Innovating towards sustainability in plant variety testing

Innovations in Wheat

28th November 2024 | Hotel Berlaymont

INNOVAR

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invite

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Vermeulen Philippe

Phenomics
Study case: FHB detection in wheat

CRA-W
INVITE

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Refer to the call: SFS-29-2018

What question in the call does your presentation address?

How to improve the wheat crop resilience to biotic stress ?

How did you address this?

Development of methods and tools to improve performance testing (including VCU) of new varieties for their sustainability profile.

In particular, by the study of 4 approaches to assess wheat diseases in laboratory and in field

- *RGB images in field (GEVES, Agroscope, CRA-W)*
- *Handheld fluorometer in field (Agroscope)*
- *Multispectral Visible NIR imaging in laboratory and in field (GEVES)*
- *Hyperspectral NIR imaging in laboratory and in field (CRA-W)*

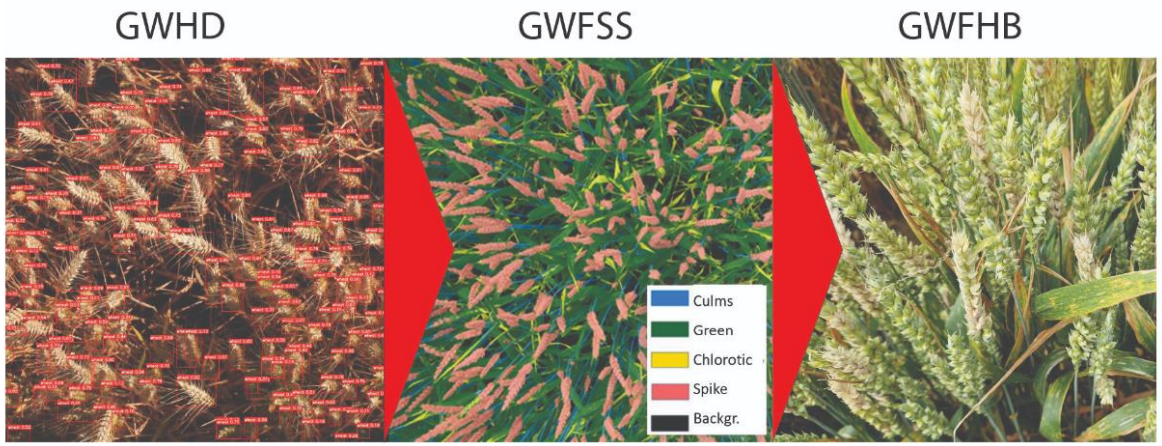
Detection of FHB on wheat ears in field using RGB images

Acquisition

+/- 3000 RGB images acquired in the field by Agroscope, CRA-W, GEVES

Results

Contribution to the GWFHB: Global Wheat Fusarium Head Blight



Head Detection	Full Semantic Segmentation	Fusarium Head Blight

https://www.global-wheat.com/gwfss.html

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Agroscope

GEVES Expertise & Performance Groupe d'Étude et de contrôle des Variétés Et des Semences

ETH zürich

Global Wheat Datasets

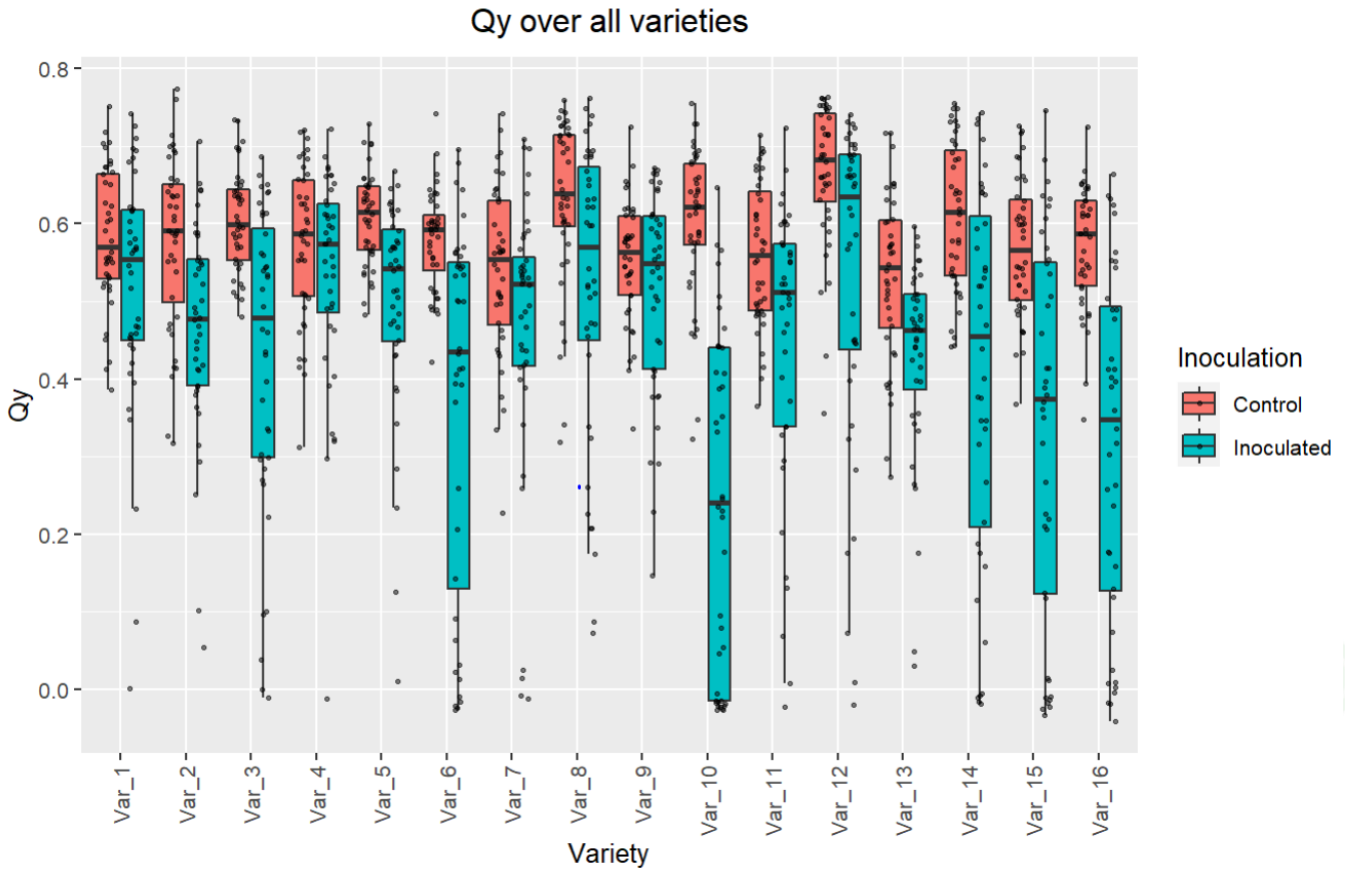
Detection of FHB on wheat ears in field using fluorescence

Acquisition

+/- 10000 fluorescence measurements in the field by Agroscope

Results

Quantum yield (Qy) results for measurements on spikes in the field showing a very large variability in relation to strong infections



Agroscope

S. Treier (2025). Digital optical lean phenotyping methods in the context of wheat variety testing. Thesis in Agroscope

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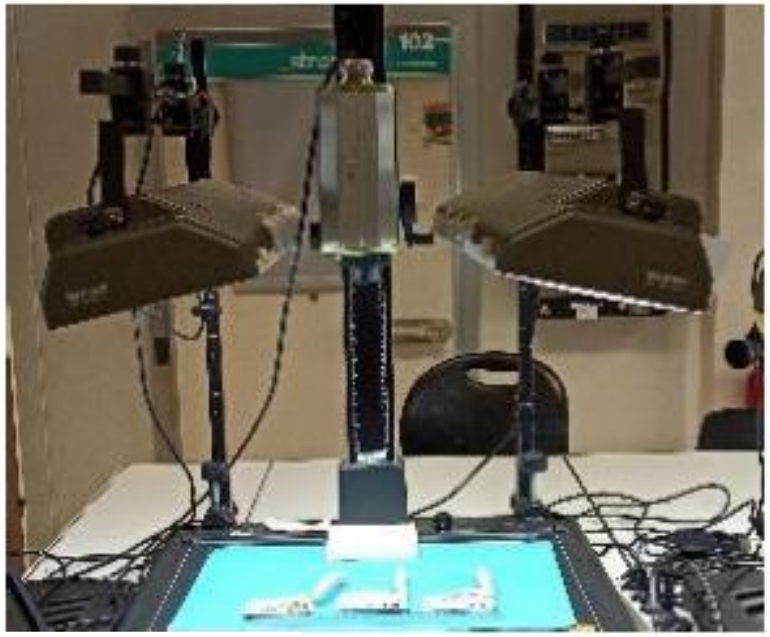
Detection of FHB on wheat ears in laboratory using VIS-NIR multispectral imaging CMS4

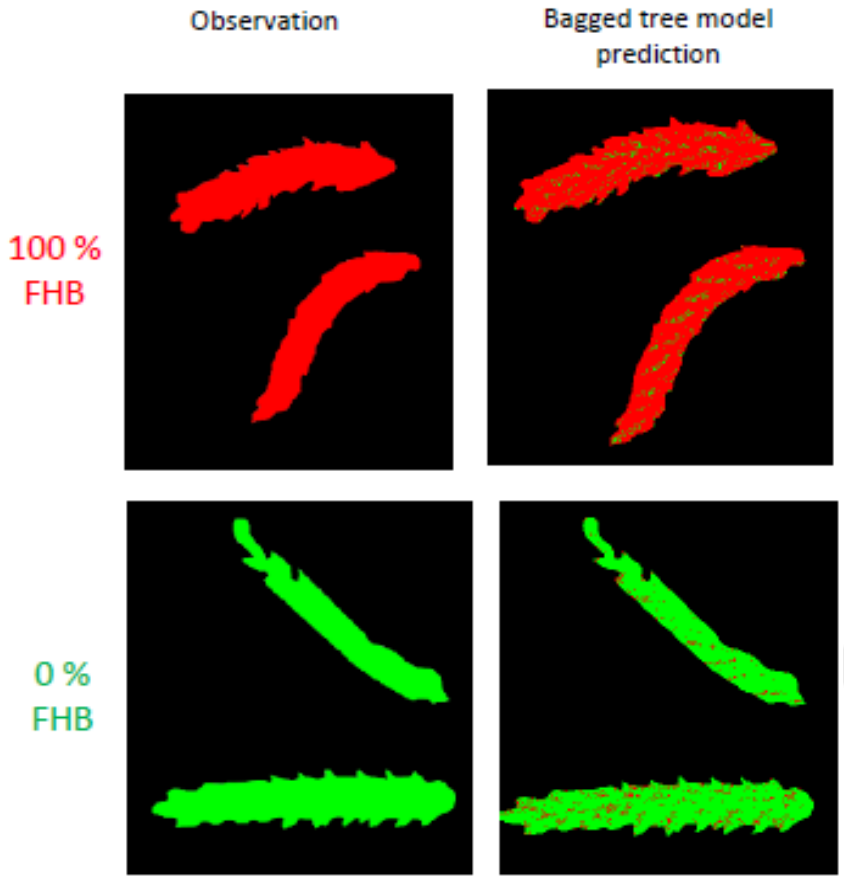
Acquisition

Multispectral imaging system CMS4

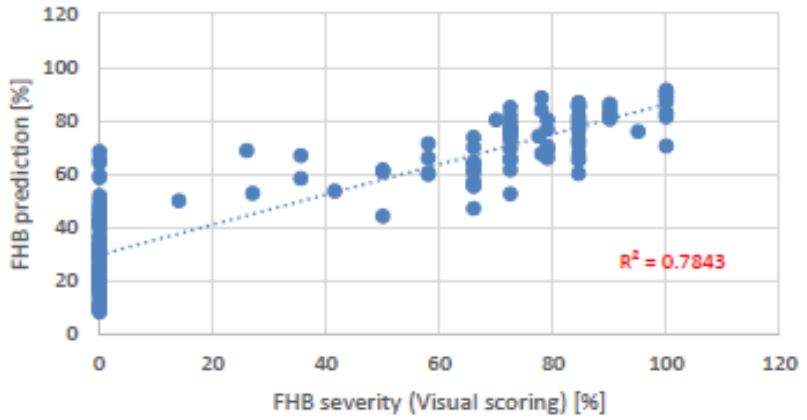
- 4 spectral channel
- 4.2 Mpx global spatial resolution



Annotated and predicted images



Results



GEVES
Expertise & Performance
Groupe d'Étude et de contrôle des Variétés Et des Semences

H. Garbouge (2022). Deep learning applied to multi-componet imagery for variety testing problems. Thesis in U.Angers

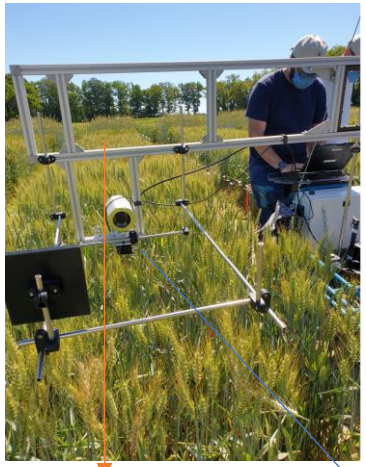
université angers

SILIOS TECHNOLOGIES

Detection of FHB on wheat ears in field using VIS-NIR multispectral imaging CMS4 in frontal view

1. Imaging acquisition

Multispectral CMS4 & RGB Sony *system using pedestrian vectors*



Multispectral

RGB

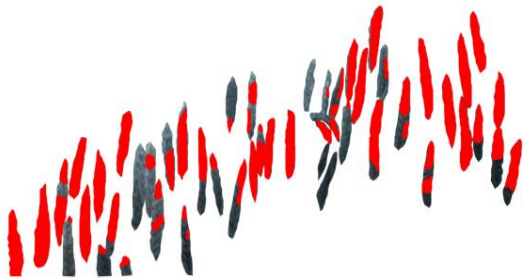
2. Annotations

Annotations of the 1st row of ears

Segmentation

U-NET

Fusarium annotations

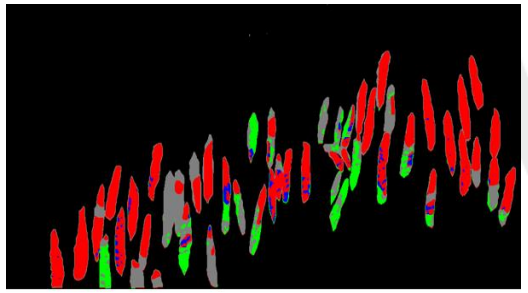


756 wheat images on 7 sites

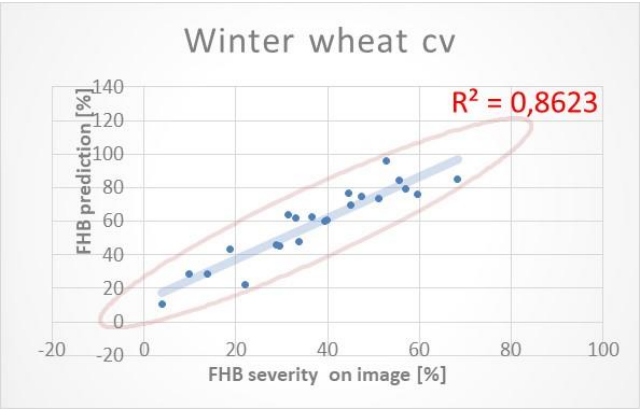
3. Creation of 2 algorithms :

Ear segmentation (U-NET)

Fusarium quantification prediction (Machine learning)



4. FHB prediction results



- Usable for assesment of FHB cv resistance
- 😊 **High correlation with annotations:** in case of good acquisition conditions & high FHB pressure
- 😔 Camera CMS4: high price≈ 20 k€, fastidious acquisition (2 to 10min), complicated annotation

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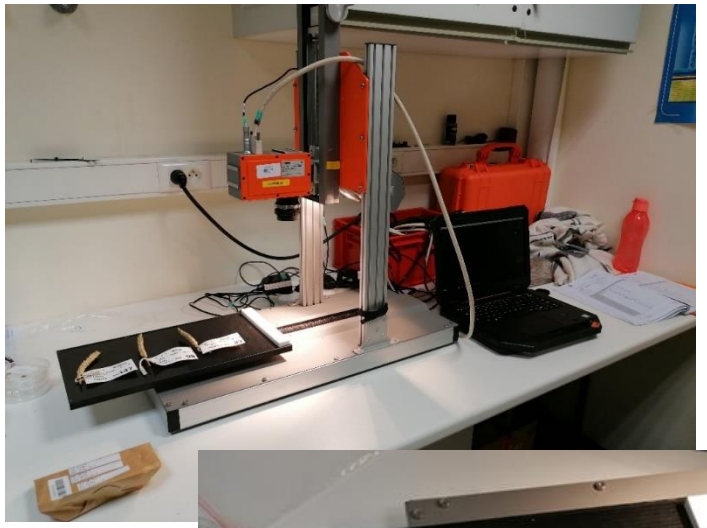
Detection of FHB on wheat ears in laboratory using NIR hyperspectral imaging

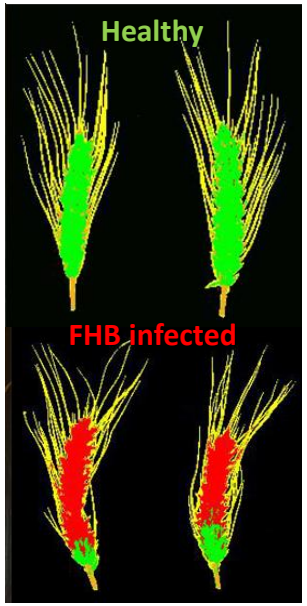
Acquisition

Hyperspectral imaging system
Specim FX17 (900-1700 nm)



NIR-HSI predicted images

MODEL VALIDATION (PLSDA)



Results

Predicted results by ear

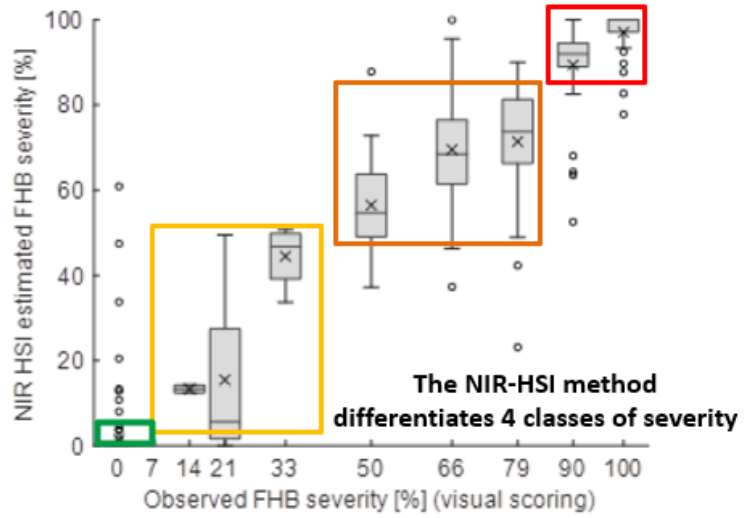
Infected or not

	Actual class: FHB-infected	Actual class: Healthy
Predicted as FHB-infected	152	13
Predicted as Healthy	2	141

Sensitivity: 98,7%

Specificity: 91,6 %

Severity



D. Vincke et al. (2023). Near infrared hyperspectral imaging method to assess Fusarium Head Blight infection on winter wheat ears. Michrochmeical Journal 191, 108812

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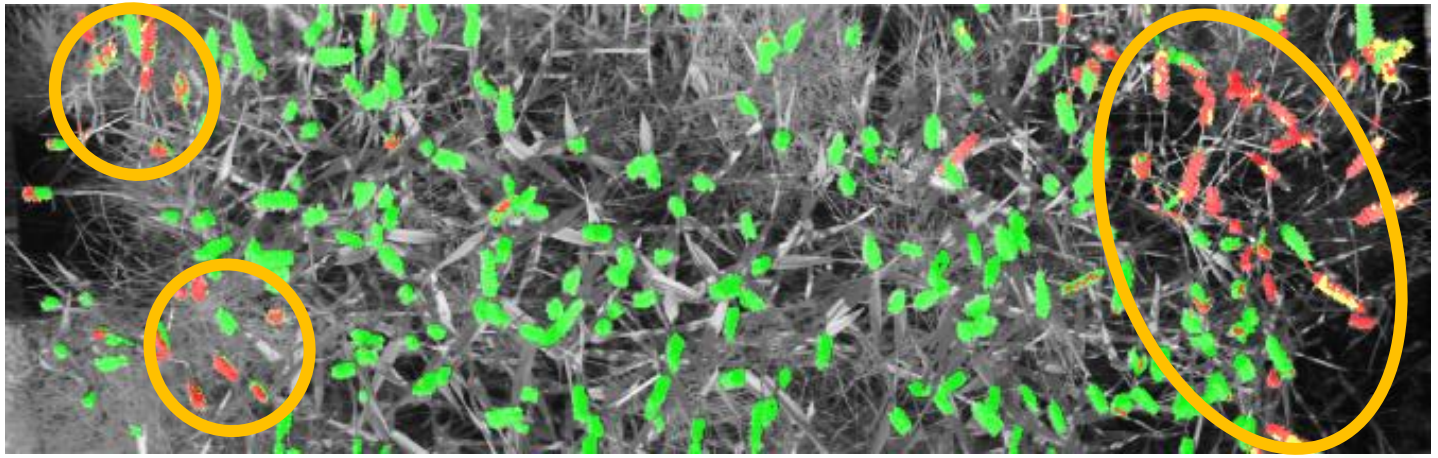
Detection of FHB on wheat ears in field using NIR hyperspectral imaging in vertical view

Acquisition

Hyperspectral imaging system with translation stage (+/- 100)

Results

Predicted images



Healthy
FHB infected
Take-all infected

	FHB		Take-all		Overall stress	
Date	RMSE	R^2	RMSE	R^2	RMSE	R^2
28-06-22	0,7	0,08	4,1	0,39	2,0	0,85
04-07-22	0,6	0,26	7,8	0,56	4,2	0,87
14-07-22	0,5	0,42	5,4	0,79	1,8	0,98

The method can assess the overall stress of the ears but …
It is not specific enough to differenciate two diseases with similar symptoms.

D. Vincke (2024). Evaluation of fusarium head blight infection on winter wheat using near infrared hyperspectral imaging from the laboratory to the field. Thesis in U.Liège Gembloux Agro-Bio Tech

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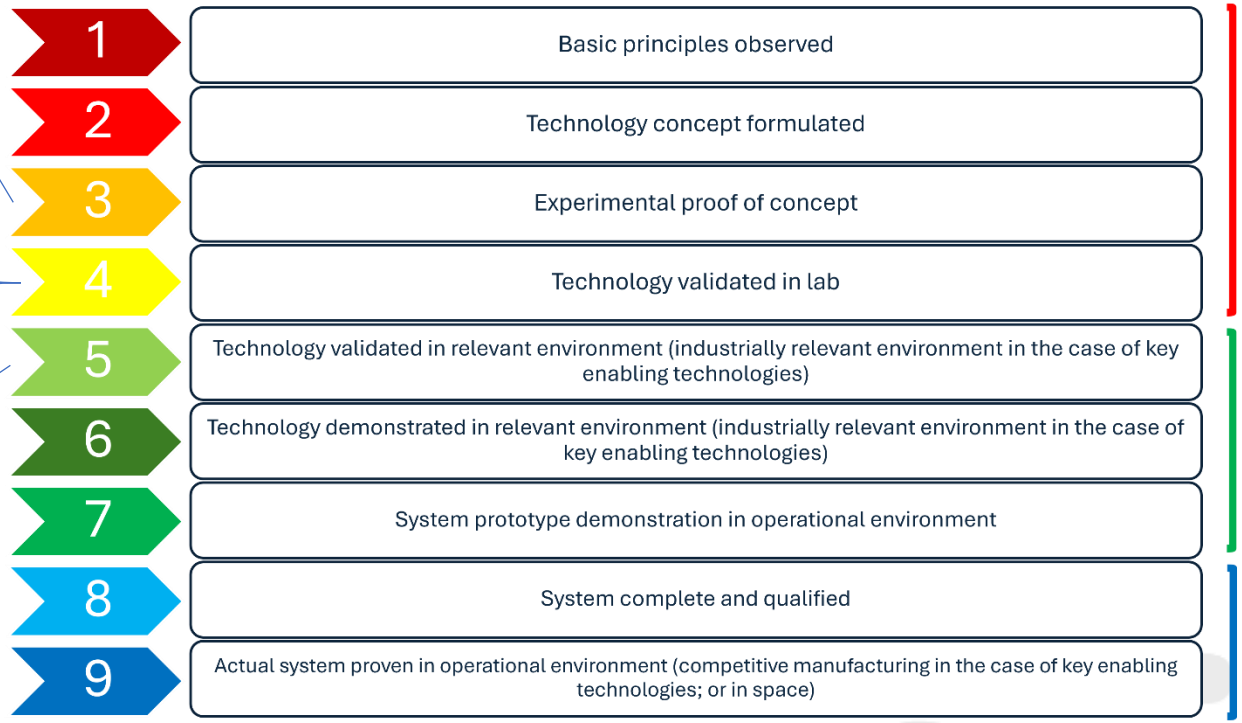
Readiness of the tools

RGB images in field
NIR hyperspectral in field

Handheld fluorometer in field
Multispectral in lab
NIR hyperspectral in lab

Multispectral in field



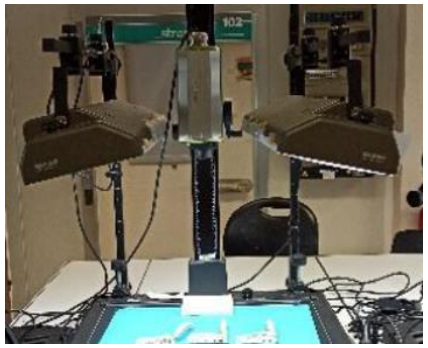
"Technology readiness levels (TRL); Extract from Part 19 - Commission Decision C(2014)4995" (PDF). ec.europa.eu.

Outcomes & relevance to variety testing (1)

- RGB images in field (GEVES, AGROSCOPE, CRA-W)
  - Method based on the color (green/white)
  - Application window: when the ears are yet green
  - Random image acquisition on plots by proximal sensing ☺
  - Low cost device ☺
  - Quick acquisition ☺
  - Image on full ears acquired with an angle of 45° ☺
  - Early detection when one spikelet is infected ☺

- Handheld fluorometer in field (AGROSCOPE)
  - Method based on the chlorophyl fluorescence
  - Application window: disease monitoring at different growing stage of the ears
  - Collection of point measurements by contact sensing on wheat ears with and without induced infections ☹
  - Low cost device ☺
  - Time consuming for symptom scoring ☹
  - Not early detection, need high infection ☹

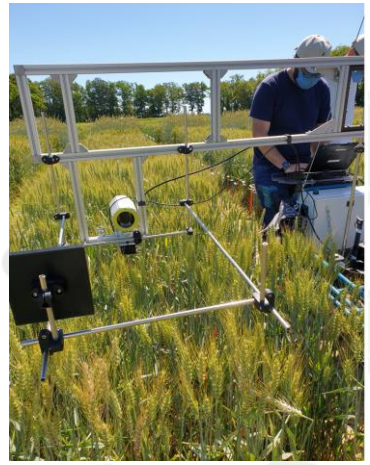
Outcomes & relevance to variety testing (2)



➢ Multispectral Visible NIR imaging (GEVES)

- Method based on the chlorophyl content
- Application window: Green and yellow ears (until 550°day post inoculation)

- In laboratory
  Random collection of 100 ears by plot,
  Image acquisition in lab and differed processing in office
- In field
  Image acquisition on the 1st row of ears and differed processing in office
  High correlation with annotation in case of good acquisition conditions & high FHB pressure

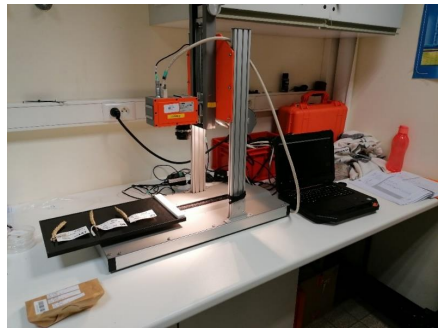


- Proximal sensing ☺
- High cost device ☹
- Time consuming ☹
- Image on full ears acquired in frontal view ☺
- Possible early detection when one spikelet is infected ☺

Outcomes & relevance to variety testing (3)

- Hyperspectral NIR imaging (CRA-W)
  - Method based on the Chlorophyl and water content
  - Application window: Independent of the maturity stage of the ears

  - In laboratory
    Random collection of 100 ears by plot,
    Image acquisition in lab and differed processing in office



  - In field
    Image acquisition on 1 m2 by plot and differed processing in office
    Useful for selective harvest

  - Proximal sensing ☺
  - High cost device ☹
  - Time consuming ☹
  - Image on ears acquired in vertical view (line scan camera) ☺
  - Possible detection on a wider area ☺

Next steps for an application by OEs or PROs

- RGB images in field (GEVES, AGROSCOPE, CRA-W):
  - Guidelines document for images semi-automatic annotating to assess biotic stress
  - Use of the annotated images for model development by GEVES
  - Use of those models to extend the portfolio of agronomics traits on existing phenotyping device such as:
    - the ***Mobile***-based Rapid Phenotyping (MoRPH) application developed by WUR
    - the ***Literal*** stick developed by Hiphen
- Handheld fluorometer in field (AGROSCOPE)
  - Assess its potential application under natural infections in a ***variety testing network*** to improve the comparability among campaigns, sites and operators
- Multispectral Visible NIR imaging in laboratory (GEVES)
  - Proof of concept validated in lab but too long for using in routine and high price
- Multispectral Visible NIR imaging in field (GEVES)
  - ***Semi-automatic annotation*** method to assess biotic stress
- Hyperspectral NIR imaging in laboratory (CRA-W)
  - ***Prediction in real time***
- Hyperspectral NIR imaging in field (CRA-W)
  - ***Transfer to tractor platform*** adapted to imaging acquisition: acquisition speed, natural light control, view angle
  - ***Model optimisation:*** Specificity, prediction in real time

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Close

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