Wallonie recherche CRA-W

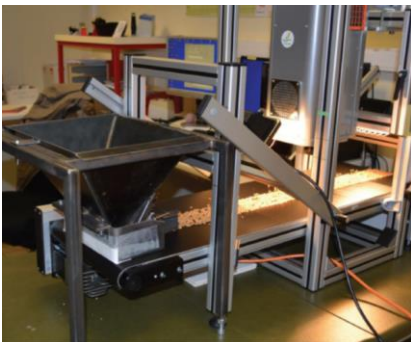**Centre wallon de Recherches agronomiques**

Research on new methods of plant phenotyping at CRA-W

Philippe Vermeulen, Damien Vincke, Vincent Baeten
Guillaume Jacquemin, Fabienne Rabier, Jean-Pierre Goffart

Food and Feed Quality Unit
p.vermeulen@cra.wallonie.be

Crops Production Systems Unit
g.jacquemin@cra.wallonie.be

CRA-W expertise on sensors

Fluorescence, visible, NIR sensors and imaging systems

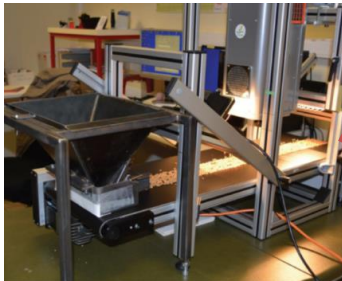**From laboratory …**   **to**   **on site measurements**

Sensors   Imaging systems

on potato plants

on apples

on cereals

For breeders

For farmers

For Agro industry

Centre wallon de Recherches agronomiques
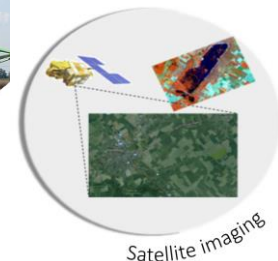Répondre aux questions d'aujourd'hui et relever les défis de demain
www.cra.wallonie.be

2
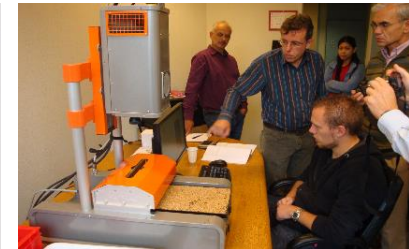
Some research projects and applications on

- Plant phenotyping
  - using handheld instruments and imaging systems
- Grain phenotyping
  - using NIR hyperspectral imaging
- Crop monitoring
  - Using handheld and embedded instruments
  - Using aerial and satellite imaging
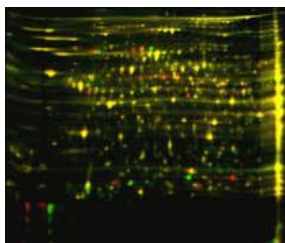

Satellite imaging

FIRST (2018-2020)

Definition and developpement of tools for the identification of genotypes associating pathogens resistance and improved nitrogen use efficiency
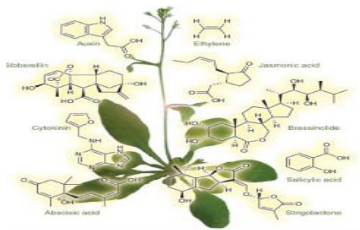Model: Solanum tuberosum x Phytophthora infestans x nitrogen.

Genetic ressources

Proteomic

Metabolomic

Visual observations in phytotron and in field

Phenomic

VIS/NIR

Fluorescence

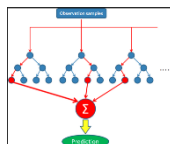**Predictif algorithm**

Data science

NIR imaging

Contact CRA-W : Sergio Mauro

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4

Wallonie recherche
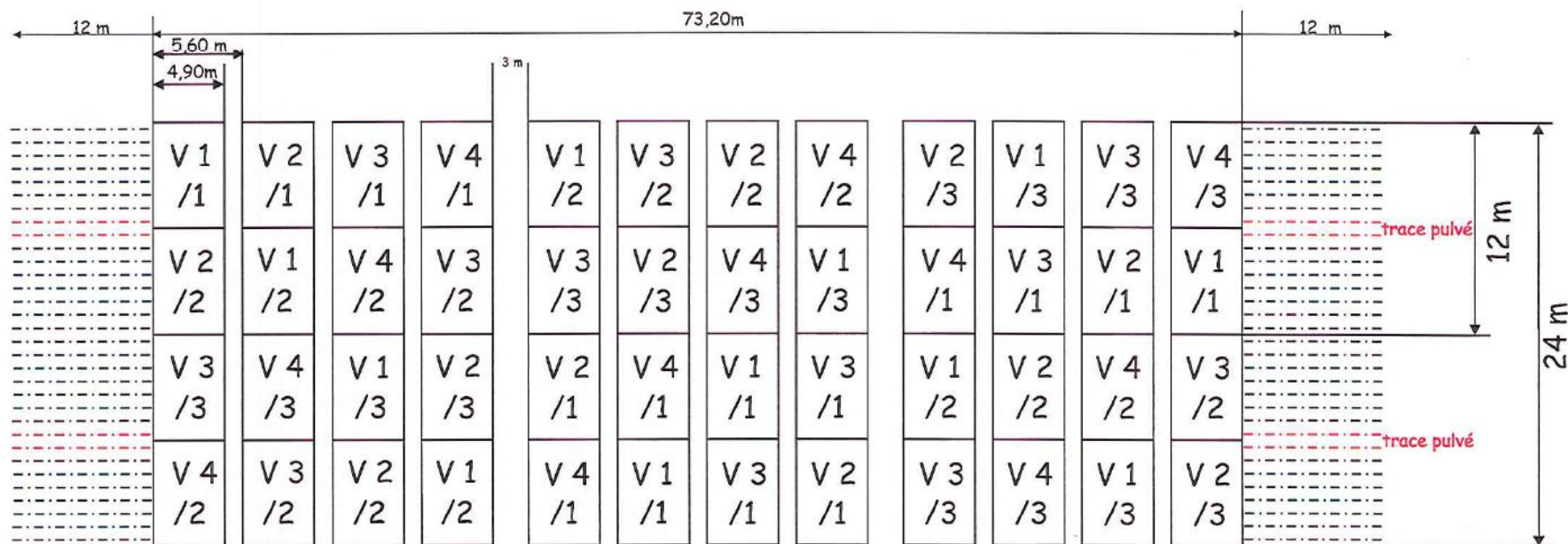CRA-W

FIRST

Trial 2018

Essai First 2018: pommes de terre

/1: 0 Kg N
/2: conseil N - 30 %(50%)
/3: conseil N
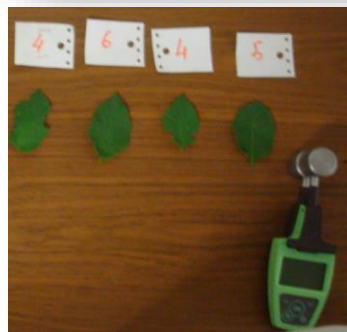V1,V2,V3,V4= différentes variétés

Superficie total: 73,20 X 24 =1758 m²

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Répondre aux questions d'aujourd'hui et relever les défis de demain
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FIRST

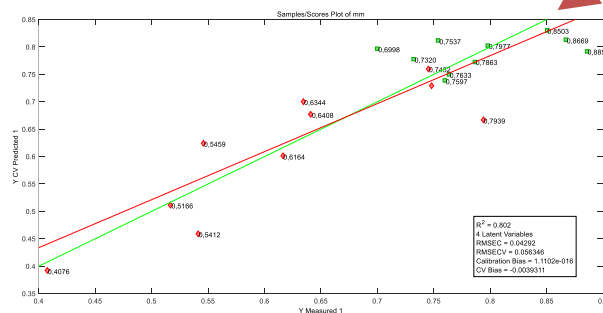Nitrogen status measurements on leaves

Phenomic

Fluo, VIS, NIR handheld instrument

Reference method: Dumas

Calibrations

Contacts CRA-W : Damien Vincke, Feriel Ben Abdallah & Philippe Vermeulen

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Répondre aux questions d'aujourd'hui et relever les défis de demain
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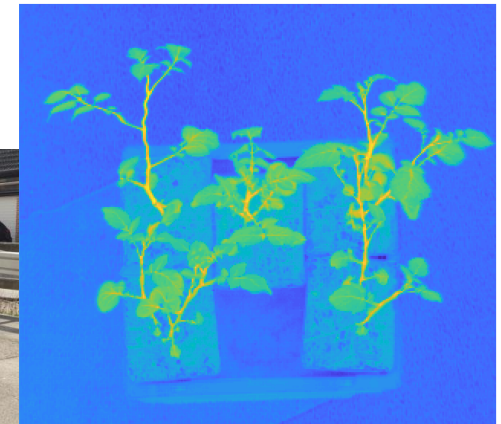
Wallonie recherche CRA-W

FIRST

Phytophthora infestans symptom analysis

Phenomic

NIR hyperspectral imaging system

Disease analysis on leaves

Healthy status analysis on plants

Contacts CRA-W : Damien Vincke & Philippe Vermeulen

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7

PHENWHEAT (2018-2020)

Characterisation of the growth dynamics of varieties of winter wheat resistant to different biotic and abiotic stress by means of a ground-based phenotyping platform

Ground-based remote sensing Stand alone use

Ground-based remote sensing Stand alone use
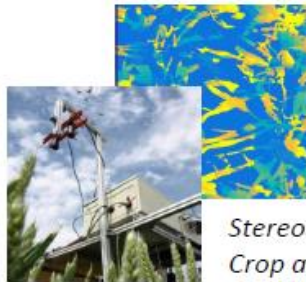
Network of trials

Stereoscopy
Crop architecture

Observation
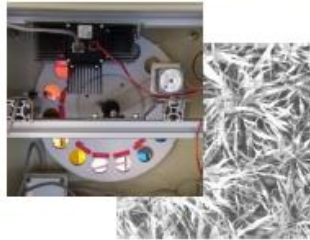
Field sensors

Multispectral and hyperspectral imaging

Hyperspectral imaging

Ground based Phenotyping platform

Data science

Contacts CRA-W: Damien Vincke, Guillaume Jacquemin & Philippe Vermeulen

Wallonie recherche CRA-W

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LIÈGE université Gembloux Agro-Bio Tech

UMONS Université de Mons

8

PHENWHEAT

VCU Trial Petermann 2018: diseases on heads

50 varieties
9 checks
1 row by variety

2 untreated trials
1 trial without inoculation
1 trial with inoculation (25/5)
Fusarium Graminearum

Wheat heads collect: 2 heads by variety
Dates: 5/6, 13/6, 20/6

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9

PHENWHEAT

VCU Trial Petermann: measurement

NIR hyperspectral camera: 900-1700 nm (100 wl)

Figure 1: FX17 Spectral Camera

Field setup

Laboratory setup

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10

BEETPHEN (2017-2019)

Sugar beet phenotyping in breeding trials (using UAVs)

Objectives:
To **evaluate** the use of **UAV's** imaging systems
and **compare** them to ground-based systems (imaging and non-imaging)
and classical field observations (time and labour consuming)
… for **crop phenotyping** in sugar beet breeding trial plots

… with the focus on **sugar beet diseases** as specific trait to phenotype

Contacts CRA-W: Damien Vincke & Philippe Vermeulen

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11

POMINNO (2008-2011)

Research of rapid methods to select new apple cultivars presenting high nutritional quality

1. Application of NIR in the apple breeding program

Calibration model for 2009-2010 with XDS

> Good results for **sugar, acidity & phenolic compounds**
>
> Not for maturity, firmness and vit C!!

Calibration model for 2009-2010 with **Phazir**

> For all parameters: low RPD values and high SECV!
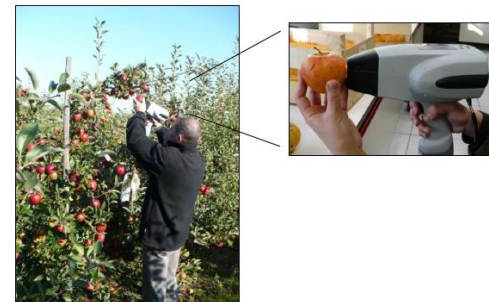
> ...Better results with XDS !

Pissard, A. , Bastiaanse, H. , Baeten, V. , Sinnaeve, G. , Romnée, J.M. , Dupont, P. , Mouteau, A. & Lateur, M. (2013). Use of NIR Spectroscopy in an Apple Breeding Program for Quality and Nutritional Parameters In: *Acta Hortica,* K.M.Evans et als. ISHS, **976,** 409-413.

Tomorrow: New generation of instruments
FELIX for dry matter and sugar

Contacts CRA-W: Marc Lateur & Audrey Pissard

XDS (FOSS NIRSystems, Inc.)

Phazir (Polychromix, Inc.)

F-750: FELIX instruments

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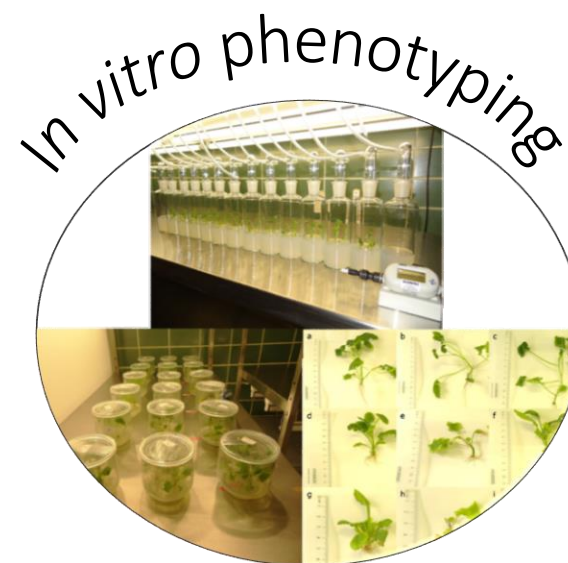**www.cra.wallonie.be**

12

SOLINDIC (2015-2019)

Oilseed rape and abiotic stresses

Objectives:
Using phenotyping and
complementary **VOC** profiling
approach

to investigate physiological response
of **Brassica napus L**. plantlets

under a concentration gradient
of two **abiotic stresses**:
cadmium and epoxiconazole
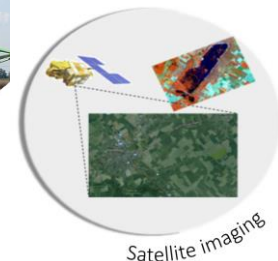
In vitro phenotyping

Contact CRA-W: Bastien Durenne

Durenne, B. , Blondel, A. , Druart, P. & Fauconnier ML. (2018). A laboratory high-throughput glass chamber using dynamic headspace TD-GC/MS method for the analysis of whole Brassica napus L. plantlet volatiles under cadmium-related abiotic stress. *Phytochemical Analysis,*

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13

Some research projects and applications on

- Plant phenotyping
  - using handheld instruments and imaging systems
- Grain phenotyping
  - using NIR hyperspectral imaging
- Crop monitoring
  - Using handheld and embedded instruments
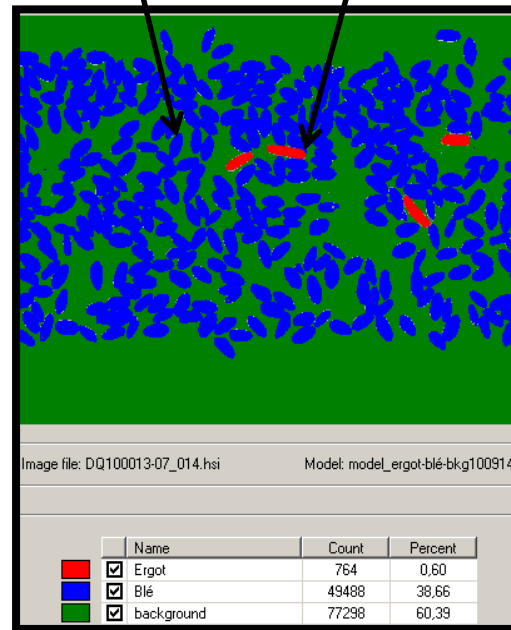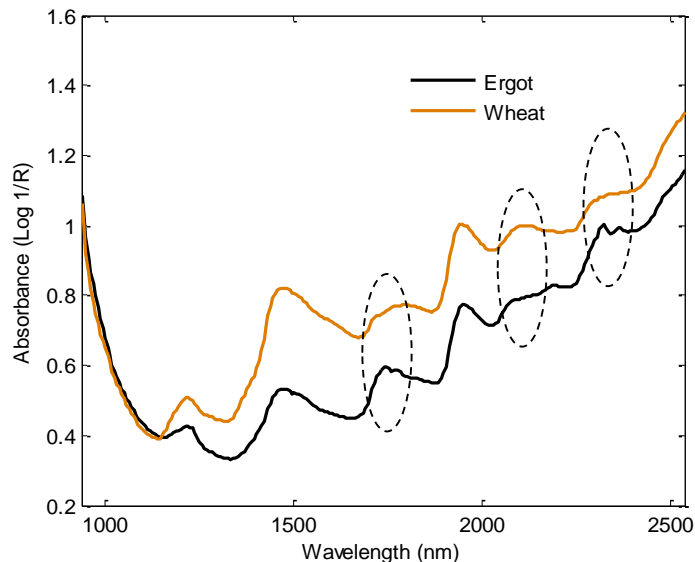 - Using aerial and satellite imaging

Satellite imaging

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14

CONFFIDENCE (2008-2012)
NIR imaging helps detect ergot in cereals …

Wheat kernels   Ergot body

Benefit of the method

Absorbance (Log 1/R) vs Wavelength (nm) — Ergot, Wheat

NIR hyperspectral imaging
Low skilled personal
A few minute / 250 g
Large samples (sampling more representative)
Multiple contaminants

Image file: DQ100013-07_014.hsi   Model: model_ergot-blé-bkg100914

	Name	Count	Percent
☑	Ergot	764	0,60
☑	Blé	49488	38,66
☑	background	77298	60,39

Vermeulen, P. , Fernández Pierna, J.A. , van Egmond, H.P. , Zegers, J. , Dardenne, P. & Baeten, V. (2013). Validation and transferability study of a method based on near-infrared hyperspectral imaging for the detection and quantification of ergot bodies in cereals. *Analytical and Bioanalytical Chemistry,* **405:** (24), 7765-7772.

Contact CRA-W : Philippe Vermeulen

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… and many other impurities …

Legend:
- Background (green)
- Germinated seeds (dark blue)
- Broken wheat (cyan)
- Weed seeds (yellow)
- Wheat kernels (orange)
- Straw, husks (magenta)
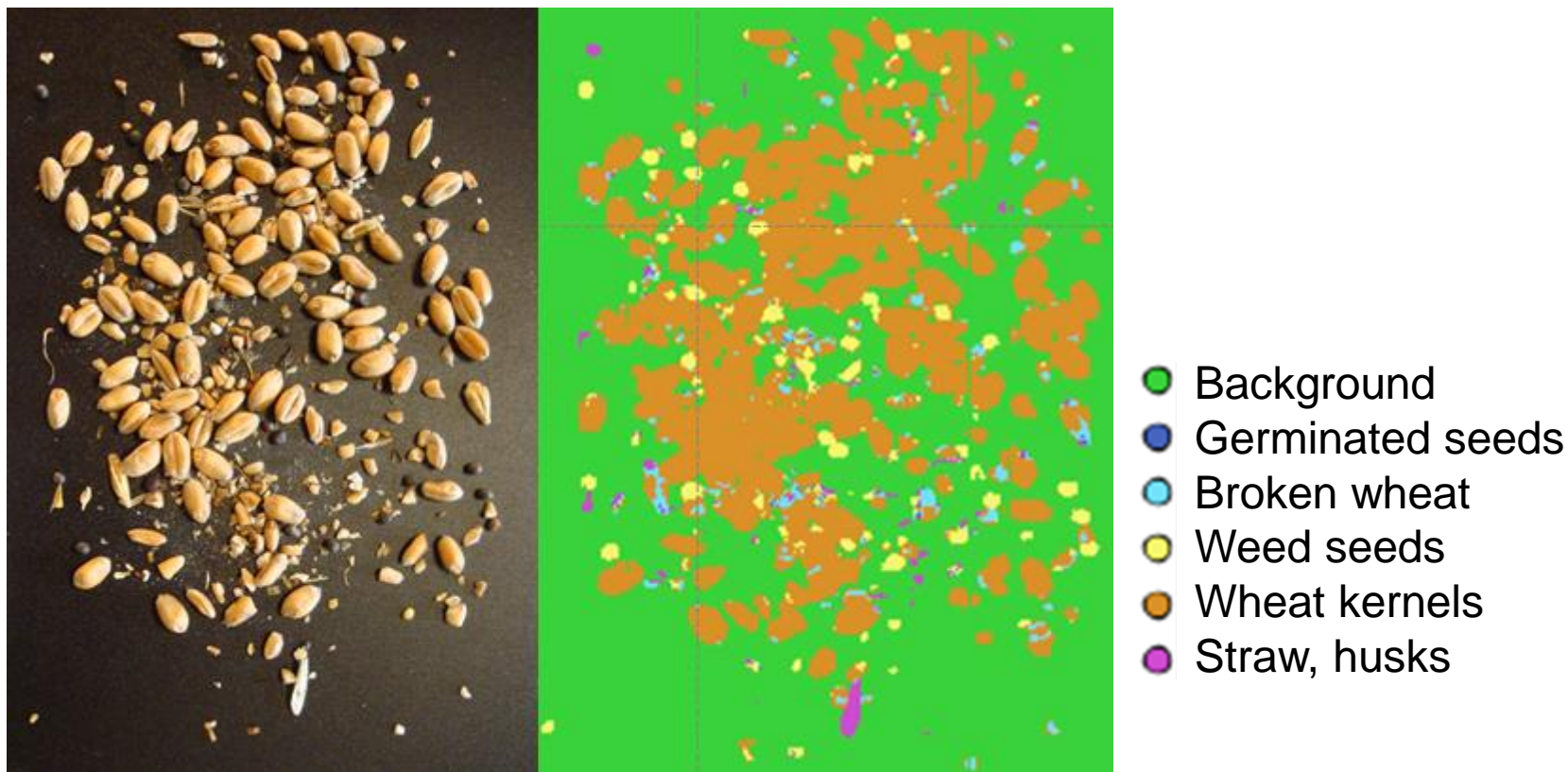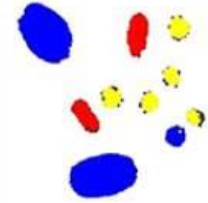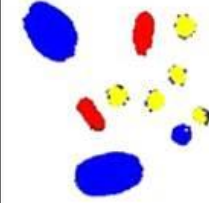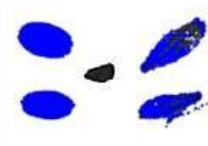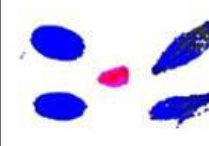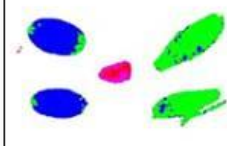
Fameree, L. (2012). Détection de contaminants dans les céréales par imagerie hyperspectrale proche infrarouge (TFE). Huy, Belgium,

Contact CRA-W : Philippe Vermeulen

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16

… using chemometrics

- ## SVM discrimination models

Original image	Background vs rest	Animal contaminant vs rest	Cereals vs rest	Botanical impurities vs rest	Other contaminants vs rest	Cellulose waste vs rest

▸ Fernandez Pierna, J.A. , Vermeulen, P. , Amand, O. , Tossens, A. , Dardenne, P. & Baeten, V. (2012). NIR hyperspectral imaging spectroscopy and chemometrics for the detection of undesirable substances in food and feed. *Chemometrics and Intelligent Laboratory Systems*, **117**: 233-239.
http://dx.doi.org/10.1016/j.chemolab.2012.02.004

Contact CRA-W : Juan Antonio Fernandez Pierna

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FOODINTEGRITY (2014-2018)
NIR imaging helps detect fraud in cereals
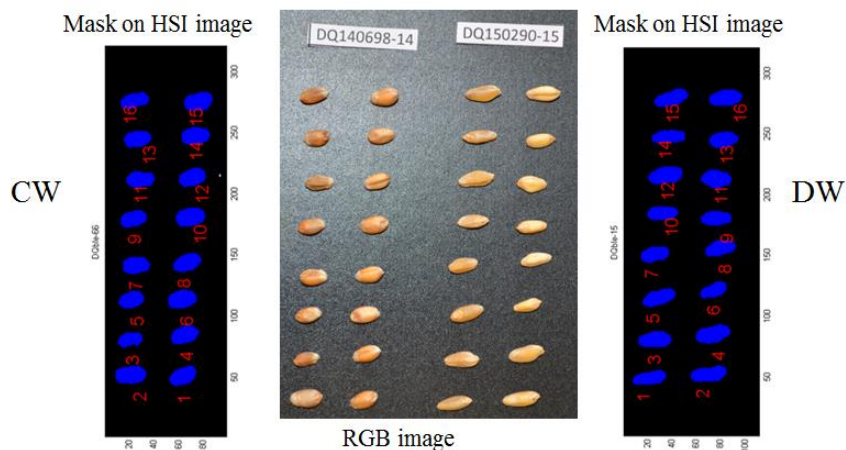
RGB picture and mask on NIR images

Common wheat (CW) in Durum wheat (DW)
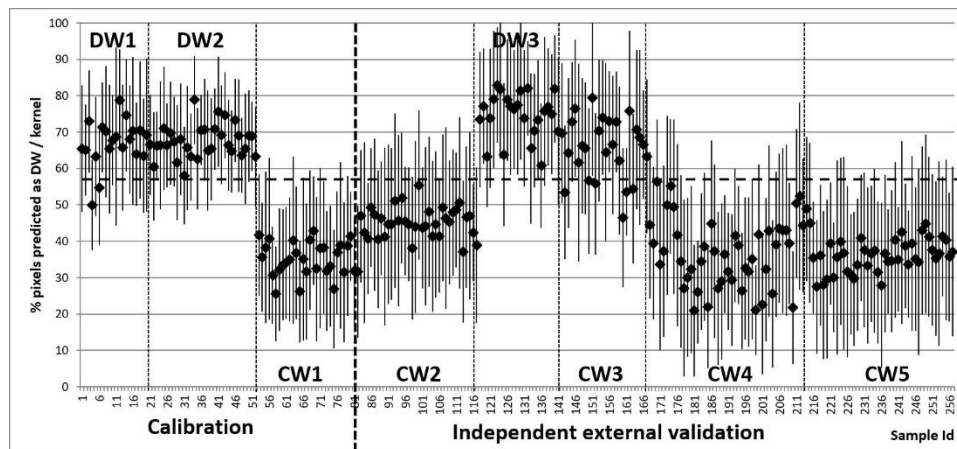
Results of NIR spectral profile approach

		on 4112 kernels		on 257 samples	
		DW (1232 kernels) %	CW (2880 kernels) %	DW (77 samples) %	CW (180 samples) %
	1 criterion				
Morphological criteria (Fig. 1)	C1 (16 kernels)	82.9	97.1	87.0	100
NIR spectral profile (Fig. 2)	C2 (16 kernels)	88.1	85.0	97.4	89.4
	2 criteria				
	C1+C2 (16 kernels)	98.1	82.2	98.7	97.2

Discrimination between durum and common wheat kernels using near infrared hyperspectral imaging

Current status: Submission Initiated (04/Jun/2018)

Contact CRA-W : Philippe Vermeulen

NIR imaging helps assess protein content

DQ150290-35 | 35 | 11.9 | 72%
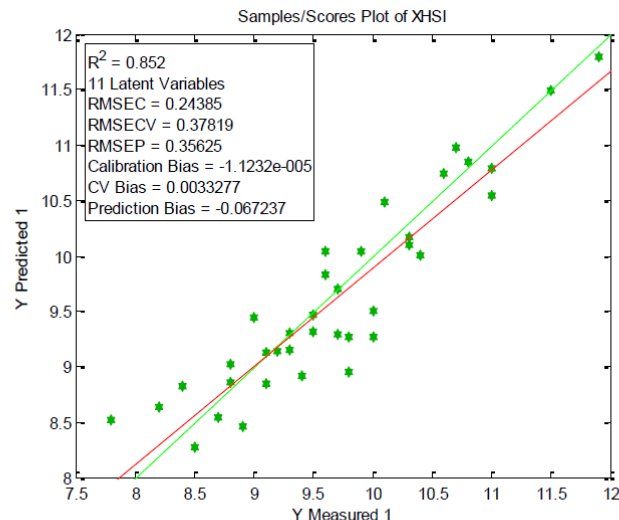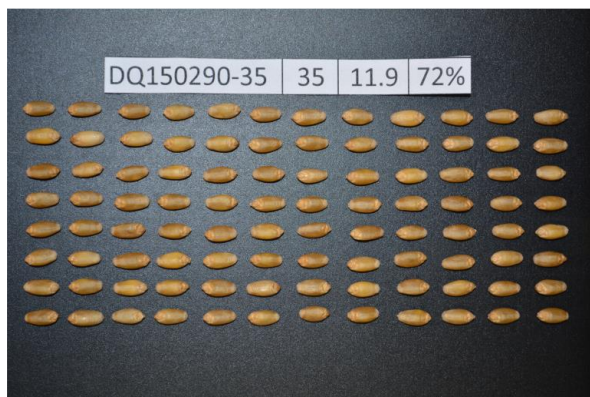
Figure 82 : Modèle PLS en validation de l'échantillon DQ150402-07 sur la caméra infrarouge

Figure 74 : Graphique en bâtonnets d'un échantillon de 96 blés durs et d'un échantillon de 96 blés tendres avec la caméra infrarouge

Distribution of protein content
predicted at kernel level
for 2 wheat varieties
with low and high protein content

Dijon Arthur (2017). *Évaluation de différents instruments de spectroscopie proche infrarouge pour la prédiction de la teneur en protéines de céréales analysées en graine à graine.* Huy, Haute Ecole Charlemagne - ISIa, 108.

Contact CRA-W : Philippe Vermeulen

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19

NIR imaging helps improve seed QC

CONTROLLING THE QUALITY OF CEREAL SEED TREATMENT

THE TREATMENT OF SEEDS WITH PLANT PROTECTION PRODUCTS IS STRONGLY ADVISED TO FIGHT DIFFERENT PLANT DISEASES AND PESTS IN EARLY STAGES OF PLANT GROWTH. BUT WHICH ANALYTICAL METHODS ARE USED TO CONTROL THE DOSE AND HOMOGENEITY OF THE TREATMENT ON A SEED LOT?

Thanks to near-infrared hyperspectral imaging, it was also possible to detect the potential presence of seeds from another species/variety in a seed lot, untreated seeds or seeds treated with a different formulation. It was also possible to assess the homogeneity of the treatment on each seed individually and to classify them according to the target dose. For some lots, the active ingredient content in more than 75 % of the seeds was higher than the acceptable 30 % around the target dose.

This technology opens up new opportunities in terms of seed quality control. This study was the subject of an article in the Journal of Spectral Imaging (doi: 10.1255/jsi.2017.a1).
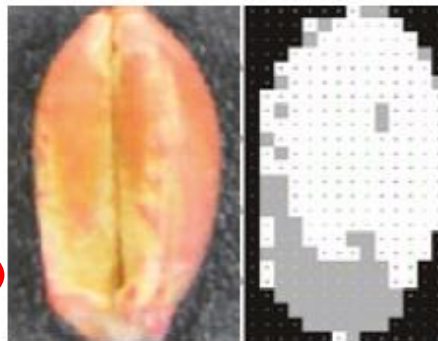
Visible image and predictive hyperspectral image of a wheat seed showing the treated area in white and the non-treated area in grey.

Contacts: Philippe Vermeulen, p.vermeulen@cra.wallonie.be and Patricia De Vos, p.devos@cra.wallonie.be

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20

Some research projects and applications on

- Plant phenotyping
  - using handheld instruments and imaging systems
- Grain phenotyping
  - using NIR hyperspectral imaging
- Crop monitoring
  - Using handheld and embedded instruments
  - Using aerial and satellite imaging

Satellite imaging

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21
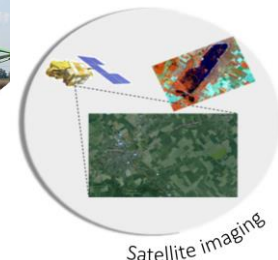
POTFLUO (2012-2018)
Potato crop monitoring: Fluo handheld instrument

The use of the ratio of fluorescence combining the estimation of concentrations of leaf chlorophyll and flavonoid content appears to be a relevant potential method to assess crop nitrogen status.

Feriel Ben ABDALLAH, William PHILIPPE & Jean-Pierre GOFFART
Use of chlorophyll fluorescence for the evaluation of crops nitrogen status. A review

Contact CRA-W : Feriel Ben Abdallah

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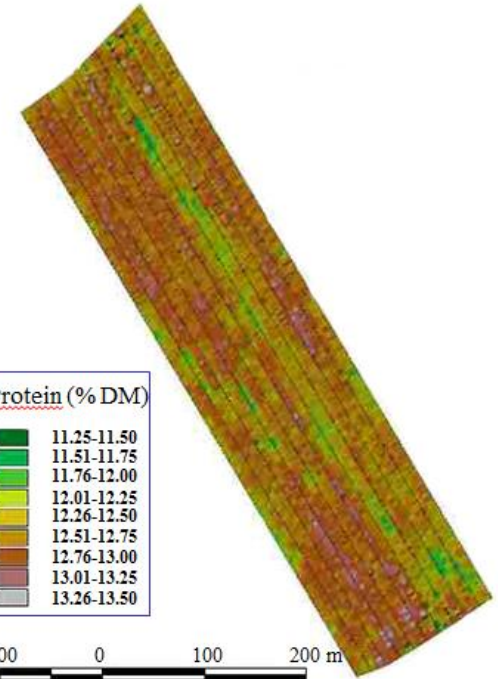**www.cra.wallonie.be**

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22

Wheat crop monitoring: NIR embedded instrument

Protein by NIR
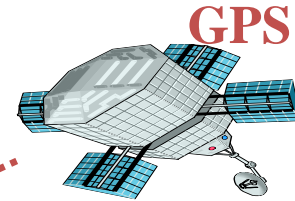
GPS

Protein (% DM)
- 11.25-11.50
- 11.51-11.75
- 11.76-12.00
- 12.01-12.25
- 12.26-12.50
- 12.51-12.75
- 12.76-13.00
- 13.01-13.25
- 13.26-13.50

100   0   100   200 m

Sinnaeve, G. , Baeten, V. , Tissot, S. , Dardenne, P. & François, E. (2000). *Application d'un spectromètre NIR à barrettes de diode pour l'analyse de céréales au niveau de la moissonneuse batteuse.* Proceedings in: Journée Agriculture de précision, Gembloux - Belgique, 20/12/2000,

Contact CRA-W : Georges Sinnaeve

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23

IPOT (2014-2017)
Potato crop monitoring: Satellite +Drone

Georeferenced Data Acquisition

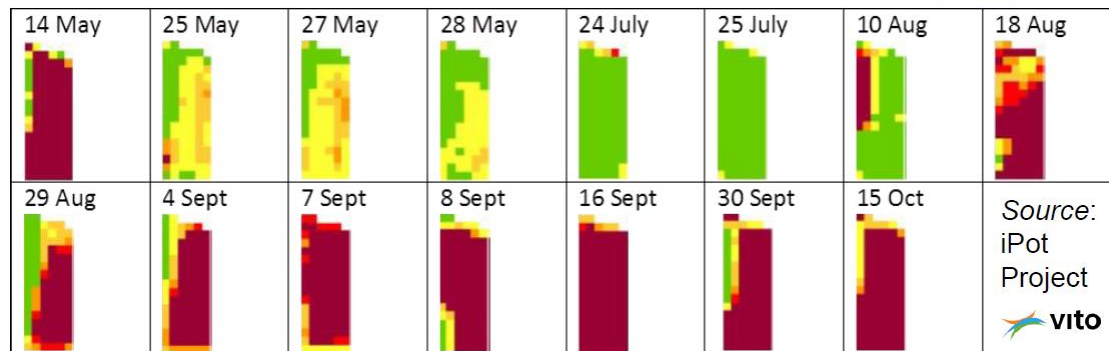Use of UAV's and embedded cameras to assess the variability of the crop during the growing season, and also support satellite image calibration…

| 14 May | 25 May | 27 May | 28 May | 24 July | 25 July | 10 Aug | 18 Aug |
| 29 Aug | 4 Sept | 7 Sept | 8 Sept | 16 Sept | 30 Sept | 15 Oct | *Source*: iPot Project |

Potato crop evolution
- 🟥 bare soil
- 🟨 / 🟧 Starting or decaying crop
- 🟩 full developing crop

GOFFART, J.P. , Curnel, Y. , Planchon, V. , Piccard, I. , Nackearts, K. , Gobin, A. , Wellens, J., , Tychon, B. , Cattoor, N. & Cools, R., (2015). *The iPot project: improved potato monitoring in Belgium using remote sensing and crop growth modelling*. Poster in: POTATOEUROPE 2015, Kain, 2-3-septembre-2015.
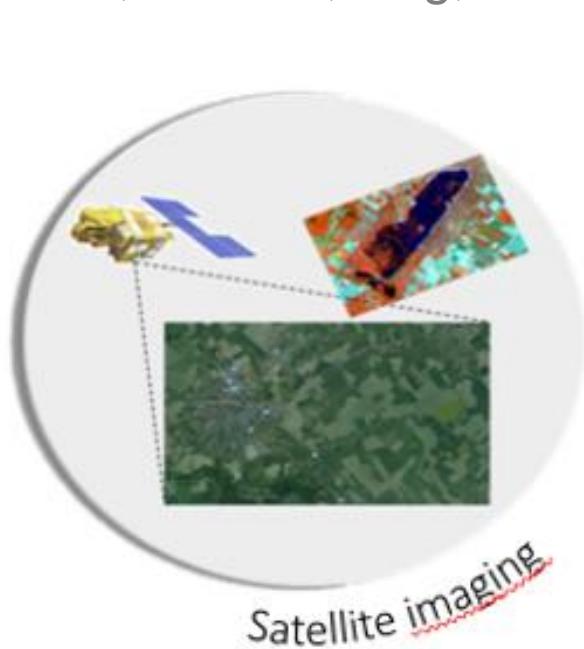
Contacts CRA-W : Yannick Curnel & Viviane Planchon

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24

BELCAM (2017-2020)
Potato, wheat, corn monitoring: satellite

BELgian Collaborative Agriculture Monitoring system for sustainable cropping systems
UCL, CRA-W, ULg, VITO et INRA

Satellite imaging

Contacts CRA-W : Yannick Curnel & Viviane Planchon

Centre wallon de Recherches agronomiques
Répondre aux questions d'aujourd'hui et relever les défis de demain
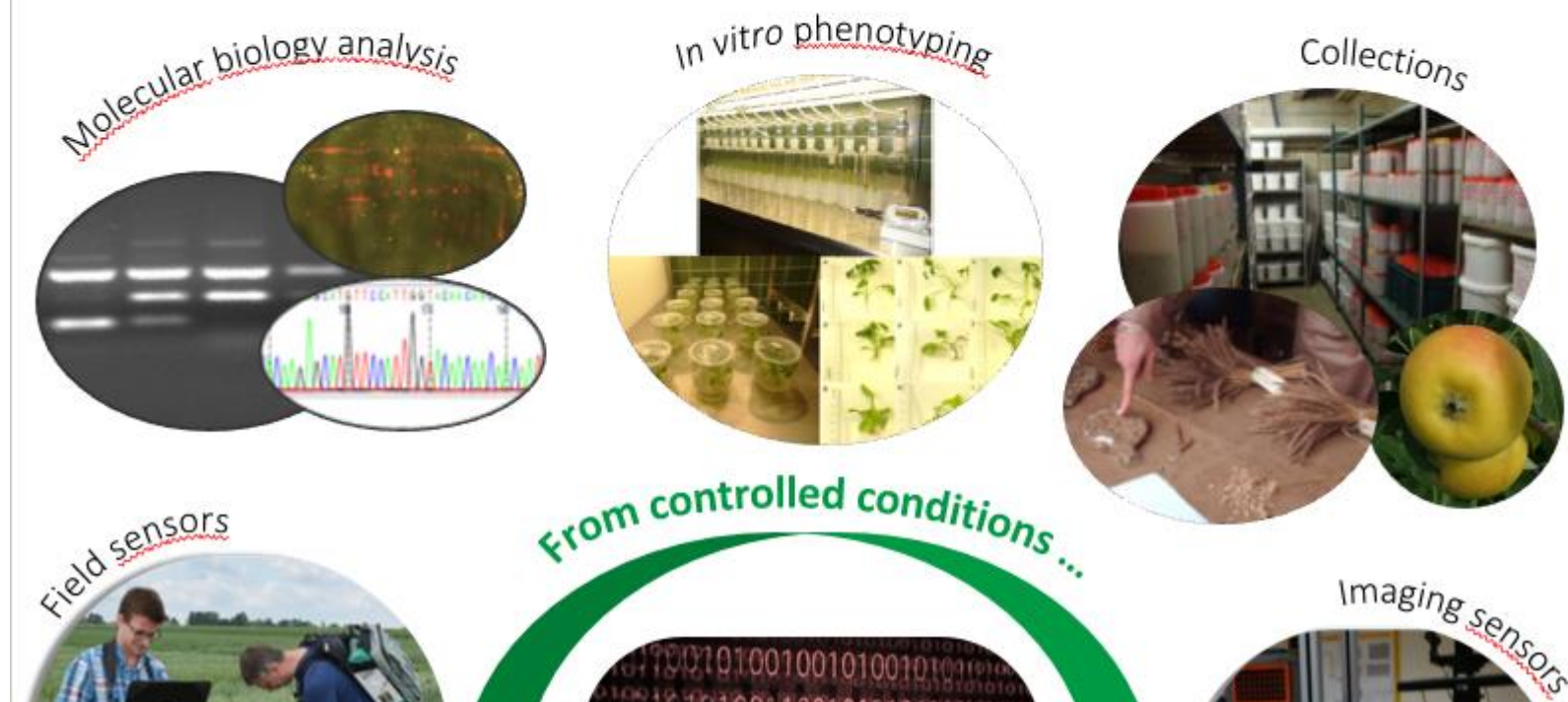**www.cra.wallonie.be**

25

Plant phenotyping activities at the Walloon Agricultural Research Centre

Damien Vincke[5], Bastien Durenne[1], Dominique Mingeot[1], Emmanuelle Escarnot[2], Guillaume Jacquemin[3], Feriel Ben Abdallah[3], Yannick Curnel[4], Sergio Mauro[1], Pascal Geerts[1], Marc Lateur[2], Viviane Planchon[4], Vincent Baeten[5], Philippe Vermeulen[5], Jean-Pierre Goffart[3]
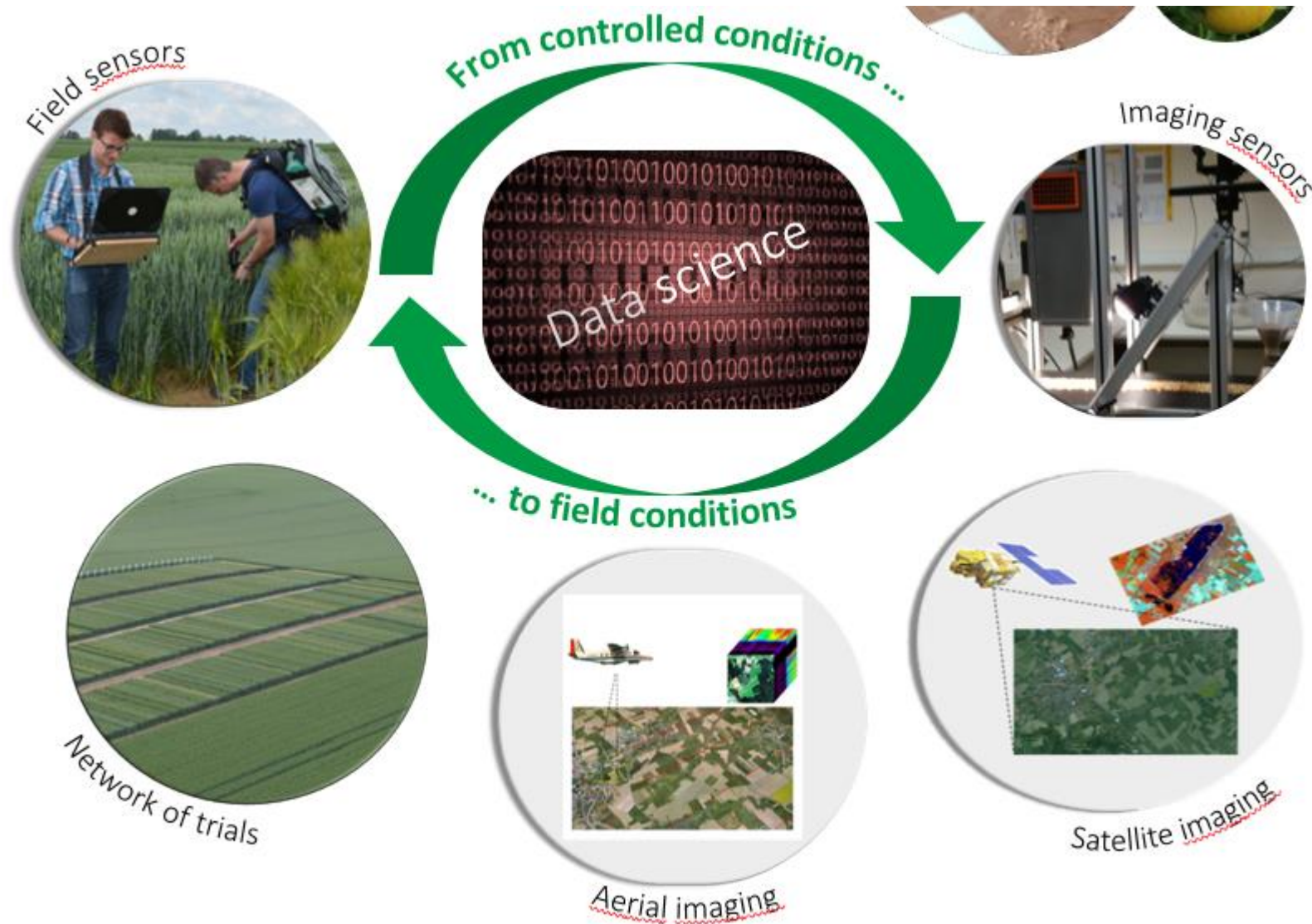
Research Units: [1] Bioengineering [2] Breeding and biodiversity [3] Crops production systems [4] Farming systems, territory and information technologies, [5] Food and feed quality

Contacts: b.durenne@cra.wallonie.be & p.vermeulen@cra.wallonie.be

Molecular biology analysis

In vitro phenotyping

Collections

From controlled conditions ...

Field sensors

Imaging sensors

Belgian
Plant
Phenotyping
Network

European Plant Phenotyping Network
EPPN 2020

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Répondre aux questions d'aujourd'hui et relever les défis de demain
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26

Contacts CRA-W: phenotyping work group: Bastien Durenne et Philippe Vermeulen

Belgian
Plant
Phenotyping
Network

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27

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Thank you for your attention

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