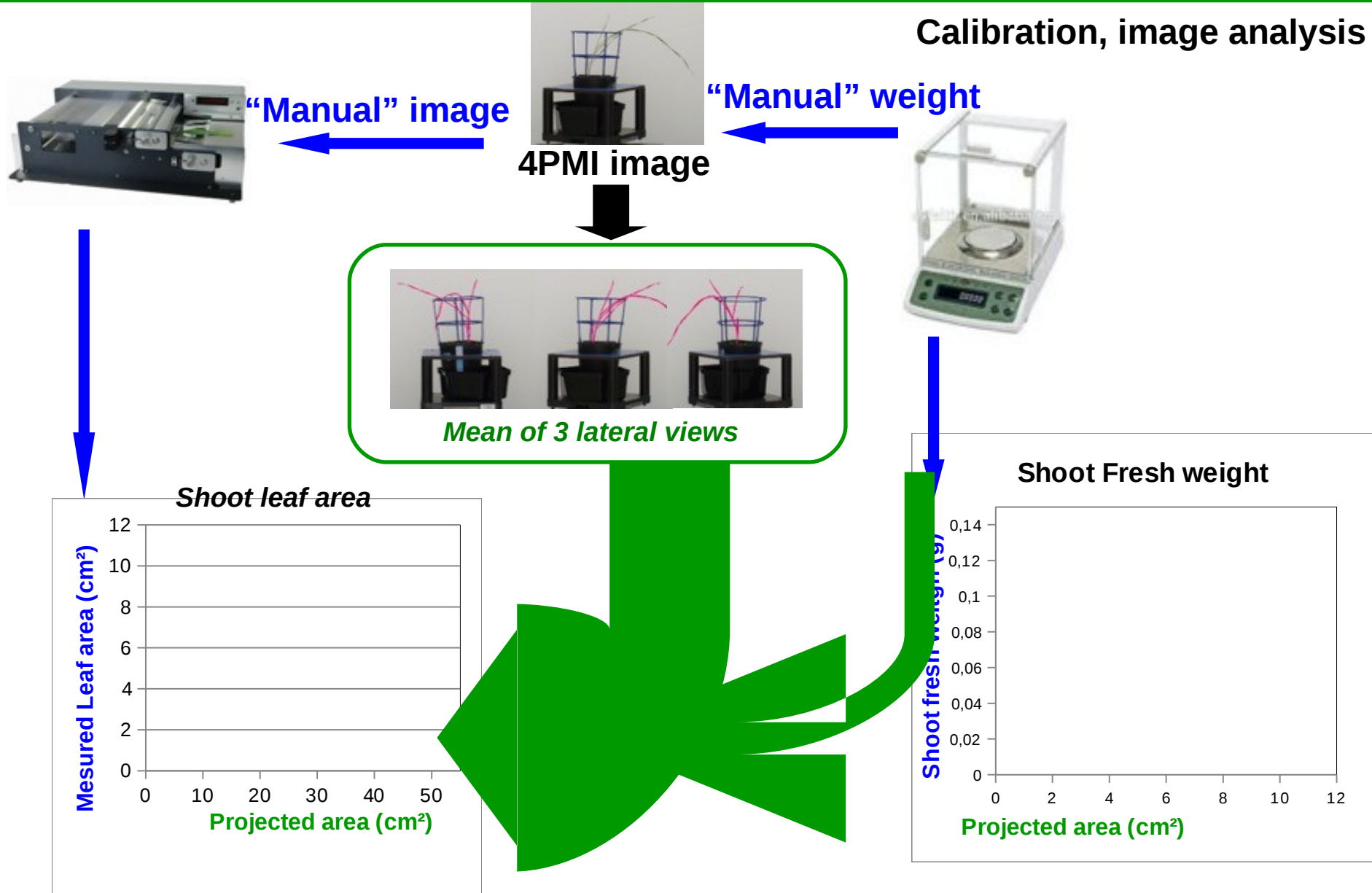


Wheat



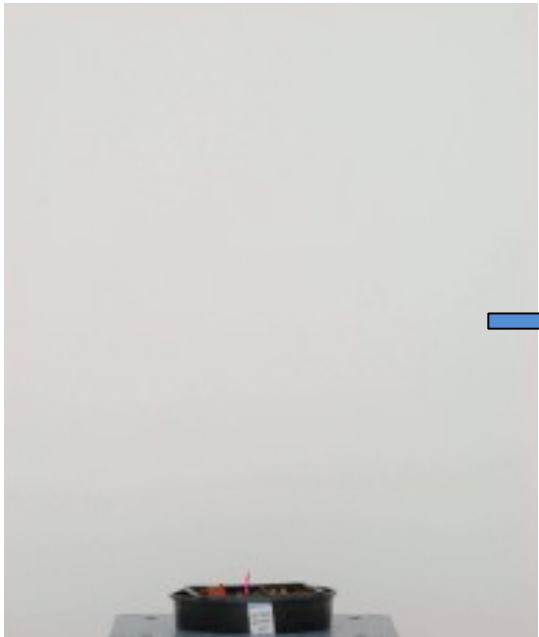
Pea

# Achievements: Shoot phenotyping

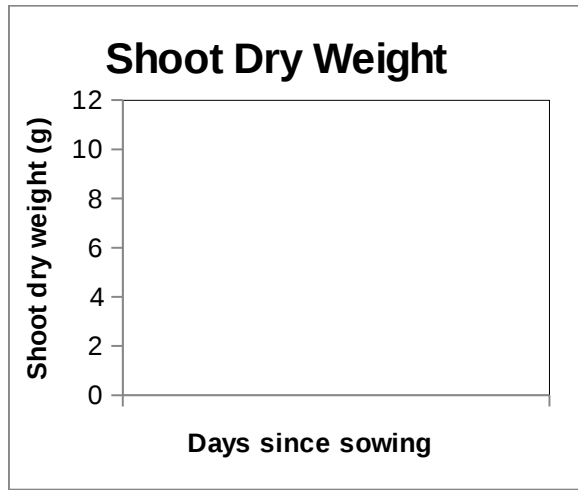
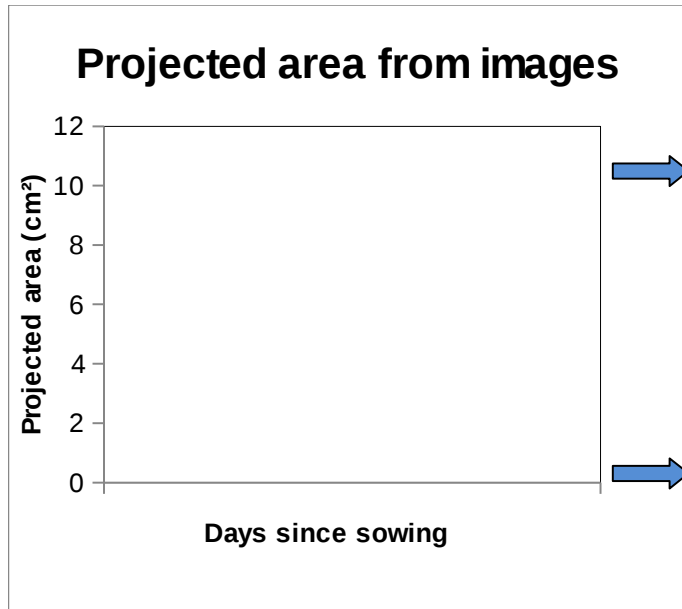


***Choice of best image acquisition model !***

Wheat

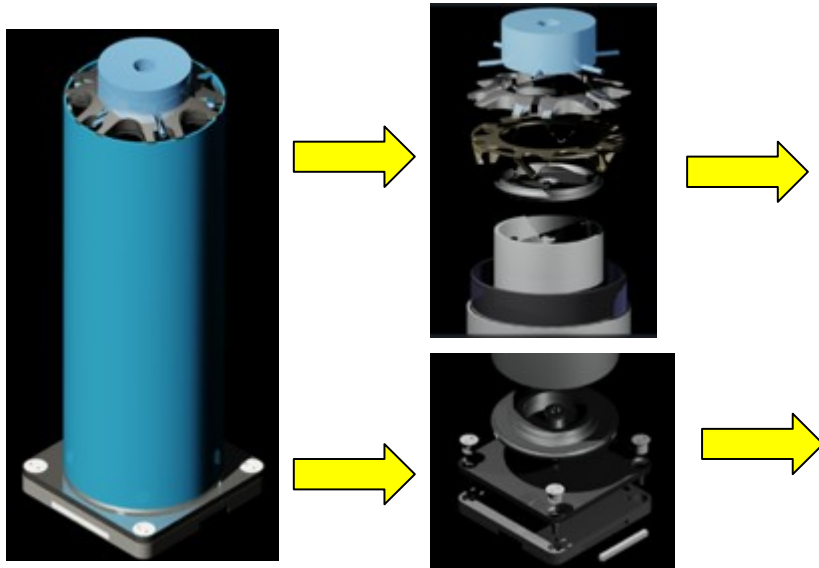


4PMI image



**Prototyping approach:** Partnership with SMEs (Inoviaflow and Shakti):

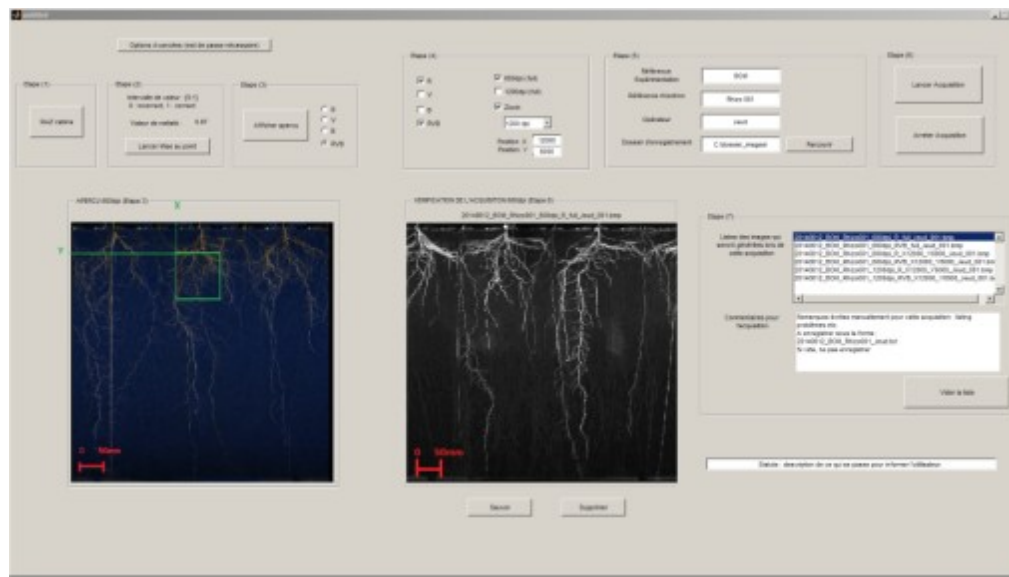
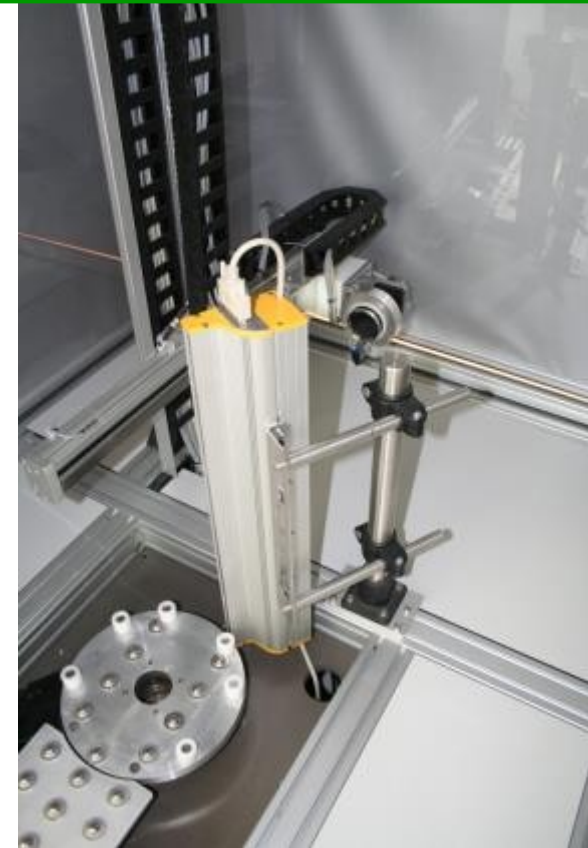
- very innovative rhizotrons (European patent) called RhizotubeHD,
- associated imaging cabins (Rhizocab and Rhizocab-HT) and software,
- irrigating, potting depotting tools.



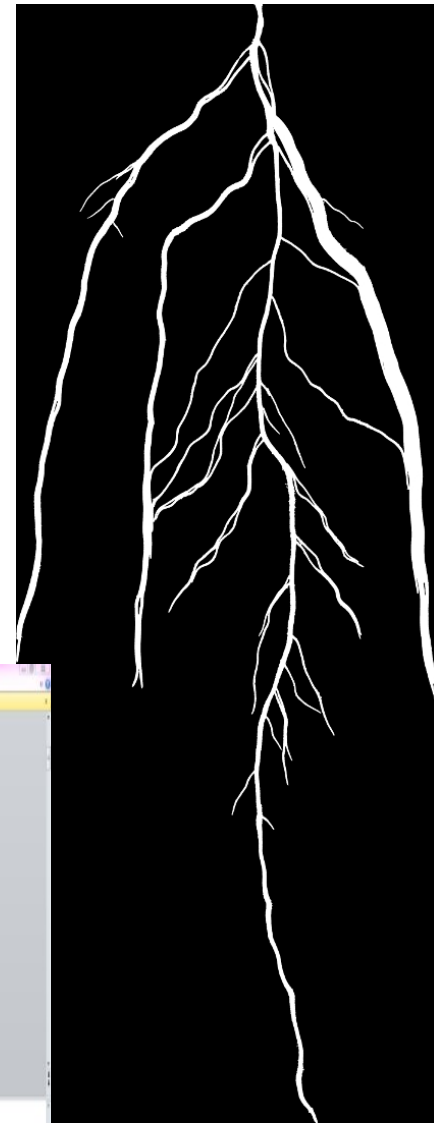
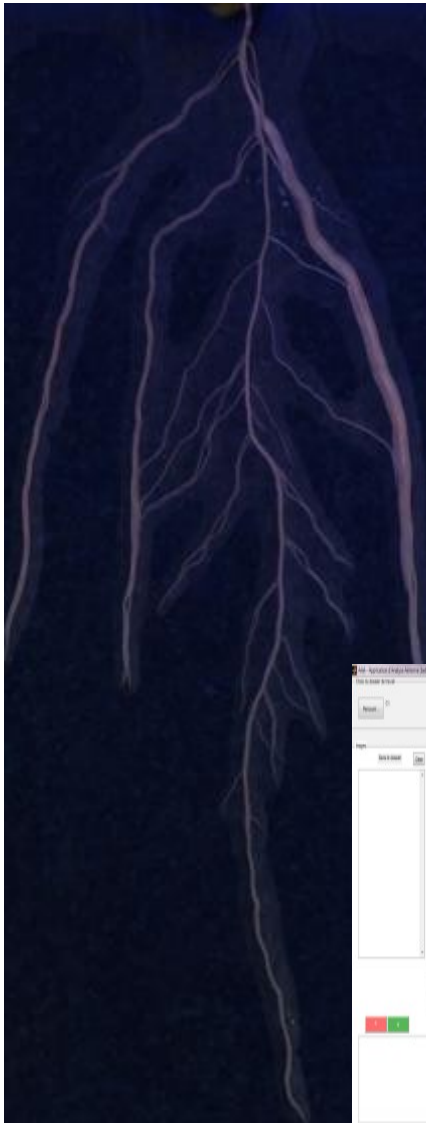
**PHENOME**  
Réseau Français  
Phénomique végétale  
F P P N



**EU Patent INRA InoviaFlow,  
World licence distributions  
ongoing (INRA-Inoviaflow)**



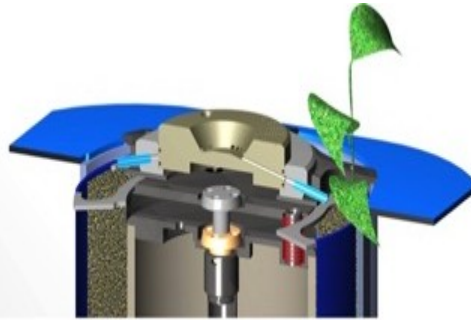
# Segmentation software



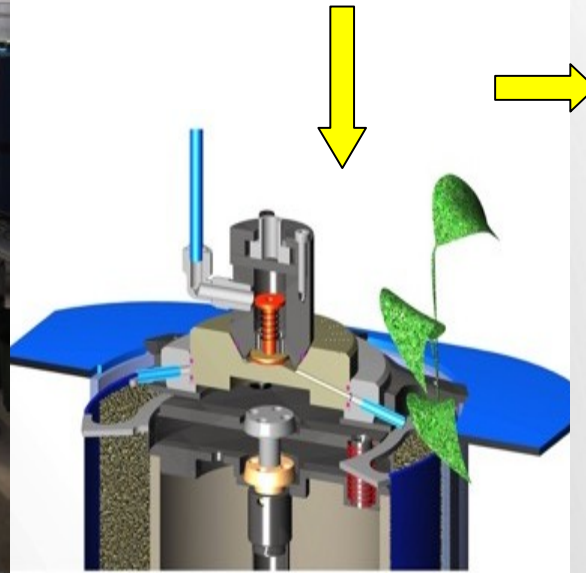
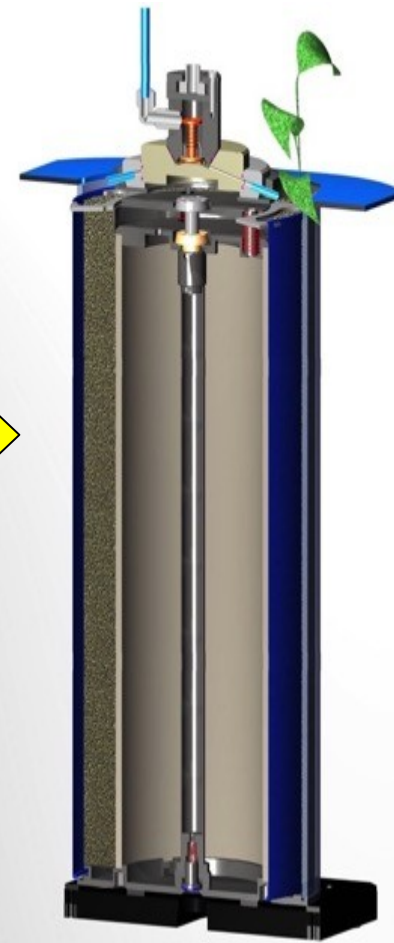
The screenshot shows a software interface for image segmentation. On the left, there are several control panels for adjusting parameters like 'Seuil' (Threshold) and 'Niveau' (Level). The main window displays a grayscale image of a tree trunk and branches, with a yellow circle highlighting a specific region. The interface includes a 'Mappe' (Map) section on the right, showing a list of 'Lignes éventuelles' (Possible lines) and a 'Recapitulatif' (Summary) section. The bottom of the interface features a status bar with the text 'En attente' (Waiting).



## Irrigation arm



## Shell

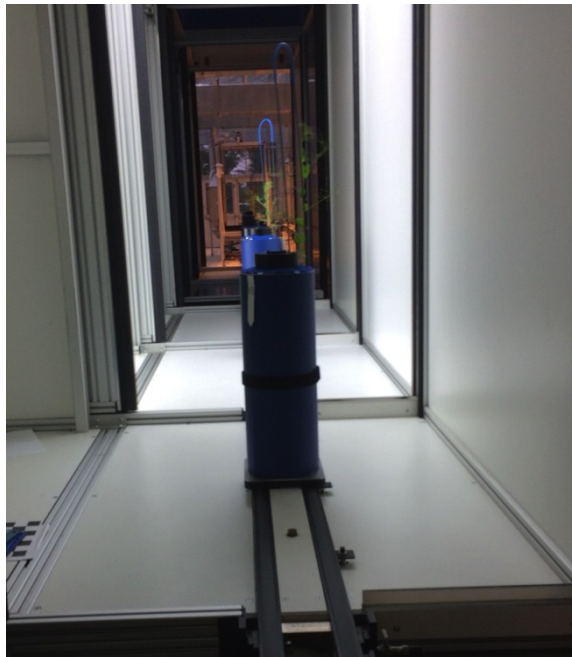
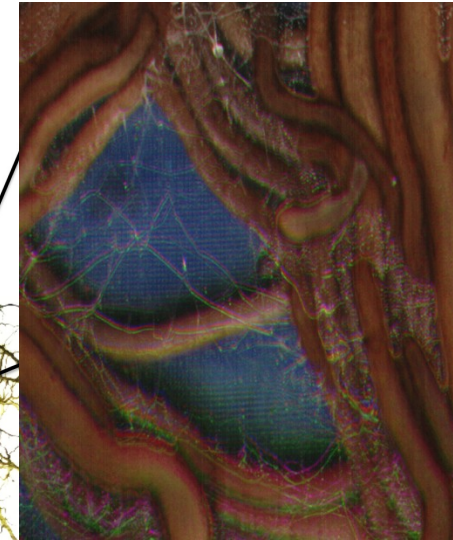
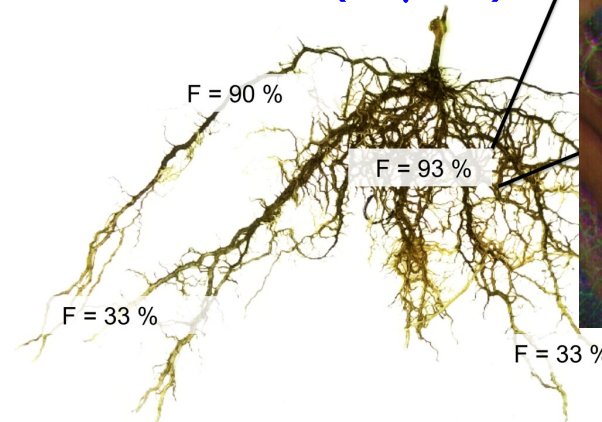


**Ok for small amount of nutritive solutions**  
**Drainage hole**

# RhizoCab HT development



Low throughput:  
50 RT/day, 45s/RT  
Very high resolution (7  $\mu\text{m}$ )



High throughput:  
100ds/day  
15s/RT  
Medium resolution (42  $\mu\text{m}$ )

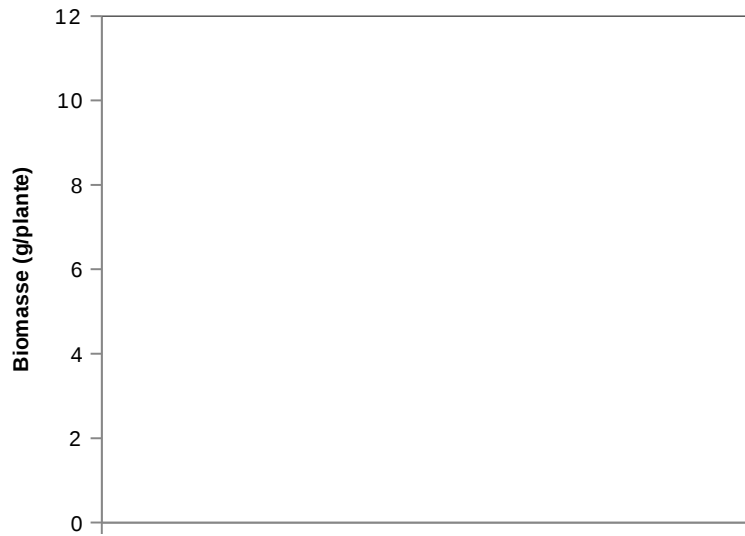




# BOM: RhizoTubes vs Pots ?

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Shoots over root biomass ratio



Mean Nodule weigth

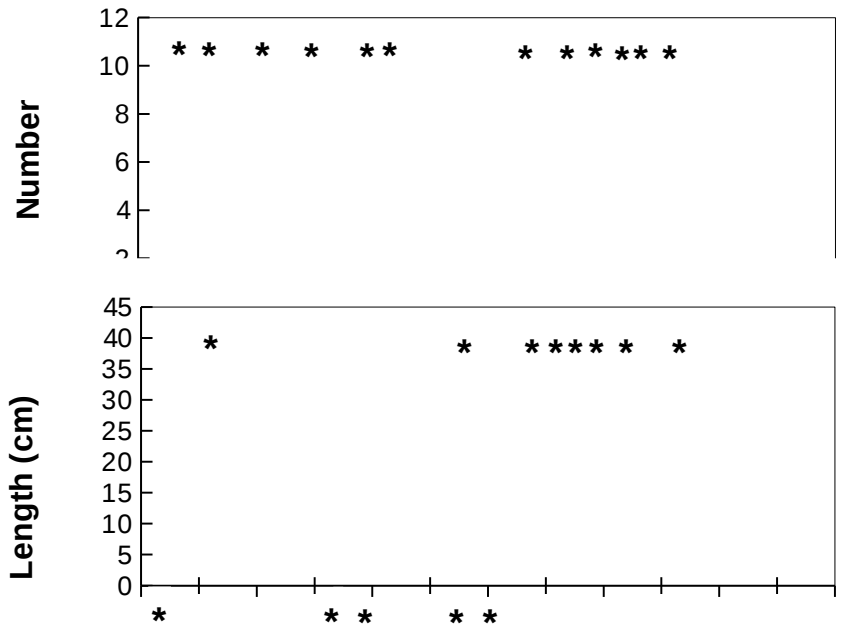


*Similar plant compartments and  
nodule traits*



# BOM: RhizoTubes vs Pots ?

1st order lateral roots

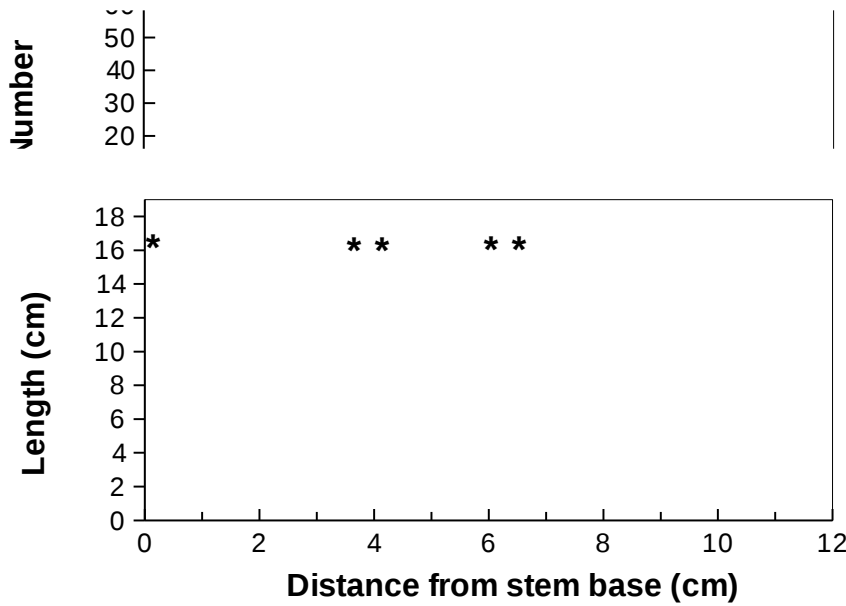


○ Pot ● RhizoTube

*Same length upper*

*... but pot vs RhizoTube depth !*

2nd order lateral roots

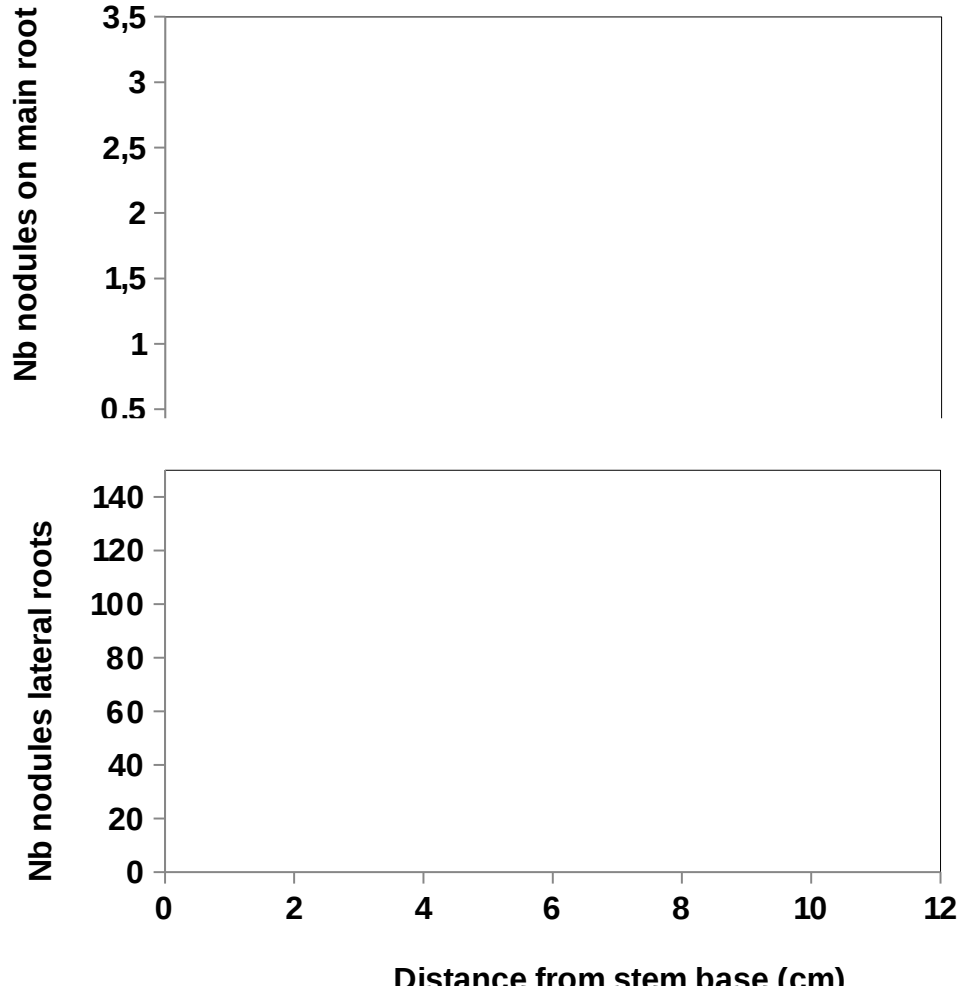


*Same number and distribution of roots on 2nd order laterals*



# BOM: RhizoTubes vs Pots ?

- *Pot*
- *RhizoTube*



*Same nodule profile distribution, shifted*

cm

# Length main root

Length (cm)

0 \_\_\_\_\_

Date \_\_\_\_\_

Number

# Number of nodule

0 \_\_\_\_\_

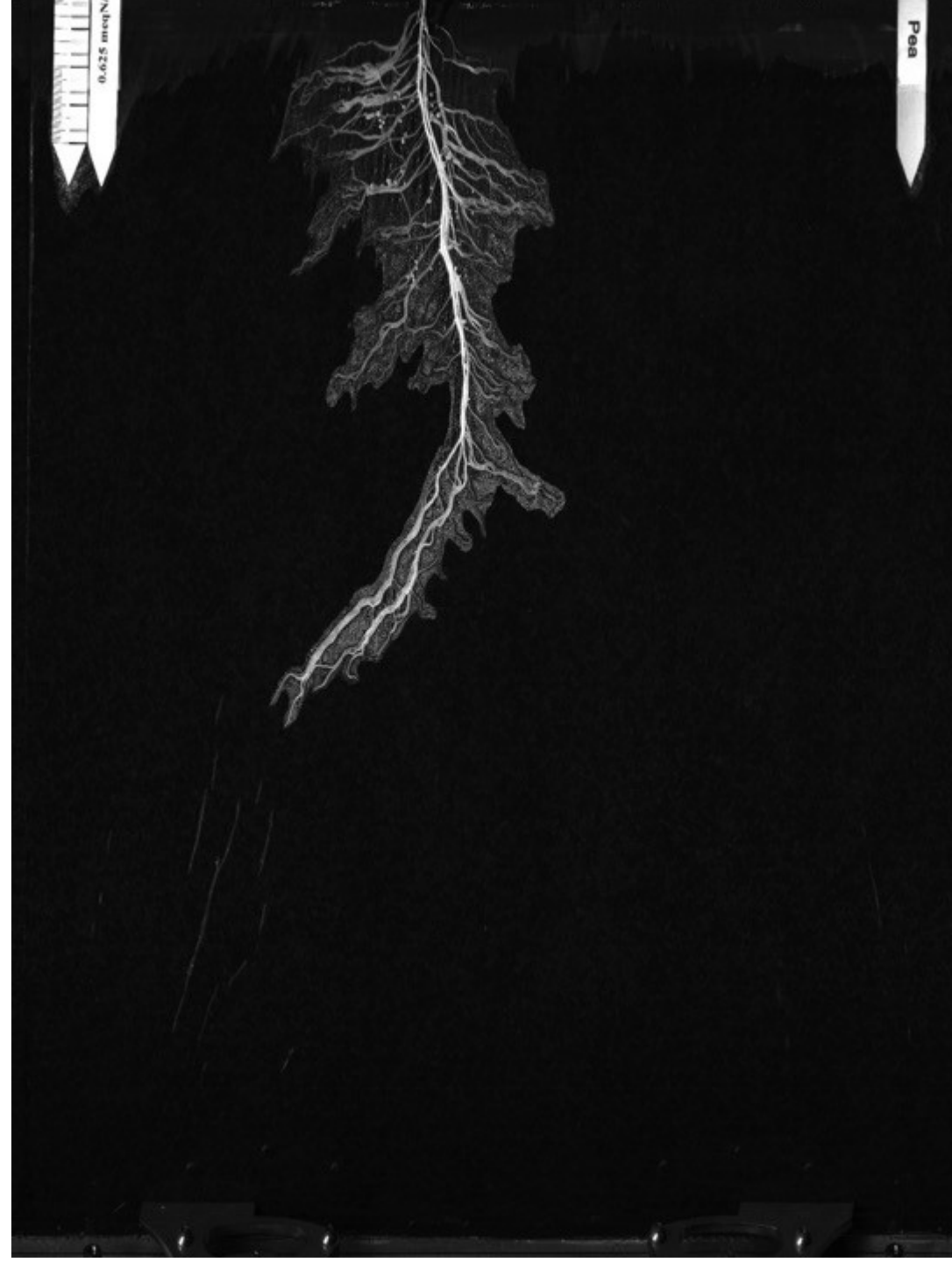
Date \_\_\_\_\_

Number

# Number of laterals

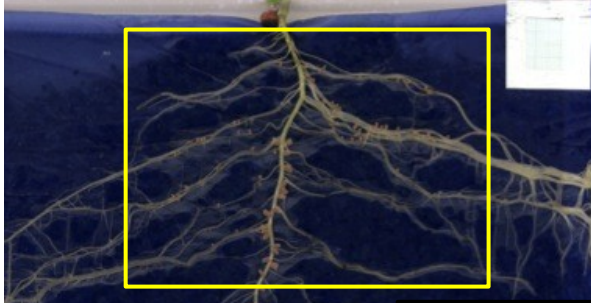
0 \_\_\_\_\_

Date \_\_\_\_\_

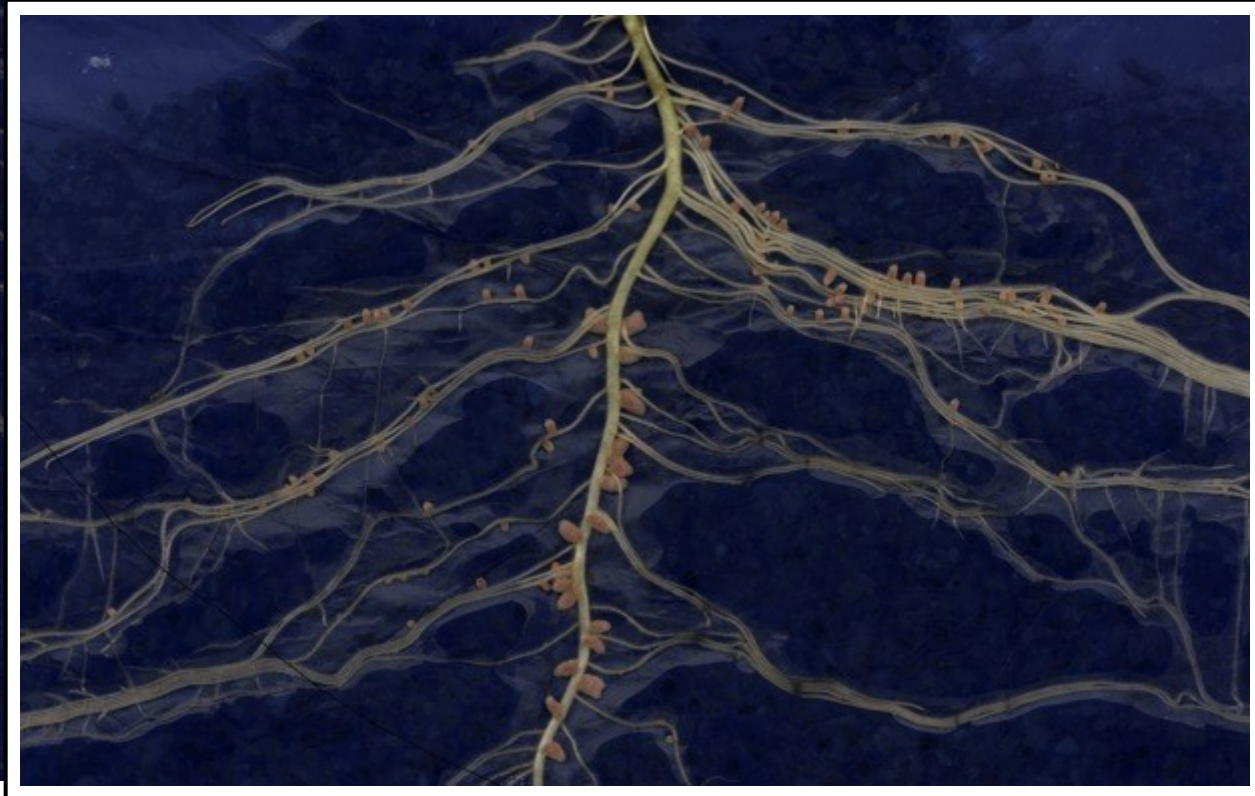


# Phenotypic traits: examples

**Nodules:** Number, projected surface, position, color

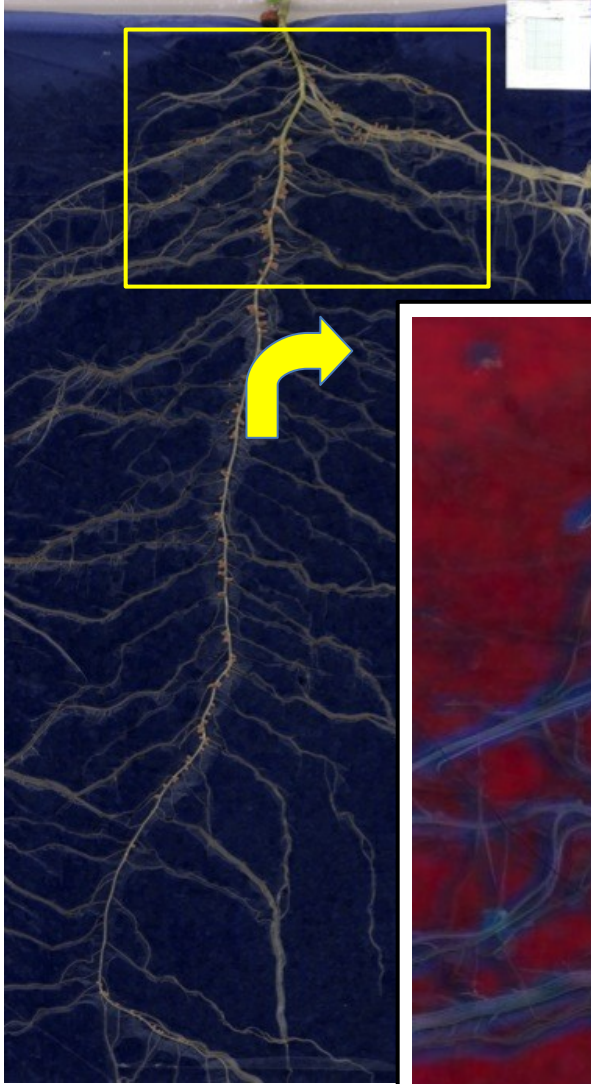


Focus on image



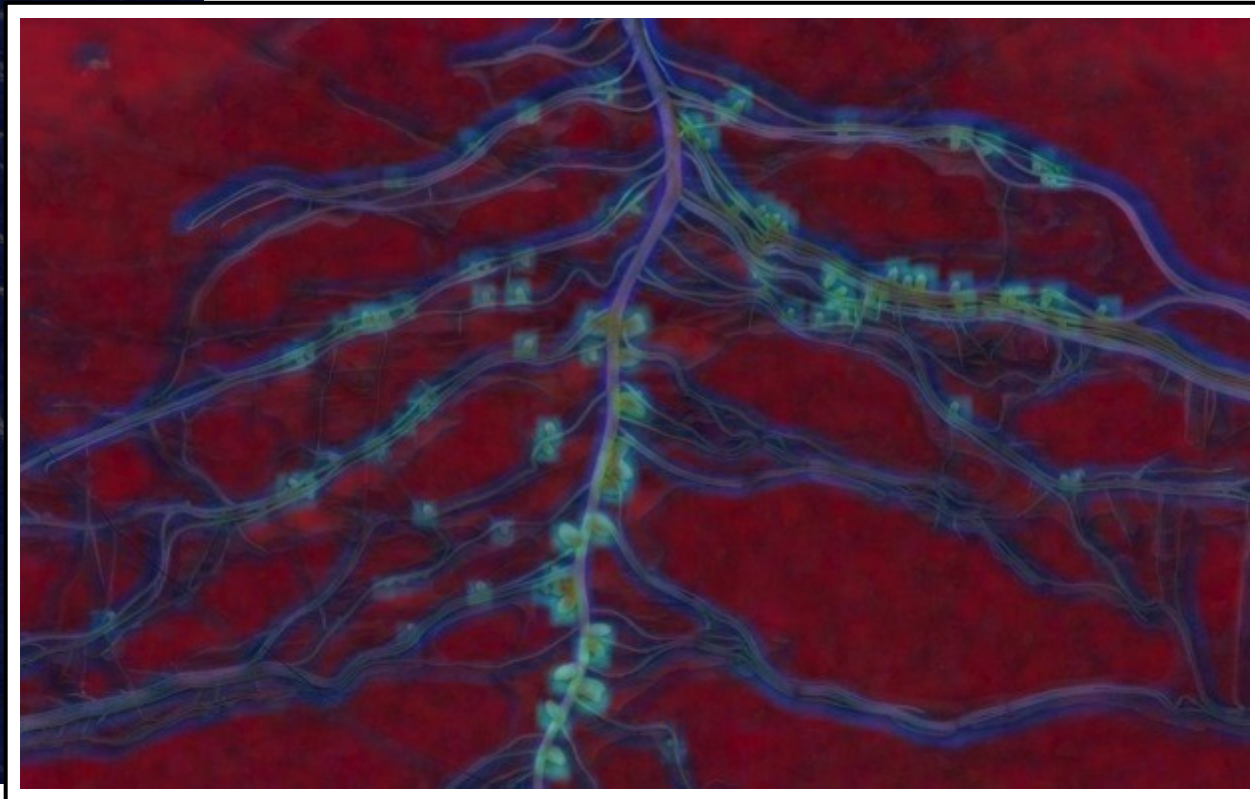
# Phenotypic traits: examples

**Nodules:** Number, projected surface, position, color



**Hybrid spaces (color + texture)**

(Cointault et al, 2008)





# Phenotypic traits: examples

**Nodules:** Number, projected surface, position, color

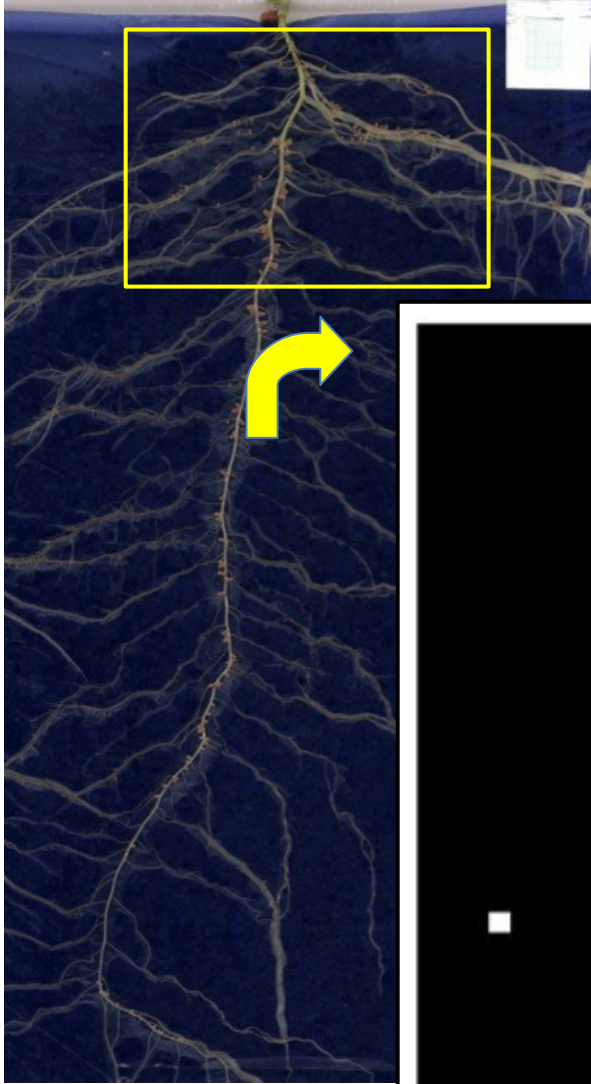
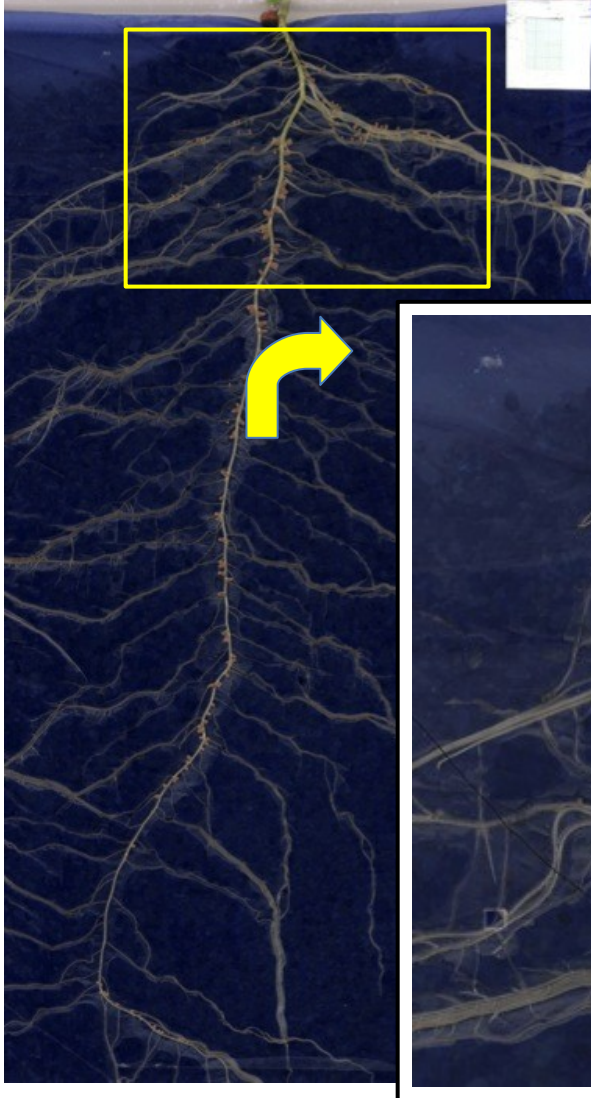


Image with nodules

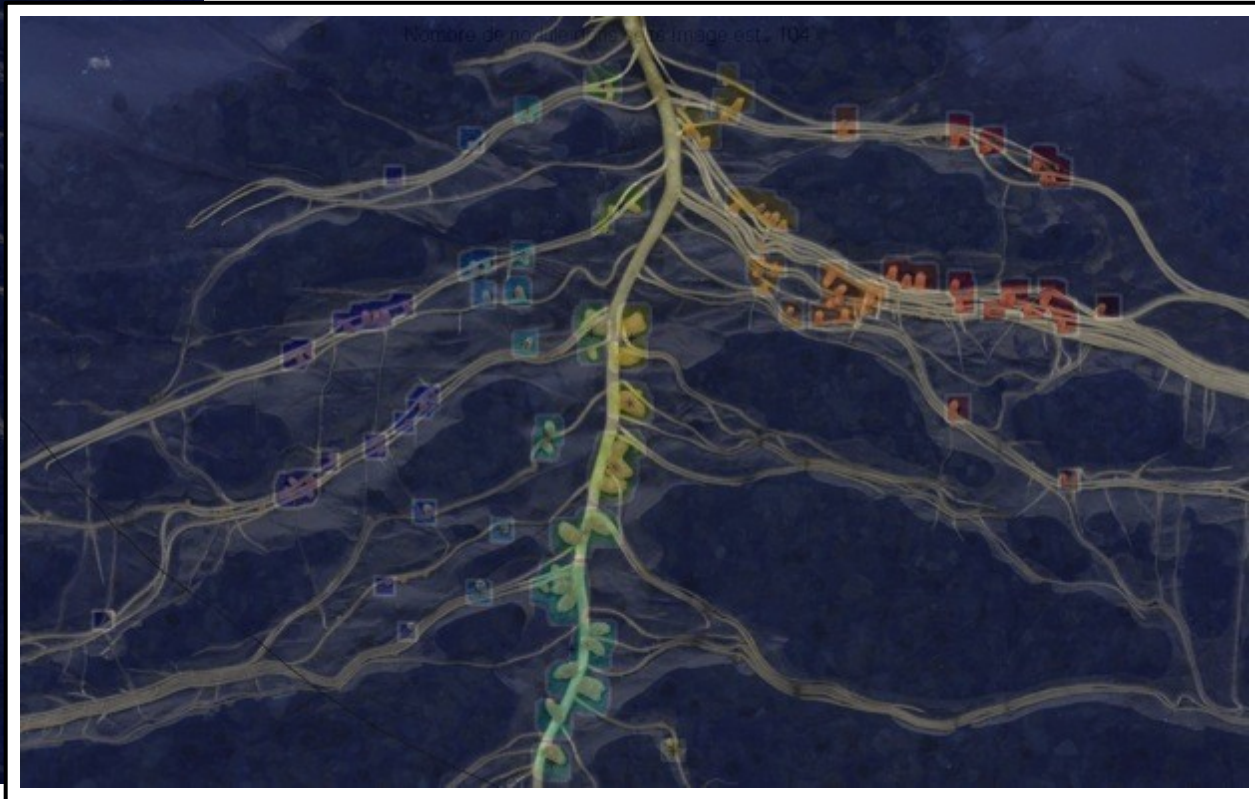


# Phenotypic traits: examples

**Nodules:** Number, projected surface, position, color

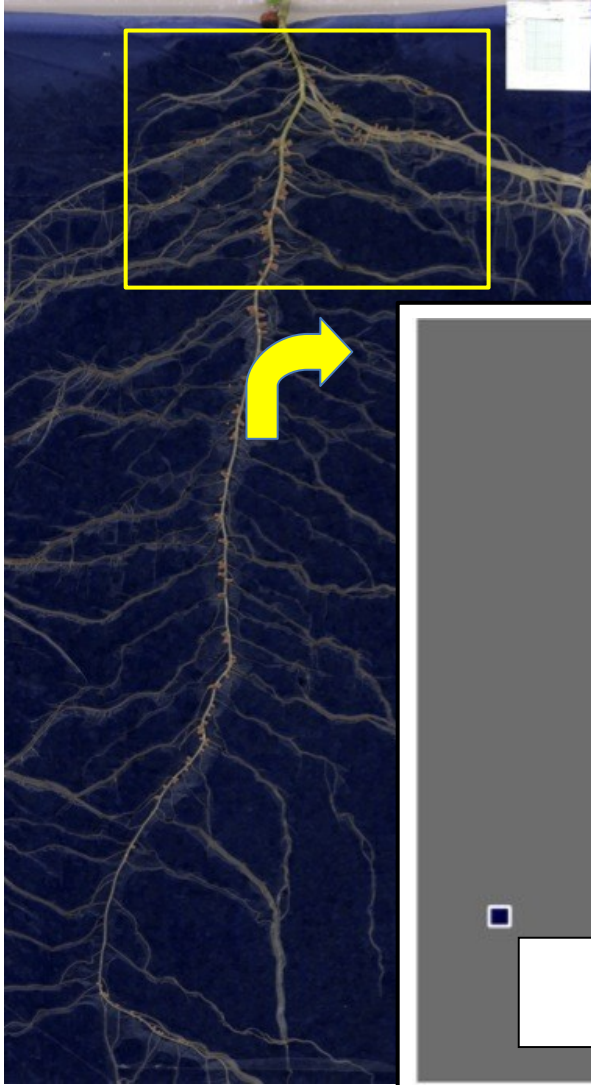


**Original image + superimposed nodules**

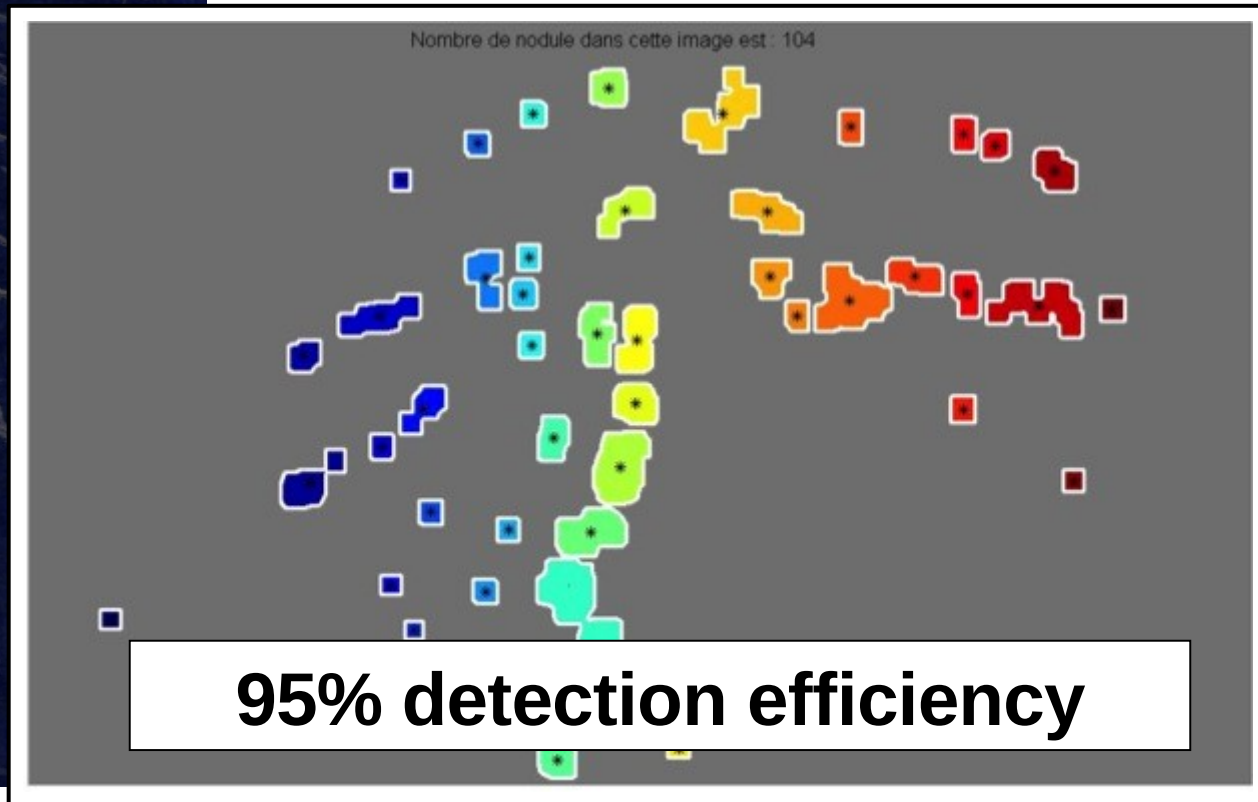


# Phenotypic traits: examples

**Nodules:** Number, projected surface, position, color



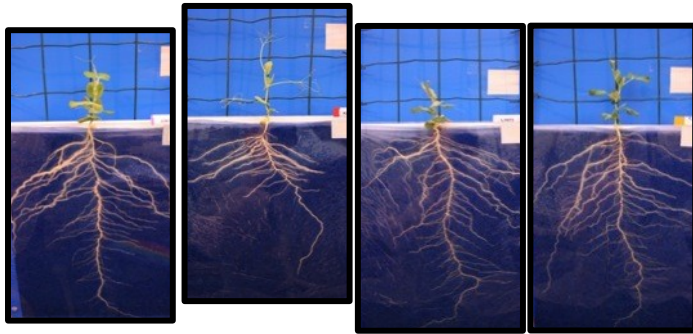
**Nodules automatically detected**



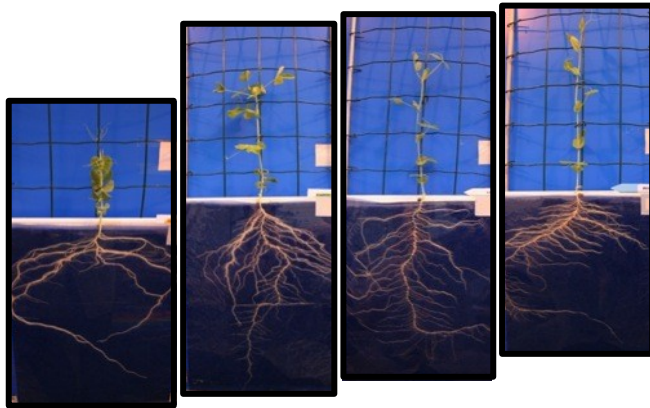
# Phenotypic traits: examples

**Nodules:** Number, projected surface, position, color

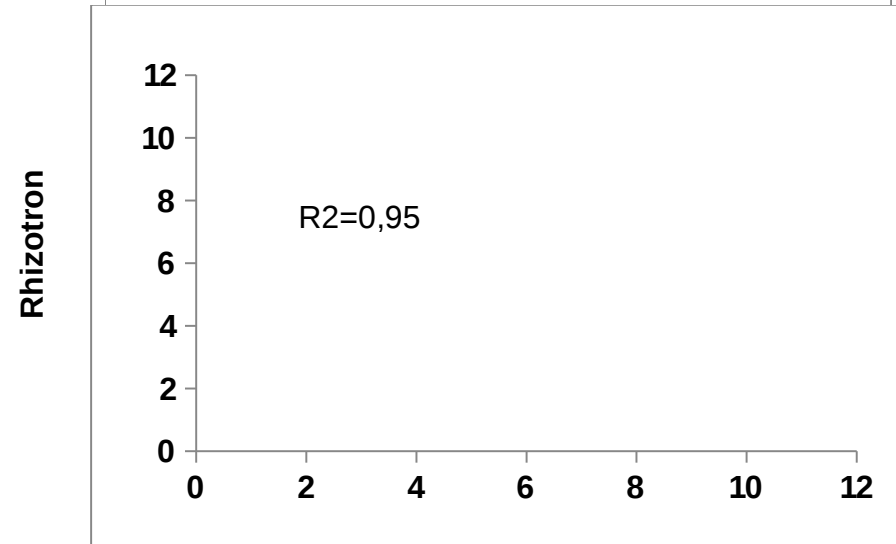
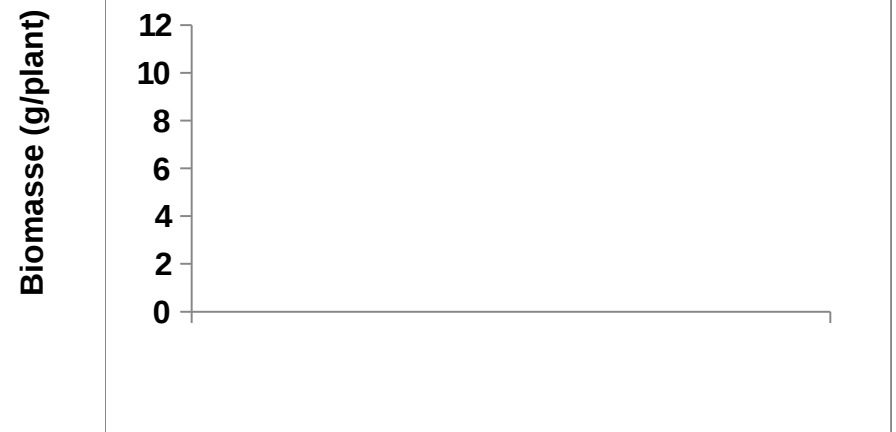
*Pea core collection*



AMINO KAYANNE L1073 CAMEOR



ISARD CUZCO LIVIOLETTA PI186093



Hydroponique et substrat

# Some root example



Pois



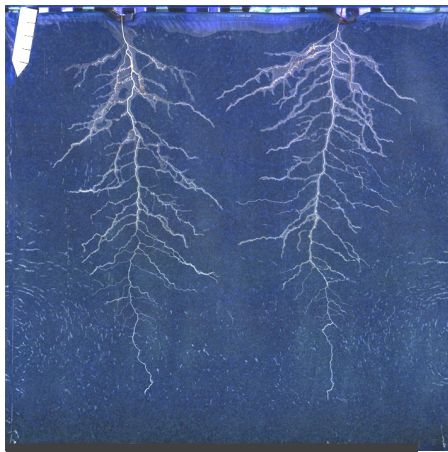
Féverolle



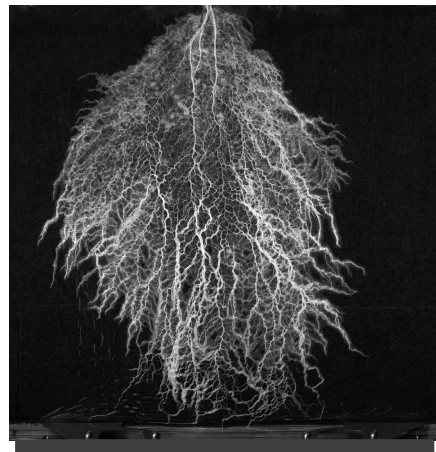
Lupin



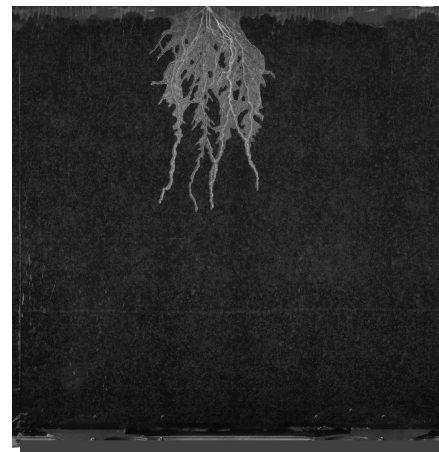
Haricot



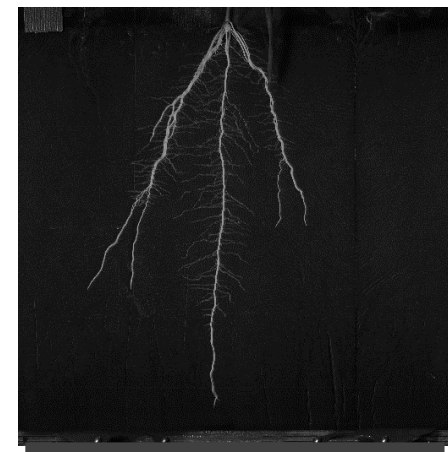
Vesce Commune



Colza

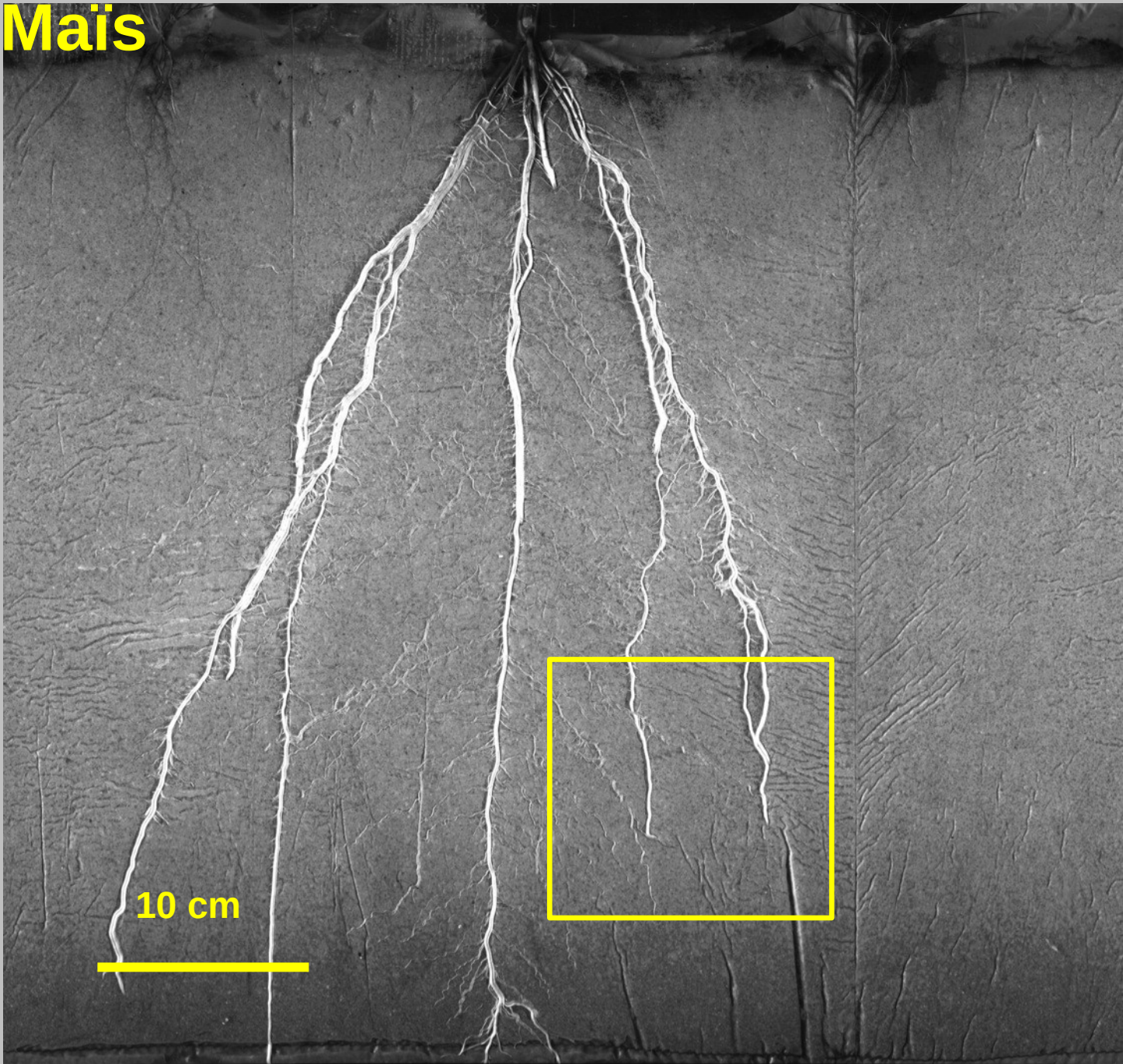


Vulpie



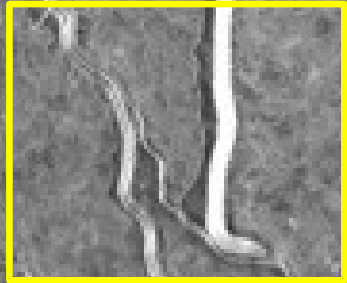
Maïs

**Mais**



**10 cm**

**Mais**

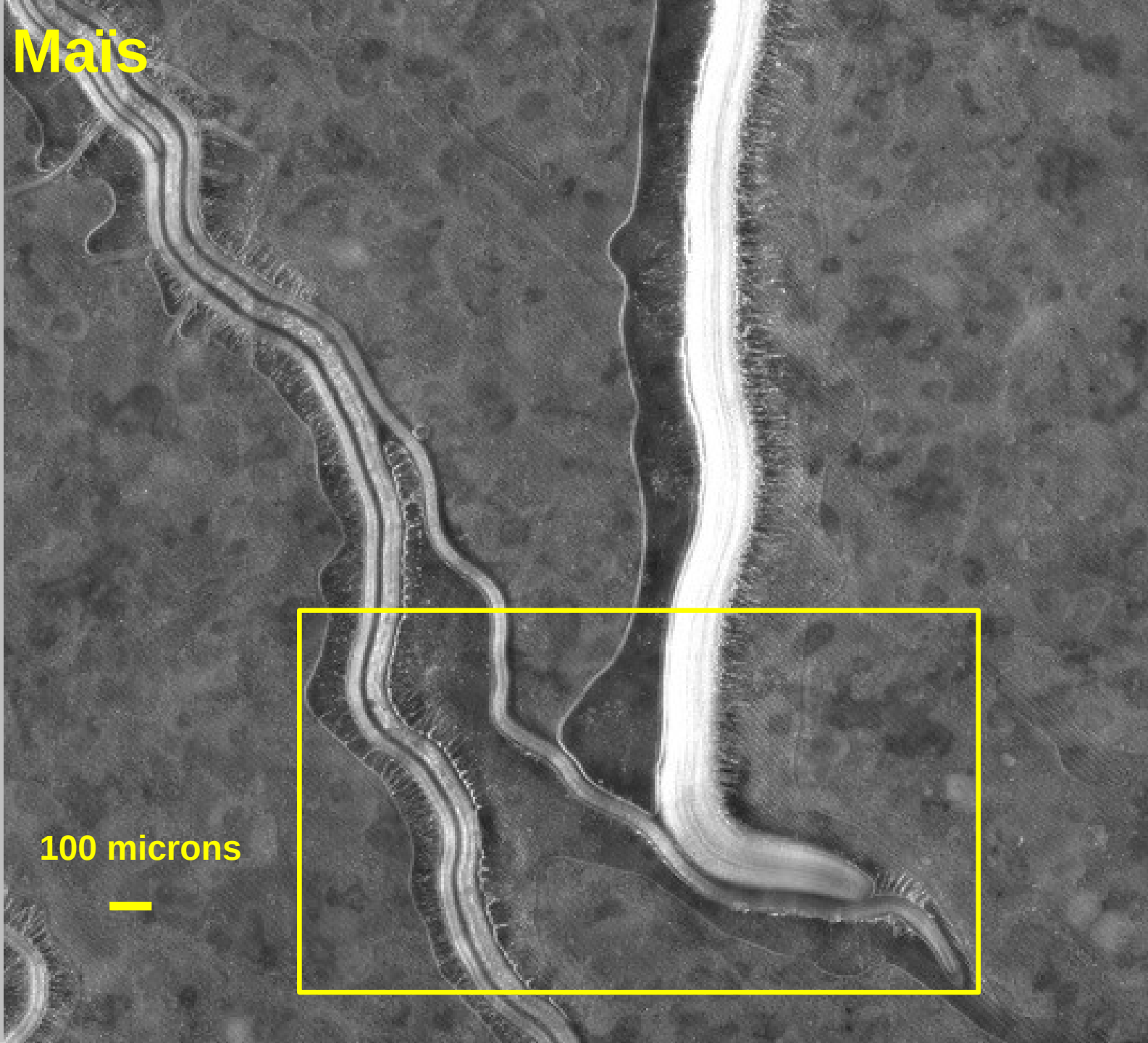


**1 cm**



**Mais**

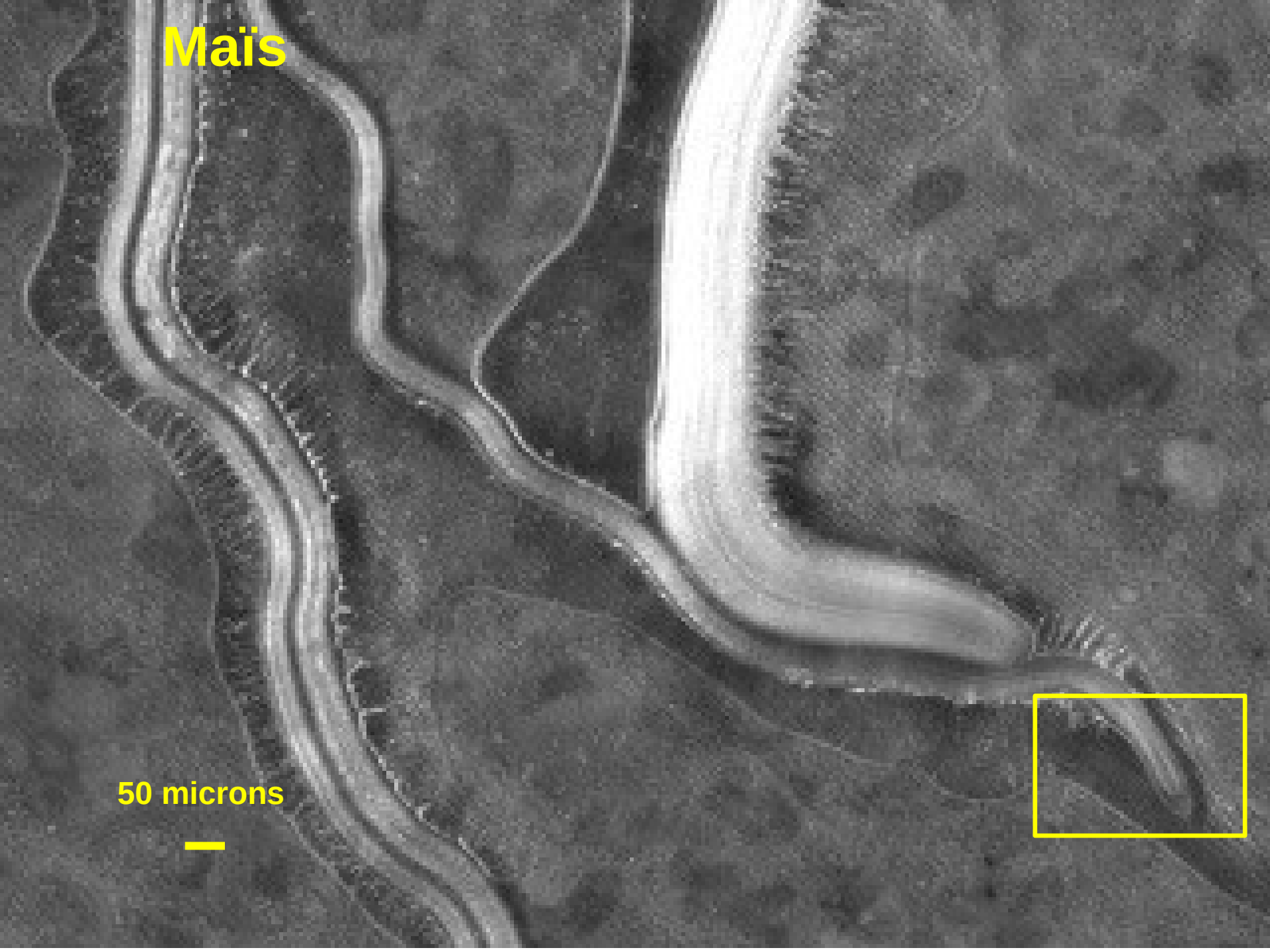
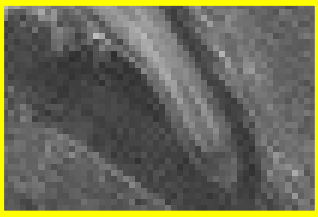
**100 microns**





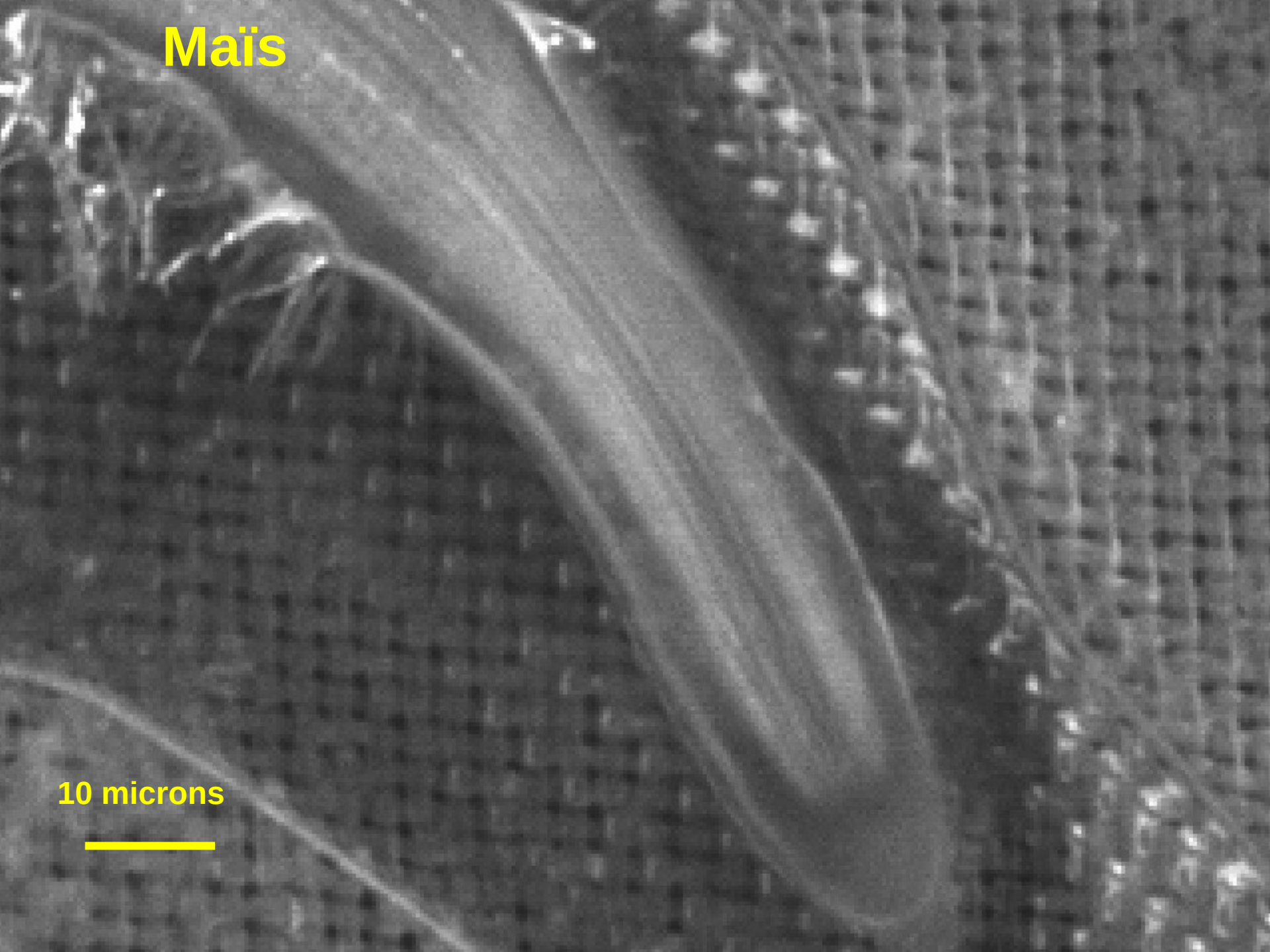
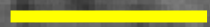
**Mais**

**50 microns**

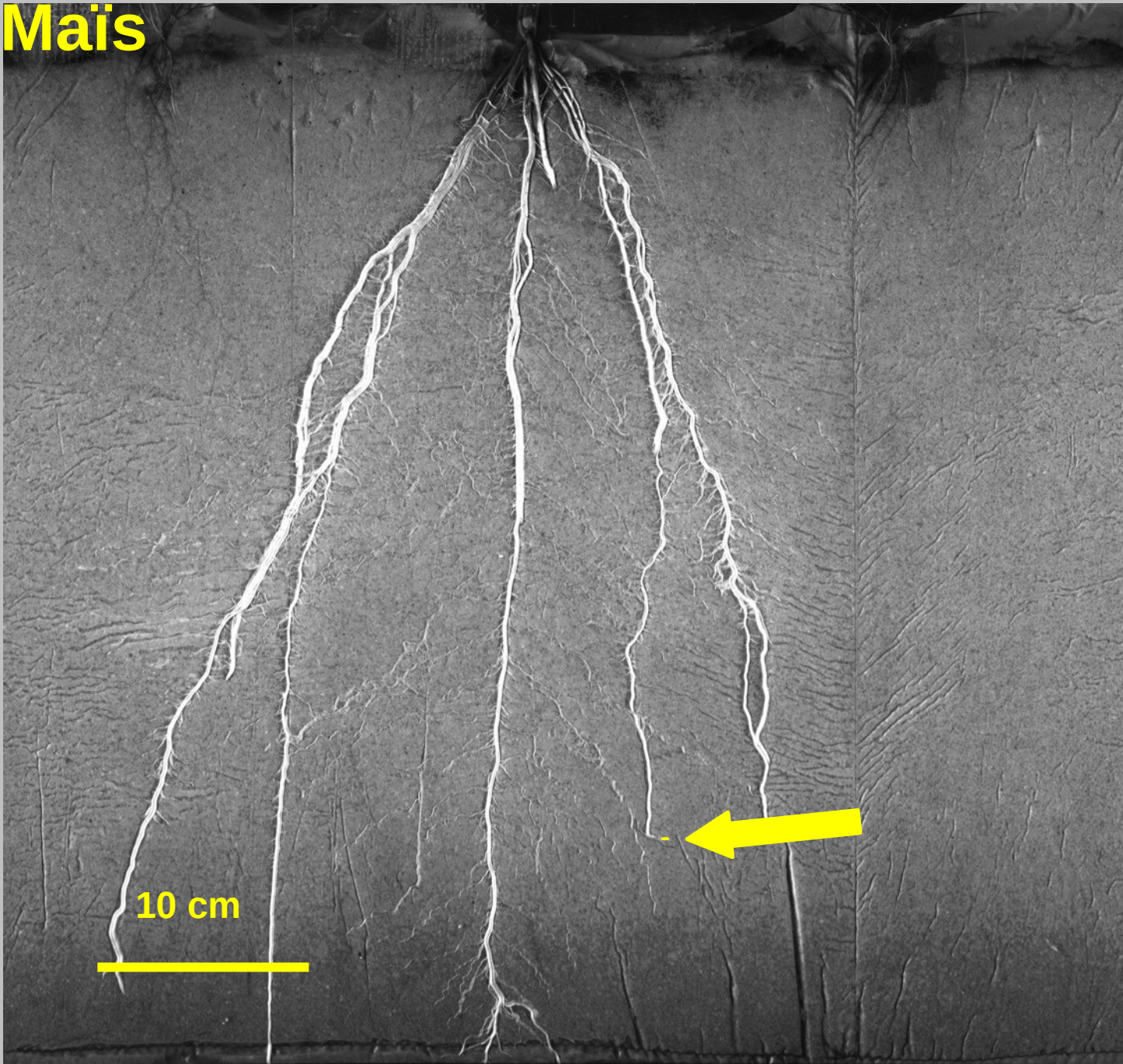


**Mais**

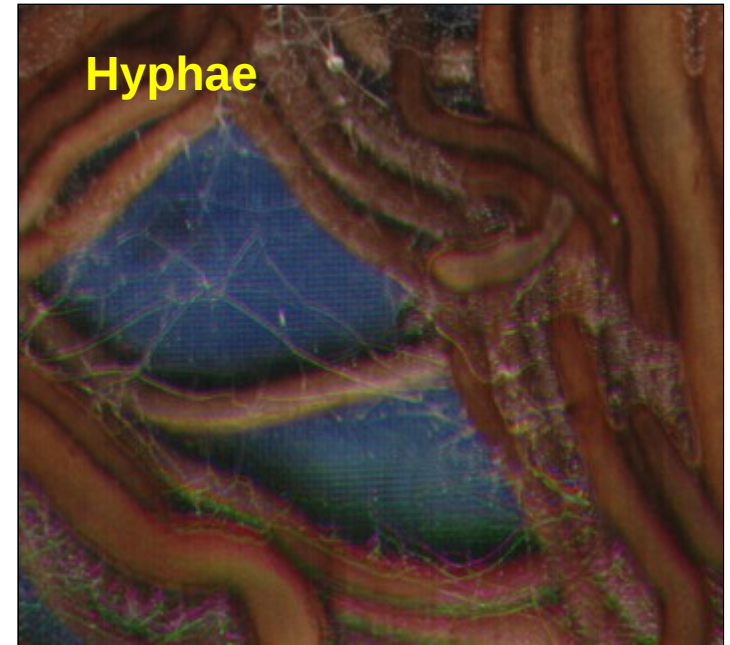
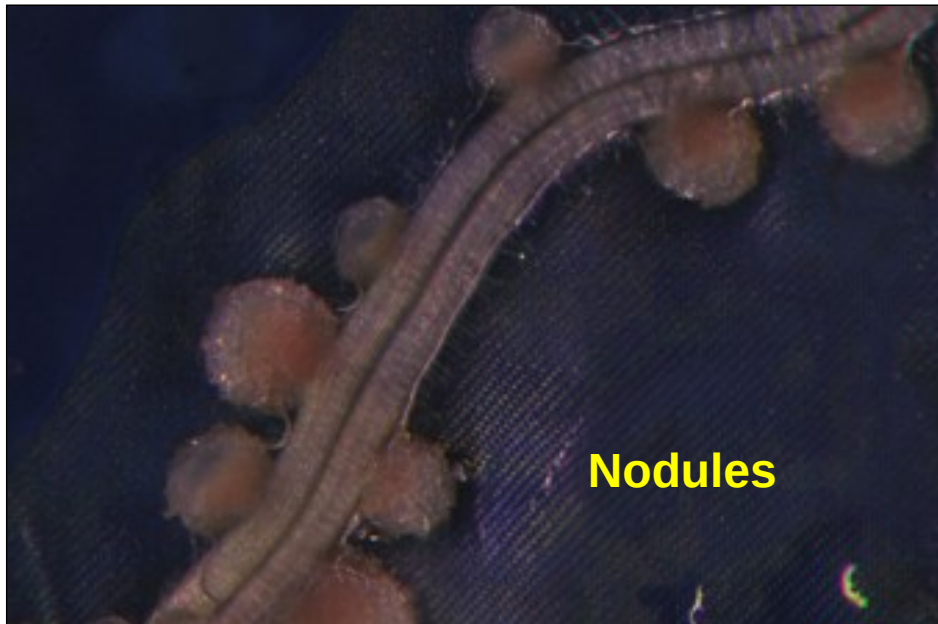
**10 microns**



**Mais**



# Root phenotyping: High resolution



**Down to 7 microns**



**Merci pour votre attention!**