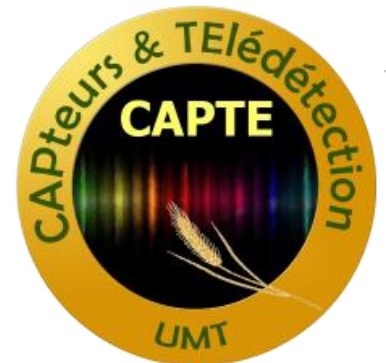


PHENOMOBILE for High-throughput Phenotyping in Field Conditions



Two main time scales for crop monitoring

Short term crop reaction

Monitoring the diurnal course of some crop state variables

- Surface temperature
- Leaf rolling
- PRI
- fluorescence

The diurnal course of these variables is driven by (at least!):

- | | | |
|--|---|---|
| <ul style="list-style-type: none">• stomatal conductance• photosynthesis• leaf water potential | } | Radiation
VPD
T°
Wind ... |
|--|---|---|

➔ **Need to complete observations of the whole experiment within few minutes**

Integrated crop reaction

Impact of water stress on growth:

- Plant Height
- Green Fraction
- Green Area Index
- Senescence
- FIPAR (Fraction of Intercepted Radiation)
- Organ Size (leaves, flower, stem diameter)

Importance of the seasonal time course to understand the establishment of the stress for each microplot

➔ **Need repeated observations with strong temporal consistency
Fine resolution (organ size & height)**

Several (U)GV SYSTEMS



Boom

<300 plots

Small payload-autonomy

Phenotypette

<500 plots

Small payload-autonomy, height

Tractor based

<1000 plots

Non automatic, height

Several (U)GV SYSTEMS



Pulled system (Osnabruk)

Height

Manoeuvre

Semi-automatic



Bonny-rob (Osnabruk)

Height

Autonomy

fully-automatic

Buggy (CSIRO)

Height

Semi-automatic

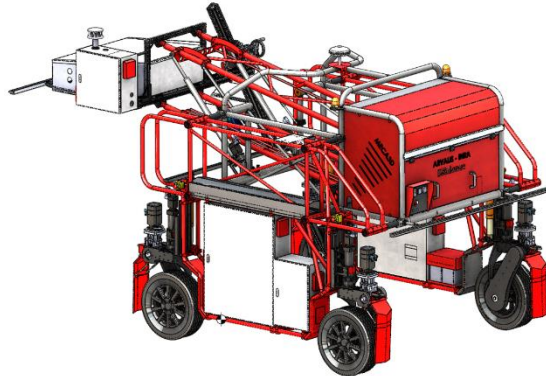


Several UGV SYSTEMS



Gantry system (rails or wheels)

Weight: 2-6 t
Height: ≈ 4 m
Mobility: limited
Pressure soil: very high
Width < 15 m
Interplot ≈ 1 m



PHENOMOBLE V1

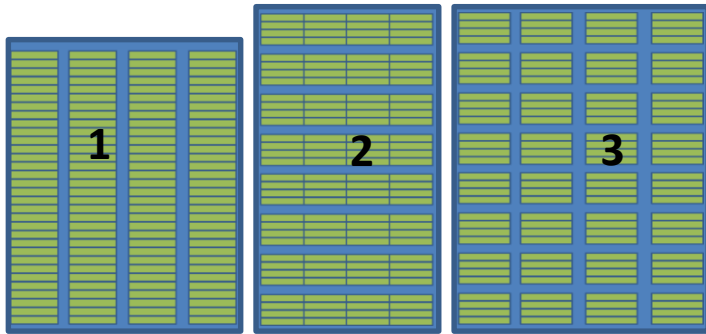
Weight: < 1 t
Height: < 1.35 m
Mobility: good
Pressure soil: high
Width: ≈ 2 m
Interplot: 30-40 cm



PHENOMOBLE V2

Weight: 8 t
Height: ≈ 4 m
Mobility: good
Pressure soil: low
Width: 10 m
Alleys: ≈ 2.5 m

Several UGV SYSTEMS



The 3 main
Experimental
plot design

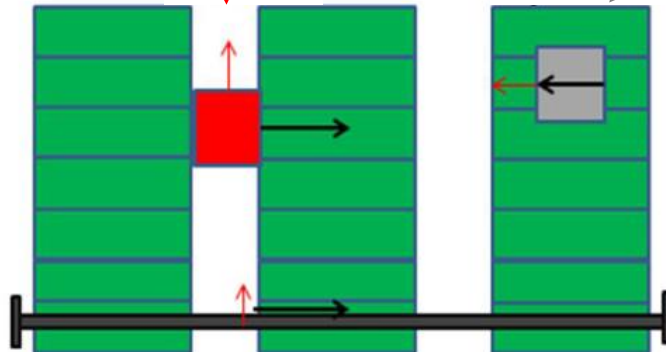
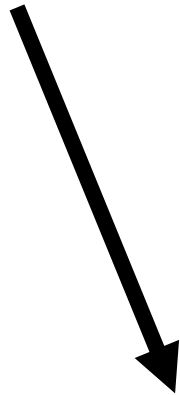
Gantry
(wheels or rails)



PHENOMOBILE
V2

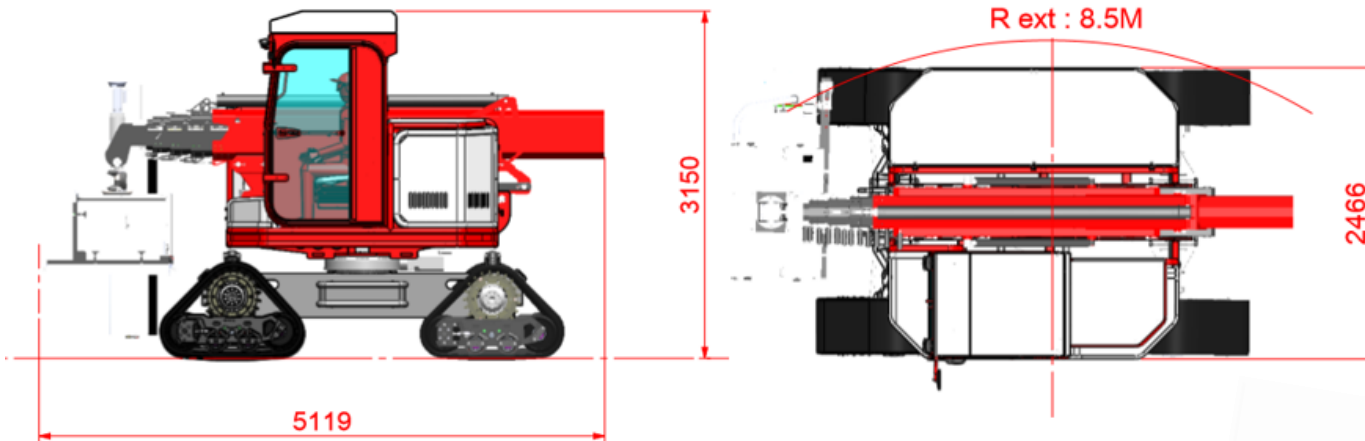


PHENOMOBILE
V1

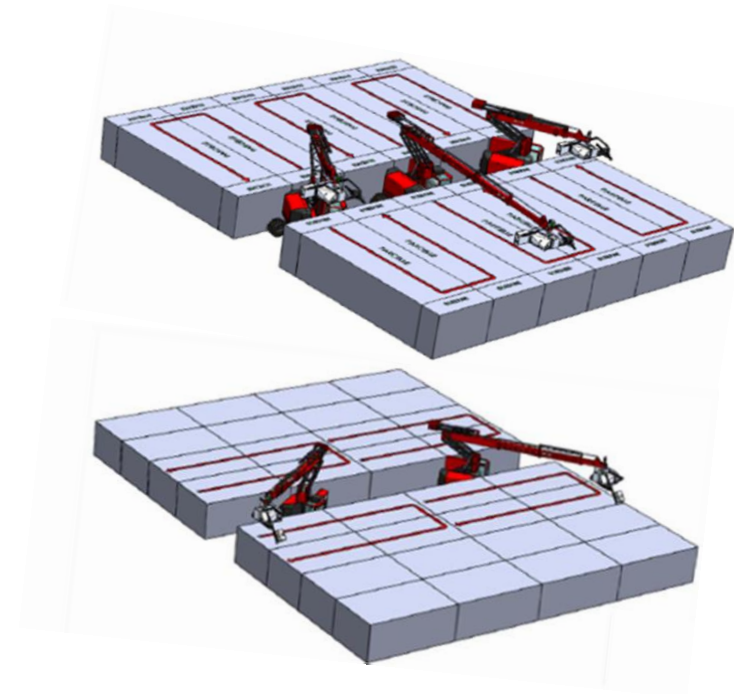


**Great interest of PHENOMOBILE V2
Height 4 m**

PHENOMOBILE V2



- Weight: 7.85t
- Turning radius: 8.5m
- Width: 2.46m
- Length: 5.2m
- Height: 3.15m
- Diesel engine powering the hydraulic and electric systems
- Autonomy: 10h
- 4 steering-powered caterpillars
- Airconditioned cabin
- Maximum speed: 12 km/h
- Throughput: >180 microplots/hour



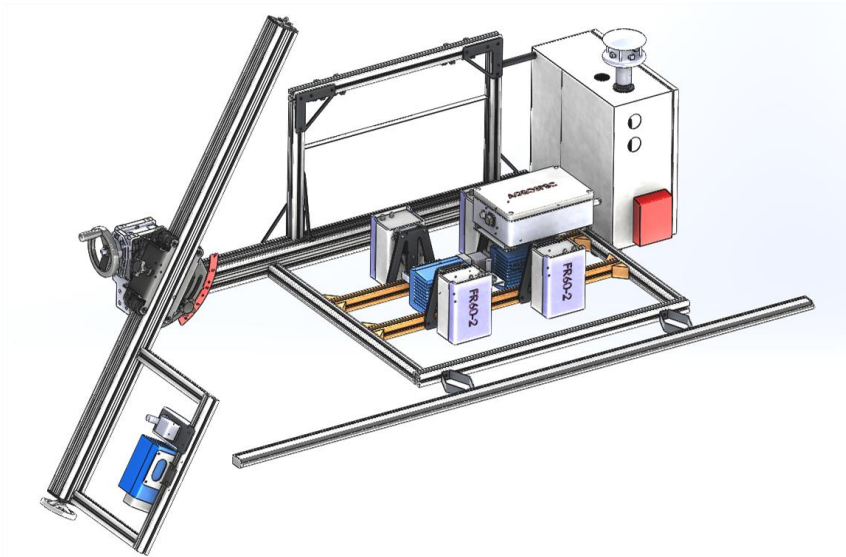
PHENOMOBILE V2



Just delivered to Avignon!!

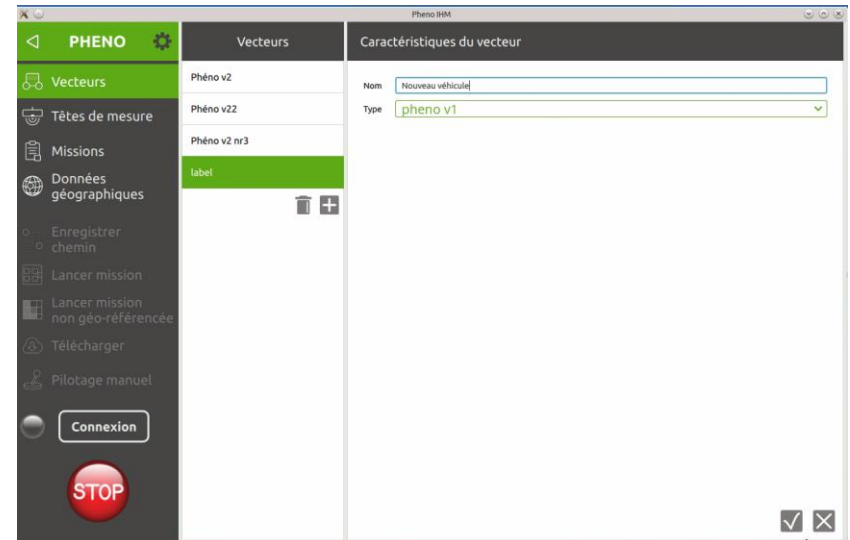


A universal measurement head and command system



Measurement head that can

- be mounted on several vectors
- host any sensor



A flexible and user friendly interface

Command system

PHENO

Vecteurs

Têtes de mesure

Missions

Données géographiques

Enregistrer chemin

Lancer mission

Lancer mission non géo-référencée

Télécharger

Pilotage manuel

Connexion

STOP

Vecteurs

Phéno v2

Phéno v22

Phéno v2 nr3

label

Caractéristiques du vecteur



Nom Nouveau véhicule


Type pheno v1


✓


✗


Command system


 **PHENO** 


 Vecteurs


 **Têtes de mesure**


 Missions


 Données géographiques


 Enregistrer chemin


 Lancer mission

 Lancer mission non géo-référencée

 Télécharger

 Pilotage manuel



 Connexion



Têtes de mesure

Tête standard

Tête standard nr2


Pheno IHM


Caractéristiques de la tête de mesure

Dirname

Capteurs

Nom	Type	Position (XYZ)	Orientation (RPY)
d_lms_front	d_lms	4 5 6	180.023° 0° 28.647...
d_lms_rear	d_lms	7 8 9	180.023° 0° -28.64...

Editer les programmes 



Command system

PHENO

Vecteurs

Têtes de mesure

Missions

Données géographiques

Enregistrer chemin

Lancer mission

Lancer mission non géo-référencée

Télécharger

Pilotage manuel

Connexion

STOP

Editeur de programmes

Programmes

prog cool (1)

prog2

prog3

A program :)

Actions

Nom

prog cool (1)

Uuid

123456

Actions

lms

lms

tec5

height

delay

Configuration des actions

Activé

☒

Délai de déclenchement

-

0ms

+

Temps d'intégration

-

20 ms

+

Nombre d'échantillons

-

5

+

Nettoyer CCD

☐

✓

✗

Command system

PHENO

Vecteurs

Têtes de mesure

Missions

Données géographiques

Enregistrer chemin

Lancer mission

Lancer mission non géo-référencée

Télécharger

Pilotage manuel

Connexion

STOP

Missions

Mission 1

Mission 2

mission 3

Caractéristiques de la mission

Nom

mission 3

Tête de mesure

Tête standard

Vecteur

Phéno v2

Mission

Affichage

☒

plot1

Obstacles

☒

obstacles nr 2

Couche raster

☒

2200FNR1_O101

Direction of triggers

Following long side

Campagne

campaign

Lieux

place

Champs

field

Essais

trial

Séquencement des micro-parcelles

Planifier la trajectoire

Command system

PHENO

Vecteurs

Têtes de mesure

Missions

Données géographiques

Enregistrer chemin

Lancer mission

Lancer mission non géo-référencée

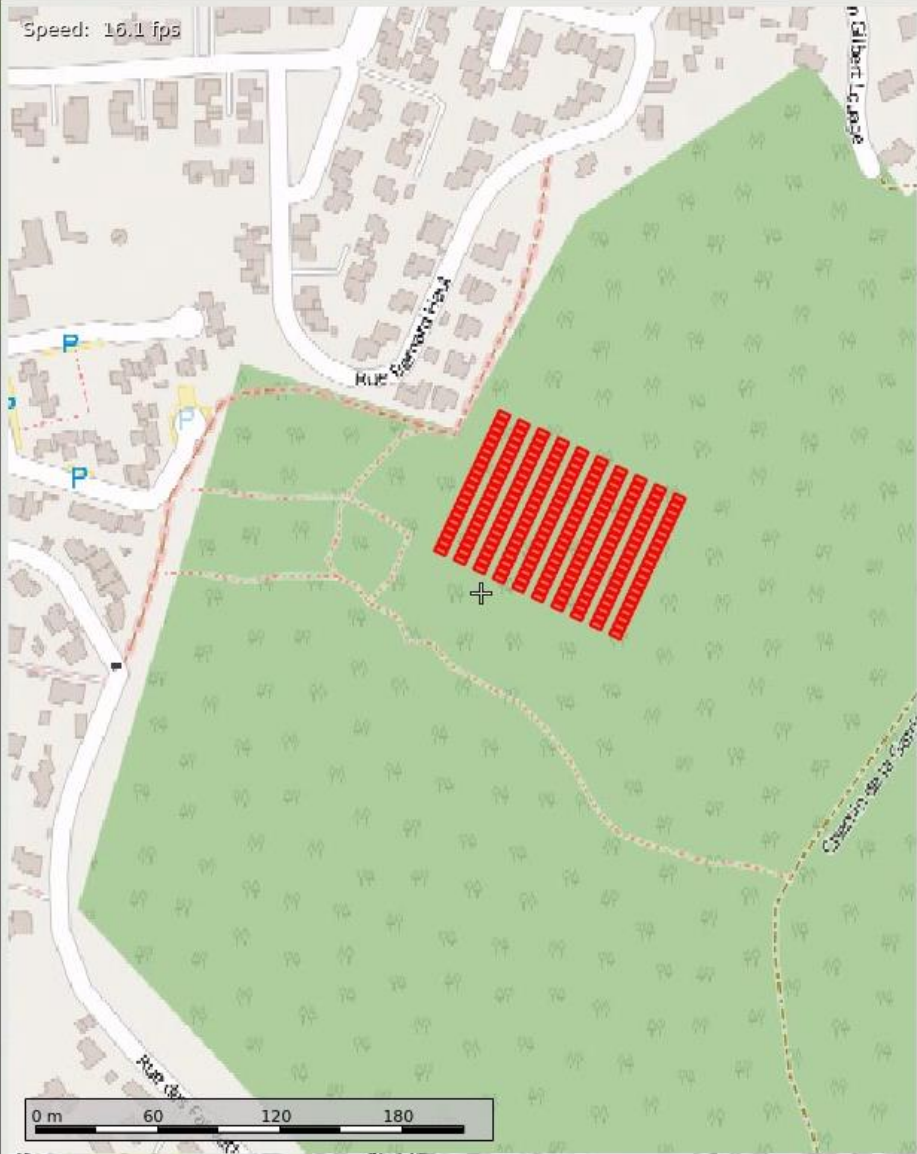
Télécharger

Pilotage manuel

Connexion

STOP

Speed: 16.1 fps



0 m 60 120 180

Tiles download :

Editeur de séquences et déclenchements

ID de la mi...	Script
1	script A
2	script 2
3	script 3
4	script A
5	script A
6	script A
7	script A
8	script A
9	script A
10	script A
11	script A

Script script A

Appliquer à la sélection

Appliquer à tout

Editer les scripts

✓

✗

Command system

Pheno IHM

Speed: 41.7 fps

PHENO

Vecteurs

Têtes de mesure

Missions

Données géographiques

Enregistrer chemin

Lancer mission

Lancer mission non géo-référencée

Télécharger

Pilotage manuel

Connexion

STOP

0 m 10 20

Editeur de séquences et déclenchements

ID de la mi...	Script
1	script A
2	script 2
3	script 3
4	script A
5	script A
6	script A
7	script A
8	script A
9	script A
10	script A
11	script A

Script: script A

Appliquer à la sélection


Appliquer à tout

Editer les scripts

✓ ✕

Command system

Pheno IHM

PHENO  **Editeur de scripts**

Vecteurs
Têtes de mesure
Missions
Données géographiques
Enregistrer chemin
Lancer mission
Lancer mission non géo-référencée
Télécharger
Pilotage manuel

Connexion

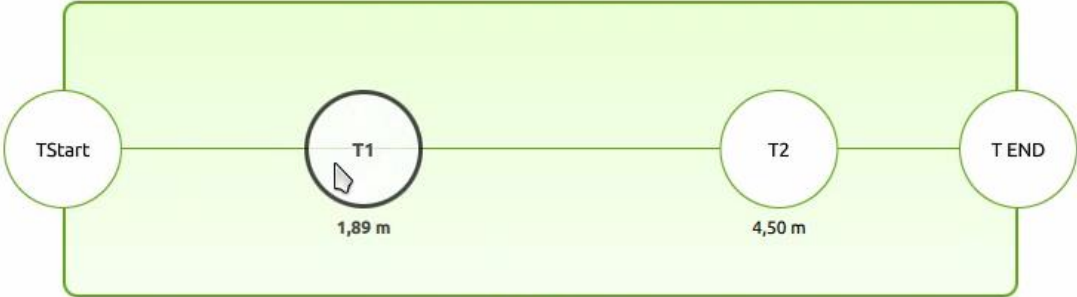
STOP

Scripts

- script A
- script 2
- script 3
- New script



Editer les scripts




script A







6,00 m



Nom: T1

Distance:  1,89m 

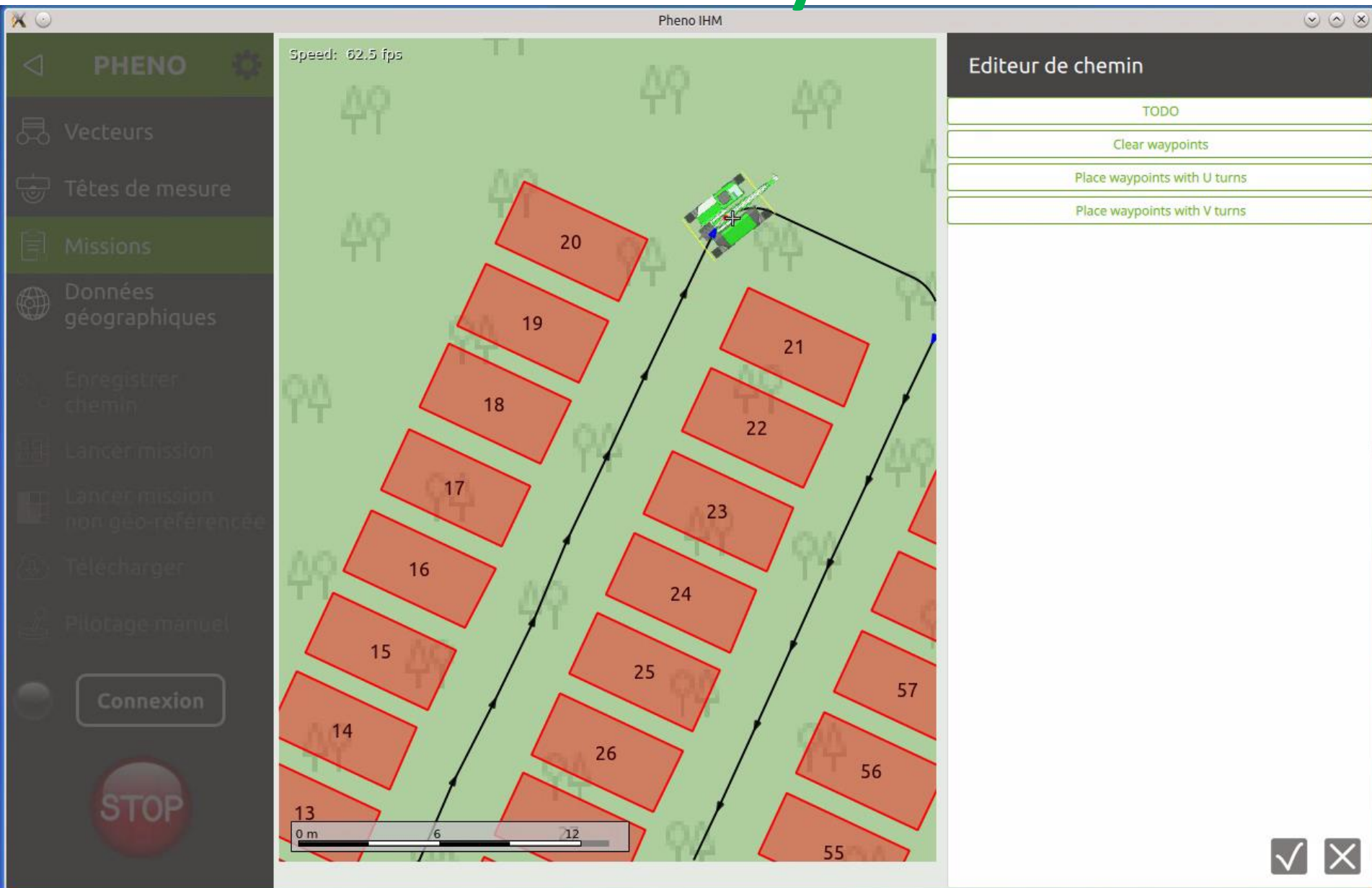
Programme:  prog2  

Command system



Command system

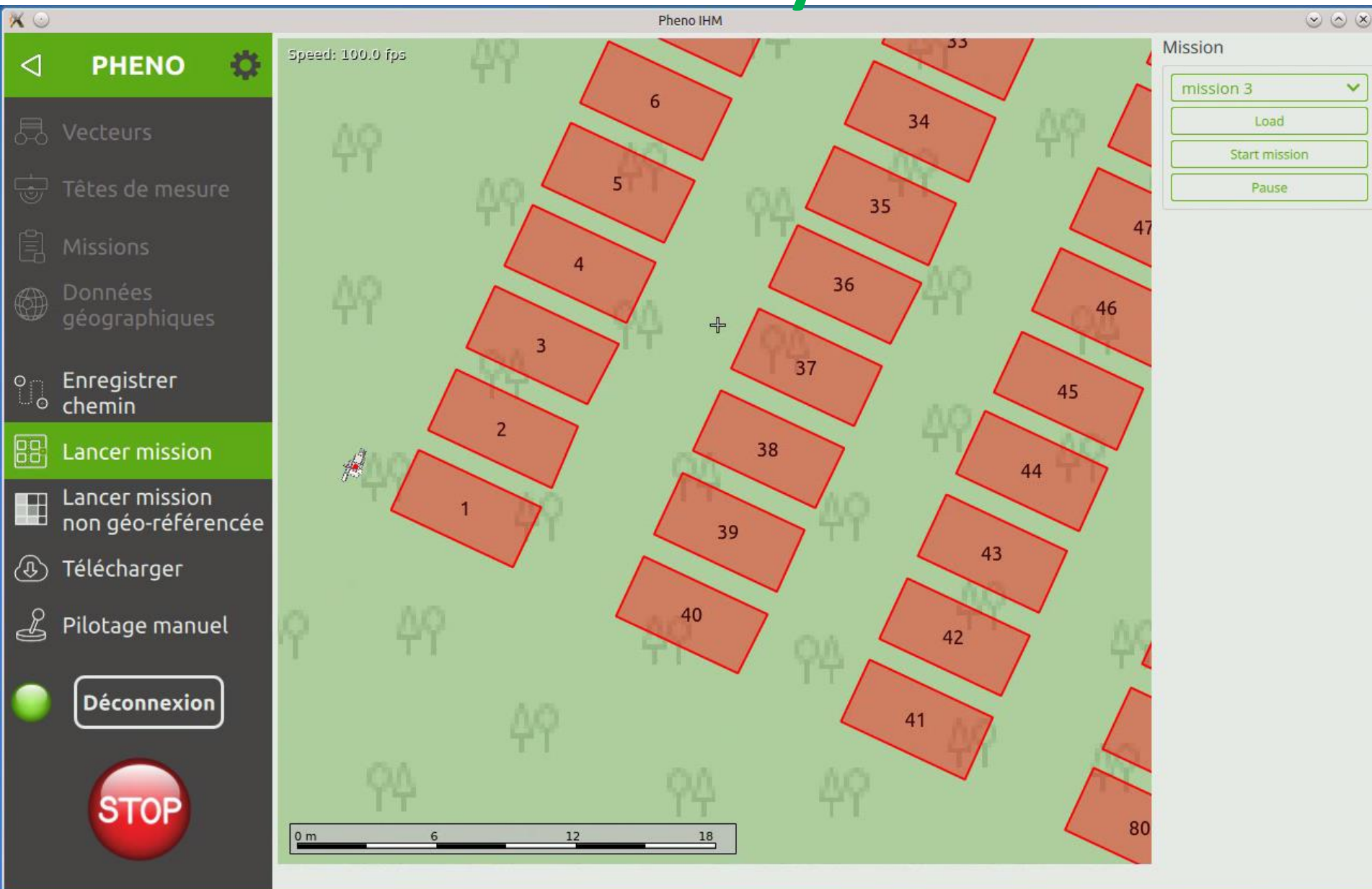
Pheno IHM

PHENO

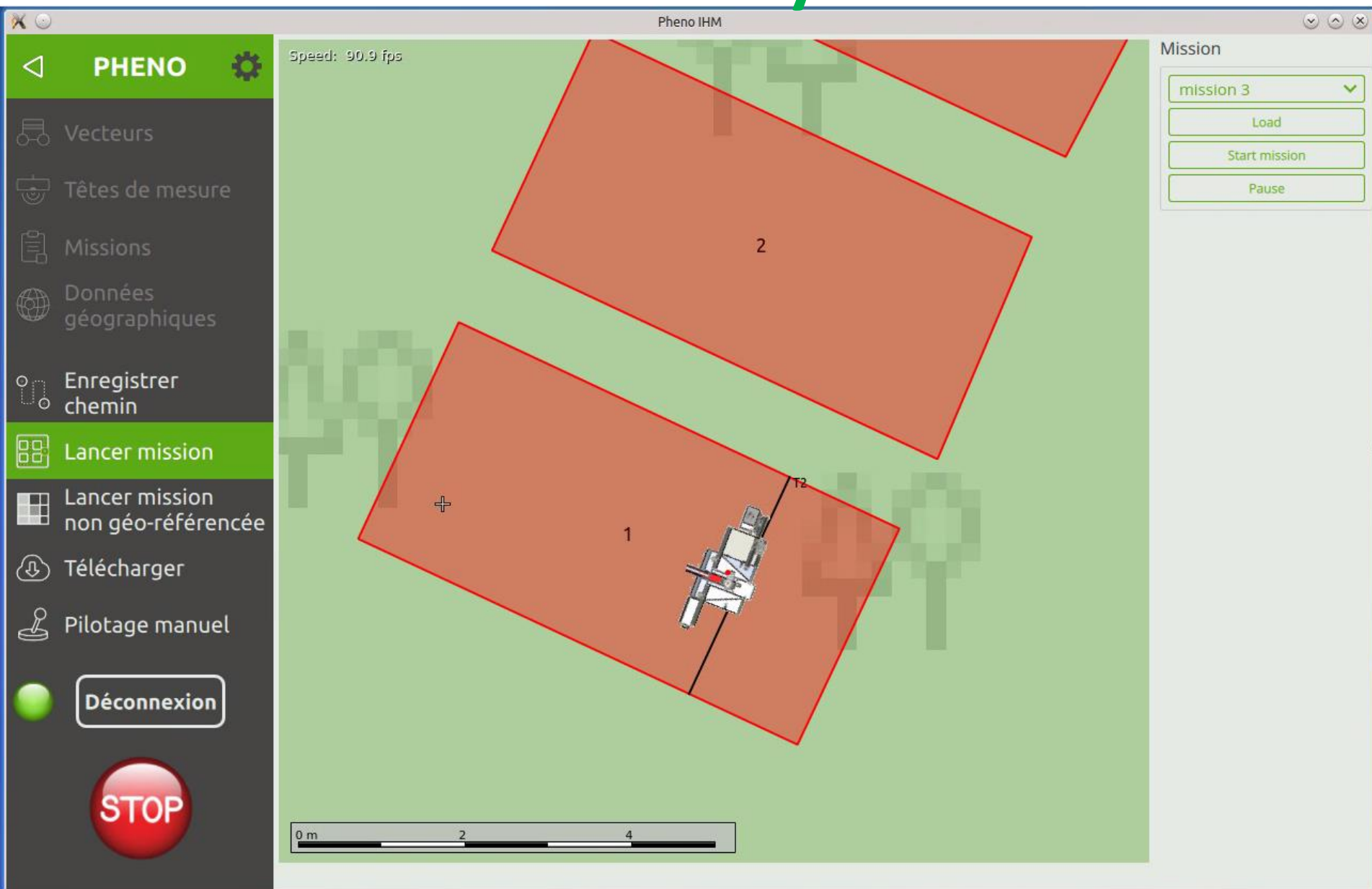
- Vecteurs
- Têtes de mesure
- Missions
- Données géographiques**
- Enregistrer chemin
- Lancer mission
- Lancer mission non géo-référencée
- Télécharger
- Pilotage manuel
- Connexion
- STOP

Plateforme expérimentale	Obstacles	Geotiffs
intercept_panel3_v3	obstacles nr 2	2200FNR1_O101
New plot	obstacles1	2200FNR2_O101
new plot2		2200FNR2_O101_croix
plot1		
Vieuro_greoux_2015		
Vieuro_greoux_2015_ordered		

Command system

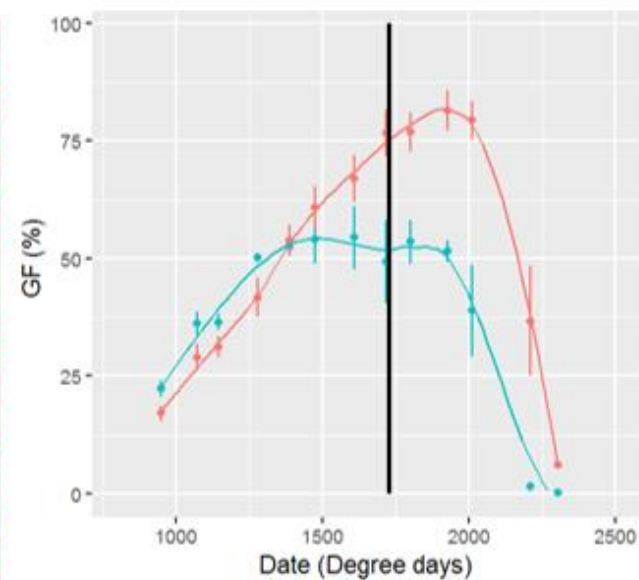
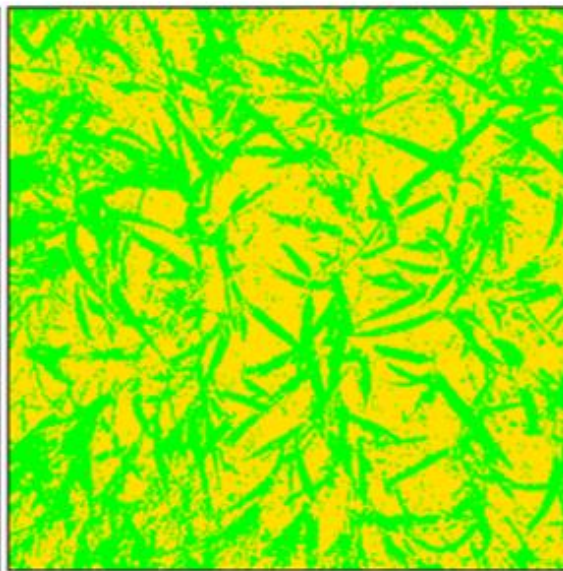
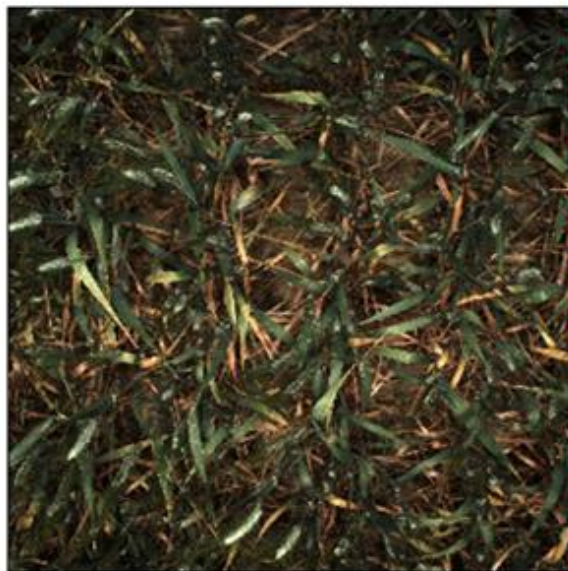


Command system



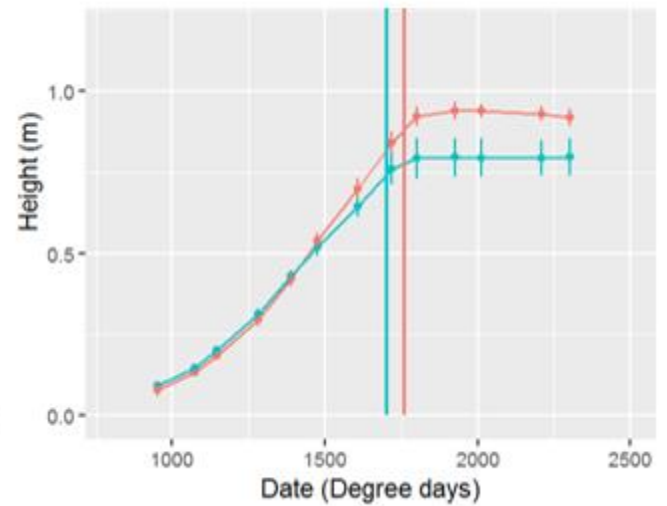
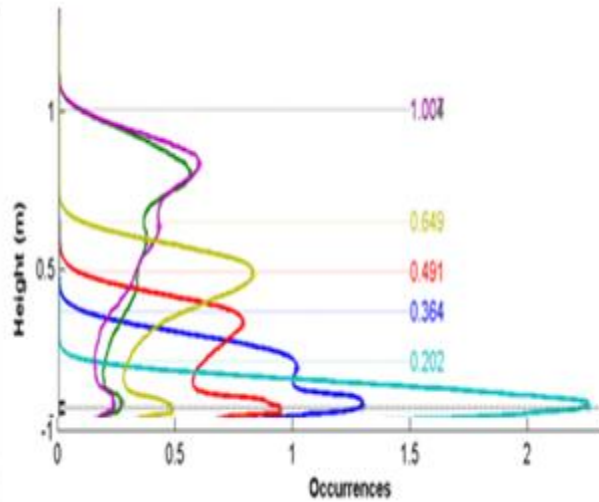
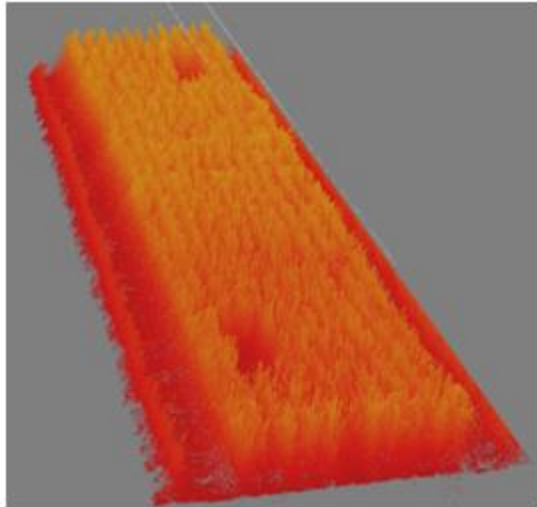
Sample results

Green fraction from RGB camera working in active mode



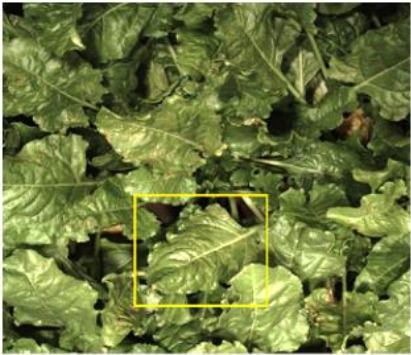
Sample results

3D point cloud from LiDAR

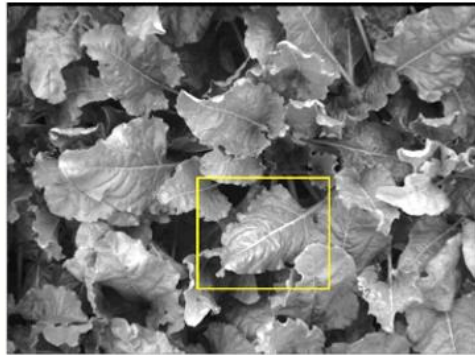


Sample results

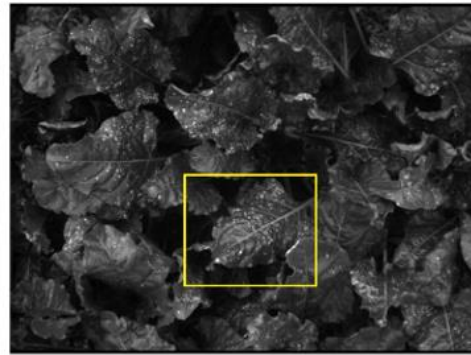
Disease symptom quantification from RGB and AIRPHEN multispectral camera



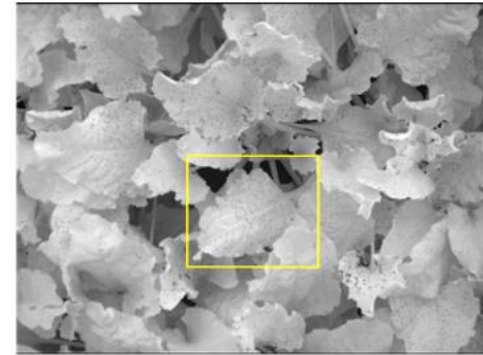
RGB



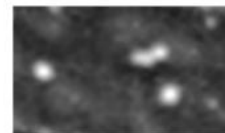
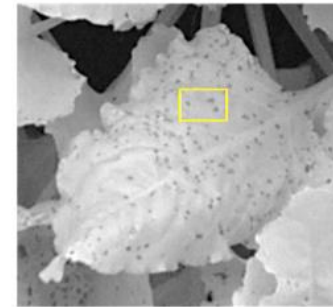
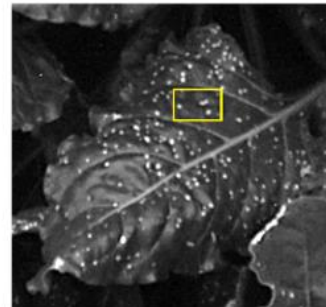
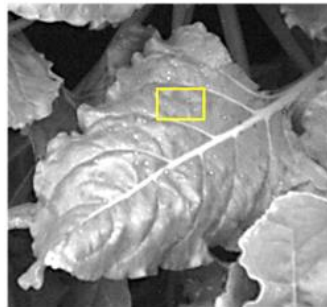
Airphen – 530 nm



Airphen – 675nm



Airphen – 730 nm



CONCLUSIONS

❑ Technology is maturing very fast:

- ➡ PHENOMOBILE V2 provides an advanced solution allowing
- Easy integration of new sensors
 - High repeatability (heritability)
 - Active measurements
 - Autonomy (automatic, more than 10 hours autonomy)
 - Flexibility (height, experimental design, soil conditions)

❑ The Bottleneck²:

➡ the phenotyping bottleneck is data interpretation!



- ➡ Need to integrate repeated measurements into functioning models
- Combining several observations and dates
 - Accounting for environmental variability
 - Exploiting knowledge accumulated on processes
 - Providing higher level traits

Thanks for your attention

