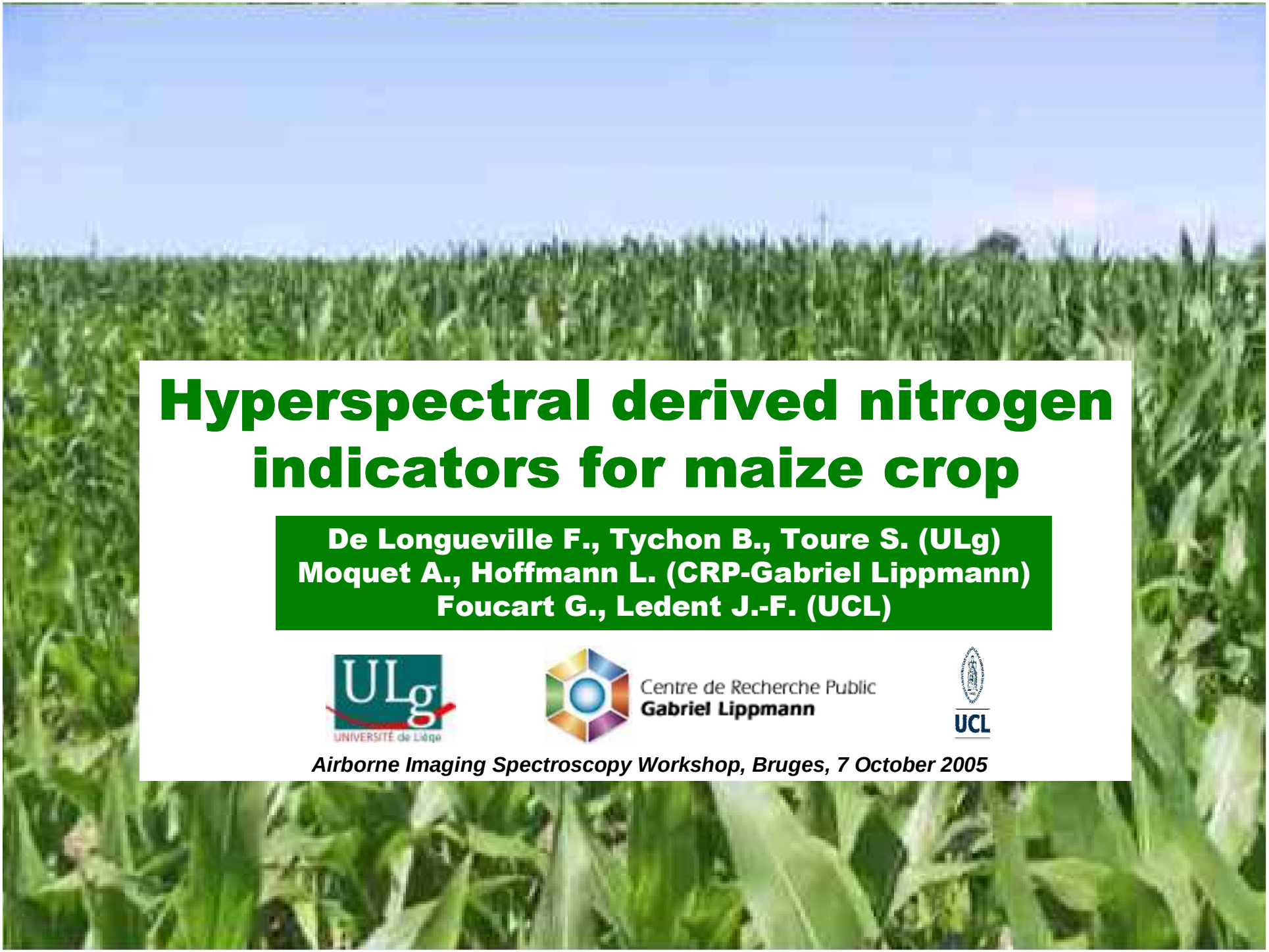

Hyperspectral derived nitrogen indicators for maize crop

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Airborne Imaging Spectroscopy Workshop, Bruges, 7 October 2005

Objectives

Evaluate the potential of airborne hyperspectral to detect maize parcels with inappropriate nitrogen fertilization

- → **Analysing experimental plots (two varieties and four N fertilization levels)**
- → **Proposition of indicators related to nitrogen supply in order to detect over- and under-fertilization.**
- → **Validation of the indicator based on farmer parcels**
- → **Extension to the whole maize parcels covered by the image**

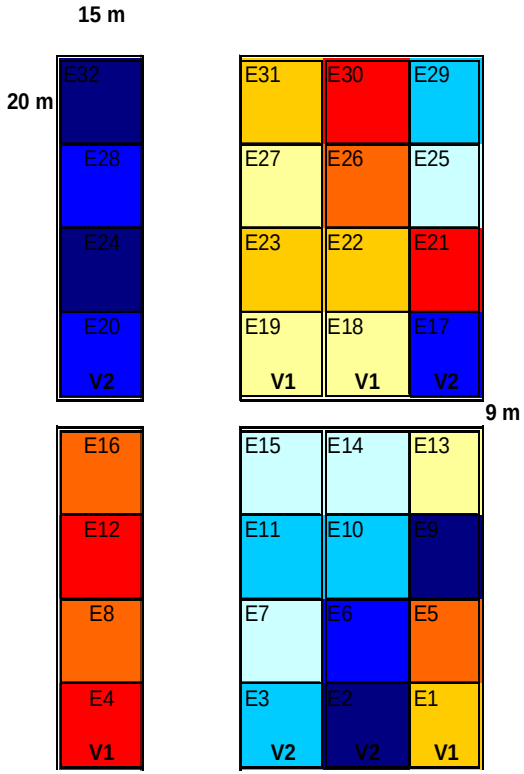
Study Area

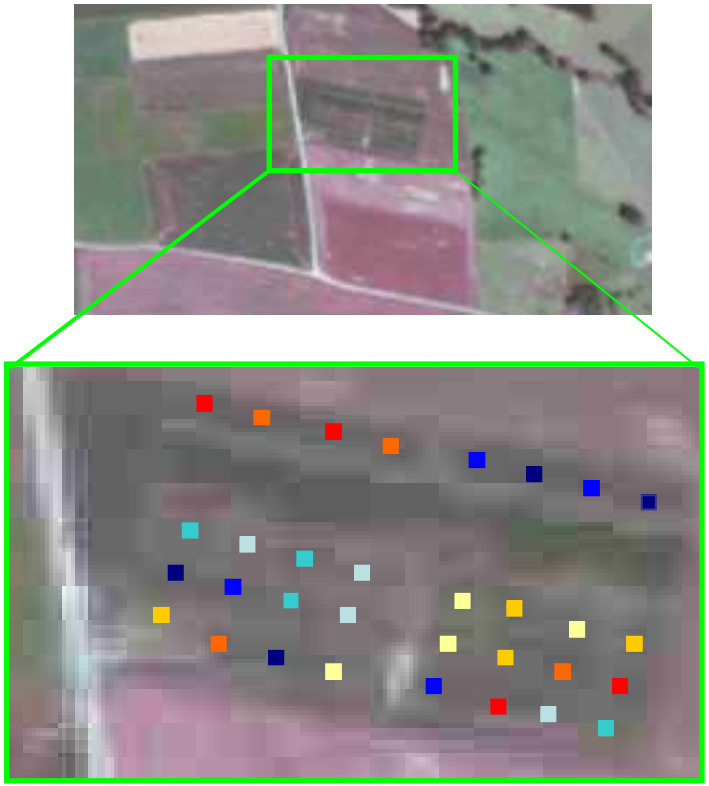
Experimental parcel

1 parcel located in Attert (South of Belgium)

32 experimental plots

- **2 varieties (Orange / Blue)**
- **4 nitrogen levels (Light → Dark)**





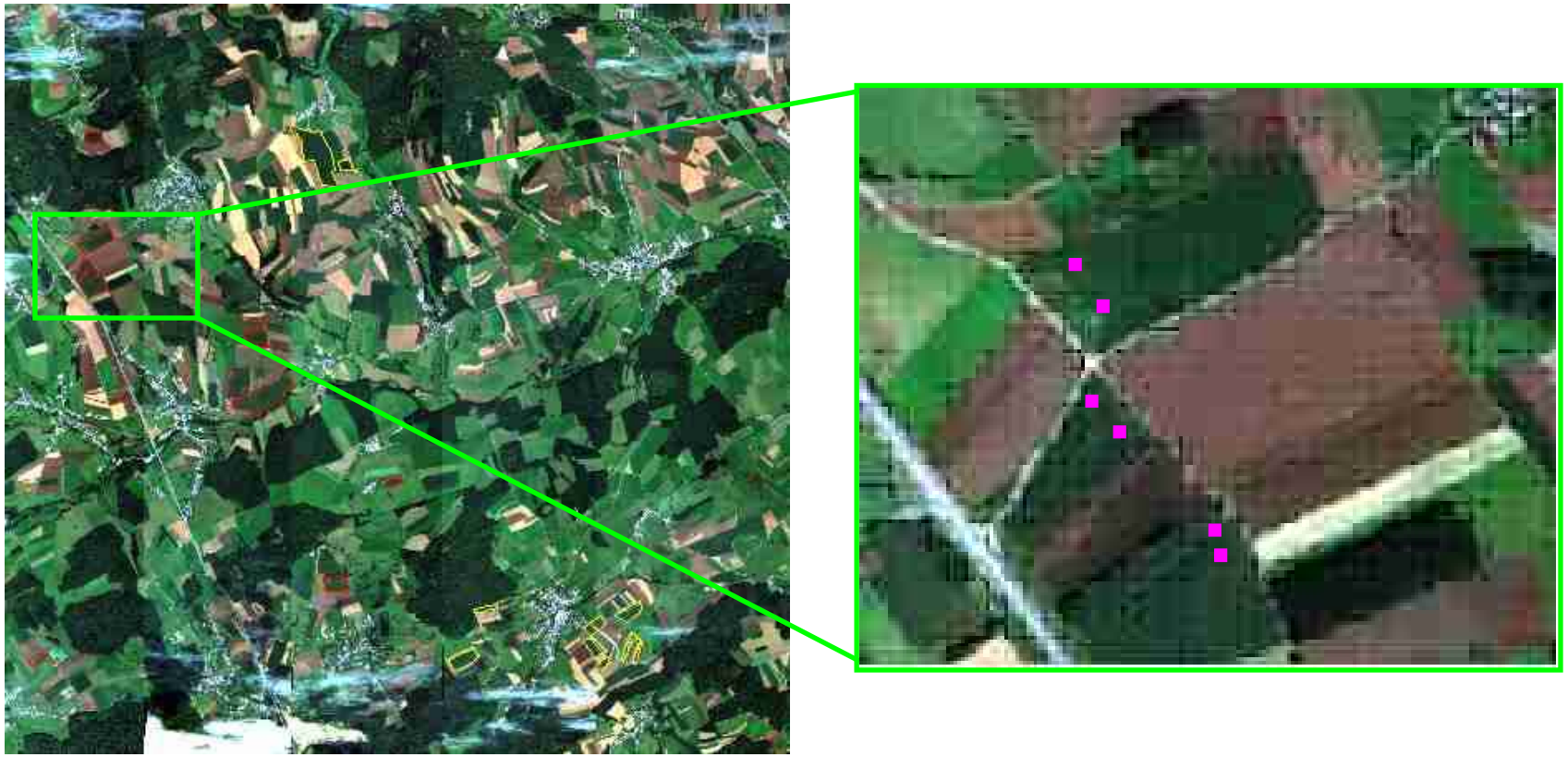
Study Area

Farmers parcels

20 farmer parcels

- **10 in Belgium**
- **10 in Luxemburg**

2 samples in each parcel



Ground Measurements

Field campaign date : 30/07/2004

Plants	• Fresh / Dry biomass • Phenology • Chlorophyll content • Leaf Area Index • Plant height • Fluorescence • Nitrogen content	*July 2004* *October 2004*
Soil	• N min	*April / May 2004* *Octobre 2004*
Agricultural practices	• Previous crops • Sowing date • Nitrogen fertilization • Harvest date • Winter cover	

Spectral measurements

TLD

- Between 440 et 2482 nm

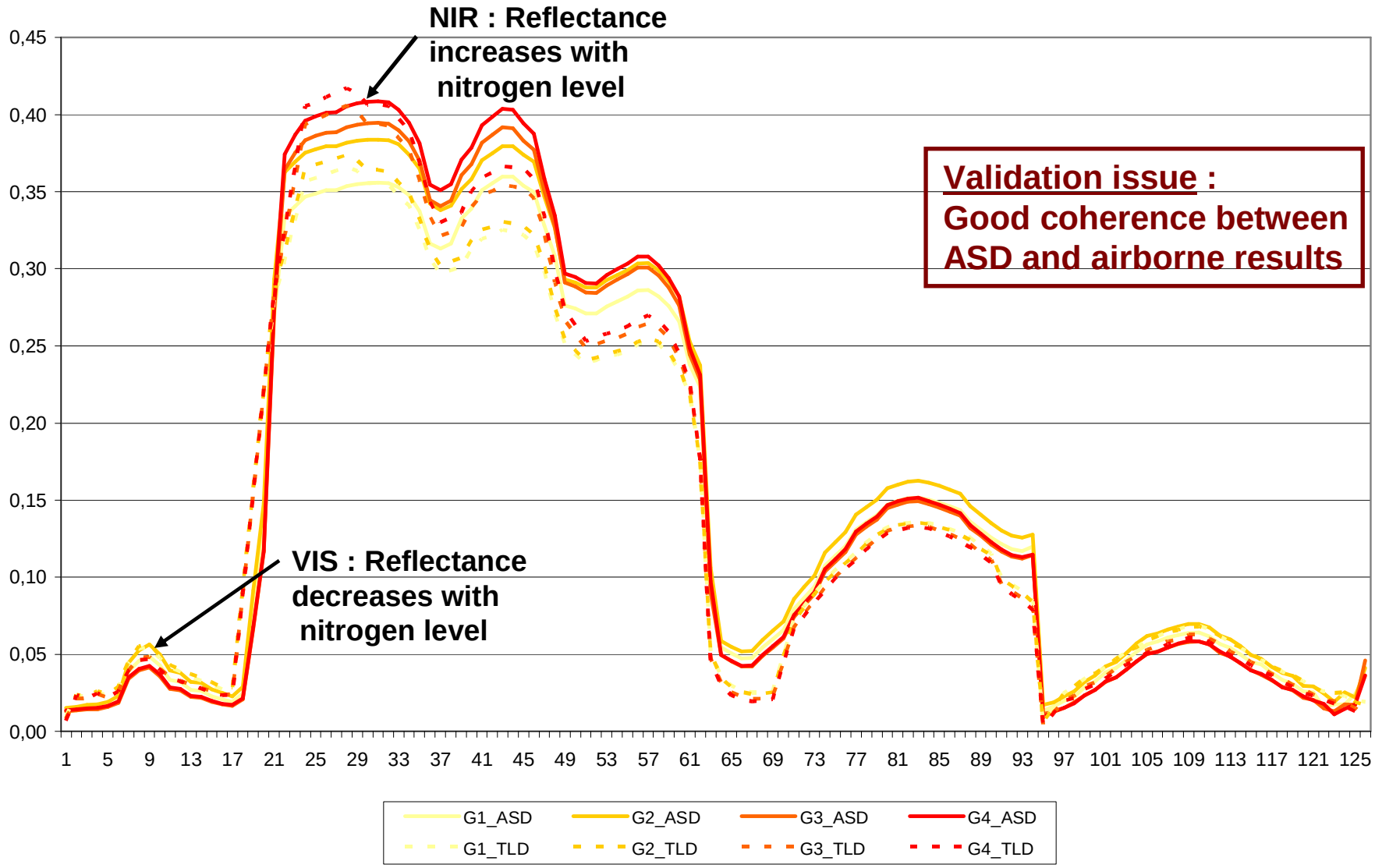
- Chanel : 15 to 16 nm

- Between 350 et 2500 nm

- Chanel : 1 nm

ASD

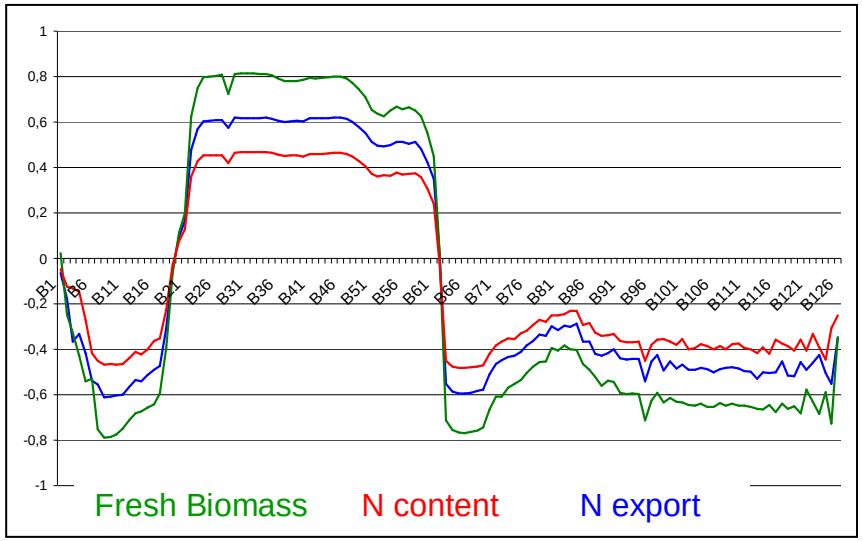
Preliminary discrimination



Statistical analysis

To select relevant bands

Correlation with biophysical parameters



+

Multiple regression (Stepwise, Principal Components, Partial Least Square)

Selected bands

B9	558
B32	896
B66	1448
B45	1099
B21	740
B126	2482
B6	512
B5	498
B10	573
B16	667
B17	680
B19	717
B22	750
B28	846

Variance analysis

N level	Variety	Interaction
S	NS	NS
S	NS	NS
S	NS	NS
S	NS	NS
NS	NS	NS
NS	NS	NS
NS	NS	NS
NS	NS	NS
S	NS	NS
S	NS	NS
NS	NS	NS
NS	NS	NS
S	NS	NS
S	NS	NS

S = Significative (5%)

NS = Non Significative (5%)

Interesting bands in Visible and Near Infrared

First conclusions

And indicators proposal

I. Good coherence between ASD and airborne results → We will work only with Airborne hyperspectral data (spatialisation objective)

II. Good discrimination of nitrogen levels in spectrum → Combination of different bands from different spectral regions should improve the spectral signature recognition (vegetation indices)

III. 8 bands in visible and near infrared → Focus on these spectral bands

+ Literature

I1 : Reflectance B9 (558 nm)

I2 : TCARI (Transformed Chlorophyll Absorption in Reflectance)

I3 : NDVI B32 (896 nm) and B22 (750 nm)

I4 : NDVI B45 (1099 nm) and B22 (750 nm)

I5 : GNDVI B27 (831 nm) and B9 (558 nm)

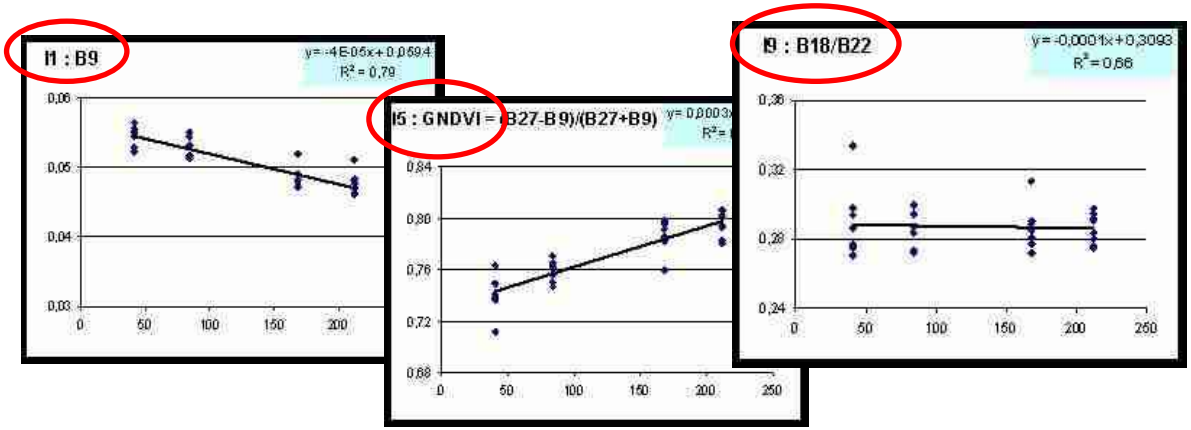
I6 : Red-edge

I7 : Reflectance B32 (896 nm)

I8 : NDVI B22 (750 nm) and B9 (558 nm)

I9 : Simple Ratio (B18/B22)

Indicator selection

Indicators	Criteria	Illustration
I1, I2, I3, I4, I5, I6, I7, I8, I9	High variability inter N level Low variability intra N level	
I3, I4, I5, I8	Significative effect of N level No significative effect of variety Best determination coefficient value	

Indicator	N level	Variety	R^2	Adjusted R^2
I3	S**	S*	0.864	0.823
I4	S**	NS**	0.791	0.727
I5	S**	NS**	0.818	0.763
I8	S**	NS**	0.797	0.735

* Significative at 1% ** Significative at 5%

I5

$$GNDVI = (NIR - G) / (NIR + G)$$

831 nm 558 nm

GNDVI tresholds

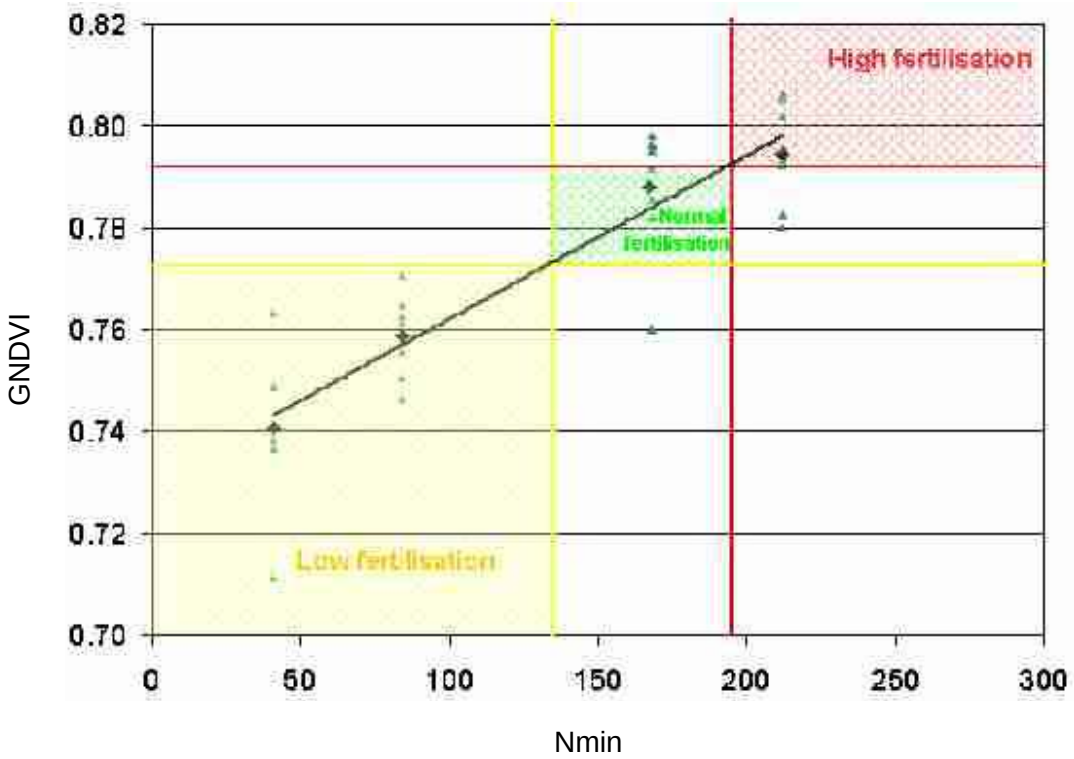
Based on experimental plots

Empirical method

Reference : Low fertilisation : Nmin <= 135 kg/ha

High fertilisation : Nmin >= 195 kg/ha

Empirical Method based on N min / GNDVI relation



Fertilization classes

Low fertilization : GNDVI <= 0.773

High fertilization : GNDVI => 0.792

Normal fertilization : 0.773 < GNDVI <0.792

GNDVI tresholds

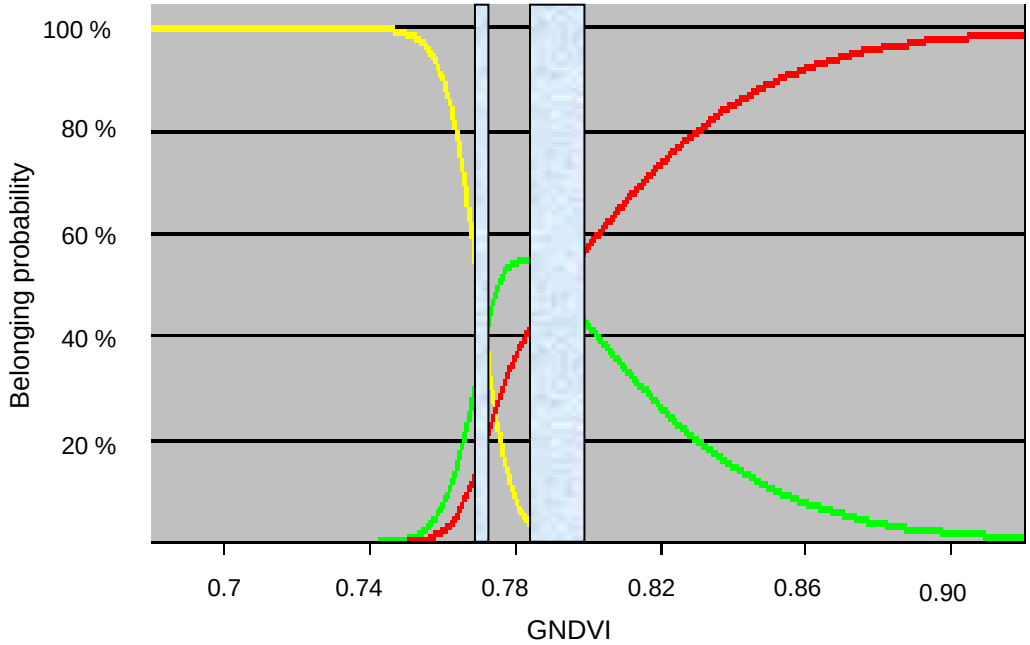
Based on experimental plots

Statistical method

Reference : Low fertilization : Nmin <= 135 kg/ha

High fertilization : Nmin >= 195 kg/ha

Linear discriminant analysis



Fertilization classes

Low fertilization : GNDVI <= 0.770

High fertilization : GNDVI >= 0.800

Normal fertilization : 0.773 < GNDVI <0.783

0.770 – 0.773
0.783 – 0.800
} **Undetermined**

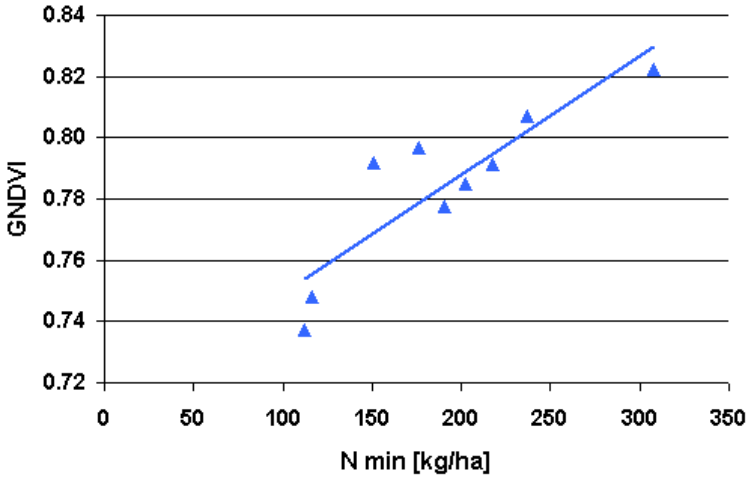
Validation

On farmer's fields

Validation on 9 farmer's parcels located in Luxemburg

	Low (%)	Normal (%)	High (%)	Calculated class	Reference class
1	1	49	50	-	**3**
2	0	25	75	**3**	**3**
3	0	36	64	**3**	**3**
5	3	54	43	-	**3**
6	0	45	55	-	**2**
7	14	53	33	**2**	**2**
8	0	49	50	-	**2**
9	100	0	0	**1**	**1**
10	99	1	0	**1**	**1**

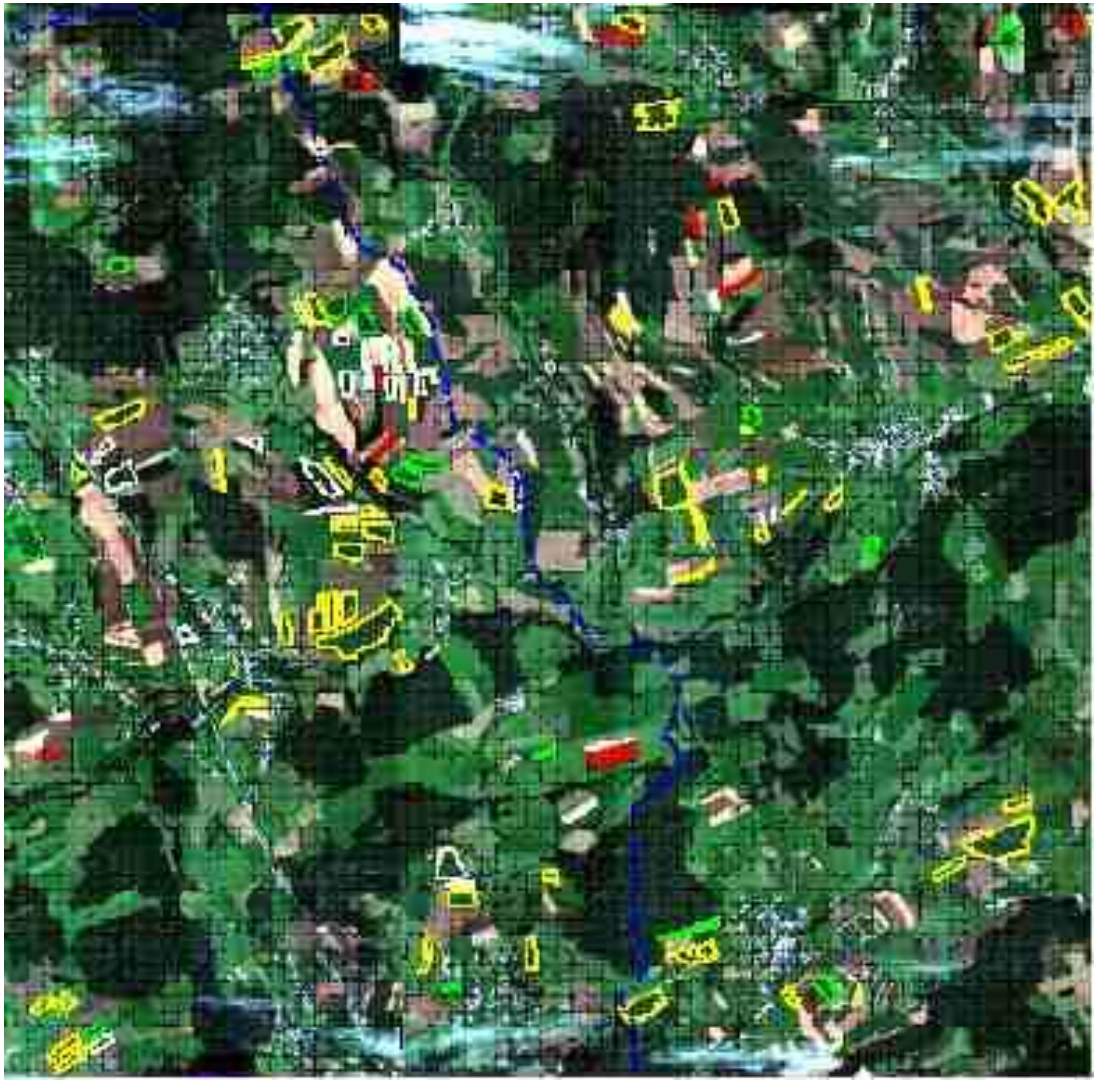
R^2 = 0.77



- **The class is assigned according to the highest belonging probability**
- **If (P_{max} – P_{med}) <15, then class = undetermined**
- **100% succes BUT not enough parcels**
- **Good correlation between Nmin and GNDVI for the validation parcels**

Spatialisation

On agricultural fields



Low fertilisation

Normal fertilisation

High fertilisation

Undetermined

Belgium

Luxemburg

Conclusions

- **GNDVI combining green and NIR information**

$$(R_{831} - R_{558}) / (R_{831} + R_{558})$$

- **Under-fertilization better discriminated than over-fertilization, normal fertilization less easily differentiated from high level fertilization**

- **No significative effect of the variety on the N_{min} – GNDVI relationship**

- **The belonging probability allows to focus on parcels with the most extreme fertilizations (low or high)**

→ **Tool to select parcels where N-Fertilization looks abnormal.**

But the validation has to be carried on a larger number of parcels in Belgium and Luxemburg.

Thank you