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SPAGHYTI

constellr Wallonie recherche CRA-W UCLouvain

Walloon Agricultural Research Centre

Assessing the nitrogen status and monitoring the (a)biotic stress levels of winter wheat using hyperspectral satellite imagery

L. Leclère

With the collaboration of
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EARSeL, Valencia, Spain - 16-18 April 2024

Walloon Agricultural Research Centre

CRA-W = **C**entre **W**allon de **R**echerches **A**gronomiques

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The CRA-W provides together **scientific research**, **service** and **support** functions to Walloon farmers, stockbreeders, horticulturists, forestry producers and operators in the agri-food sector.

4 main research domains :

Precision farming   Precision livestock farming   Risk management   Understanding products

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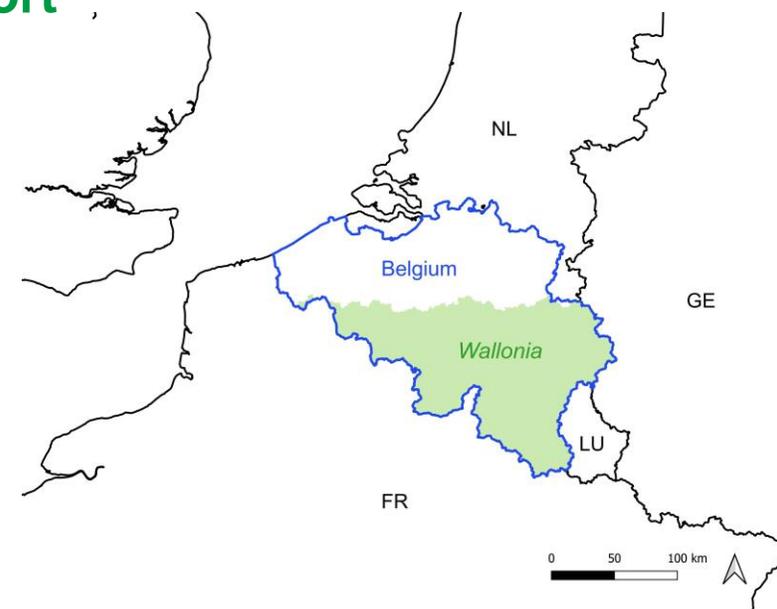
Context

Agriculture

Evolution of **agricultural practices** is needed to mitigate their **negative environmental impacts** and to ensure their **resilience**, while maintaining acceptable **levels of productivity**

Digital agriculture

Promising approach that brings together a wide range of **modern technological tools**

Hyperspectral imaging

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The SPAGHYTI project

SPAGHYTI

Space for **Ag**riculture with **Hy**perspectral **T**eledetection & **I**nnovation

The SPAGHYTI project aims to assess the **relevance of hyperspectral satellite imagery** in the field of **agriculture**

- High value information (hyperspectral satellite imagery)
- Global coverage
- Parcel level applications
- Frequent revisits
- Reduced operational costs

CRA-W contributes to the 'user' segment of the SPAGHYTI project by developing applications for agriculture (farmers, agri-food industry …)
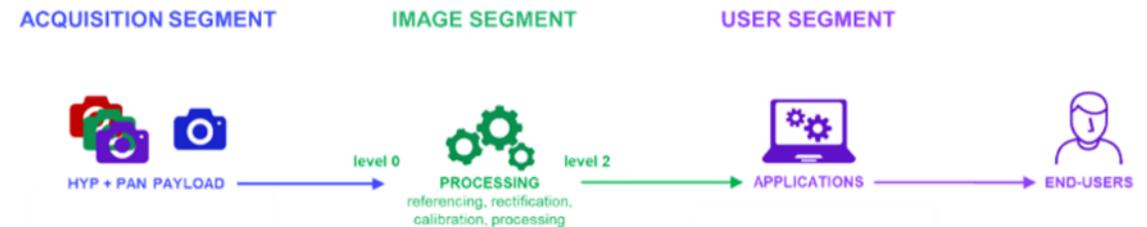
ACQUISITION SEGMENT   IMAGE SEGMENT   USER SEGMENT

HYP + PAN PAYLOAD   level 0   PROCESSING referencing, rectification, calibration, processing   level 2   APPLICATIONS   END-USERS

Skywin   wagralim   Wallonie recherche SPW   constellr   UCLouvain   EARTH & LIFE INSTITUTE   Wallonie recherche CRA-W   DELTATEC   MOS ADVANCED MECHANICAL & OPTICAL SYSTEMS

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The SPAGHYTI project

Target crop

Winter wheat

2 applications

- Nitrogen status assessment

- (A)biotic stress monitoring

Yellow rust

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Field campaign
Location

From April to July 2023

Legend :
- Field campaign location
- Wallonia
- Belgium

0 25 50 km

Legend :
- Field trials
- Farmers' fields

RGB ortho-image 2020

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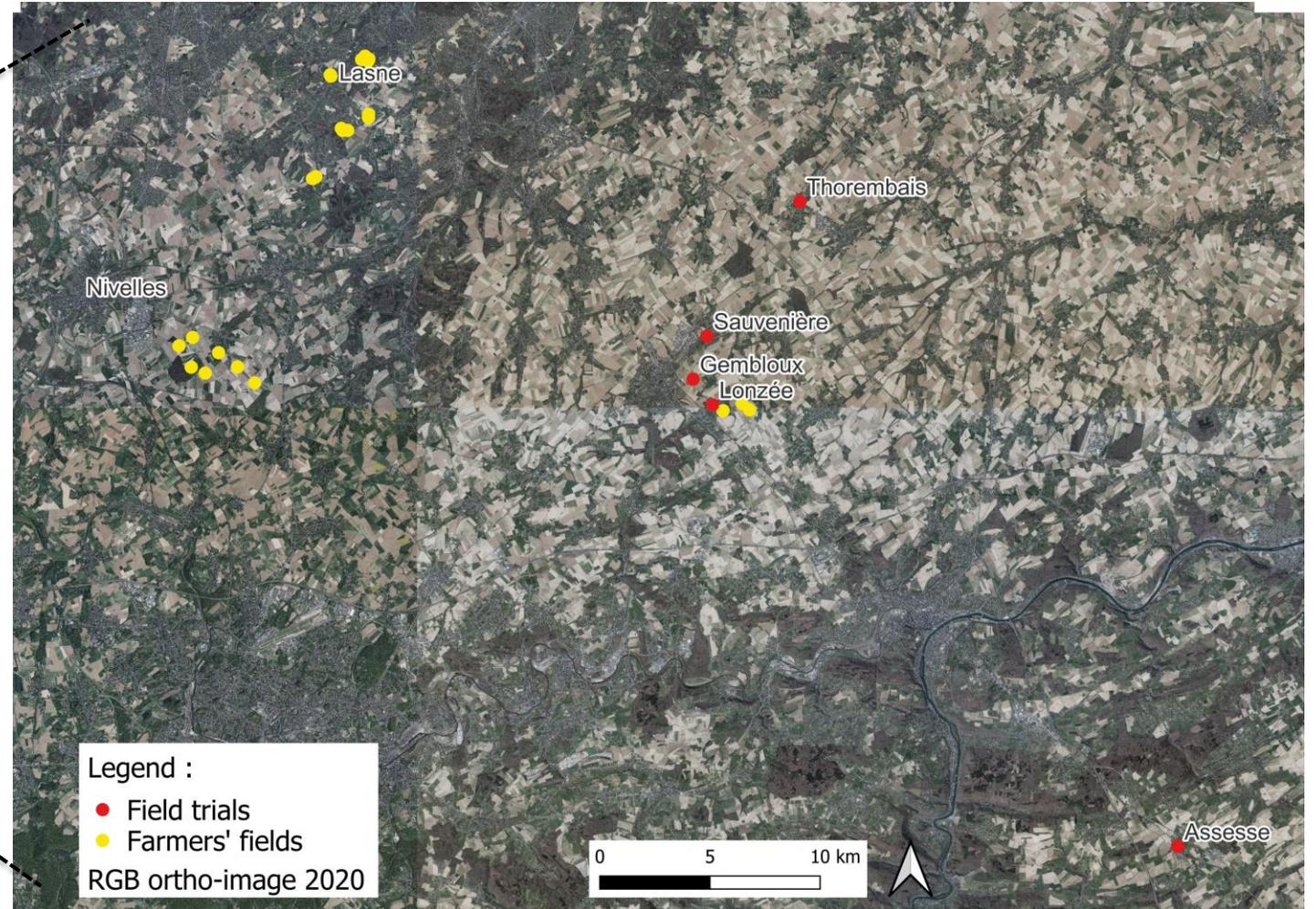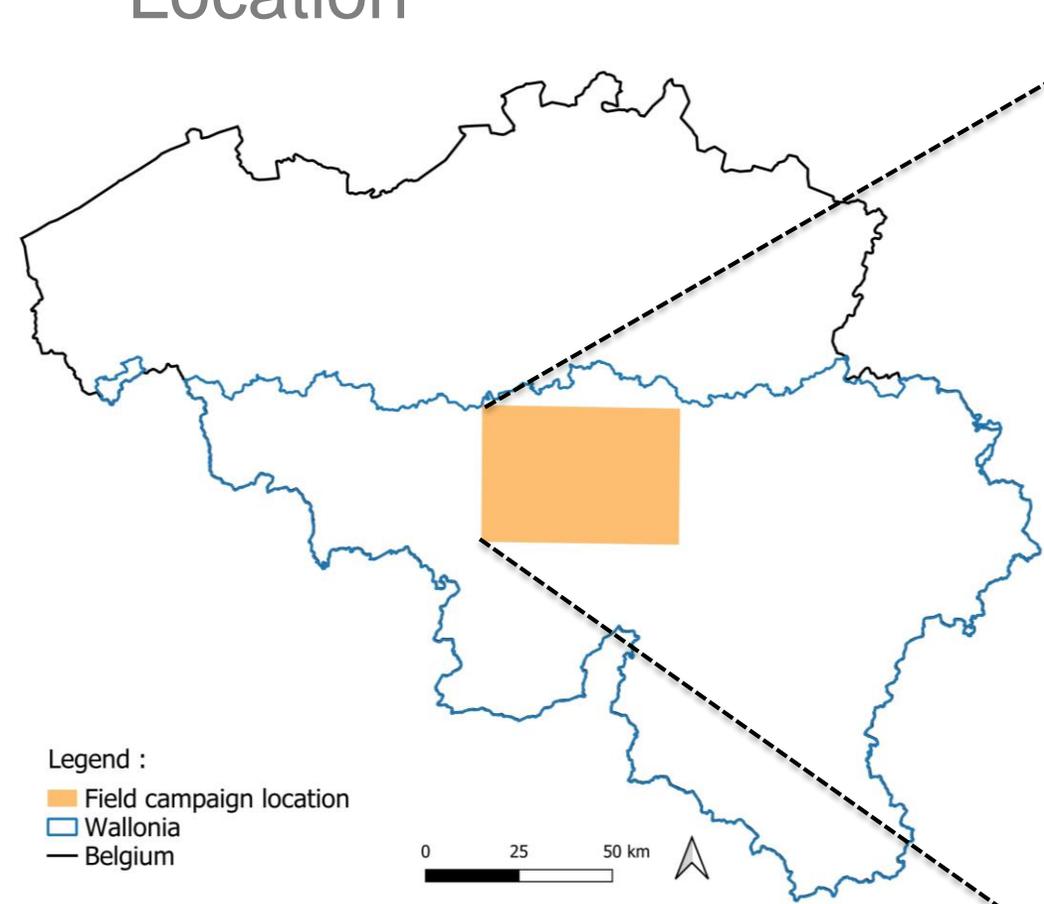
Field campaign
Field trials

Small plots
(8m x 2.05m)

- 2 fertilization trials (CePiCOP)
  - 30 [N] x 1 variety
  - 6 [N] x 5 varieties

- 2 variety trials
  - Conventional management x 8 varieties
  - Organic management x 8 varieties

- 6 fungicide trials
  - Yellow rust, Septoria, Brown rust, Fusarium, Bunt

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Field campaign

Farmers' fields

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Field campaign

Ground-based measurements

- Disease severity scorings ; BBCH stage identification

- Reflectance data ; ASD FieldSpec 4 (350-2500 nm)

- Digital hemispherical pictures ; Canopy cover and LAI
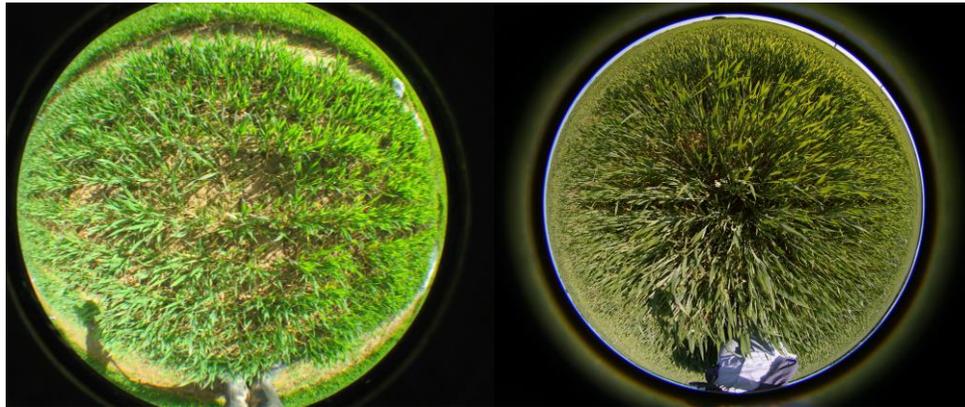
Digital hemispherical pictures collected on trial plots

Reflectance data acquired using the ASD FieldSpec 4 equipped with the pistol grip

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Field campaign

Samples collection and laboratory measurements

Oven ; 2 days at 60°C

Dry matter

FOSS NIR XDS

Nitrogen content (N)

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Field campaign
Summary

Nitrogen status

    220 samples collected (04/04/2023 – 31/05/2023)

(A)biotic stress levels

    2953 observations (24/04/2023 – 16/07/2023)

Yellow rust

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Satellite images

Spatial resolution : 30 m
240 spectral bands:
    VIS/NIR : 400-1010 nm
    NIR/SWIR : 920-2505 nm
Spectral resolution : ≤ 12 nm
Revisit time : 7 to 14 days
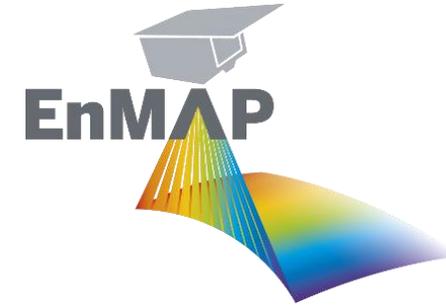
Spatial resolution : 30 m
244 spectral bands:
    VIS/NIR : 420-1000 nm
    NIR/SWIR : 900-2450 nm
Spectral resolution : ≤ 10 nm
Revisit time : 4 to 27 days

… depending on weather conditions (cloud conditions)

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Applications development

Processing steps :

1. Identification of the most relevant wavelengths
2. Evaluation of existing spectral indices (identified in a literature review)
3. Identification of new spectral indices
4. Modelling

Data processing is still ongoing …

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Applications development - Assessing the nitrogen status

Field data
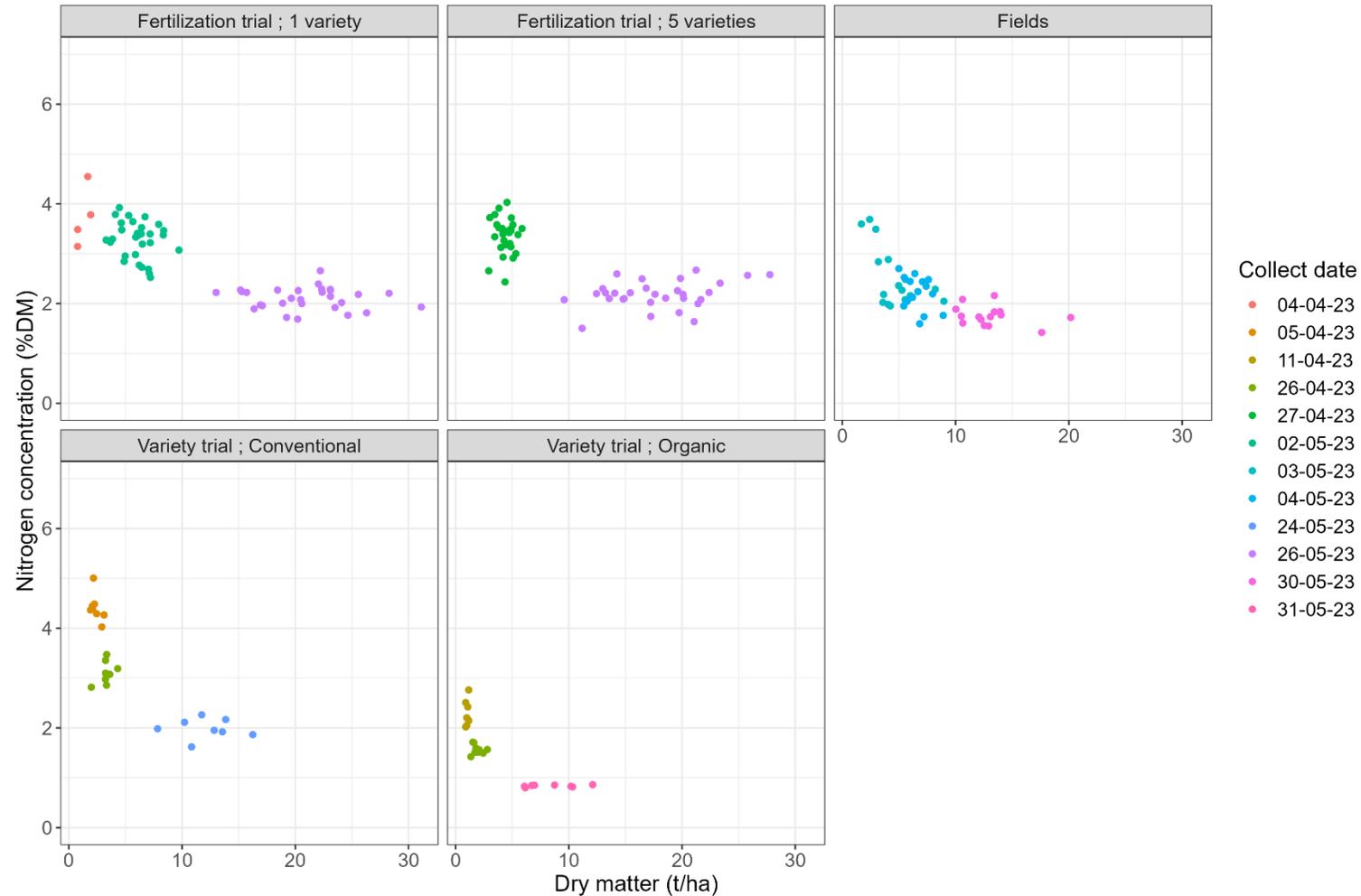
(Delloye et al. 2018)
(Carlier et al. 2023)

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Applications development - Assessing the nitrogen status

ASD spectra

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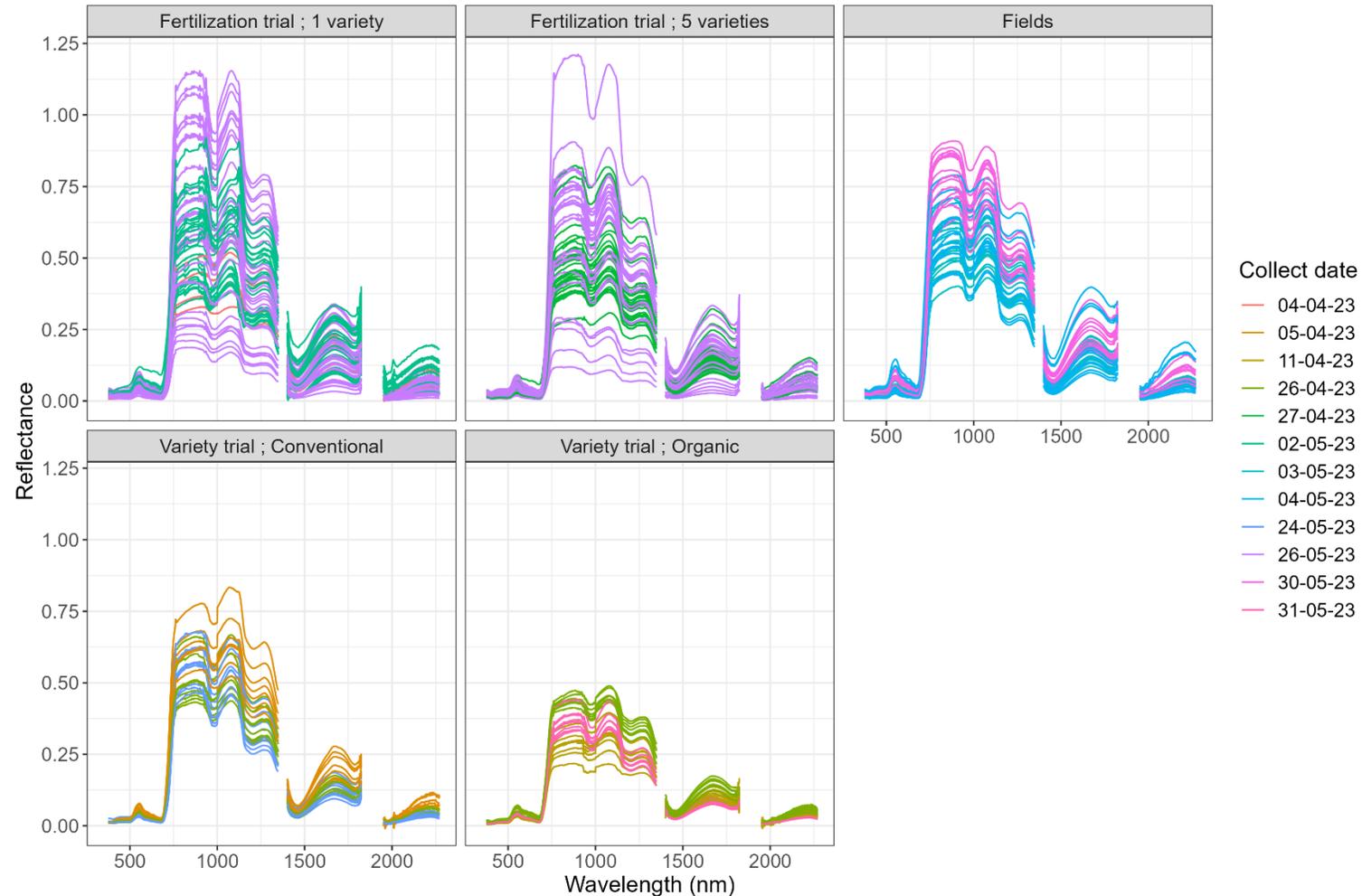
Applications development - Assessing the nitrogen status

ASD spectra - Most relevant wavelengths

Vertical bars = Proteins areas
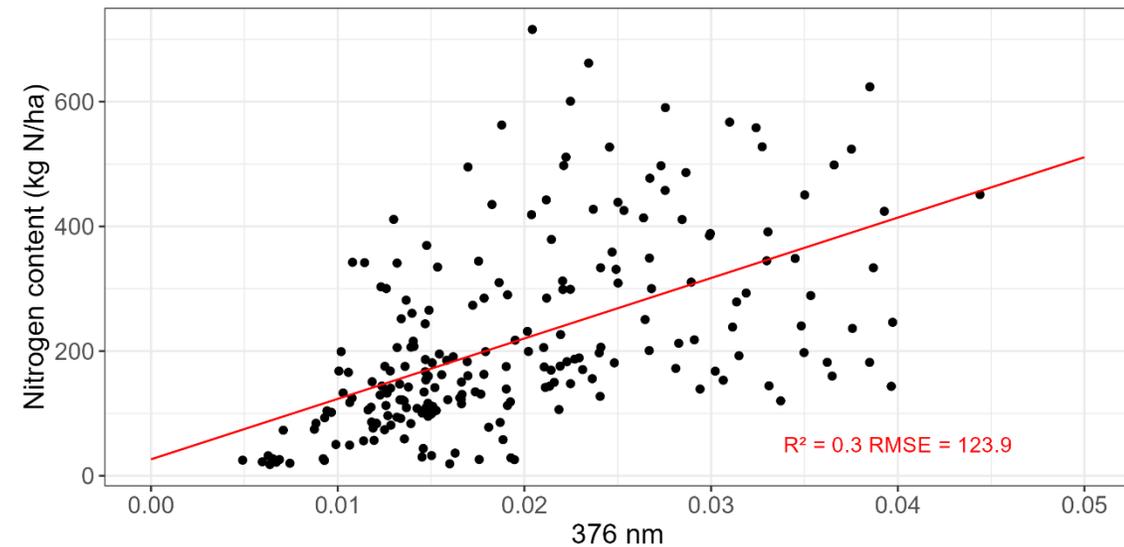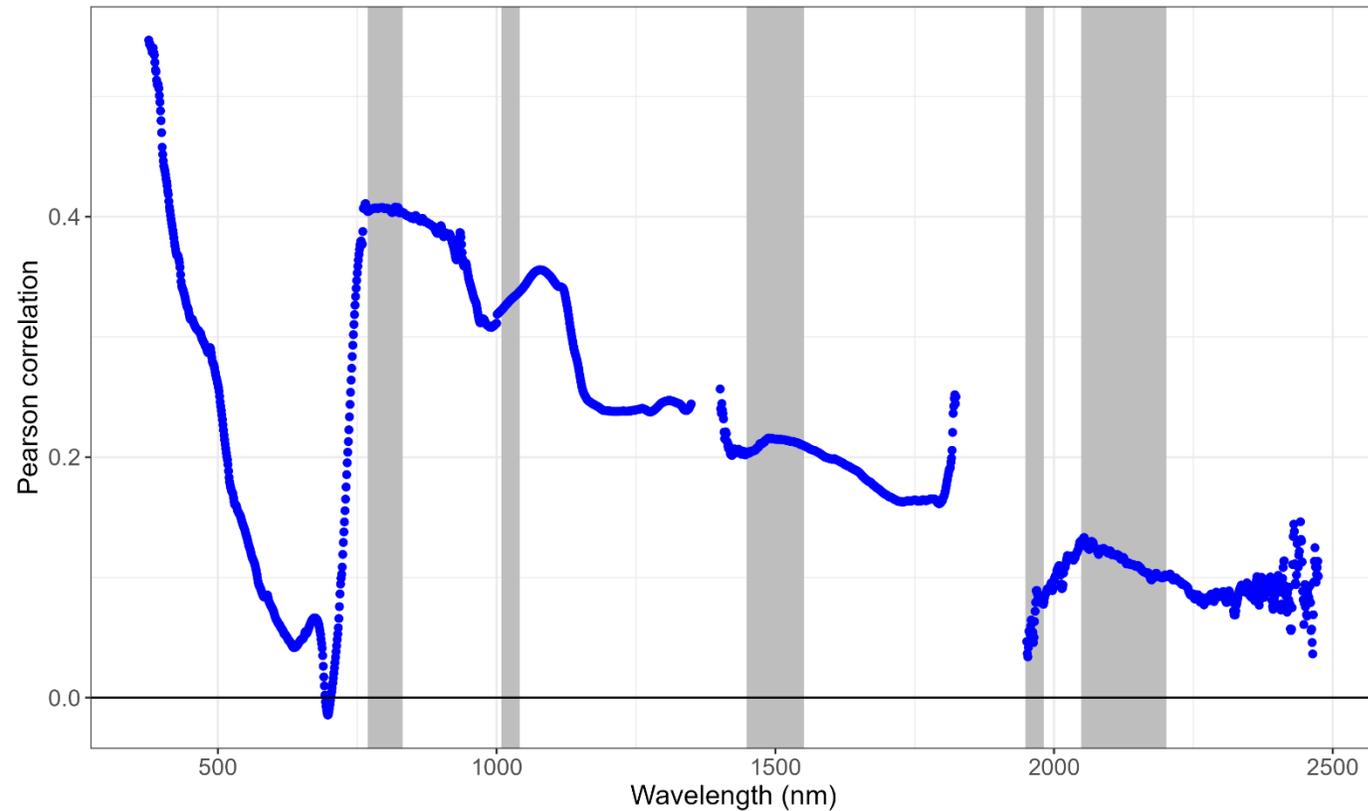
Applications development - Assessing the nitrogen status

ASD spectra - Existing spectral indices (literature review)
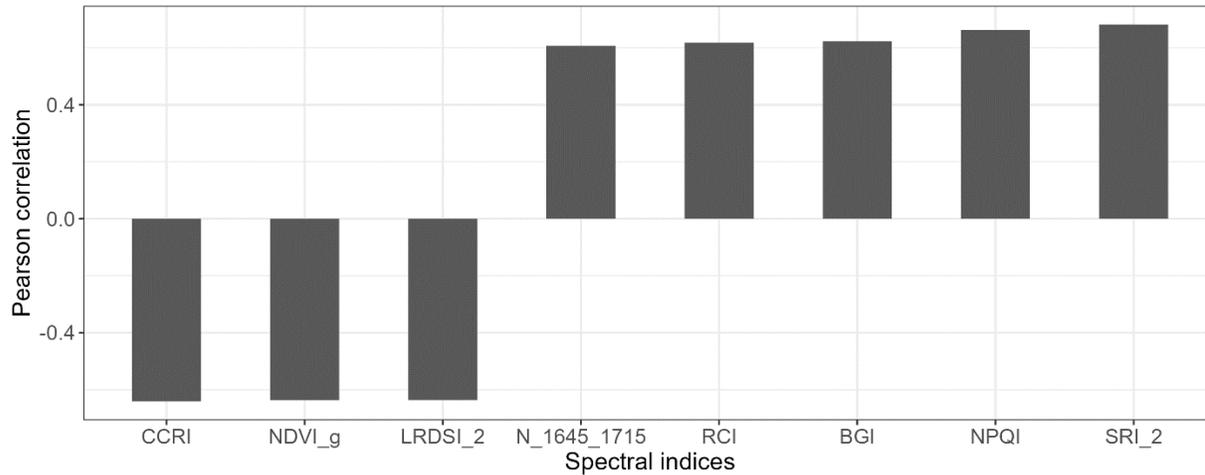
LRDSI_2 = 4.2 * (R695/R455) - 0.38
RCI = R440/R690
NDVI_g = (R573-R440)/(R573+R440)
CCRI = ((R720-R521)*R705)/((R750-R705)*R521)
SRI_2 = R515/R570
BGI = R460/R560
NPQI = (R415-R435)/(R415+R435)
N_1645_1715 = (R1645-R1715)/(R1645+R1715)
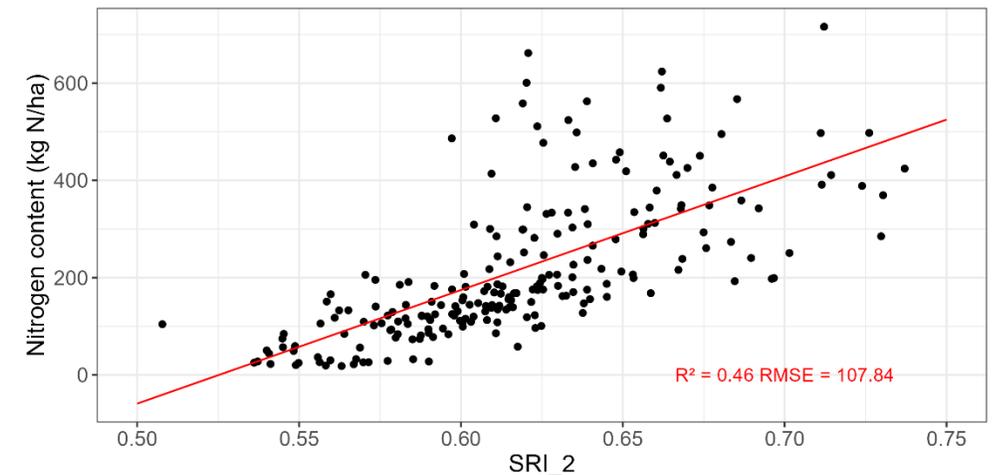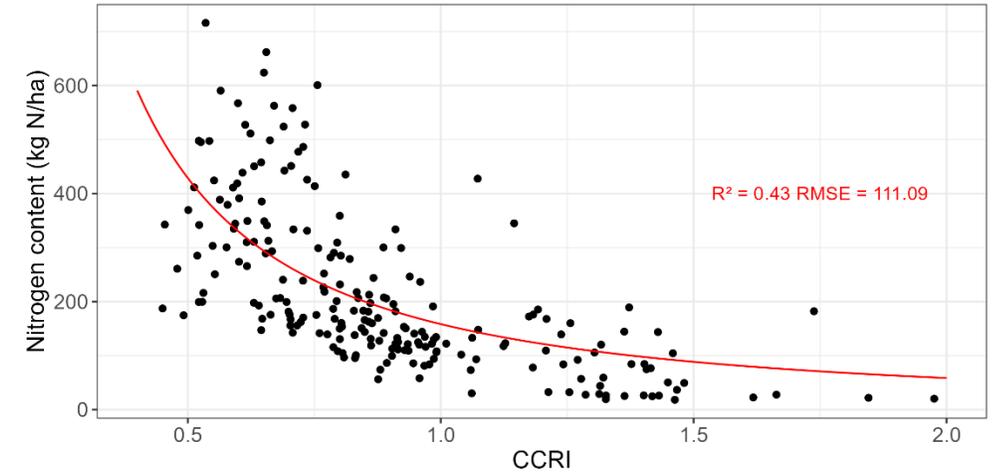
R² = 0.43 RMSE = 111.09

R² = 0.46 RMSE = 107.84

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Applications development - Assessing the nitrogen status

ASD spectra – New spectral indices

Form : (X1-X2)/(X1+X2)

Form : (X1-X2)/(X1+X2)   Hotspots

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Applications development - Assessing the nitrogen status

ASD spectra – New spectral indices

R²: 0.52 RMSE: 102.49 Bias: 0.00

R²: 0.52 RMSE: 102.36 Bias: 0.00

R²: 0.44 RMSE: 110.3 Bias: 0.00

R²: 0.35 RMSE: 118.72 Bias: 0.00

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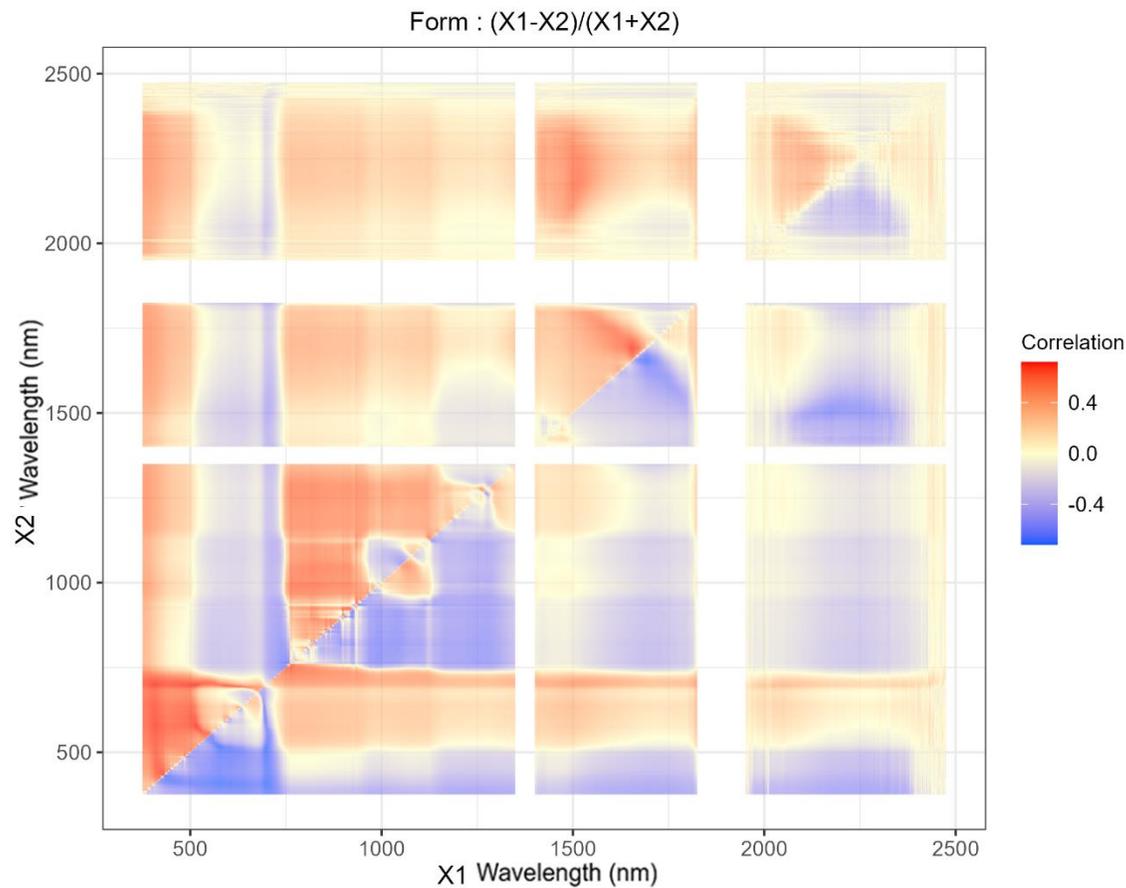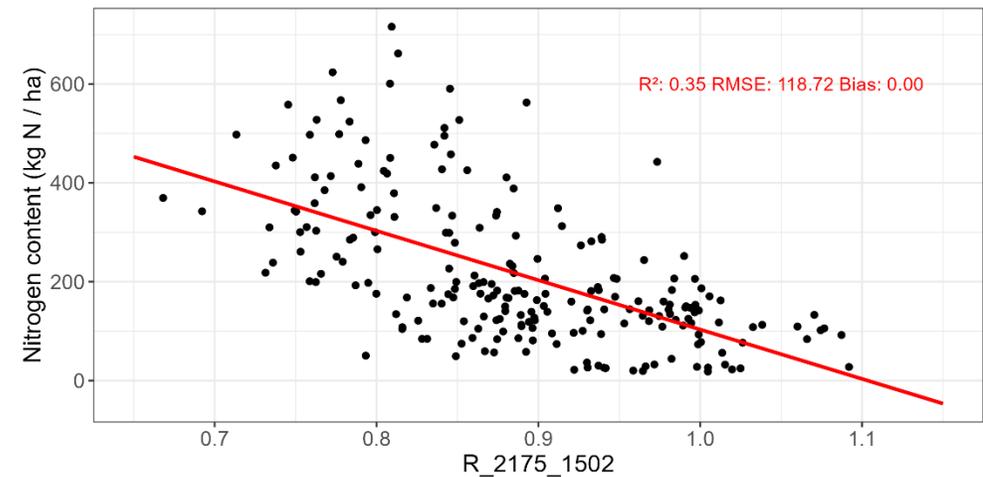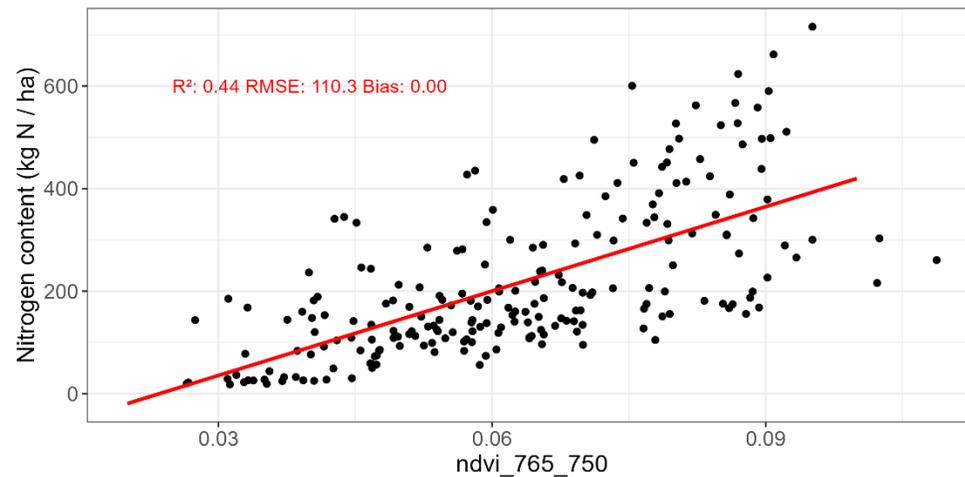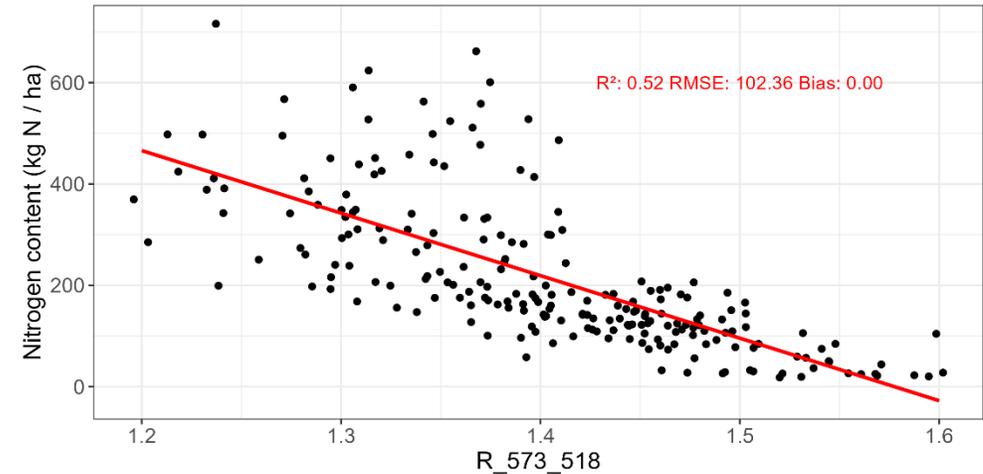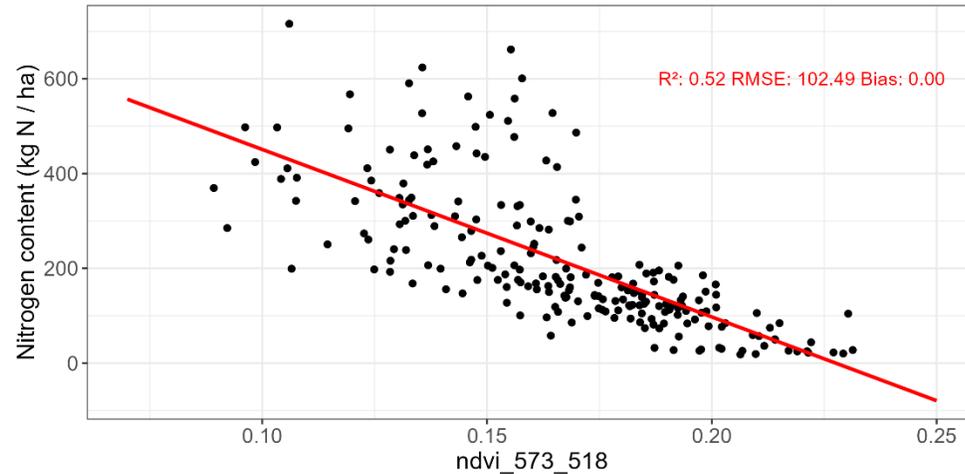
Applications development - Assessing the nitrogen status

ASD spectra – PLS-R modelling

**A**   Training dataset

B   Validation dataset

R²: 0.67 RMSE: 119.84 Bias: 0.00

R²: 0.59 RMSE: 96.92 Bias: -6.08

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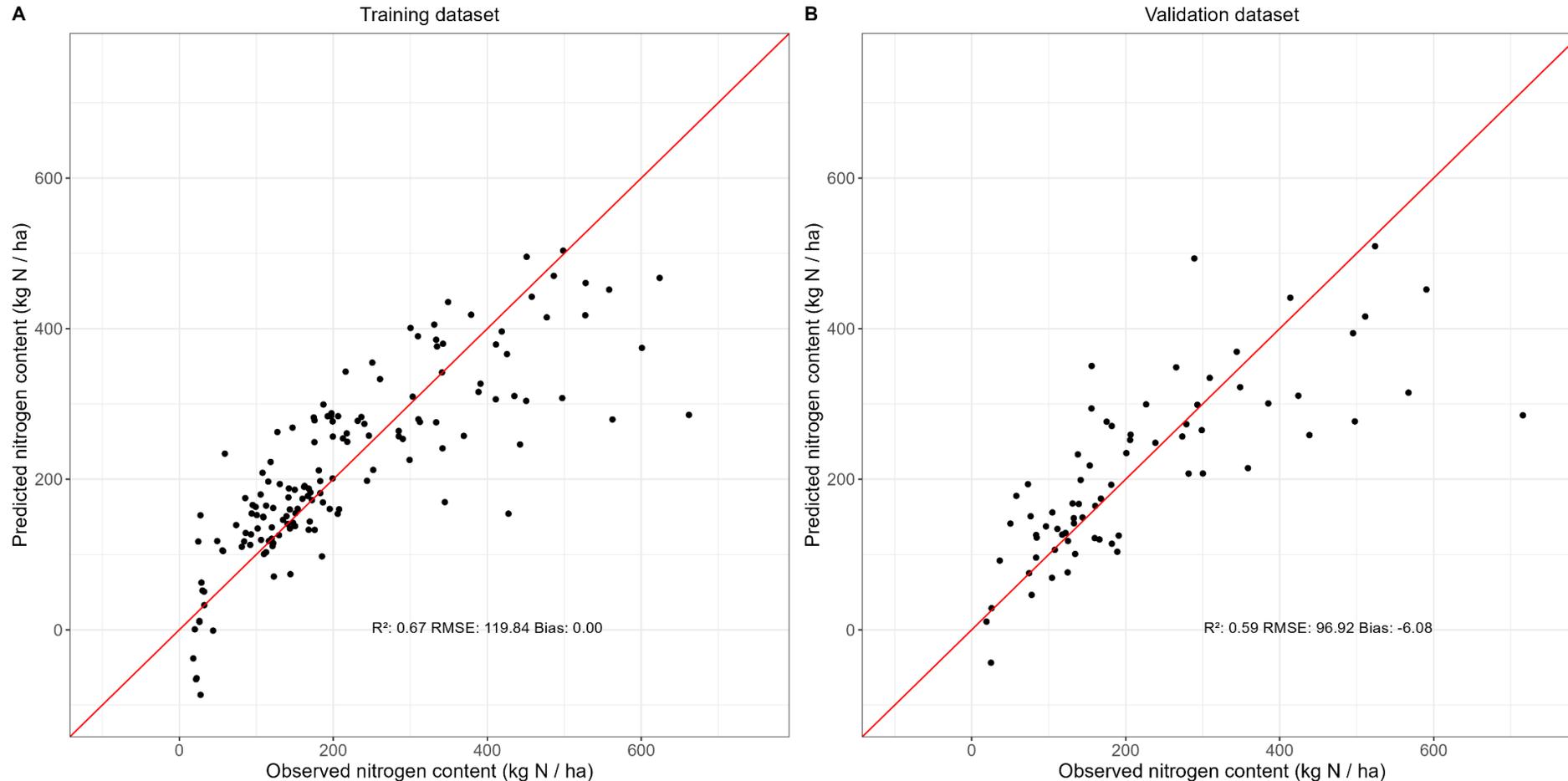
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Satellite imageries – Comparison with ASD spectra

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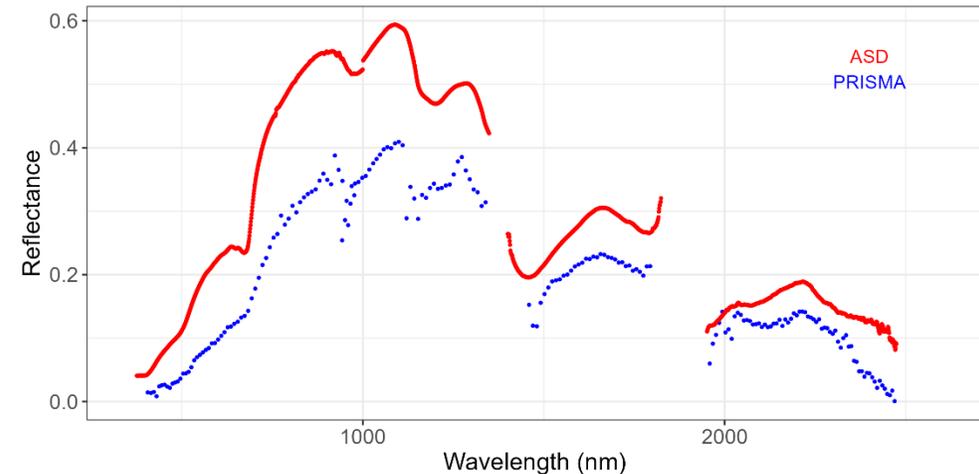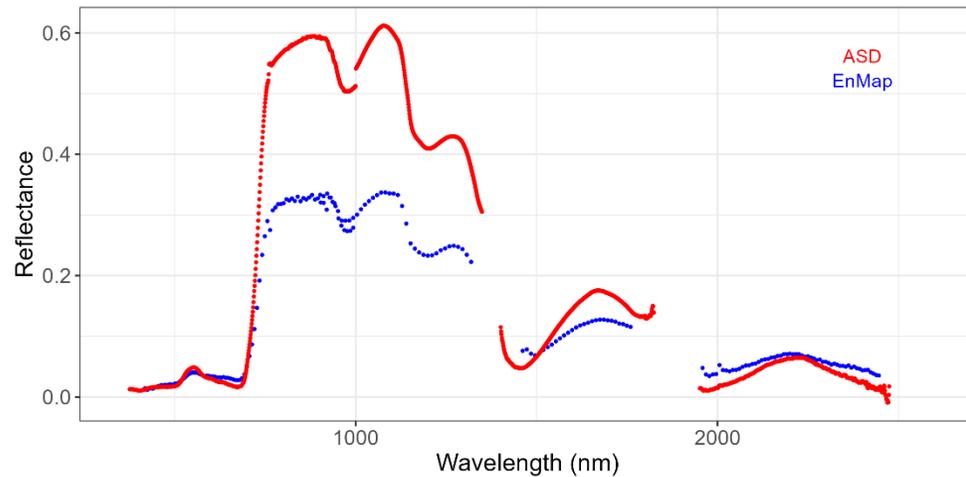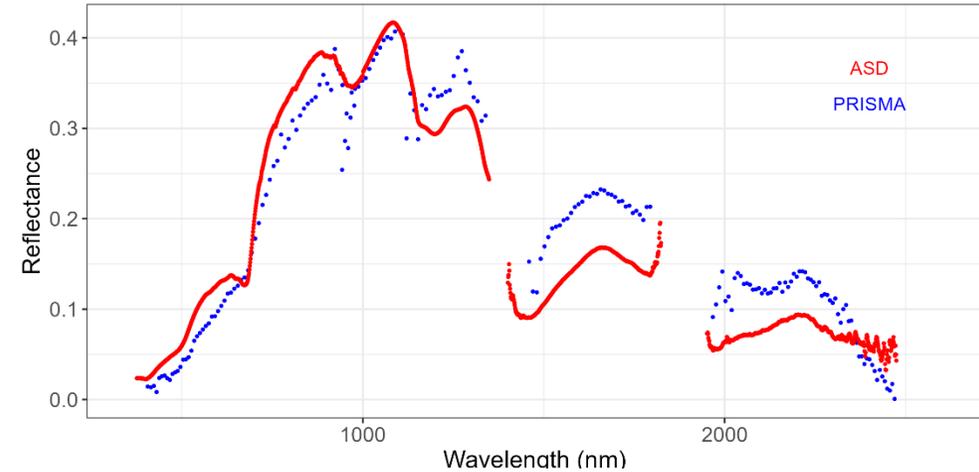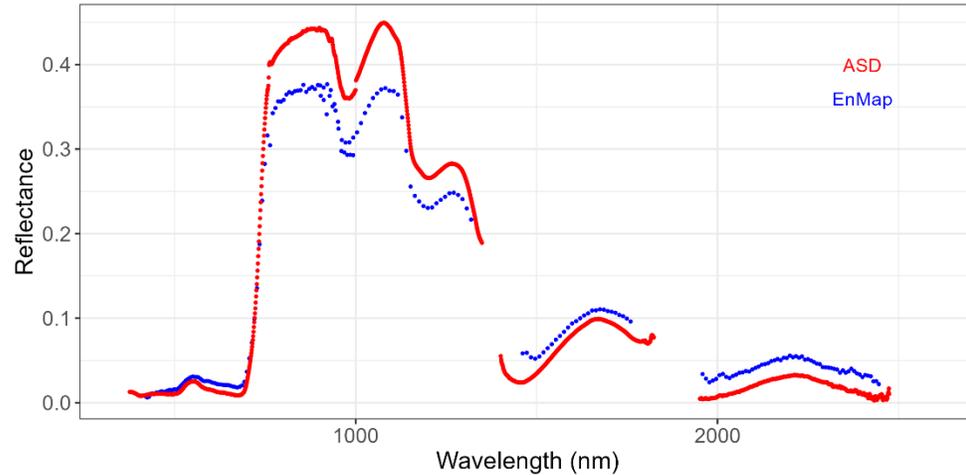
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Satellite imageries - Most relevant wavelengths

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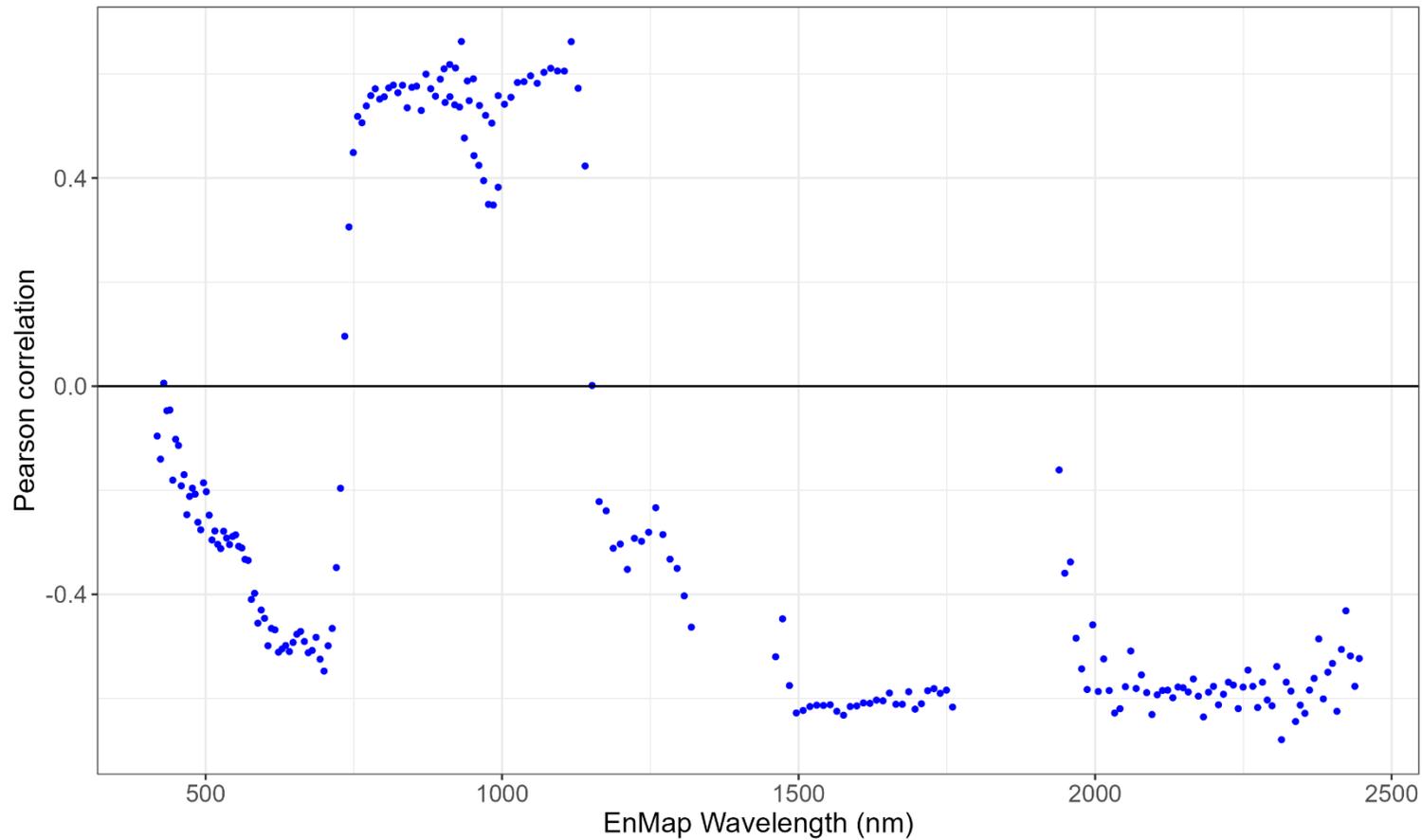
Perspectives
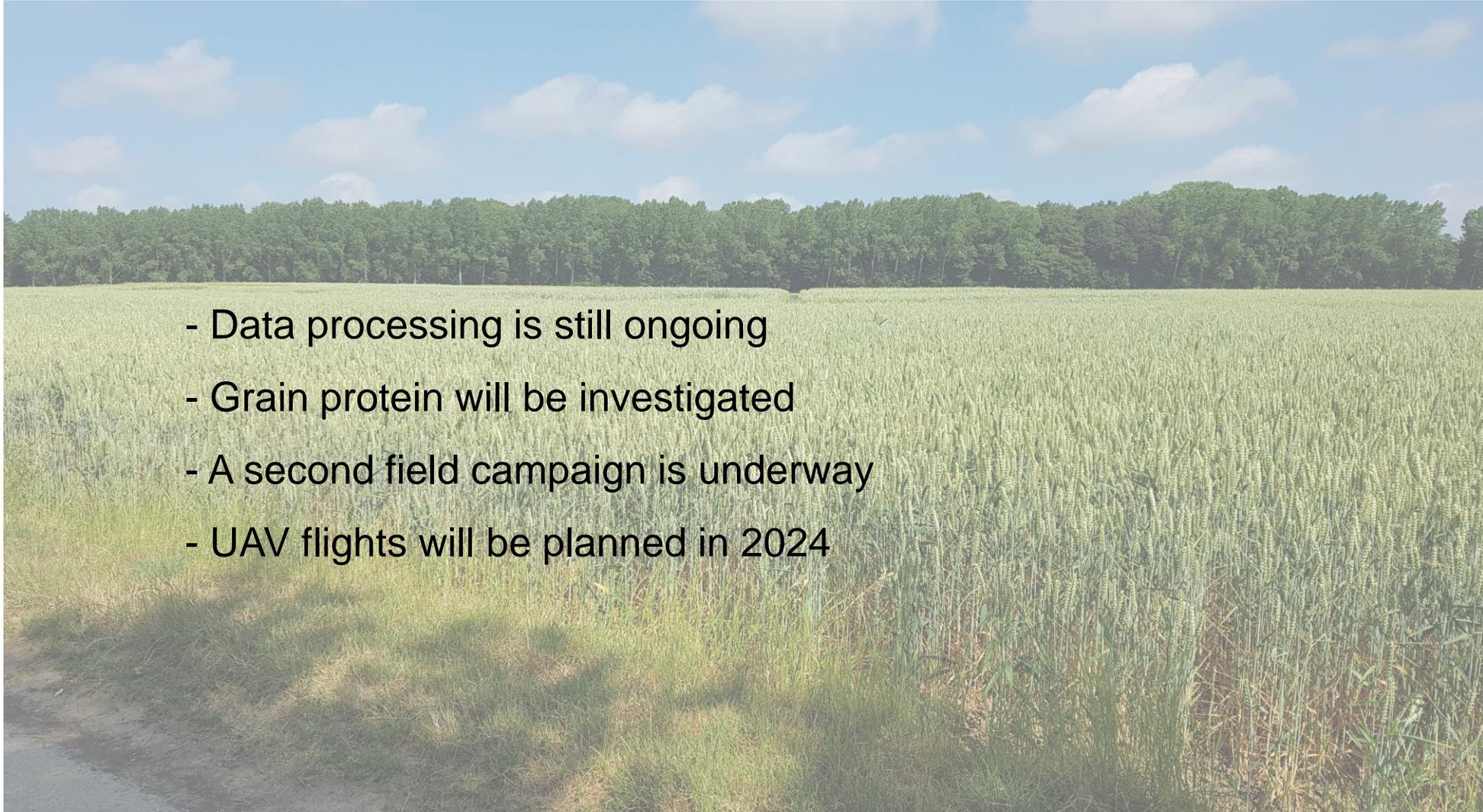
- Data processing is still ongoing

- Grain protein will be investigated

- A second field campaign is underway

- UAV flights will be planned in 2024

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Thank you for your attention !

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