Phenomics – Study case : Detection of fusarium head blight (FHB) on wheat

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Objectives

- Question addressed in the SFS-29-2018 call:
- How to improve the wheat crop resilience to biotic stress ?

Strategy

- How this question is addressed?
- 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.

Methodology

- 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).

Current TRL level

- TRL 3: RGB and NIR hyperspectral imaging in field;
- TRL 4: handheld fluorometer in field, VIS-NIR multispectral and NIR hyperspectral imaging in lab;
- TRL 5: VIS-NIR multispectral imaging in field.

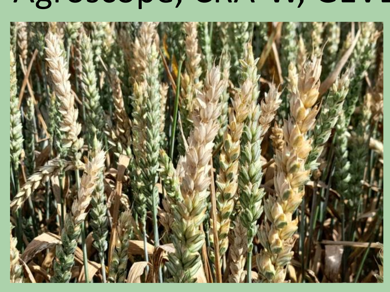
Where can innovative techniques be introduced in plant variety testing?

- In laboratory, to assess wheat diseases (FHB) at ear level, on samples collected in the field trials (100 ears / plot).
- In field, to assess wheat diseases (FHB) at plot level, directly in the field trials.

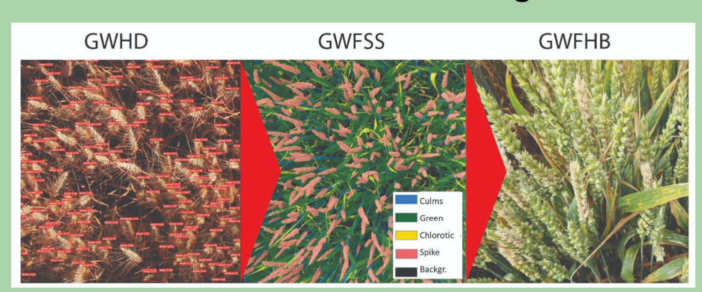
RESULTS

RGB images

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



➢ Contribution to the GWFHB: Global Wheat Fusarium Head Blight



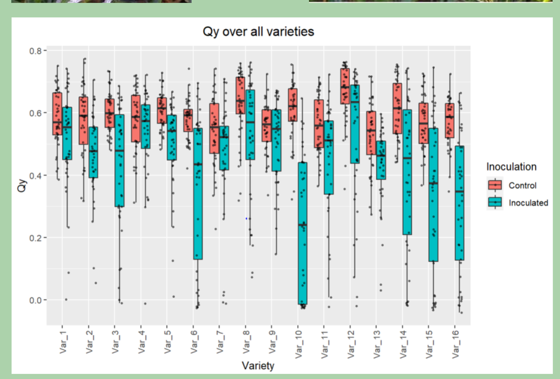
Head Detection — Full Semantic Segmentation — Fusarium Head Blight

Proximal sensing
Green ears
Based on the color (green/white)
Low cost ☺
Quick acquisition ☺
Image on full ears acquired with an angle of 45° ☺
Early detection when one spikelet is infected ☺

Global Wheat Datasets — https://www.global-wheat.com/gwfss.html

Handheld fluorometer

➢ +/- 10000 fluorescence measurements in the field by Agroscope



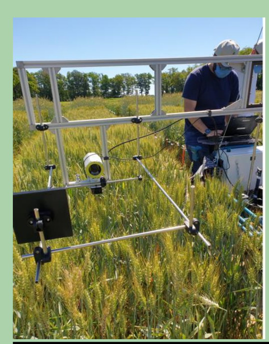
QY results for measurements on spikes in the field showing a very large variability in relation to strong infections

Contact sensing
Green and at maturity ears
Based on the chlorophyl fluorescence
Low cost ☺
Time consuming ☹
Point to point measurement ☹
Not early detection, need high infection ☹

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

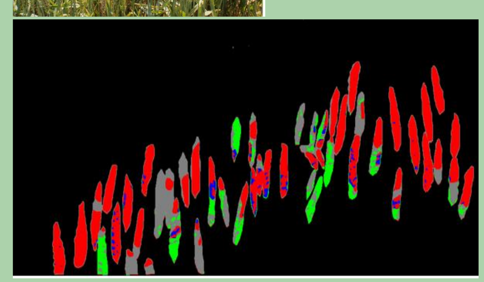
VIS-NIR multispectral imaging

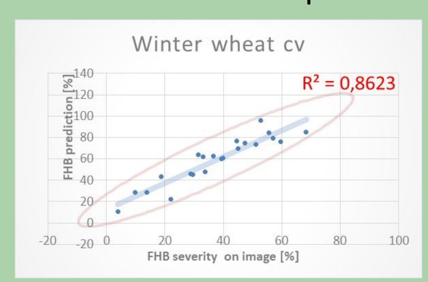
➢ 560 images acquired on 7 sites in the field by GEVES



RGB

VNIR Multispectral





Ear segmentation and fusarium quantification prediction
Usable for assesment of FHB cv resistance
Fairly good specific detection of FHB compared with yellow rust and Microdochium

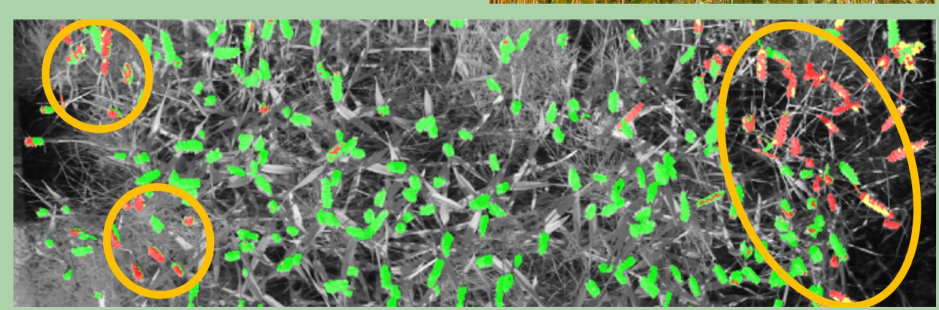
Proximal sensing
Green and yellow ears (until 550°day post inoculation)
Based on the chlorophyl content
High cost ☹
Time consuming ☹
Image on full ears acquired in frontal view ☺
Possible early detection when one spikelet is infected ☺

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

NIR hyperspectral imaging

➢ 100 images acquired on 1 site in the field by CRA-W

NIR Hyperspectral



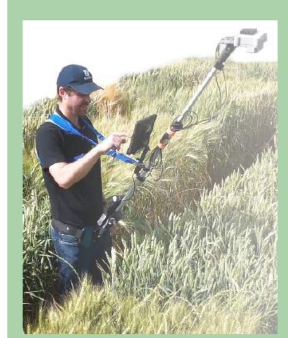
Ear segmentation and fusarium/take-all prediction
Usable for assesment of overall stress but not specific enough to differentiate two diseases with similar symptoms

Proximal sensing
Green and at maturity ears
Based on the chlorophyl and water content
High cost ☹
Time consuming ☹
Image on ears acquired in vertical view (line scan camera) ☺
Possible detection on a wider area ☺

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 Gbx-ABT

Next steps for an application by OEs or PROs

RGB images



➢ Guidelines document for images (semi-automatic) annotating to assess biotic stress
➢ Use of the annotated images for model development by GEVES
➢ Use of this model 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

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Handheld fluorometer

➢ Assess its potential application under natural infections in a variety testing network to improve the comparability among campaigns, sites and operators

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VIS-NIR multispectral imaging

➢ Develop a semi-automatic annotation method too assess biotic stress

PHENET — GEVES

NIR hyperspectral imaging

➢ Transfer to a tractor platform & adaptation with blackout box (natural light control) with angle 45 or vertical view
➢ Model optimisation: specificity prediction in real time

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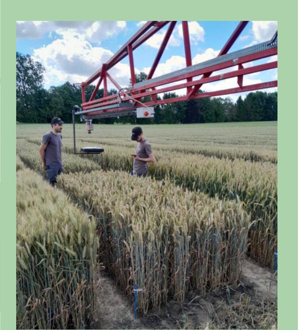

Conclusions

- Preliminary study on ears in laboratory gives good results (image on full ears, stable environmental conditions); Extension to field to avoid the “sample to the lab” process;
- Early detection for disease management on ear disease, easier than leaf disease which begins under the canopy ; Late detection for selective harvest;
- Early/late detection are interesting for the plant breeder to know the dynamics of disease development up to the harvest, in order to study the impact on yield and mycotoxins;
- The image acquisition has to be performed according to the disease development from a spatial and temporal point of view;
- Proof of concept for the use of field imagery (RGB or multispectral) to replace visual ratings has been established for classifying varietal resistance to FHB, as part of the process of registering varieties in the European Catalogue.

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