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INNO-VEG webinar

Use of sensors to assess field vegetable and potato crops

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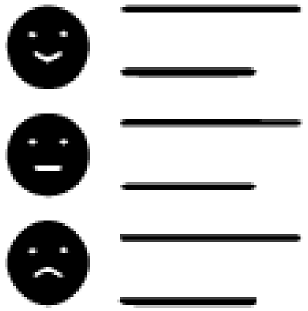
GoToWebinar attendee information

- Thank you for joining the webinar



Agenda

▪ Introduction to the INNO-VEG project	Lizzie Sagoo, ADAS
▪ Use of different types of sensors	Gies Van Den Daele, Inagro
▪ Calculation of vegetation indices	Hans Moggre, Delphy
▪ Comparability of vegetation indices calculated by different sensor types	Jean-Pierre Cohan, Arvalis
▪ Conclusions	Lizzie Sagoo, ADAS

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Introduction to the INNO-VEG project

Lizzie Sagoo, ADAS

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INNO-VEG – Increasing the speed & uptake of innovation in the field vegetable & potato sectors

ADAS

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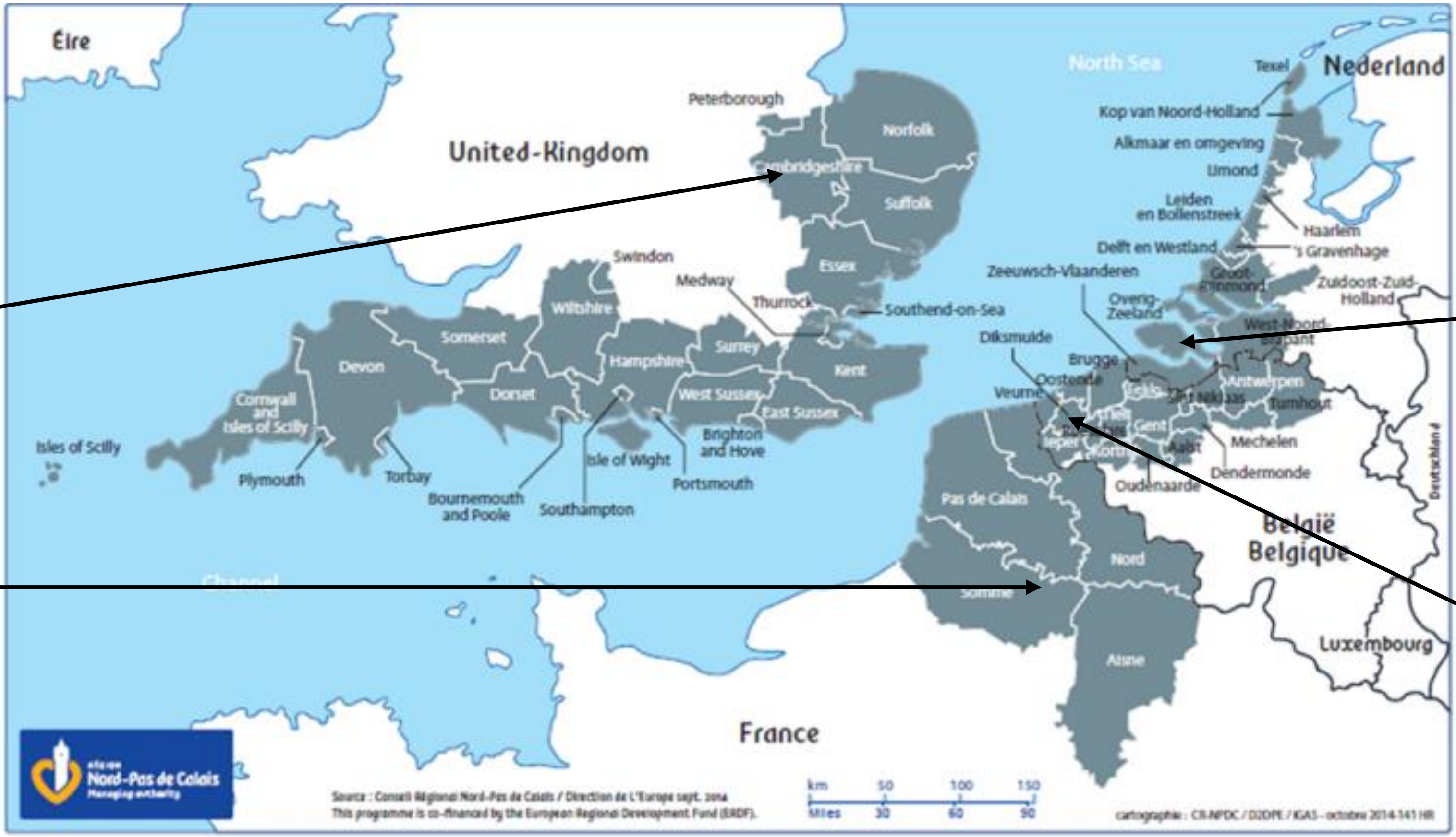

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Project objective

- To increase the speed and uptake of innovation in the field vegetable and potato sectors
- Evaluate the suitability of using crop sensing data to carry out measurements in field experiments
- Define a new approach for delivering research in the field vegetable and potato sectors

Crop types

- Alliums (leeks/onions)
- Brassicas (cauliflower/sprouts)
- Leafy salads (lettuce/spinach)
- Vining peas
- Root vegetables (carrots)
- Cucurbits (courgettes)
- Potatoes









Experimental work

- 2019 - 47 small plot field experiments in UK, FR, BE & NL
  - Range of crops
  - Use crop sensors to measure reflectance
  - Calculate range of vegetation indices & correlate to crop yield

- 2020 – 14 field scale experiments
  - Treatments applied to larger areas
  - Data collected using drone mounted sensors
  - Use spatial statistics to analyse data

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Use of different types of sensors

Gies Van Den Daele, Inagro

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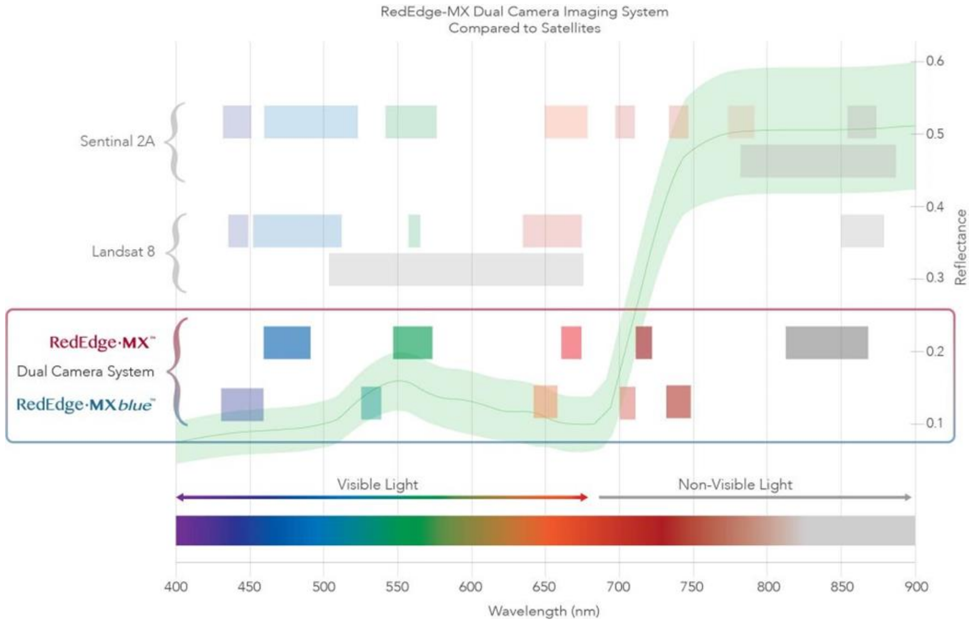
Sensor types

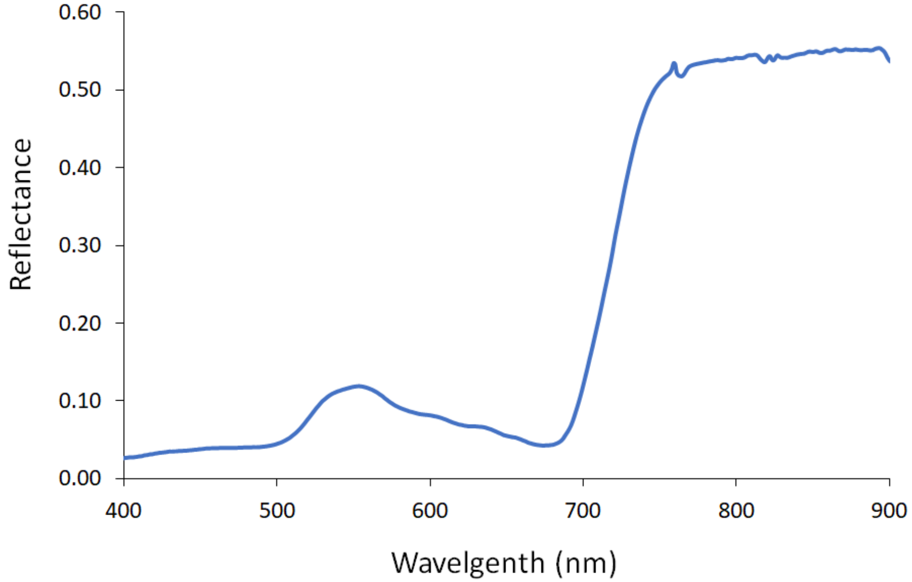
Spectral resolution

- **Multispectral**
- **Hyperspectral**
- RGB
- Thermal
- …

Lightsource

- Active
- Passive





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Sensor types

According to platform

- Handheld sensors
- Tractor mounted sensors
- Drone mounted sensors
- Satellite images

Handheld sensors

- These sensors are operated manually in the field

+

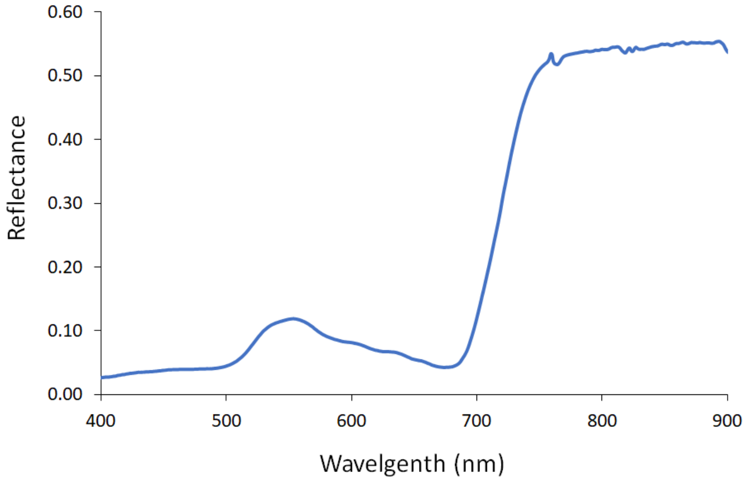
- To be used in different experimental designs
- Well suited to collecting data from small plot experiments
- Possibility of taking multi- or hyperspectral measurements
- Easy transport and use in the different fields

-

- Labour-intensive measurements
- Difficult in large plot field experiments (limited field of view)

FieldSpec HandHeld 2 (Adas)

- Hand held spectroradiometer
- used by ADAS in their small plot experiments in 2019
- **Hyperspectral** – wavelength range 325-1075 nm
- Records reflectance values every 1nm
- Passive sensor – calibrate in field using a white reference disc



Tractor mounted sensors

- Mounted on tractors, spray booms and specially developed carrier systems

+

- Faster data collection compared to manual measurements
- Possibility to have the data collection runs semi-automatically
- Hyperspectral or multispectral measurements
- Multi-sensor platform:
  - “heavy” and new sensors like lidar, thermal cameras…

-

- Tramlines need to be provided
- Plots are limited in dimensions

ALPHI® - Arvalis (France)

Description
Sensor boom
Towed or worn
One driver
Max crop height max 1.3 m

Experimental design
Parallel walkways of seedlings
Seedlings recorded at GPS RTK
Max 800 µplots
ACQ: 400 µplot/J

- Specially developed carrier system
- **Hyperspectral**

Spectracam (Delphy)

- Sensor designed to be tractor mounted
- Deplhy developed a special carrier to use the sensor on field trails
- RTK-gps system
- **Multispectral** – 5 bands:
  - 550, 670, 700, 730 and 780 nm
- Active lightsource

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Drone mounted sensors

- Mostly multispectral sensors
- Passive sensors

+

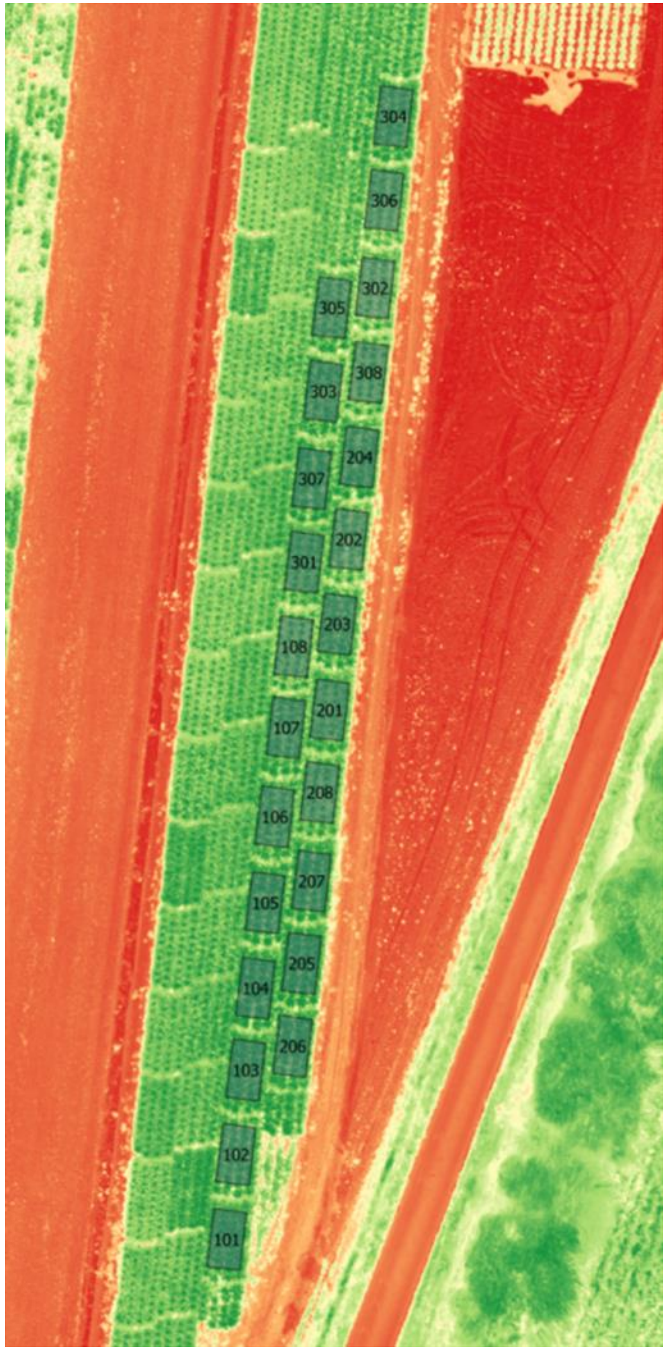
- Faster data collection
- Also possible for large plot field experiments
- Easy transport to the different fields

-

- Trained drone pilots are needed
- Restrictions in drone legislation

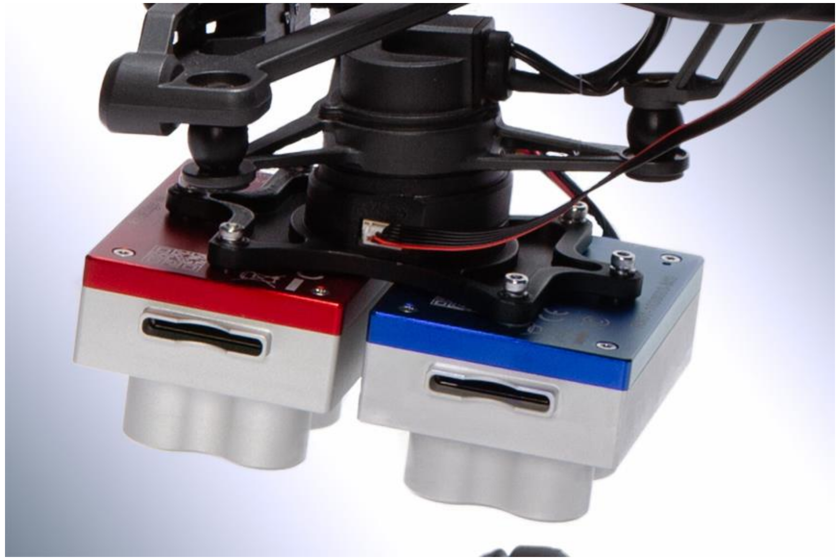
MicaSense Red Edge 3

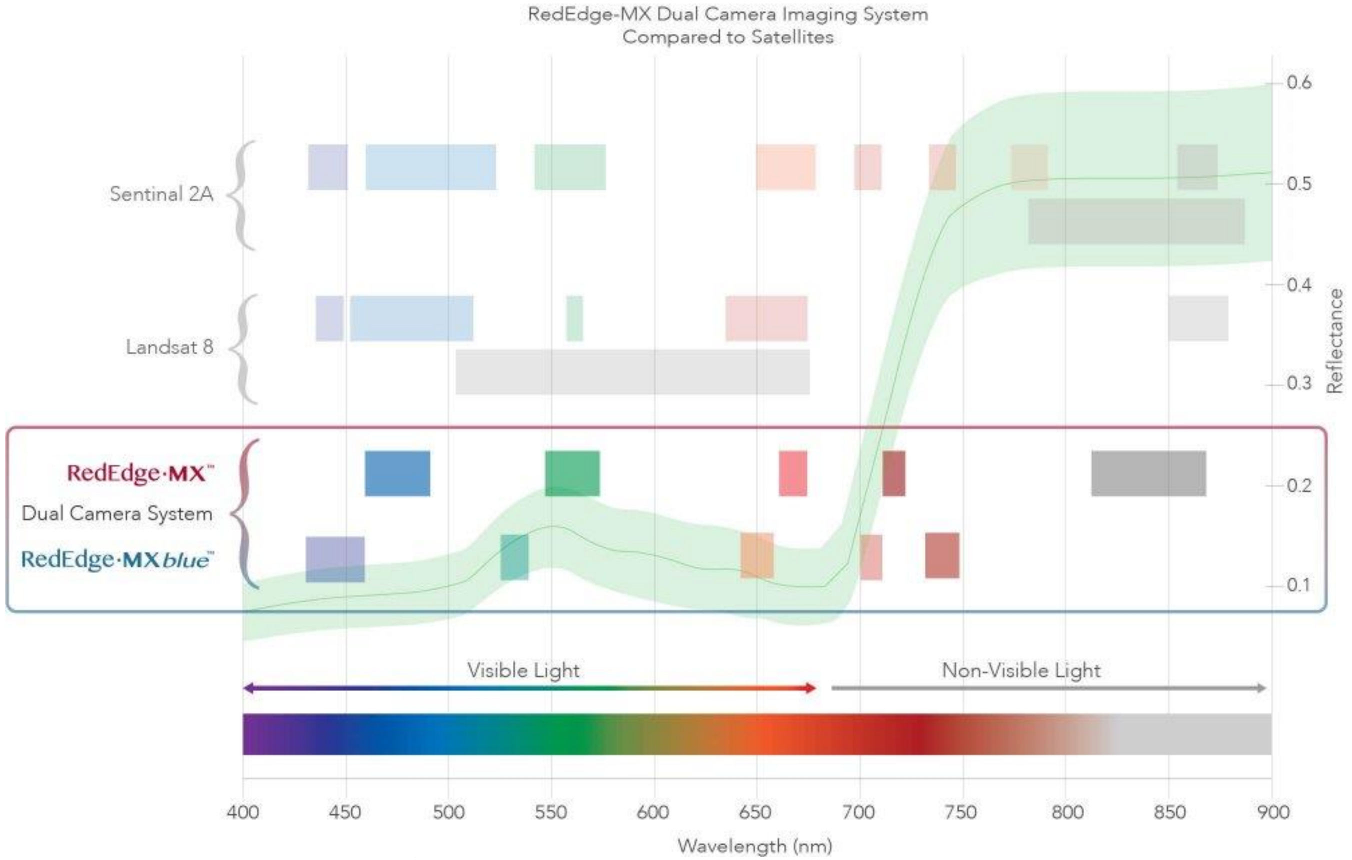
- Drone mounted
- used by ADAS in 2020 field scale experiments
- **Multispectral** – 5 bands
  - 475, 560, 668, 717, 840nm



MicaSense RedEdge MX + Blue (Inagro)

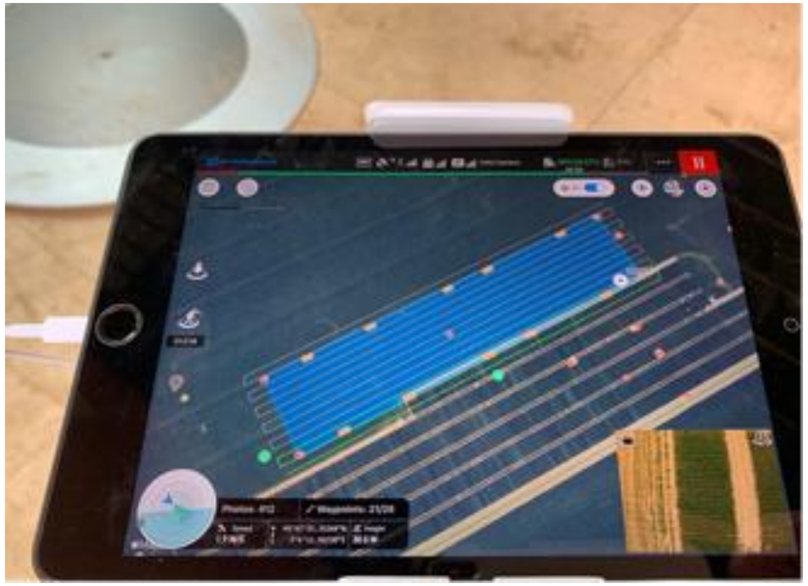
- Drone mounted (DJI M200)
- Blue is an expansion kit that provides 5 extra bands
- **Multispectral** – 10 bands
  - 444, 475, 531, 560, 650,
    668, 705, 717, 740, 842nm





DJI P4 Multispectral (Arvalis)

- RTK drone
- **Multispectral** – 5 bands + RGB
  - 450, 560, 650, 730, 840nm



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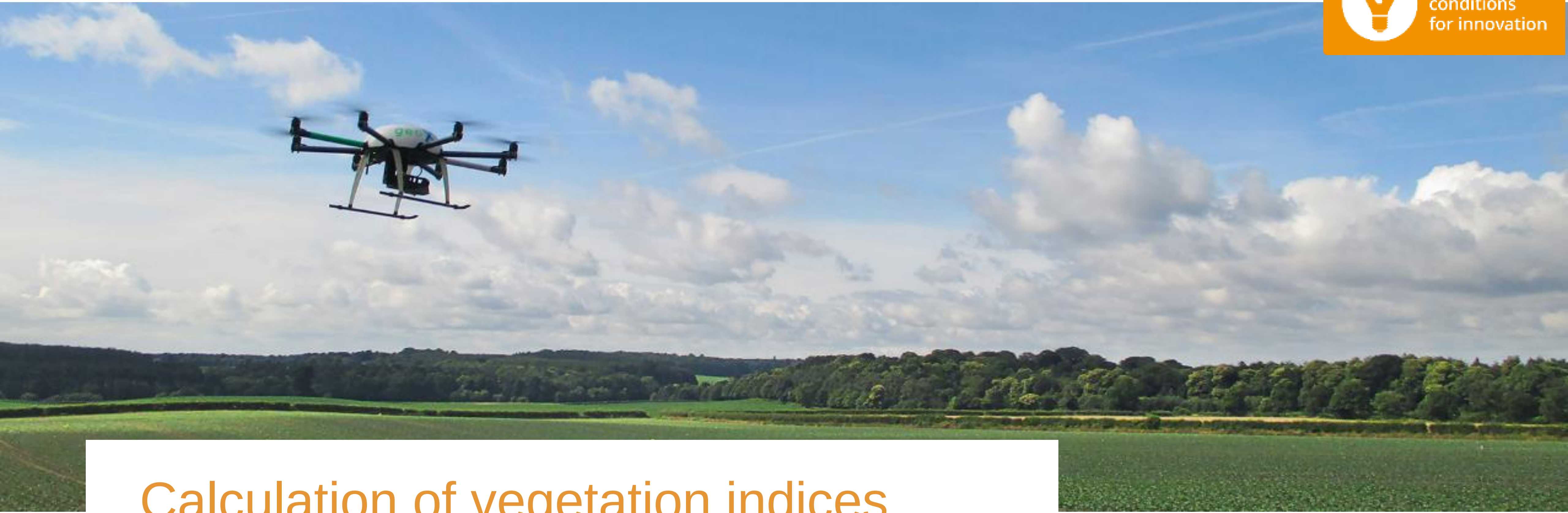

Calculation of vegetation indices

Hans Moggre, Delphy

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Introduction

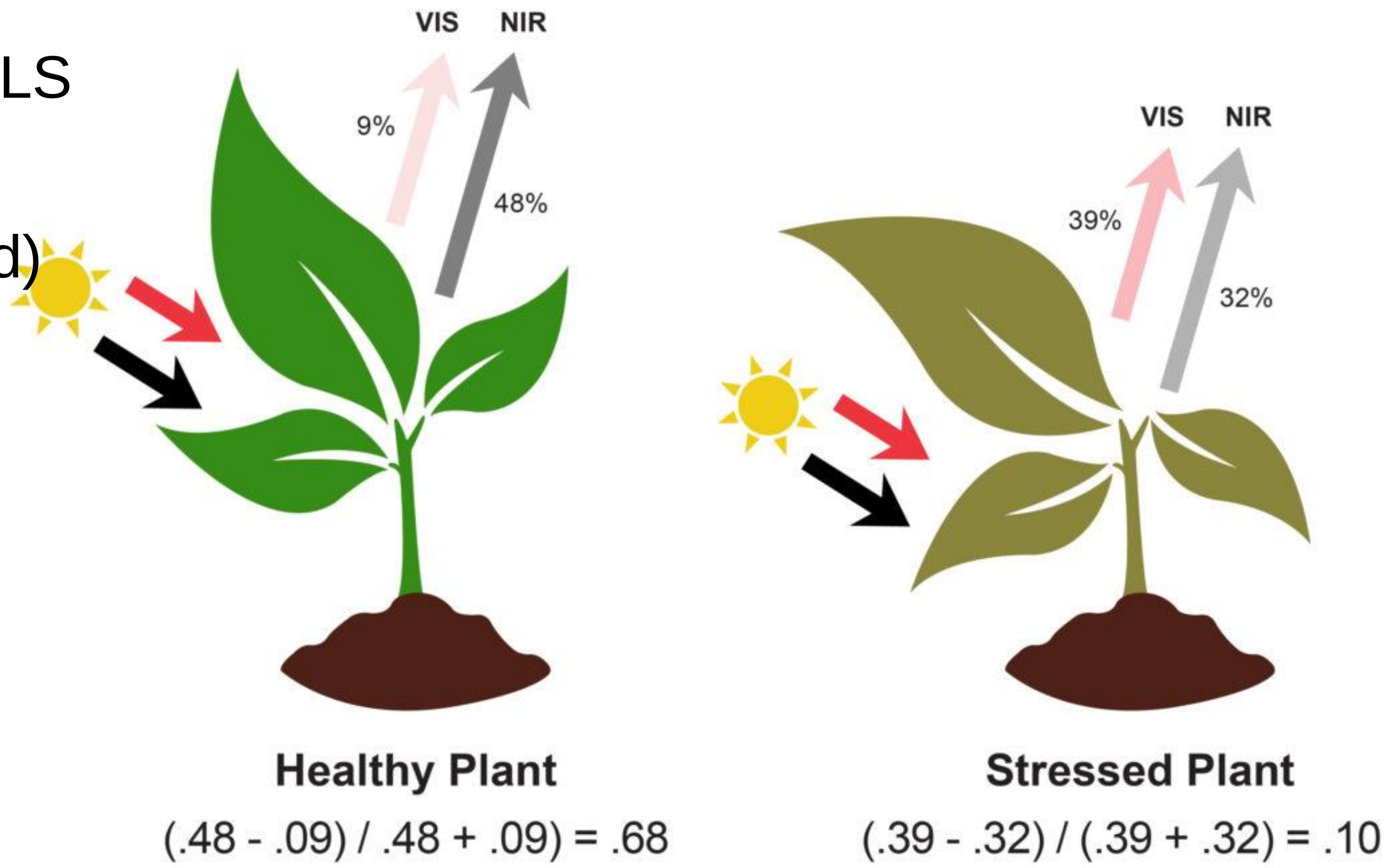
- Hans Moggré
- Consultant in Arable Farming for Delphy
- South West of the Netherlands
- Specialisation in Precision Farming

What do we measure with the sensors?

- Incoming light from sun or ALS

- Visual Light (blue, green, red)
- Near Infrared

- Reflection
- Absorpition
- Transmitting



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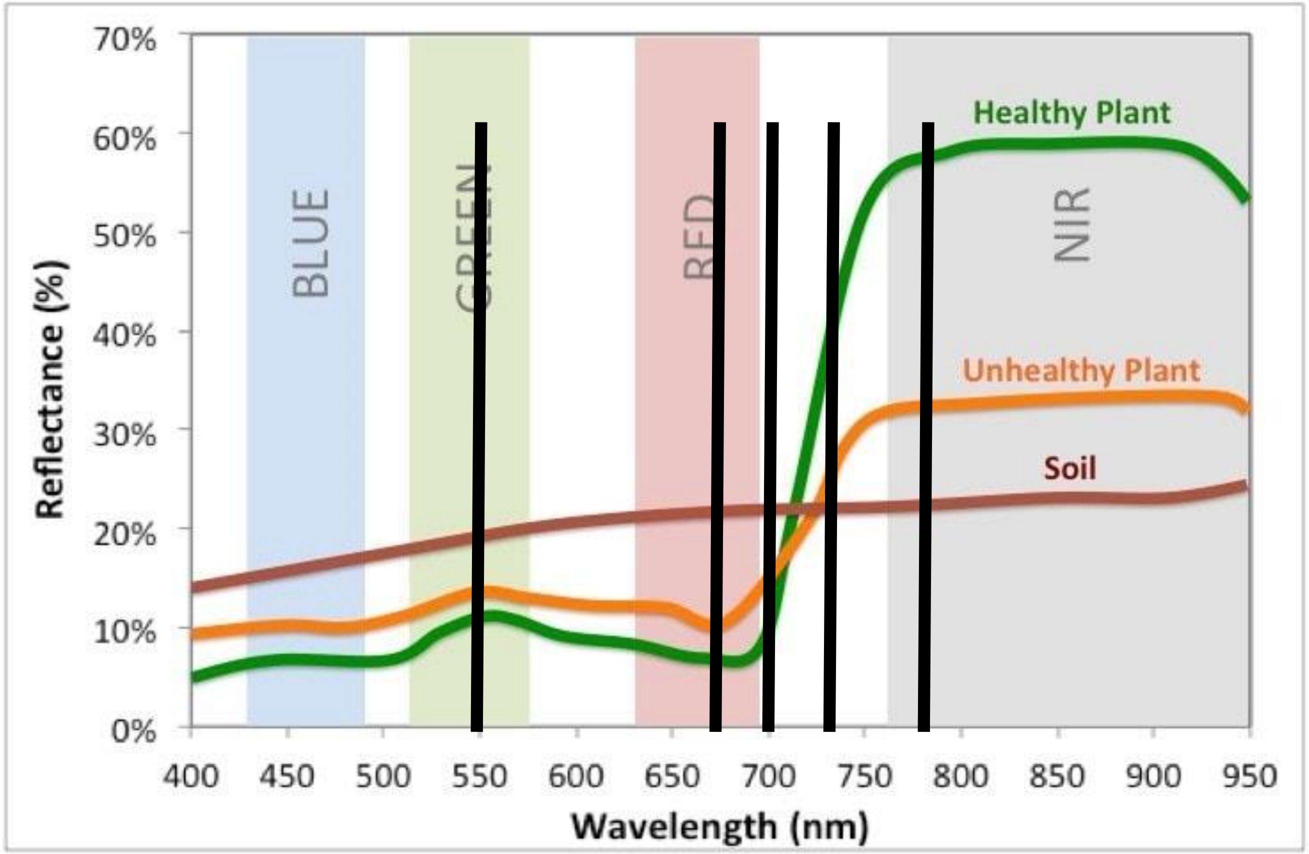
Vegetation Indices (VI)

- VI is a single number using the reflectance at two or more bands.
- Many different VI

Name	Centre wavelength nm
Green	550
Red	670
Red-edge	700
	730
NIR	780



Vegetation Indices in INNO-VEG

▪ NDVI	Normalised Difference Vegetation Index
▪ MCARI2	Modified Chlorophyll Absorption Ratio Index 2
▪ CI Green	Chlorophyll Index Green
▪ CI Red-Edge	Chlorophyll Index Red-Edge
▪ NDRE	Normalised Difference Red-Edge
▪ REIP	Red-Edge Inflection Point

- MTCI MERIS Terrestrial Chlorophyll Index

NDVI - Normalised Difference Vegetation Index

Advantage:

- Very standard index
- Most used in the World
- Robust index
- Less sensitive to different sensors

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

Disadvantage:

- Saturation at a high biomass (LAI)

REIP and NDRE

Advantage:

- Less sensitive for saturation
- Sensitive for amount of Chlorophyll
- Can say something about N-uptake and N-content

$$REIP = 700 + 40\frac{\left[\frac{(670nm + 780nm)}{2}\right] - 700nm}{740nm - 700nm}$$

Disadvantage:

- Sensitive for sensor specification

$$NDRE = \frac{790 - 720}{790 + 720}$$

MTCI

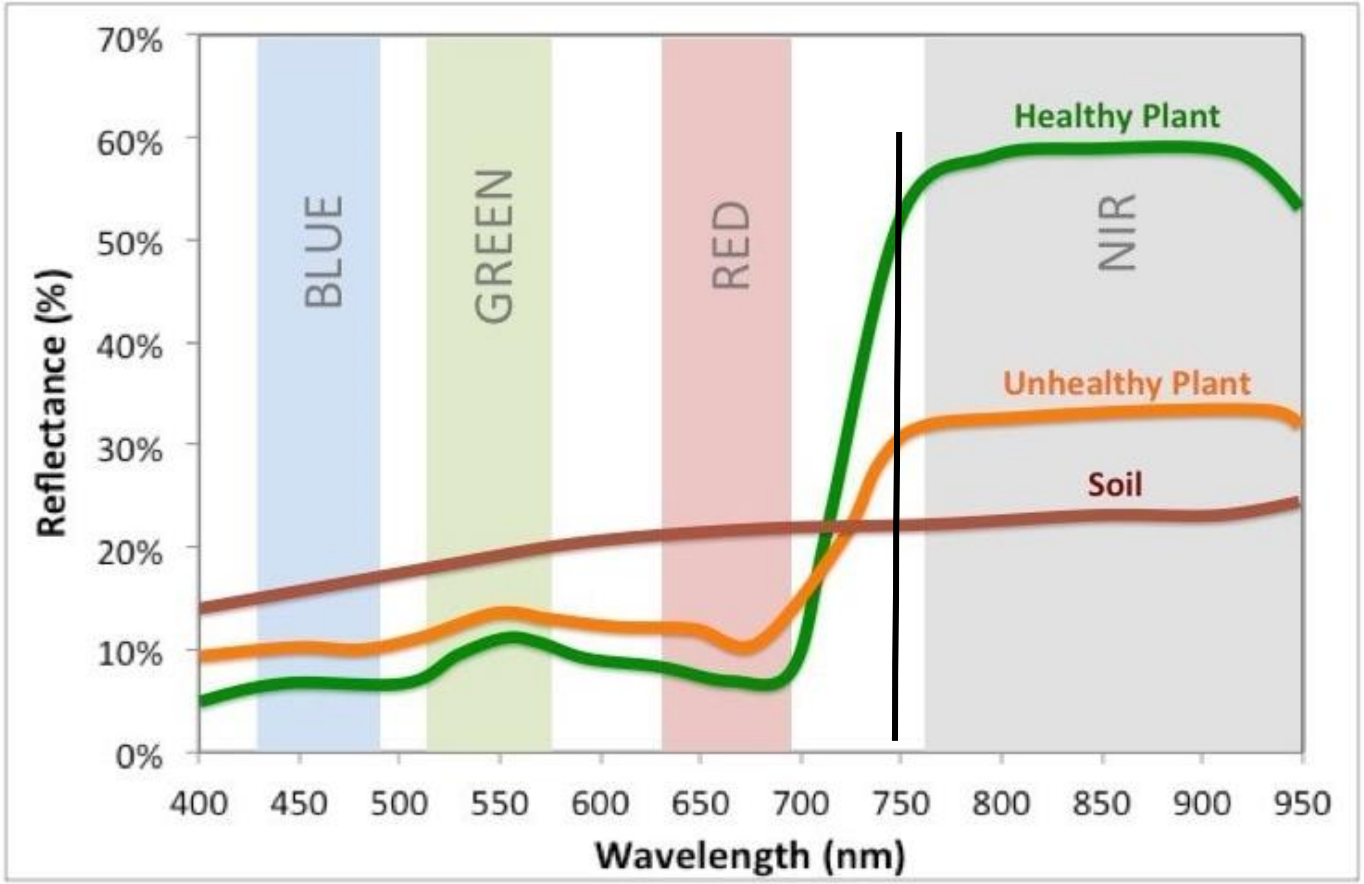
$$MTCI = \frac{753\,nm - 708\,nm}{708nm - 681\,nm}$$

Advantage:

- Can say something about N-uptake and N-content

Disadvantage:

- Sensitive to sensor specifications



CI Green

Advantage:

- More linearly correlated to N content

$$CI\ Green = \frac{NIR}{Green} - 1$$

Disadvantage:

- Sensitive for trial location (soil colour)

CI Red-Edge

Advantage:

- Simplicity
- Indicator of total chlorophyll in the canopy

$$CI\ red\text{-}edge = \frac{NIR}{rededge} - 1$$

Disadvantage:

- Sensitive for trial location (soil colour)
- Sensitive for sensor specifications

MCARI2

Advantage:

- Less sensitive to different sensors
- Less sensitive to trial location (soil colour)
- Less saturated for high biomass

$$MCARI2 = 1.5(\frac{2.5 - (NIR - Red) - 1.3 * (NIR - Green)}{\sqrt{(2 * NIR + 1)^2 - (6 * NIR - 5\sqrt{Red}) - 0.5}}$$

Disadvantage:

- Sensitive to light intensity and calibrations

Summary

	NDVI	MTCI	MCARI2	REIP	NDRE	CI Green	CI Red-Edge
Measuring at one farm	X	X	X	X	X	X	X
• Leaf area	x					x	
• Chlorophyll content		x	x				x
• N content				x	x	x	
More farms, same sensor	X	X	!	X	X	!	!
• Leaf area	x						
• Chlorophyll content		x					
• N content				x	x		
More farms, different sensors	X	!	!	!	!	!	!

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Questions

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Comparability of vegetation indices calculated by different sensor types

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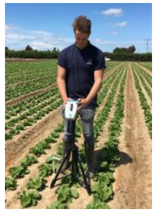
Presentation structure

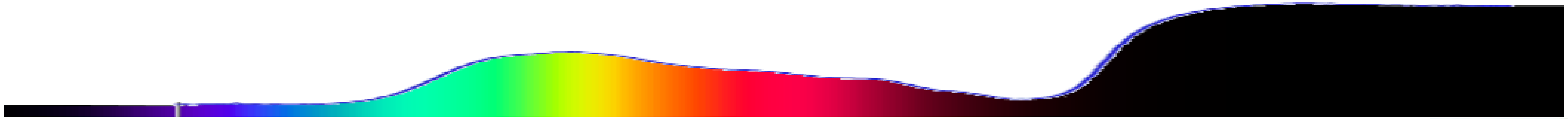
- The sensor simulator
- The principles of the comparisons
- The relative sensitivity of the VI to the sensor characteristics
- Risk of errors when mixing data from different sensors
- Conclusion : the compromise between the agronomic accuracy and the sensor robustness of a VI

The sensor simulator



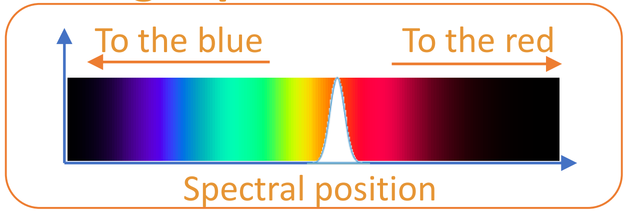
The principles of the sensor simulator :

A. Use of two hyperspectral datasets acquired by two partners on 3 species (potato, carrots and vining peas)

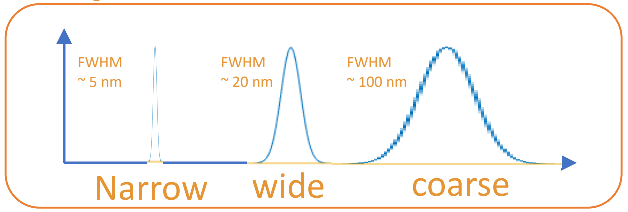


B. Used to simulate multispectral bands according to each sensor spec. defined by

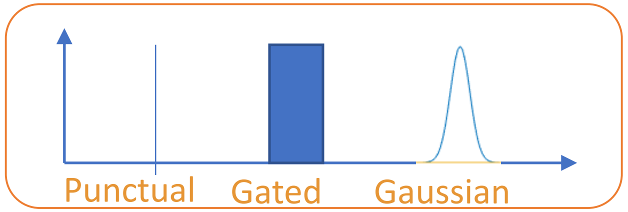
- Central wavelength position



- Width of the spectral band

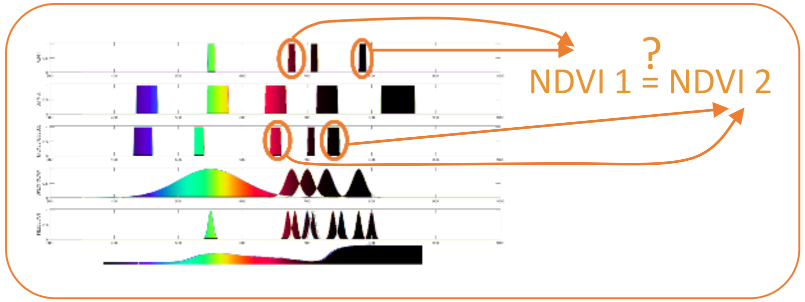


- Shape of spectral sensitivity



Virtual equivalents of the sensors

C. Compute simulated vegetation index as if acquired by different sensors



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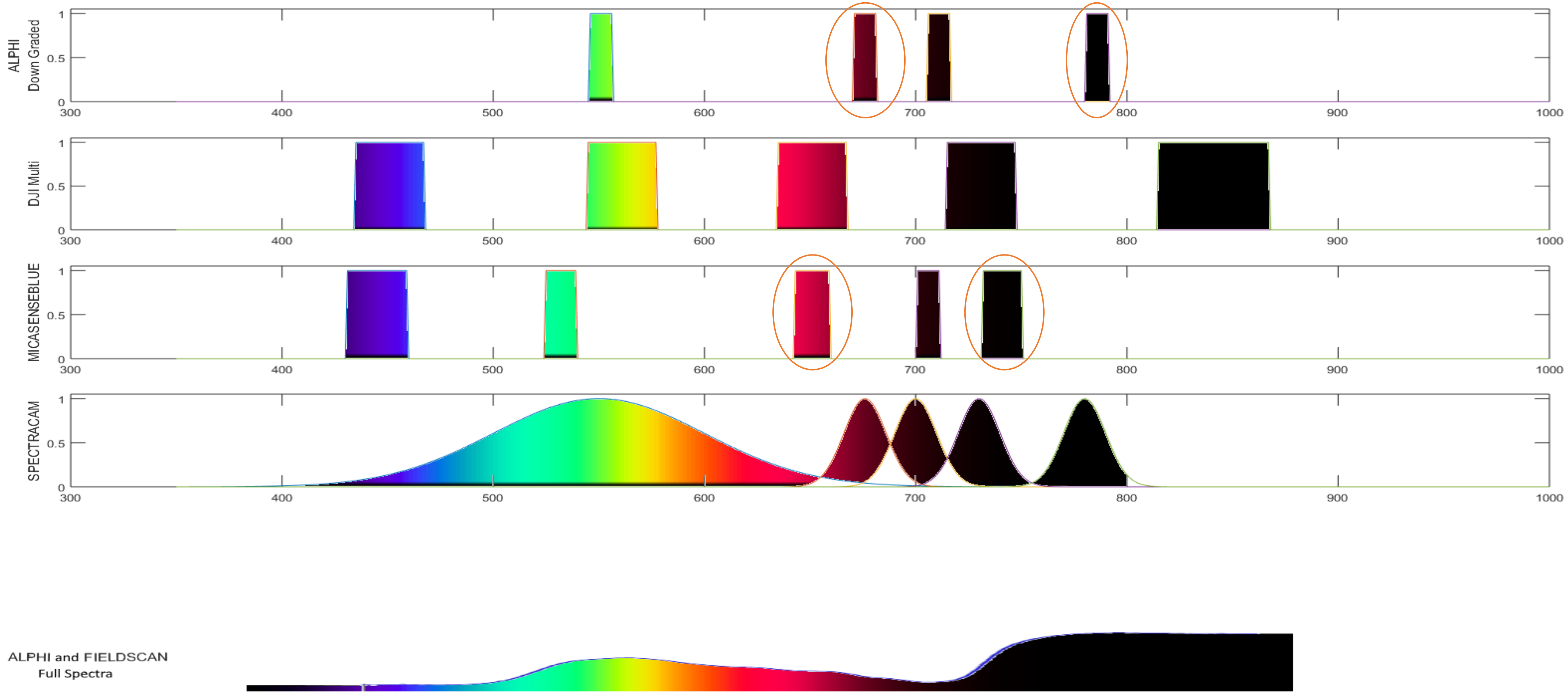
The sensor simulator

Optical sensors provide bands of specific spectral sensitivity …



… and Vegetation indices values are impacted by those specifications

The principle of comparisons

Measurements on trials

- Tools used : FieldSpec or ALPHI
- Sensor used : Spectroradiometer with full spectra reflectance
- Calculation of the references : Canonical VI (exact central wavelength, band width of 4 nm, gaussian filter)

Sensor simulator

- Creation of each virtual sensor
- Calculation of VI for each virtual sensor (with its own spec : central wavelength, band width, filtering method)

2 French trials on potato

2 UK trials on carrot

2 UK trials on vining pea

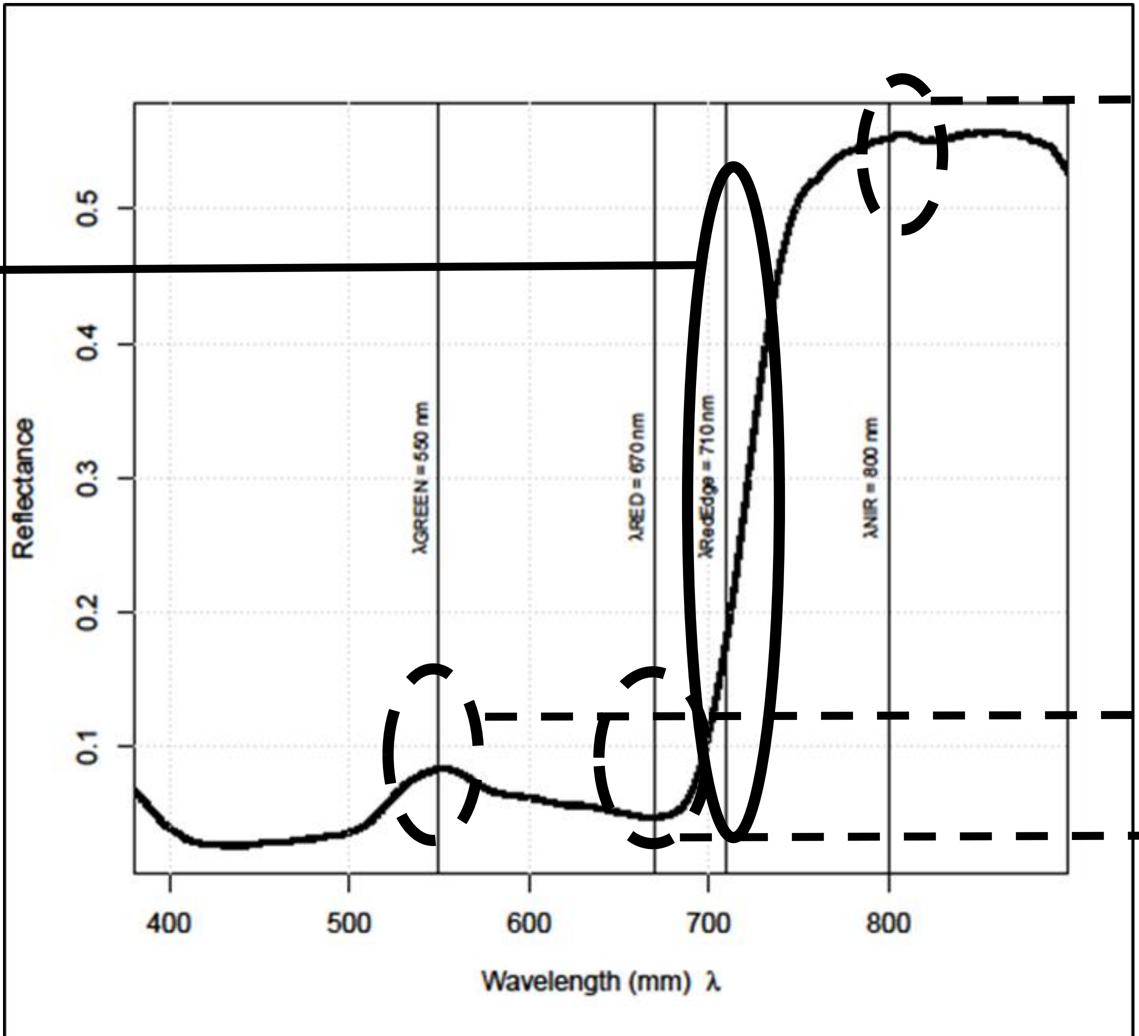
Statistical comparisons vs the references

- Basic Pearson correlations
- Relative standard error

The relative sensitivity of the VI to the sensor characteristics

The VI which use the Red-Edge band may be more sensitive to the sensor characteristics (central wavelength, band width…)

- MTCI
- CI-REDEDGE
- REIP
- …



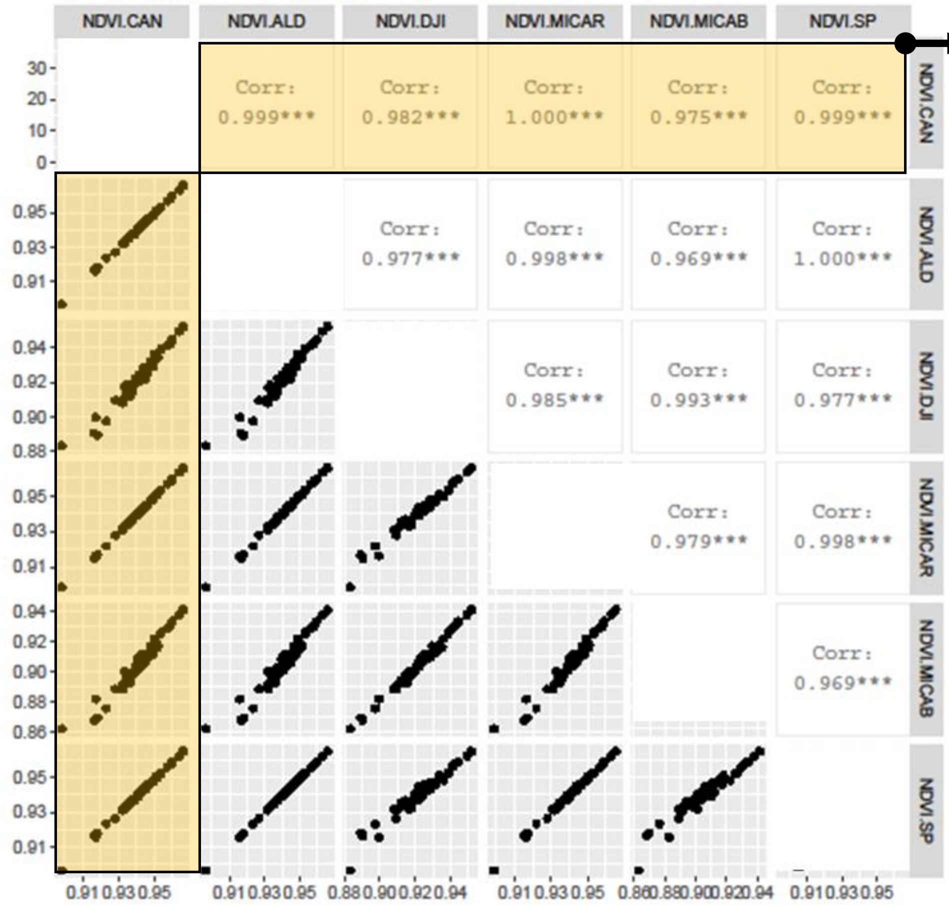
The drawned wavelengths are the canonical values choosen for the INNOVEG Project.
Spectra extracted from FR−PO−1 trial, date 08/07/19, plot 102, spectro 25

The VI which use only the green, red and NIR bands are likely to be less sensitive to the sensor characteristics (central wavelength, band width…)

- NDVI
- CI-GREEN
- MCARI2
- …

The relative sensitivity of the VI to the sensor characteristics

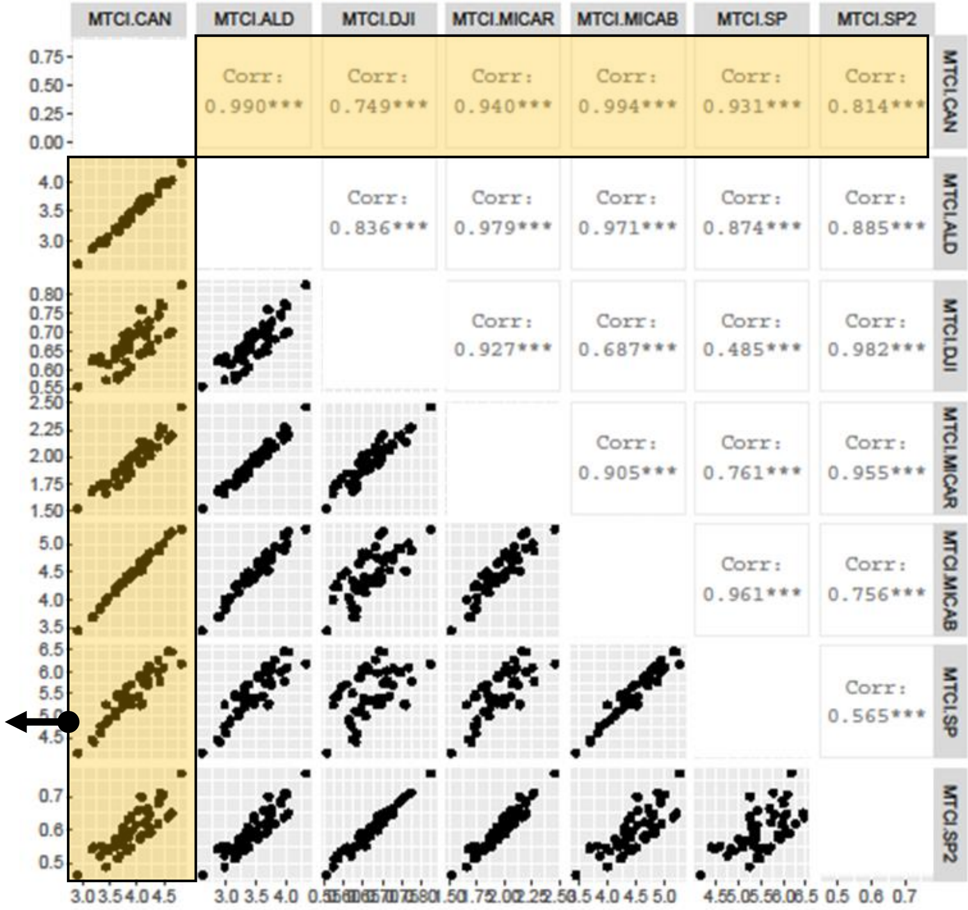
Example of NVDI correlations between sensors



Correlations are generally very high for a less sensitive VI like NDVI => no need to go deeper in the comparisons

Weaker correlations could be seen for a more sensitive VI like MTCI => need to go deeper by estimating the relative error compared to the reference

Example of MTCI correlations between sensors



Source : Trial UK-CA-2

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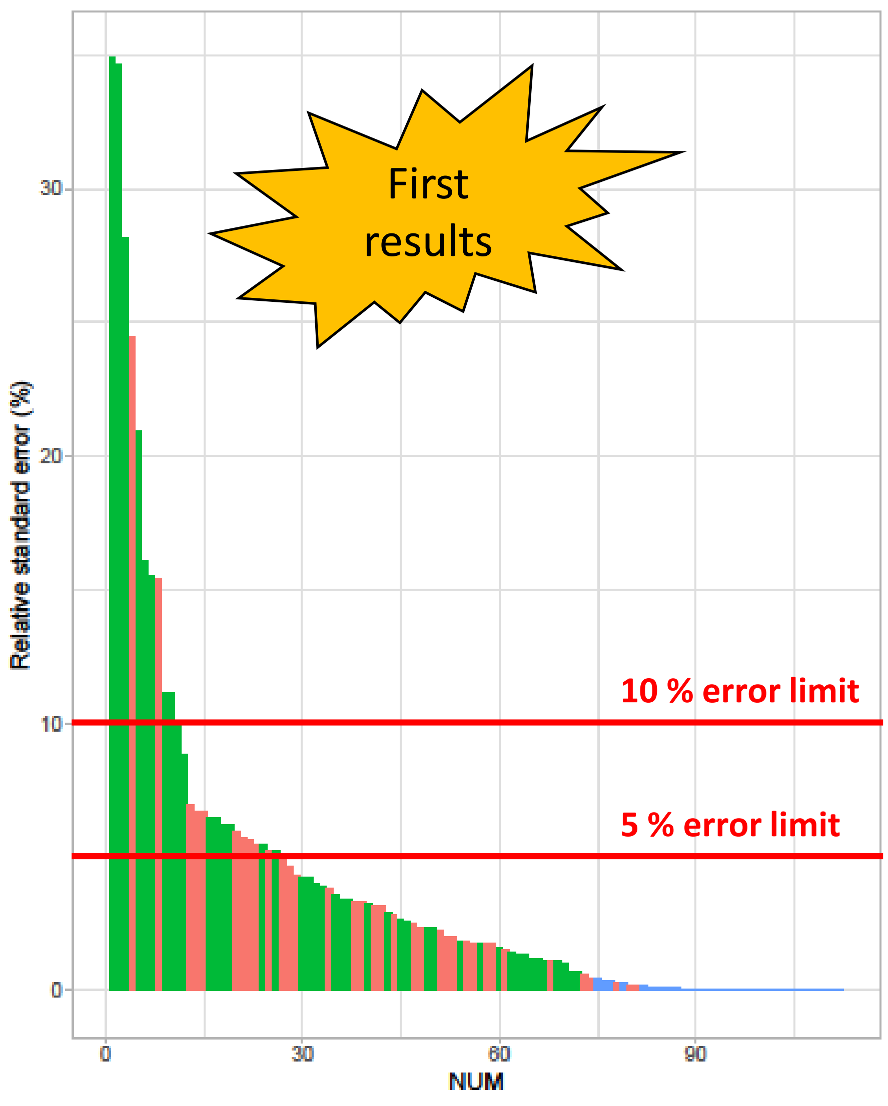
Risk of errors when mixing data from different sensors

- 112 comparisons vs the reference have been made
- 9 % of the situations are above the 10 % error limit
- 23 % of the situations are above the 5 % error limit
- MTCI seems to be the most sensitive VI to the sensor specificities
- Some work need to be done to go deeper in the interpretation of some very high error risk
- The impact of the error must also be considered regarding the agronomic interpretation of the VI



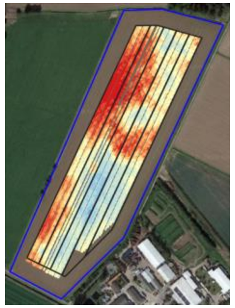
Source : all data from 6 2019 trials (2 on potato, 2 on carrot and 2 on vining pea)

Conclusion : the compromise between the agronomic accuracy and the sensor robustness of a VI

In some cases, a robust VI like NDVI will be enough to address the targeted trait

Example of a 2019 UK trial on vining pea

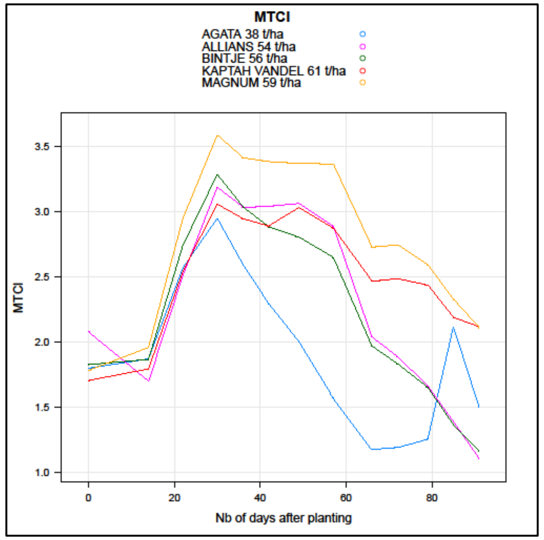
	1st flight (9 June)	2nd flight (25 June)
NDVI	84.6	67.7
MCARI2	82.3	75.1
Clgreen	83.5	69.3
Clrededge	84.2	68.9
MTCI	80.2	64.9
NDRE	85.8	67.8
REIP	84.3	60.1

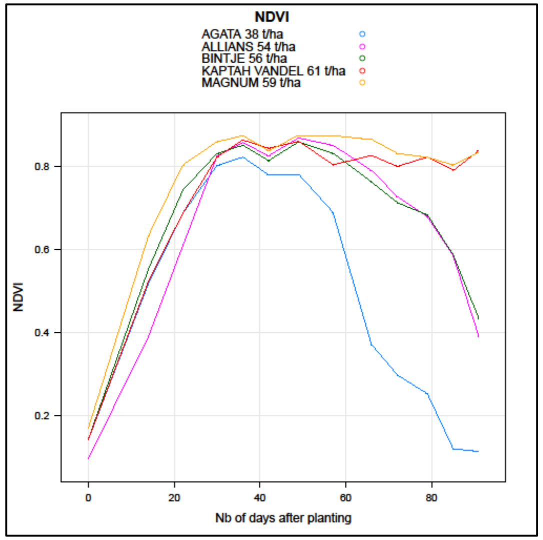


- All vegetation indices showed a high correlation with vining pea yield
- Correlations were greatest at full flower (9th June).

In some cases, we could need to use a more accurate VI to discriminate treatments, but more sensitive to the sensor specificities

Example of a 2019 FR trial on potato





Purpose of the project: finding the best sensor variables to assess the targeted traits (yield, N status…) considering their sensor robustness to be able to use them in large field trials network

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Conclusions

Lizzie Sagoo, ADAS

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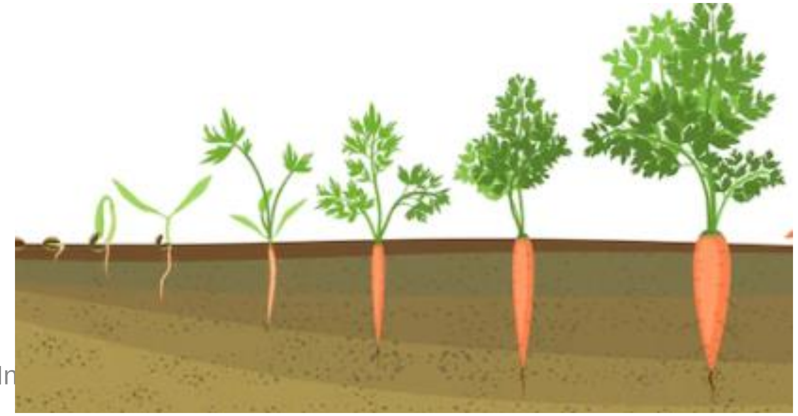
Conclusions

- Vegetation Indices can be used as an indicator of crop yields/performance
- Wide range of VIs available – look beyond just NDVI
- Timing (crop growth stage) of measurements is important
- INNO-VEG project will provide information on VI's and measurement timing from experimental work in 2019 and 2020



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Questions

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INNO-VEG Cross border innovation network

- Build links between the technology industry, research organizations & field veg/potato sectors
- Focus on realizing the value of crop sensing technology in the research process
- Join for free at www.inno-veg.org
- Members can add a profile to the Members Directory & add information on relevant services or projects

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Thanks for joining!

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