Field spectroscopy to support precision agriculture

La espectroscopía de campo como soporte a la agricultura de precisión

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agriSat Iberia, S.L.

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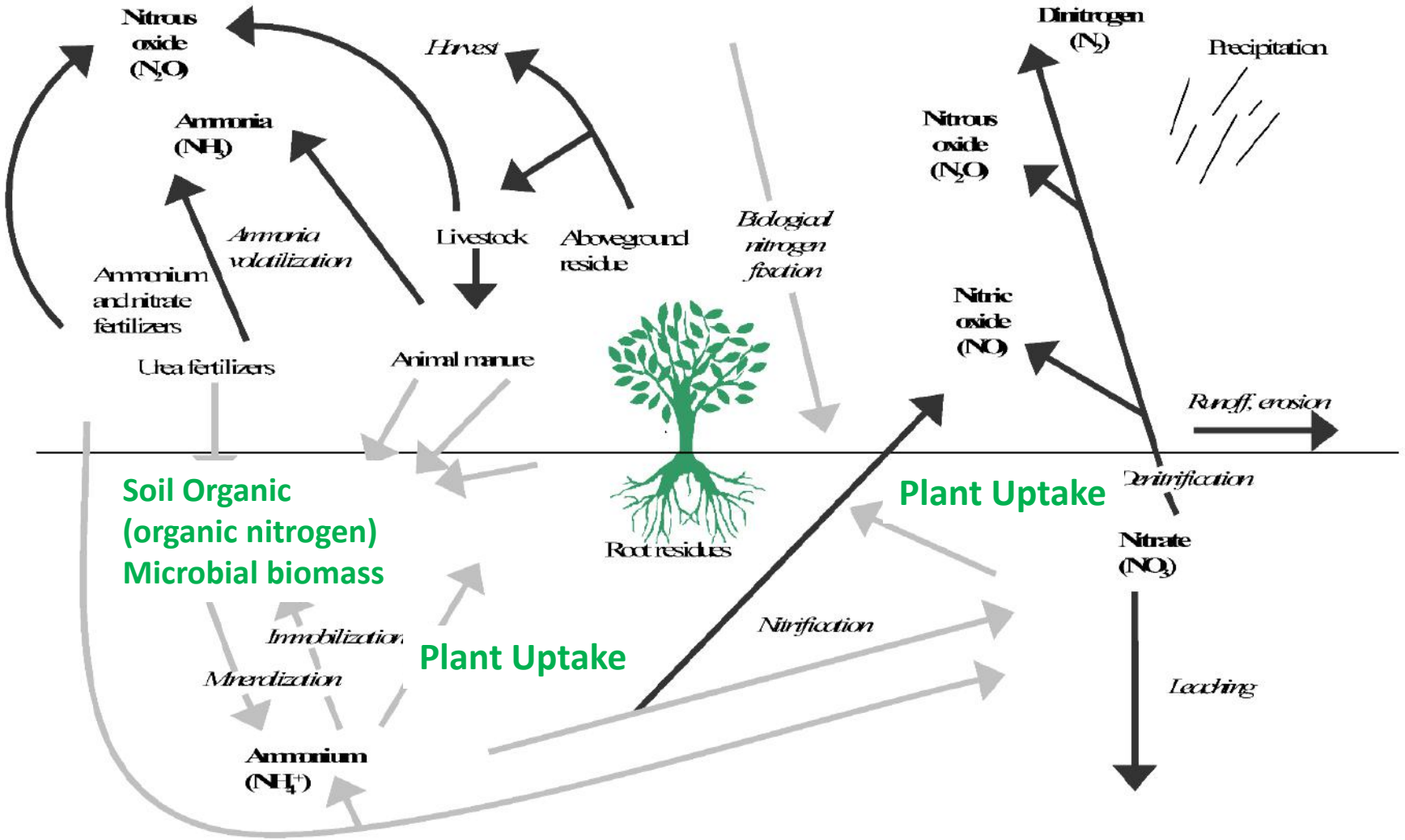
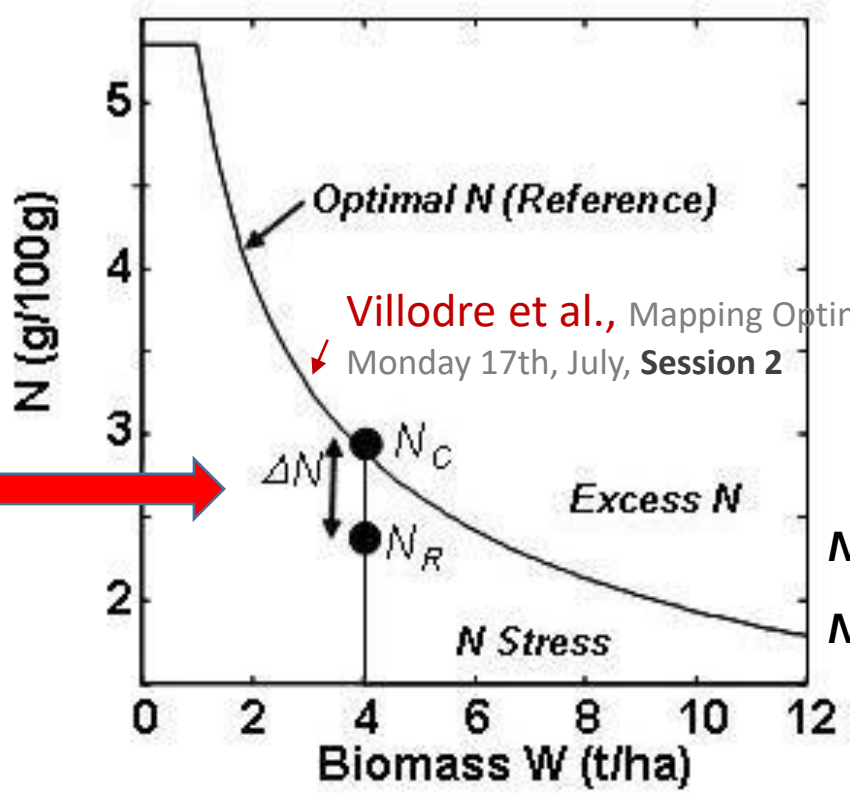


The Nitrogen cycle. Source: OECD (2001) Environmental Indicators for Agriculture-Volume 3: Methods and Results, Publication Service, Paris, France

INTRODUCTION

Field Spectroscopy to Support Precision Agriculture



Villodre et al., Mapping Optimum Nitrogen Crop Uptake, ECPA (2017) – Monday 17th, July, **Session 2**

Deficit of N

$NC = 5.35$ if $WR \leq 1$ t.ha-1

$NC = 5.35 . WR^{-0.442}$ if $WR \leq 1$ t.ha-1

N Nutrition Index

$$\mathrm{NNI}(Dimensionless) = \frac{N_R\left({}^{g}/_{100\ g\ total\ biomass}\right)}{N_C\left({}^{g}/_{100\ g\ total\ biomass}\right.}$$

$$N_R\left({}^{g}/_{100\ g\ total\ biomass}\right) = \frac{\boldsymbol{Q}\mathbf{N}\left(\frac{\boldsymbol{g}}{\boldsymbol{m^2}}\right)}{\boldsymbol{Biomass}\ \left({}^{\boldsymbol{g}}/_{\boldsymbol{m^2}}\right)}$$ ← Campos et al., (2017)

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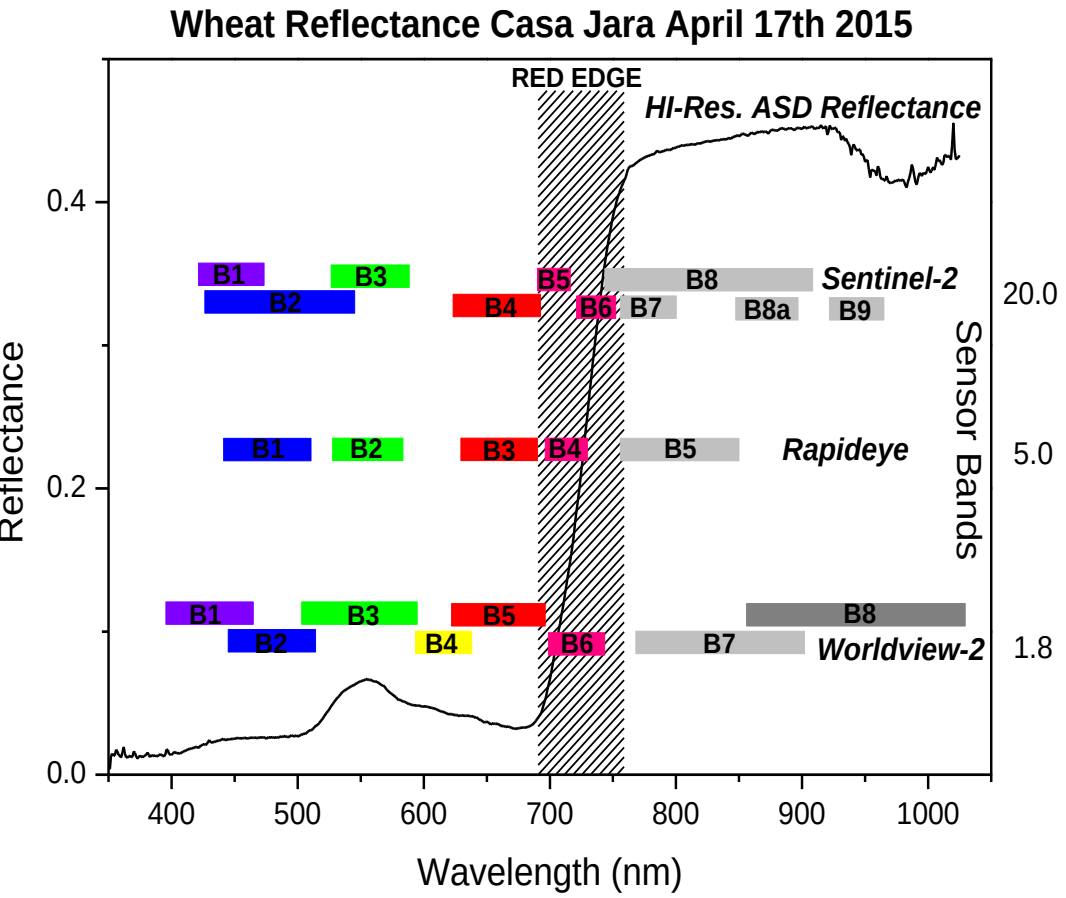
Field Spectroscopy to Support Precision Agriculture



$$NDRE = \frac{(R_{790} - R_{720})}{(R_{790} + R_{720})}$$

$$REP = 700 + 40 \cdot \frac{[(R_{670} + R_{780})/2 - R_{700}]}{R_{740} - R_{700}}$$

$$CI = \frac{R_{790}}{R_{720}} - 1$$

INTRODUCTION

Field Spectroscopy to Support Precision Agriculture

Vegetation Index	Formula	Use	Reference
Normalized difference red edge index (NDRE)	$(R_{790} - R_{720}) / (R_{790} + R_{720})$	Sensitive in variations of Clorophyll and N.	Fitzgerald et al. (2010)
Red edge chlorophyll index ($CI_{red\ edge}$)	$\frac{R_{790}}{R_{720}} - 1$	Estimation of N plant uptake.	Gitelson et al. (2005)
MERIS terrestrial chlorophyll index (MTCI)	$(R_{750} - R_{710}) / (R_{710} - R_{680})$	N uptake before heading.	Dash and Curran (2004)
Canopy chlorophyll content index (CCCI)	$(NDRE - NDRE_{MIN}) / (NDRE_{MAX} - NDRE_{MIN})$	N uptake across growth stages.	Fitzgerald et al. (2010)
REP	$700+40 \cdot \frac{[(R_{670}+R_{780})/2-R_{700}]}{R_{740}-R_{700}}$	Sensitive in variations of Clorophyll and N.	Guyot et al. (1988)
Angular Insensitivity Vegetation Index (AIVI)	$\frac{R_{445} \cdot (R_{720} + R_{735}) - R_{573} \cdot (R_{720} - R_{735})}{R_{720} \cdot (R_{573} + R_{445})}$	N at different view zenith angles.	He et al- (2016)

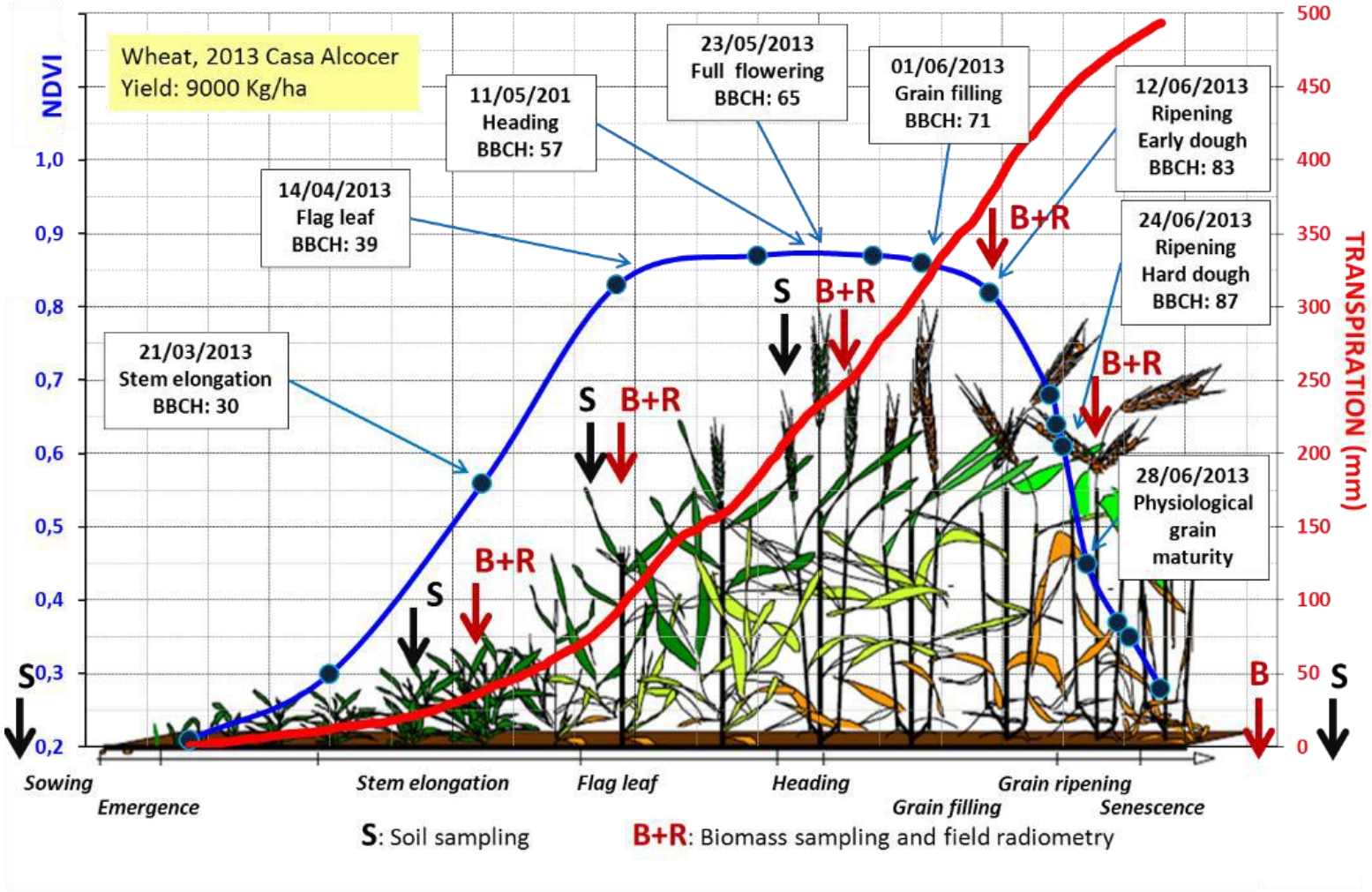
OBJECTIVES

Field Spectroscopy to Support Precision Agriculture

- Map the nitrogen content in the crop using remote Sensing techniques.
- Derive NNI (*Nitrogen Nutrition Index*) maps for variable rate fertilization.

FIELD WORK STRATEGY

Field Spectroscopy to Support Precision Agriculture



FIELD WORK STRATEGY

Field Spectroscopy to Support Precision Agriculture

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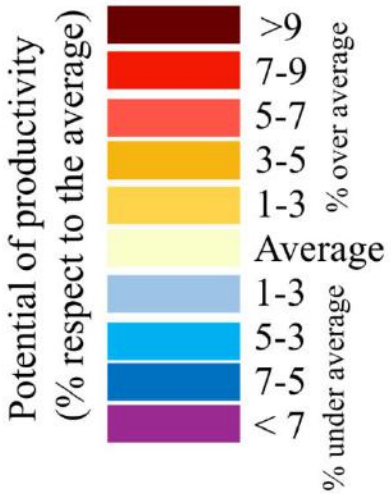
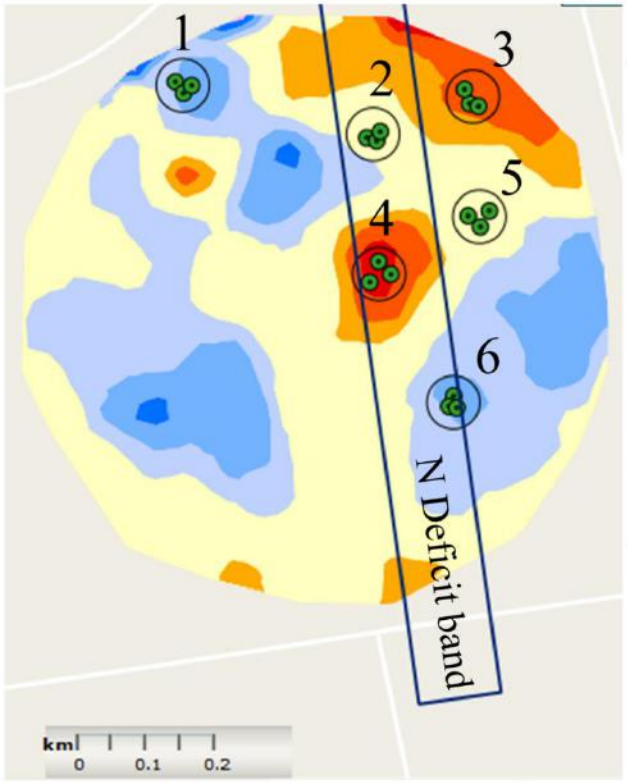
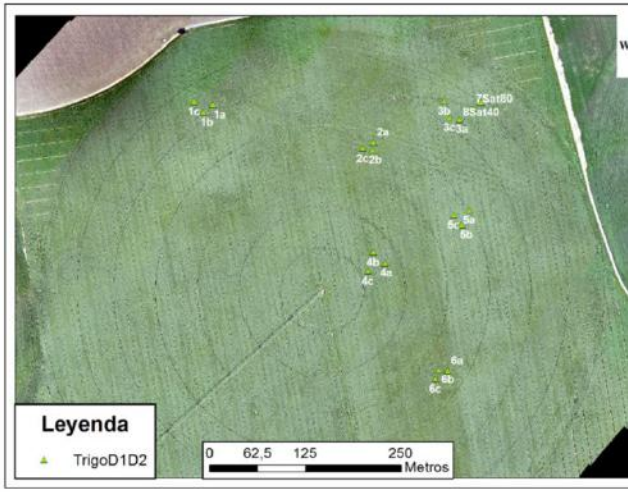
Wheat, year 2016





Radiometry, Biomass and N sampling

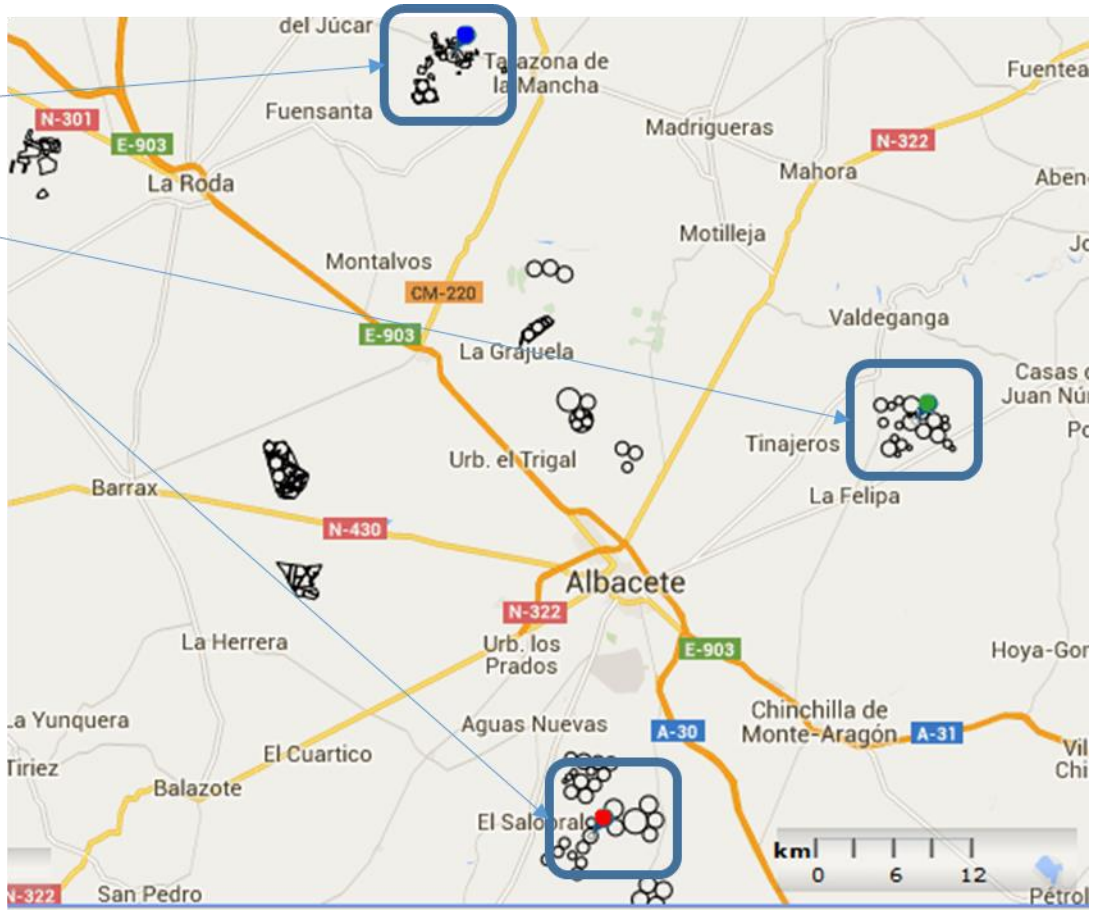


Orthophotography during cr
development on year 2016 with
ground simple distance (GSD) of 5 c

FIELD WORK STRATEGY

Field Spectroscopy to Support Precision Agriculture

- Casa Jara
- Casa del Monte
- Dehesa Los Llanos
  - *L8 images TOC (in spider)*



FIELD WORK: METHODOLOGY

Measurements at Field

Biomass Sampling

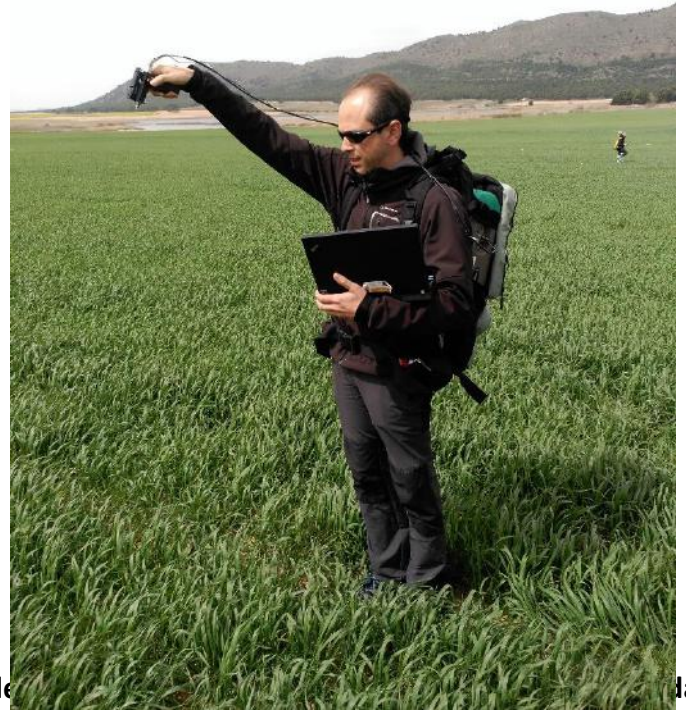
Oven (48 h. 60ºC)

Dry **Biomass**

Dumas Method

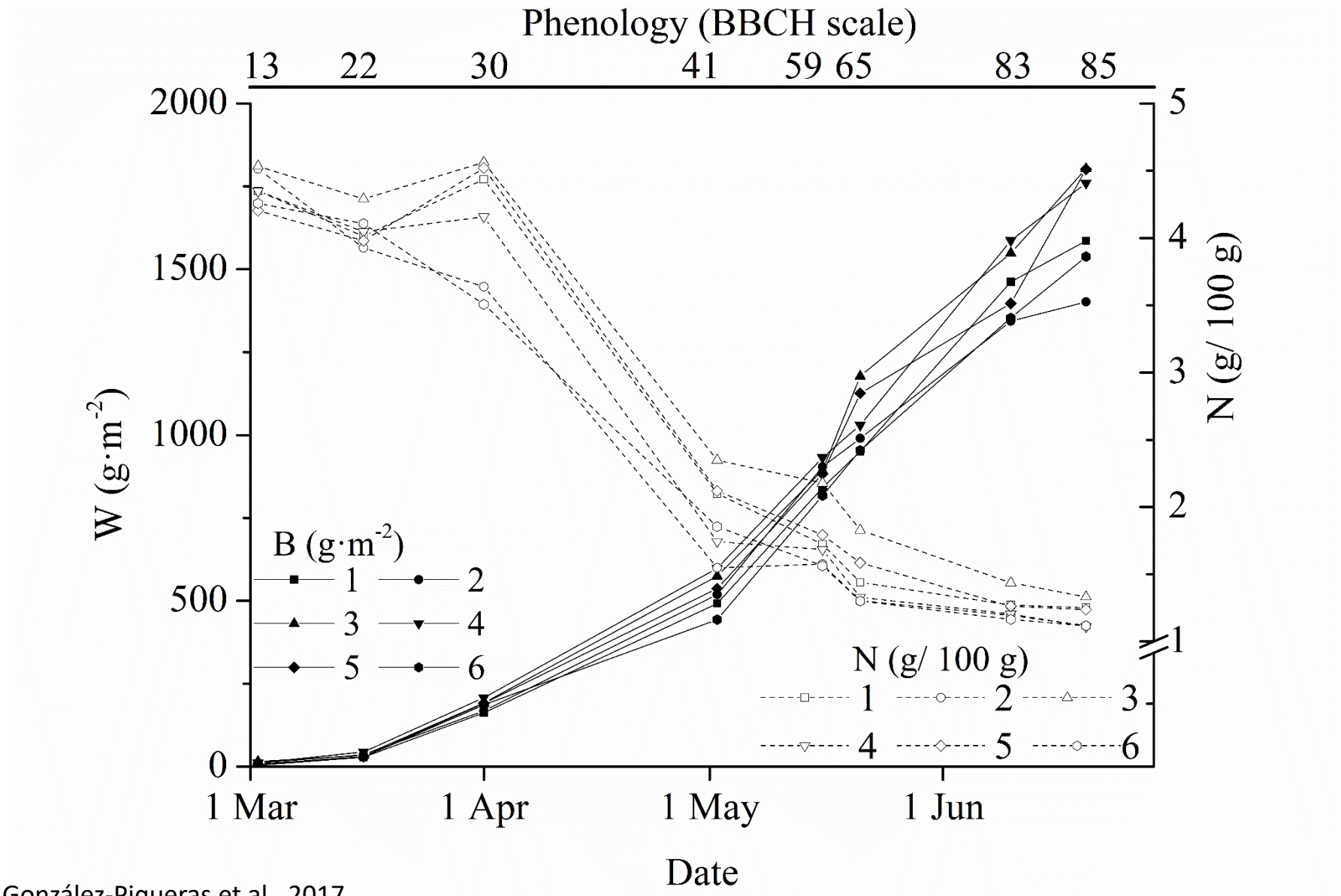
N Concentration

Spectral Reflectance
ASD Hi-Res®



FIELD WORK: AT FIELD CROP MONITORING

Field Spectroscopy to Support Precision Agriculture



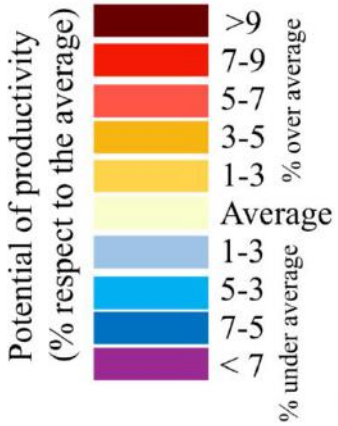
González-Piqueras et al., 2017

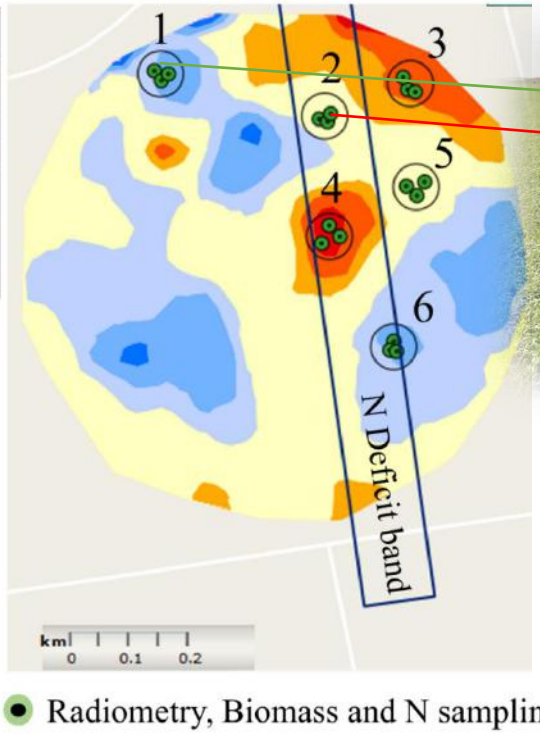
DATA STORE: ACQUISITION PROTOCOL

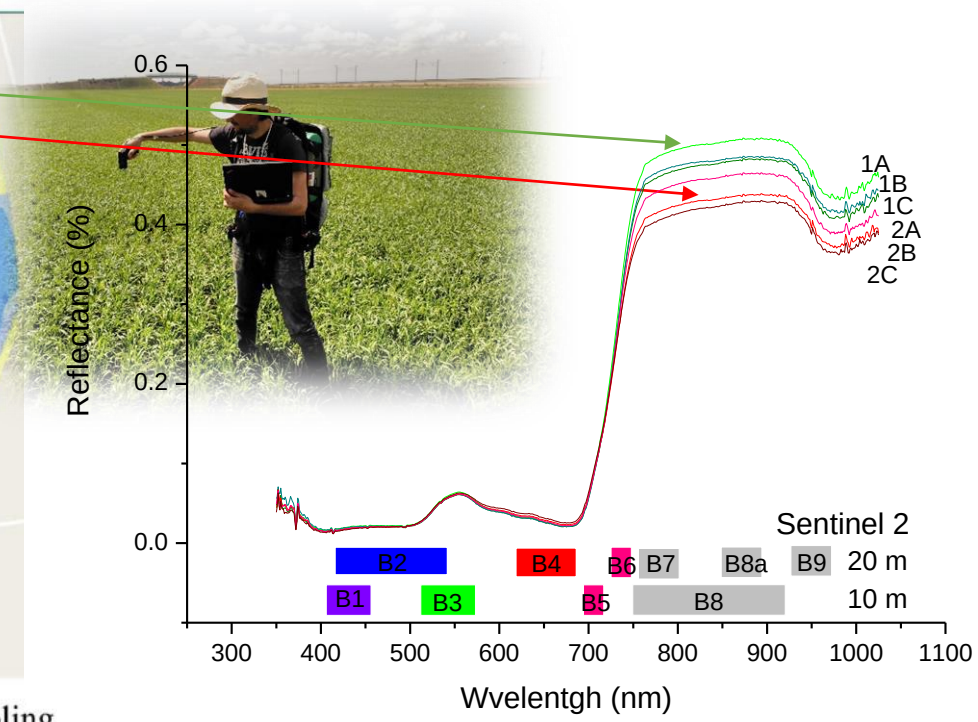
BBCH stage	Pre	11	21	29	39	55	73	85	90
									
Farming operations	✓	✓	✓	✓	✓	✓	✓	✓	✓
Date	✓	✓	✓	✓	✓	✓	✓	✓	
Assessment									
• Emergence		✓							
• Diseases		✓	✓	✓	✓	✓	✓	✓	
• Pests		✓	✓	✓	✓	✓	✓	✓	
• Accidents		✓	✓	✓	✓	✓	✓	✓	
Sampling, measurement and analysis									
Soil (30/60 cm)	✓			✓	✓				✓
Water						✓			
Above ground plant biomass									
• Complete				✓	✓		✓	✓	
• Parties									✓
Plant height								✓	
Yield components									✓
Radiometry			✓	✓	✓	✓	✓	✓	
Yield map									✓
Quality									✓

DATA STORE: SPEC. LIBRARIES CROP

Field Spectroscopy to Support Precision Agriculture







DATA STORE: SPEC. LIBRARIES CROP

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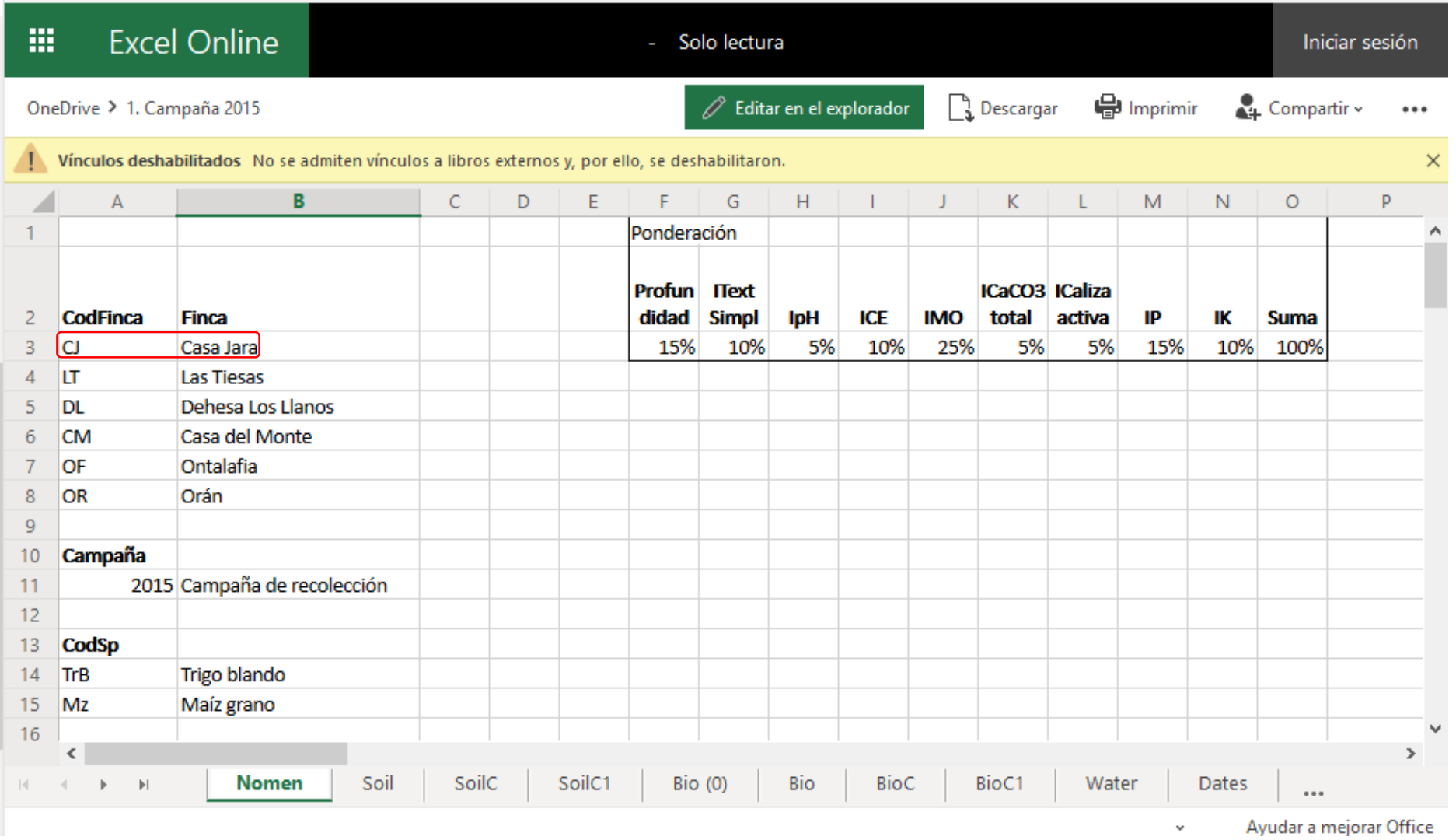
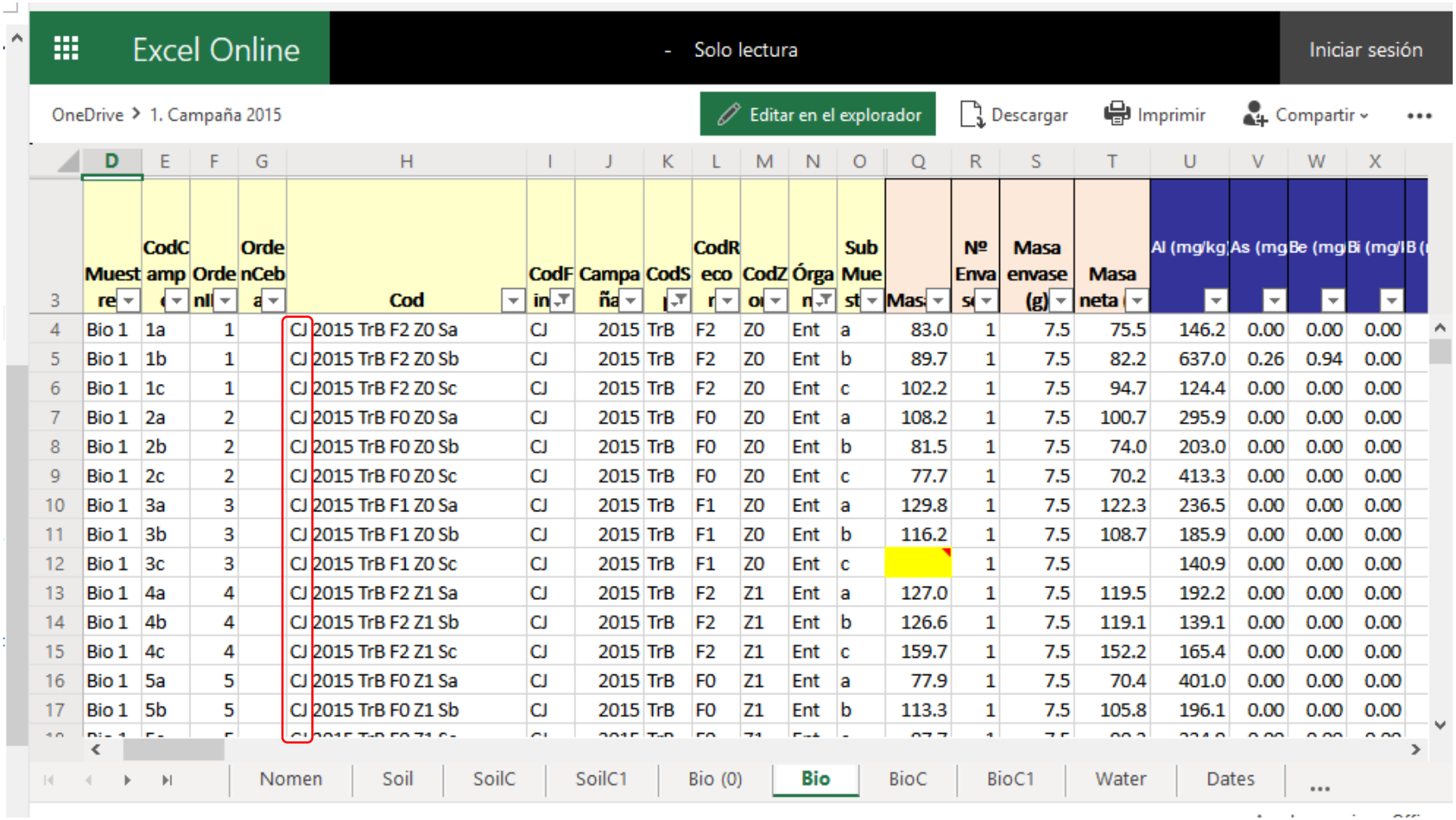


	A	B	F	G	H	I	J	K	L	M	N	O
1			Ponderación									
2	**CodFinca**	**Finca**	**Profundidad**	**IText Simpl**	**IpH**	**ICE**	**IMO**	**ICaCO3 total**	**ICaliza activa**	**IP**	**IK**	**Suma**
3	CJ	Casa Jara	15%	10%	5%	10%	25%	5%	5%	15%	10%	100%
4	LT	Las Tiesas										
5	DL	Dehesa Los Llanos										
6	CM	Casa del Monte										
7	OF	Ontalafia										
8	OR	Orán										
9												
10	**Campaña**											
11	2015	Campaña de recolección										
12												
13	**CodSp**											
14	TrB	Trigo blando										
15	Mz	Maíz grano										
16												

DATA STORE: SPEC. LIBRARIES CROP



Excel Online - Solo lectura — Iniciar sesión

OneDrive > 1. Campaña 2015 — Editar en el explorador | Descargar | Imprimir | Compartir

	D	E	F	G	H	I	J	K	L	M	N	O	Q	R	S	T	U	V	W	X
3	Muestre	CodCampo	OrdenI	OrdenCeba	Cod	CodFin	Campaña	CodSi	CodReco r	CodZo	Órgan	Sub Muest	Mas	Nº Envas	Masa envase (g)	Masa neta	Al (mg/kg	As (mg	Be (mg	Bi (mg/l	B (
4	Bio 1	1a	1		CJ 2015 TrB F2 Z0 Sa	CJ	2015	TrB	F2	Z0	Ent	a	83.0	1	7.5	75.5	146.2	0.00	0.00	0.00	
5	Bio 1	1b	1		CJ 2015 TrB F2 Z0 Sb	CJ	2015	TrB	F2	Z0	Ent	b	89.7	1	7.5	82.2	637.0	0.26	0.94	0.00	
6	Bio 1	1c	1		CJ 2015 TrB F2 Z0 Sc	CJ	2015	TrB	F2	Z0	Ent	c	102.2	1	7.5	94.7	124.4	0.00	0.00	0.00	
7	Bio 1	2a	2		CJ 2015 TrB F0 Z0 Sa	CJ	2015	TrB	F0	Z0	Ent	a	108.2	1	7.5	100.7	295.9	0.00	0.00	0.00	
8	Bio 1	2b	2		CJ 2015 TrB F0 Z0 Sb	CJ	2015	TrB	F0	Z0	Ent	b	81.5	1	7.5	74.0	203.0	0.00	0.00	0.00	
9	Bio 1	2c	2		CJ 2015 TrB F0 Z0 Sc	CJ	2015	TrB	F0	Z0	Ent	c	77.7	1	7.5	70.2	413.3	0.00	0.00	0.00	
10	Bio 1	3a	3		CJ 2015 TrB F1 Z0 Sa	CJ	2015	TrB	F1	Z0	Ent	a	129.8	1	7.5	122.3	236.5	0.00	0.00	0.00	
11	Bio 1	3b	3		CJ 2015 TrB F1 Z0 Sb	CJ	2015	TrB	F1	Z0	Ent	b	116.2	1	7.5	108.7	185.9	0.00	0.00	0.00	
12	Bio 1	3c	3		CJ 2015 TrB F1 Z0 Sc	CJ	2015	TrB	F1	Z0	Ent	c		1	7.5		140.9	0.00	0.00	0.00	
13	Bio 1	4a	4		CJ 2015 TrB F2 Z1 Sa	CJ	2015	TrB	F2	Z1	Ent	a	127.0	1	7.5	119.5	192.2	0.00	0.00	0.00	
14	Bio 1	4b	4		CJ 2015 TrB F2 Z1 Sb	CJ	2015	TrB	F2	Z1	Ent	b	126.6	1	7.5	119.1	139.1	0.00	0.00	0.00	
15	Bio 1	4c	4		CJ 2015 TrB F2 Z1 Sc	CJ	2015	TrB	F2	Z1	Ent	c	159.7	1	7.5	152.2	165.4	0.00	0.00	0.00	
16	Bio 1	5a	5		CJ 2015 TrB F0 Z1 Sa	CJ	2015	TrB	F0	Z1	Ent	a	77.9	1	7.5	70.4	401.0	0.00	0.00	0.00	
17	Bio 1	5b	5		CJ 2015 TrB F0 Z1 Sb	CJ	2015	TrB	F0	Z1	Ent	b	113.3	1	7.5	105.8	196.1	0.00	0.00	0.00	

Nomen | Soil | SoilC | SoilC1 | Bio (0) | Bio | BioC | BioC1 | Water | Dates

DATA STORE: SPEC. LIBRARIES CROP

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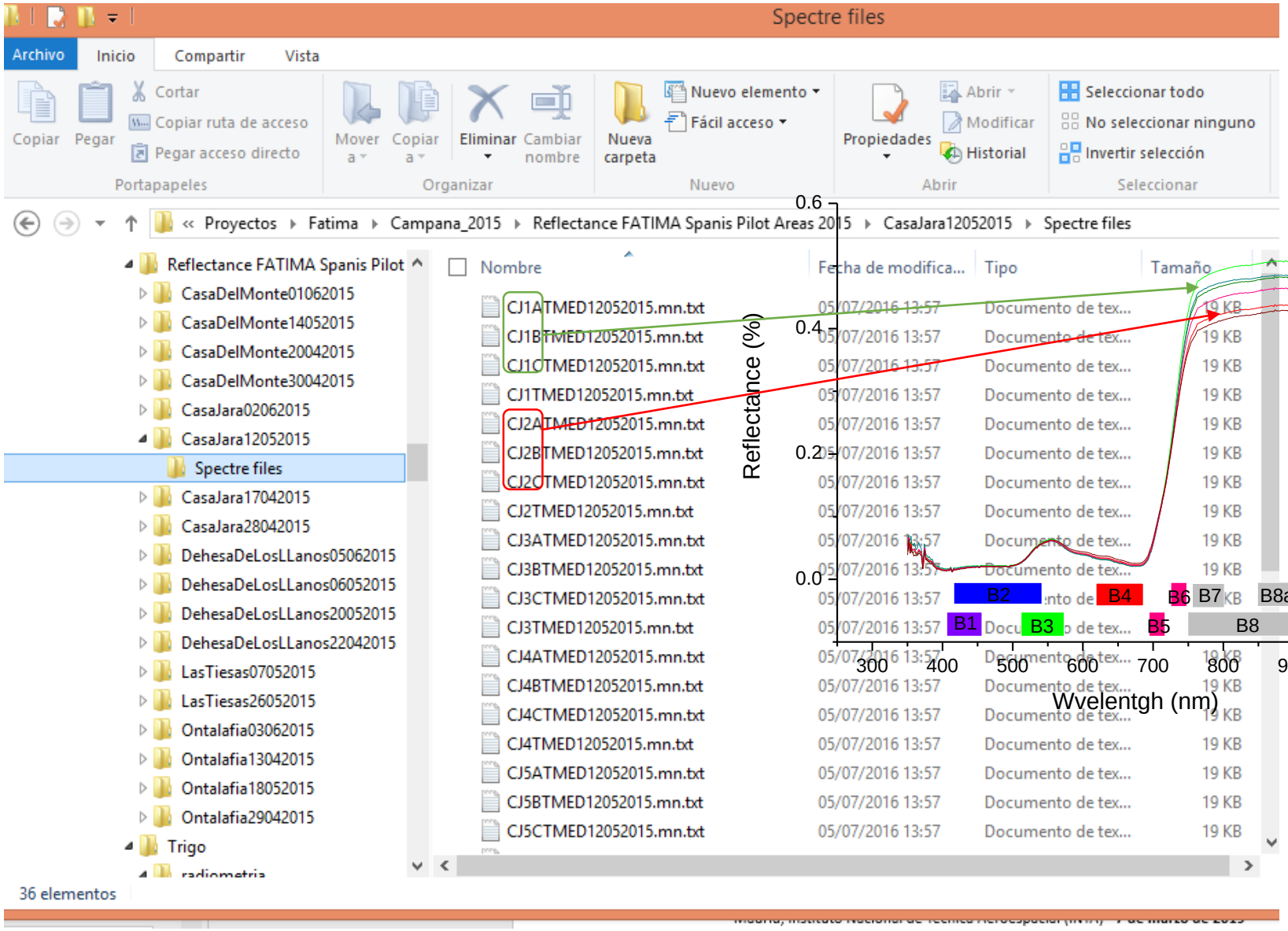
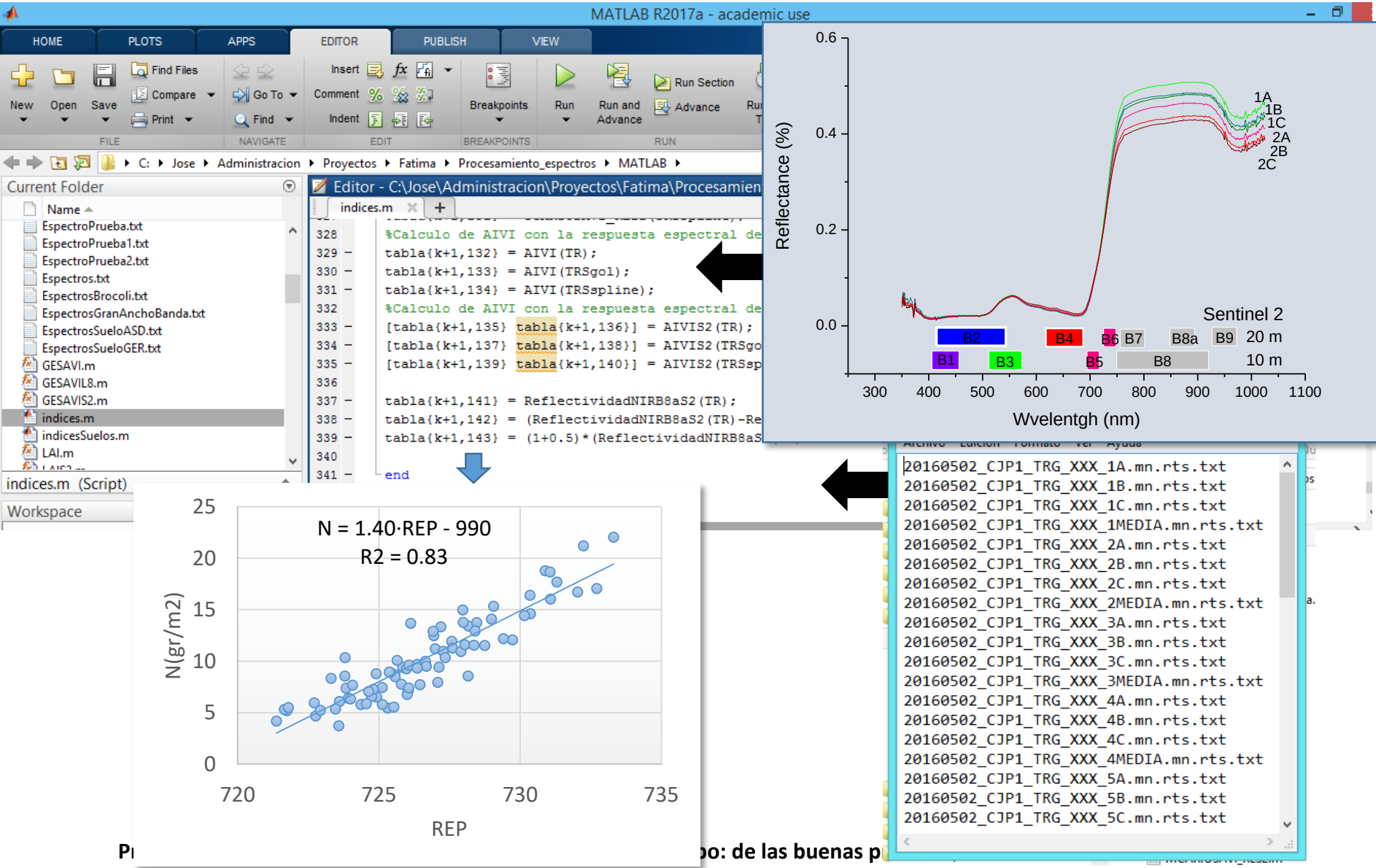
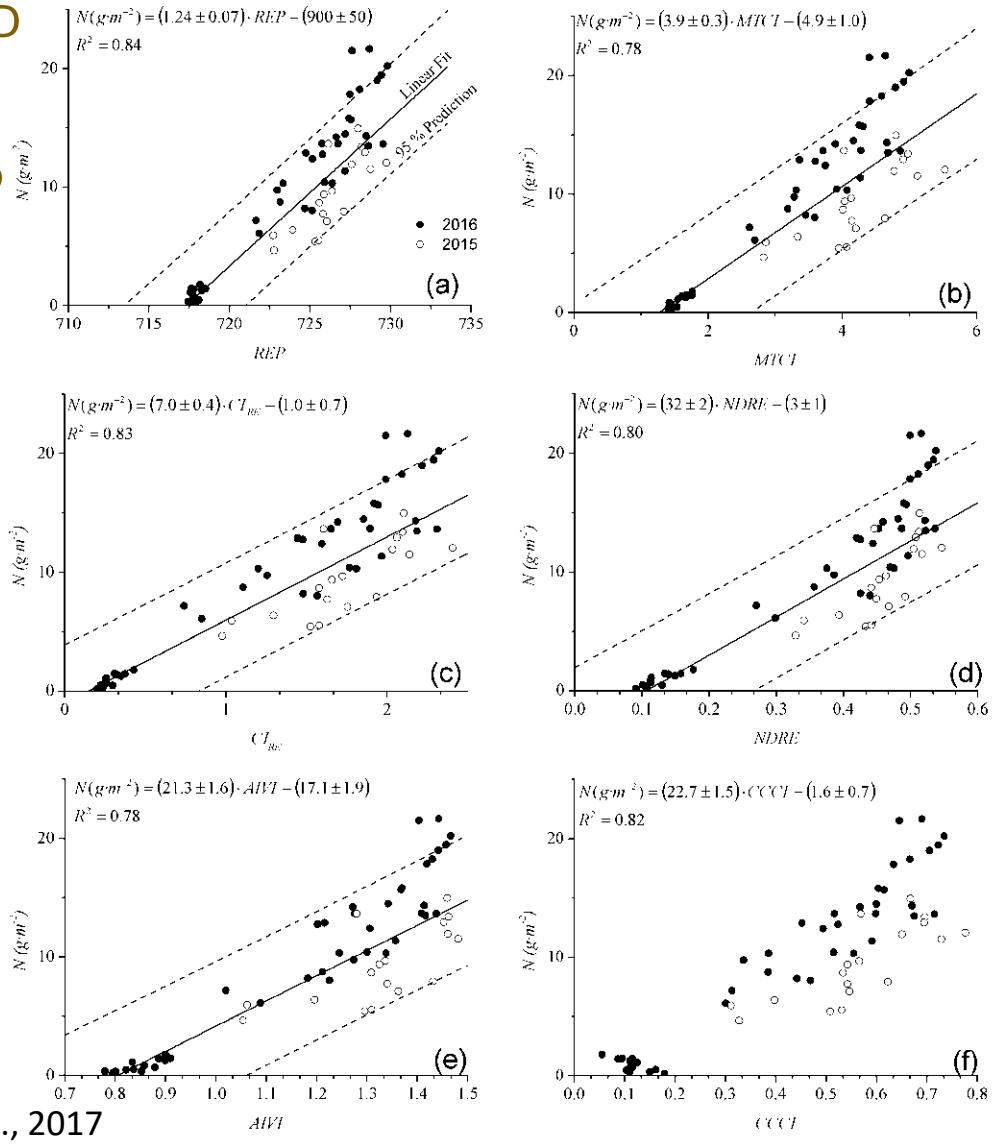


DATA PROCESS



FIELD WORK: N UPTAKE CALIBRATION

NARROW BAND WHEAT YEAR 2015 & 2016

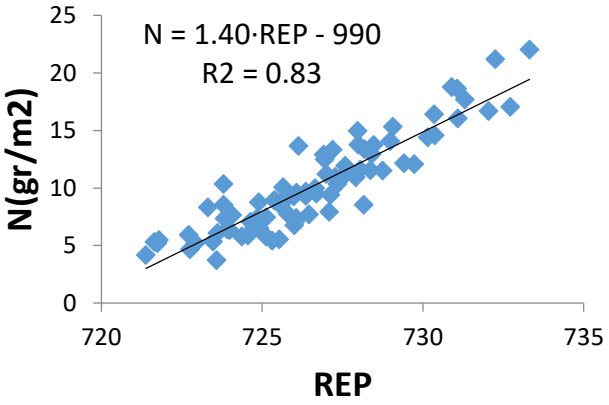


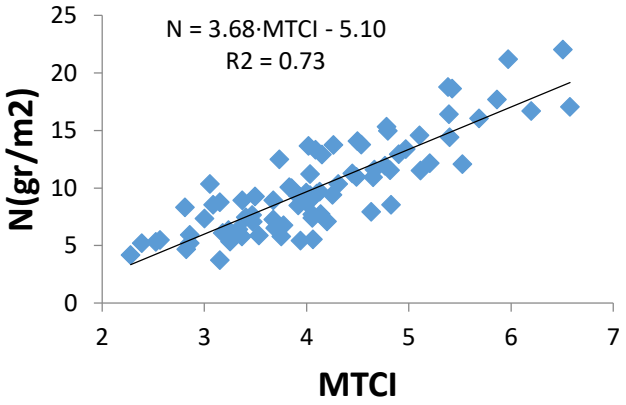
González-Piqueras et al., 2017

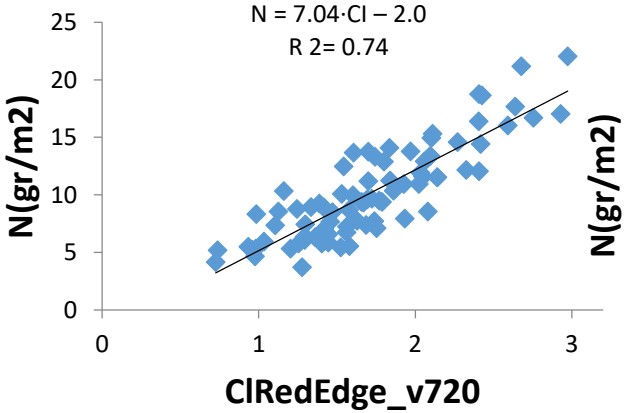
FIELD WORK: N UPTAKE CALIBRATION

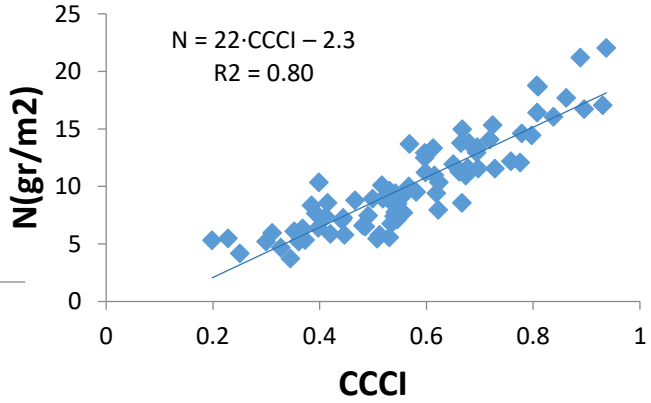
Field Spectroscopy to Support Precision Agriculture

Casa Jara, Casa del Monte & Dehesa los Llanos



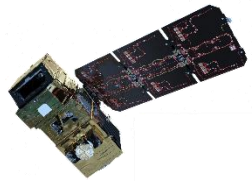




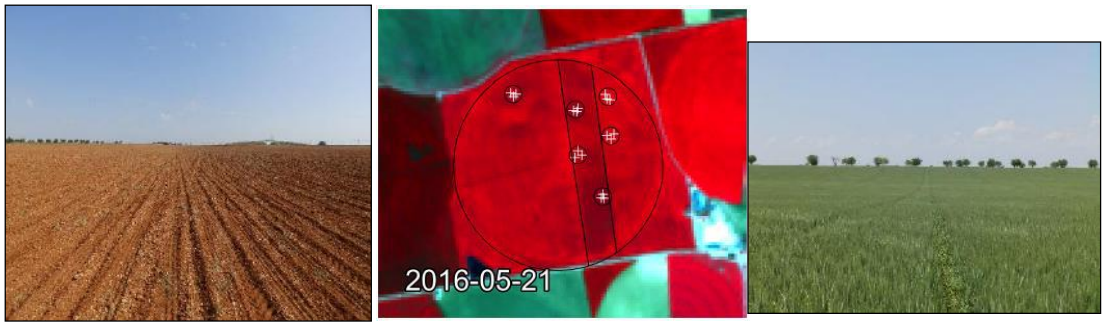


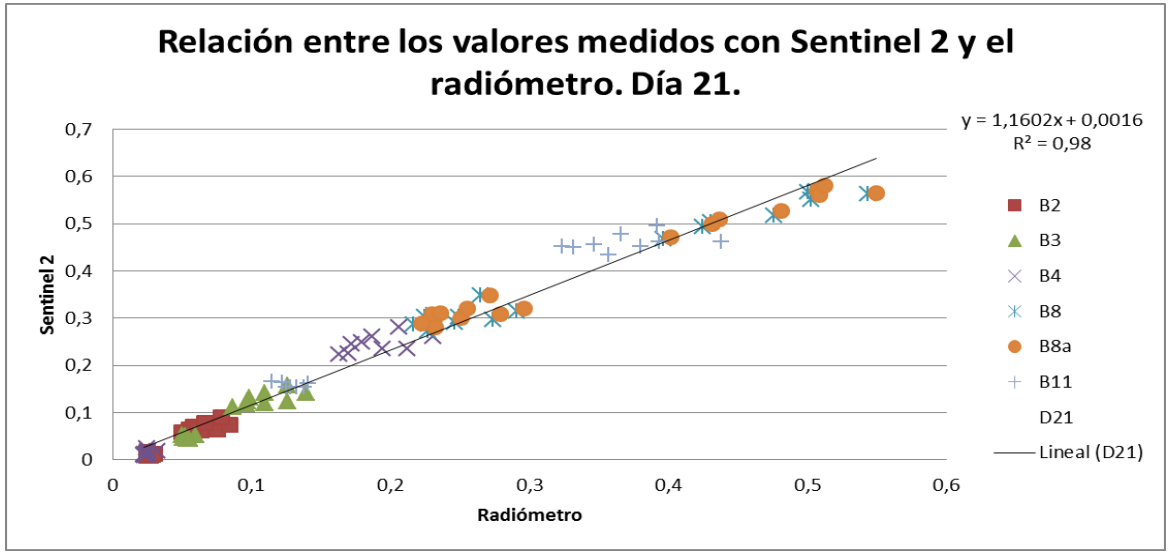
NARROW BAND WHEAT 2016 SPATIAL VALIDATION

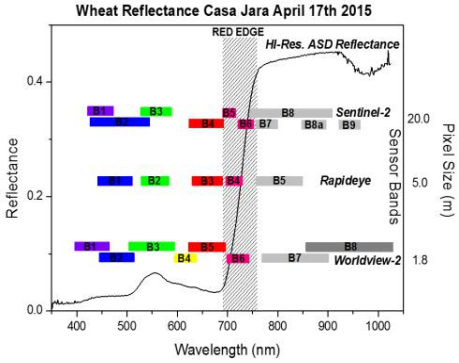
FIELD WORK: S2 ATMOSPHERIC CORRECTION



Atmospheric correction (sen2cor)

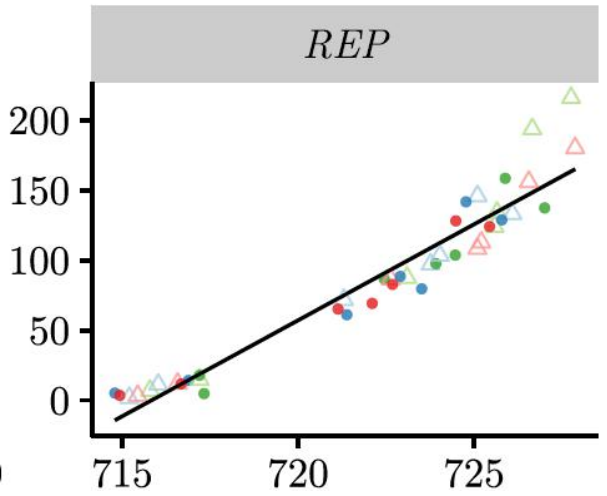


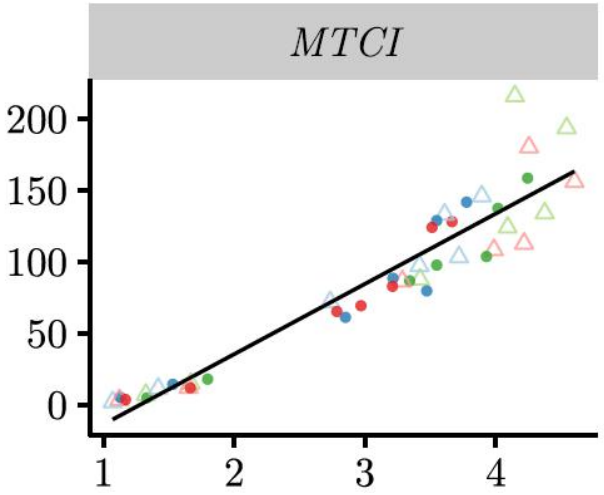


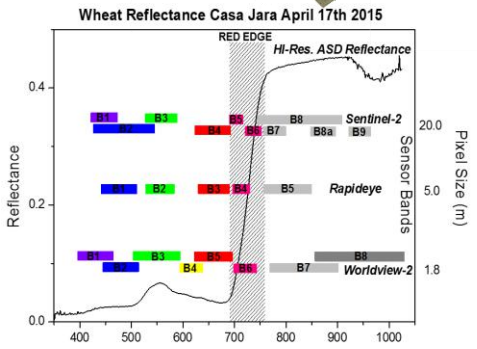


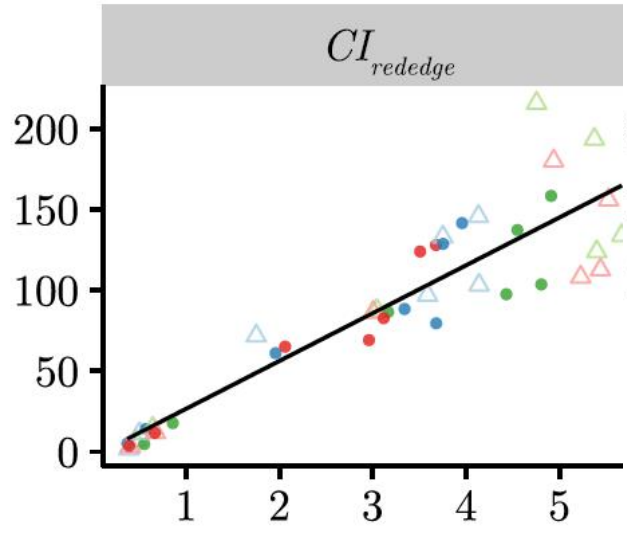
Adrián Moncholí, 2016

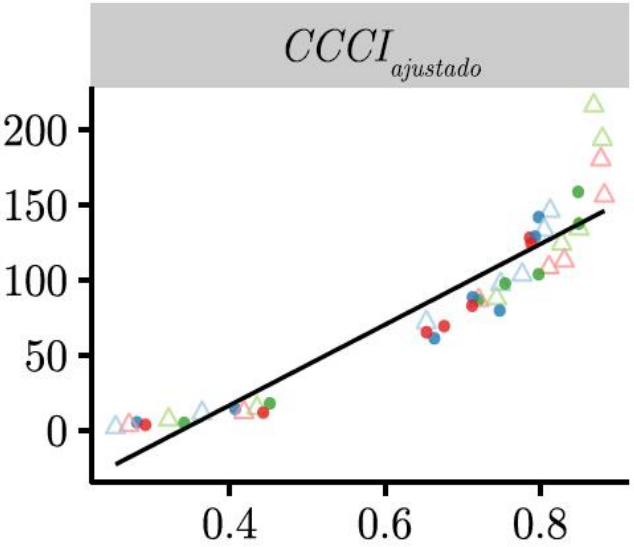
FIELD WORK: S2 NNI MAP

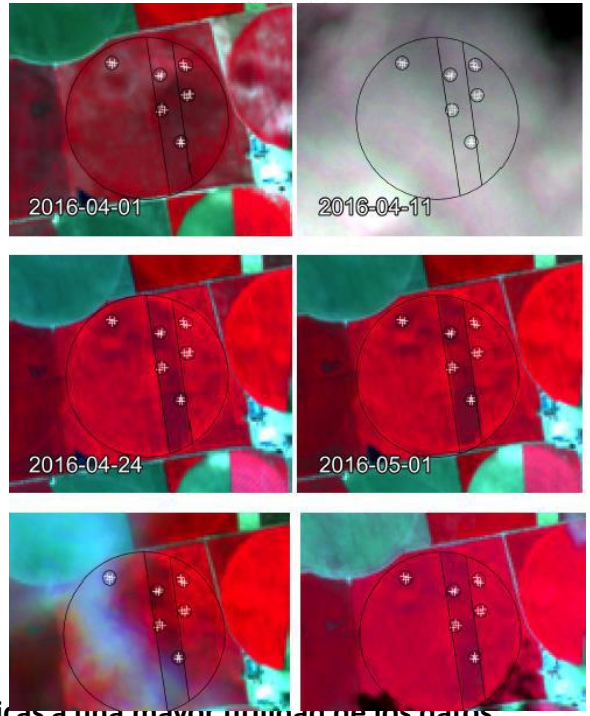






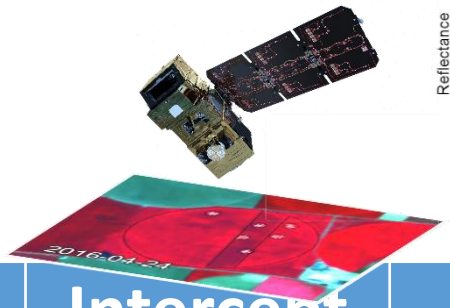


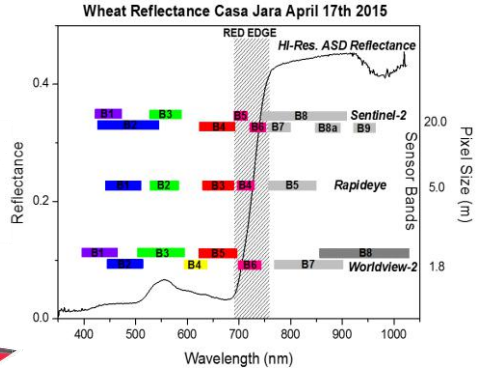




FIELD WORK: S2 NNI MAP

Resultados del ajuste en Casa Jara de los índices red-edge obtenidos de las imágenes de Sentinel 2A frente a QN medido en campo.





Index	Slope (m)	Intercept (n)	R^2
REP	1.37 ±0.06	-980 ±40	0.87
MTCI	**4.9 ±0.2**	**-6.3 ±0.8**	**0.89**
CI_{RE}	3.0 ±0.5	-3.0 ±0.6	0.84
NDRE	27 ±2	-4 ±1	0.81
AIVI	-	-	-
CCCI	26.7 ±1.2	-9.0 ±0.5	0.87

Indirect Nitrogen Nutrition Index (NNI) map on wheat 21st May 2016, from Red-Edge Sentinel 2A bands

Albacete (Casa Jara), Spain

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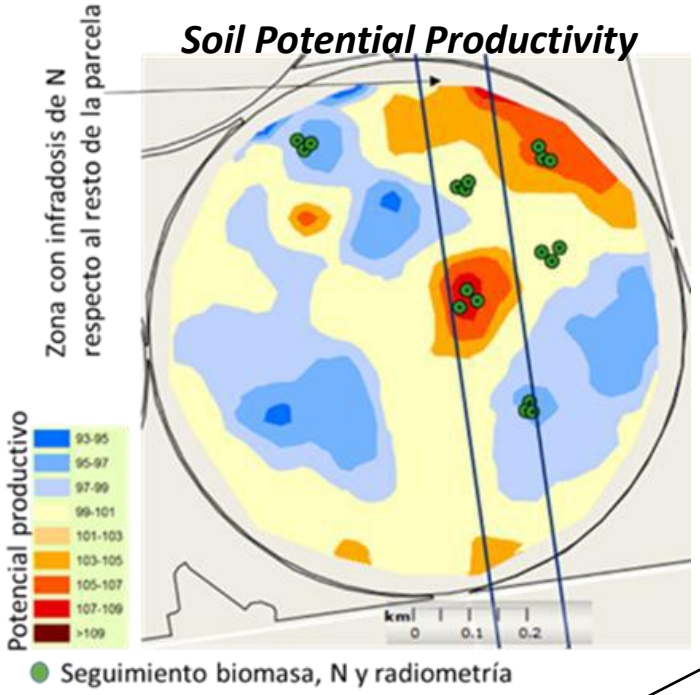
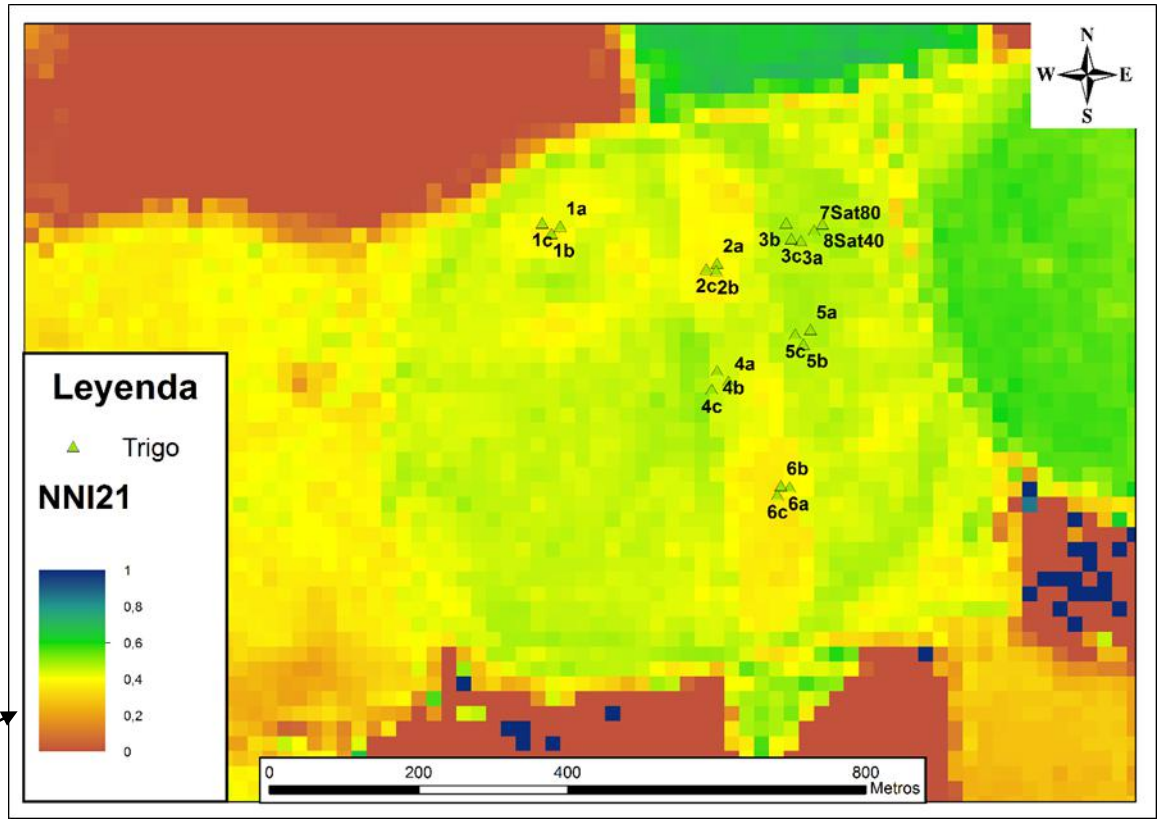
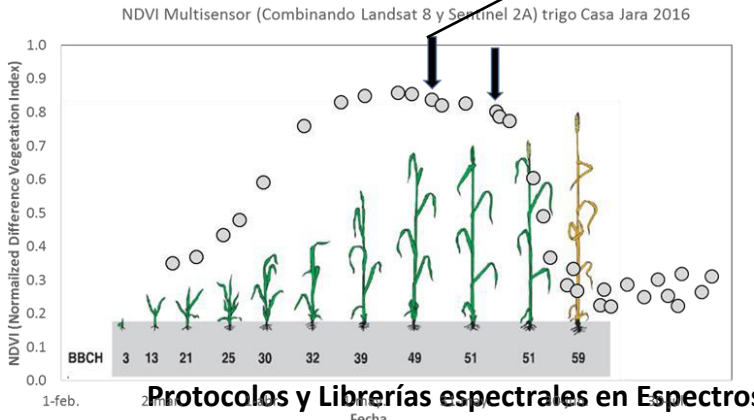
TELEDETECCIÓN Y SIG



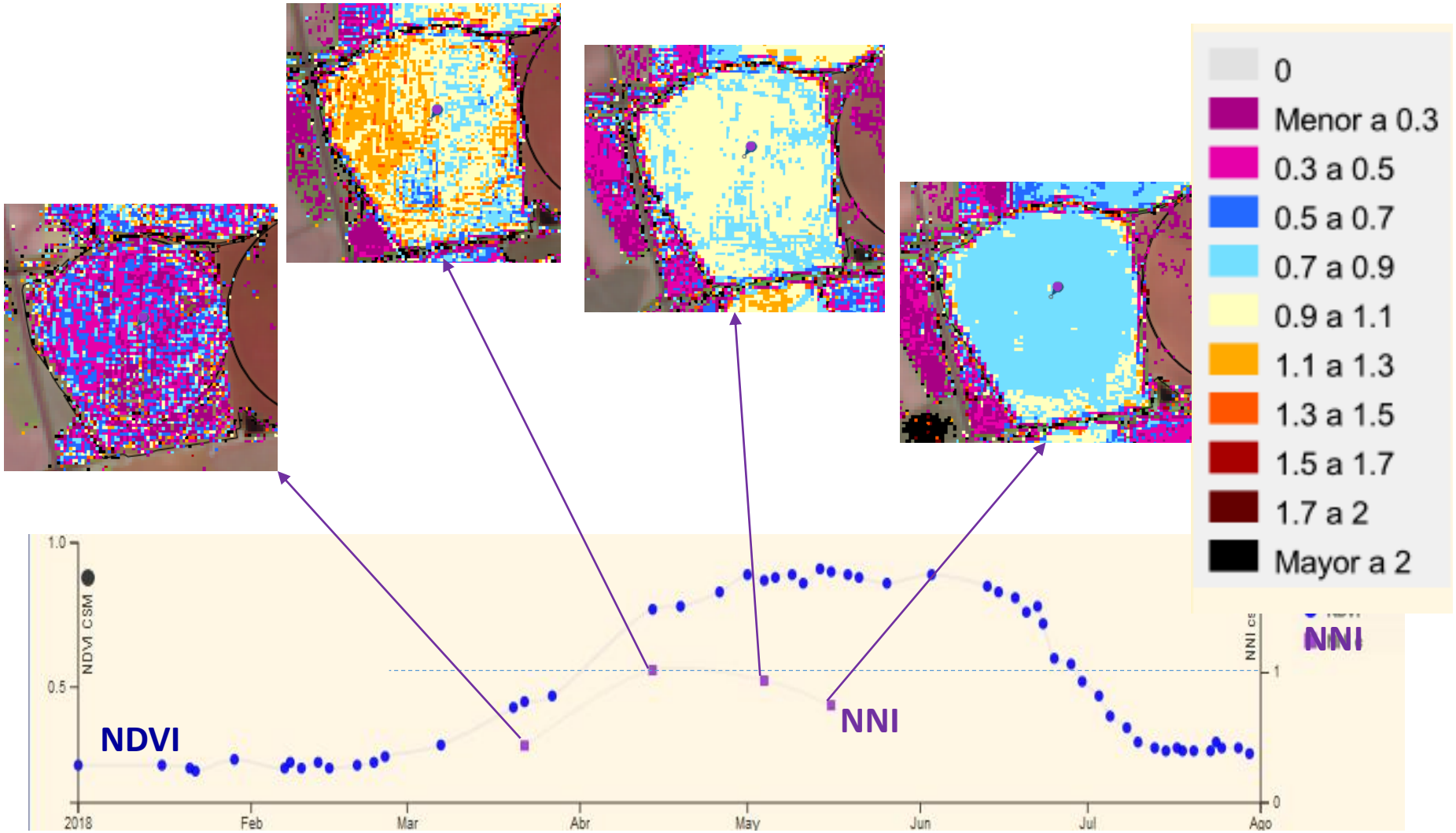




FIELD WORK: NNI MAP DECISION SUPPORT

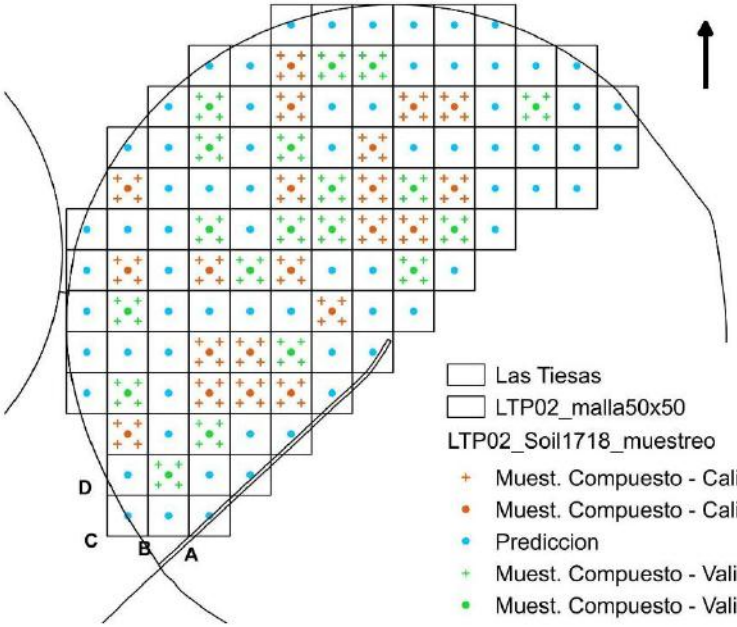
UCLM UNIVERSIDAD DE CASTILLA-LA MANCHA
TELEDETECCIÓN Y SIG

Field Spectroscopy to Support Precision Agriculture

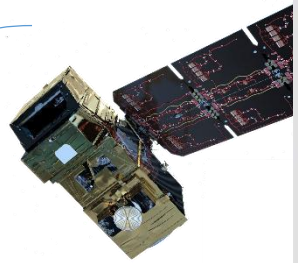


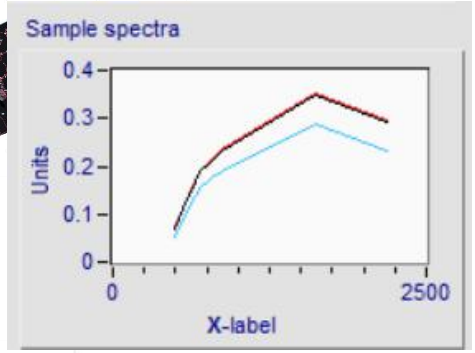
FIELD WORK: SOIL

Field Spectroscopy to Support Precision Agriculture



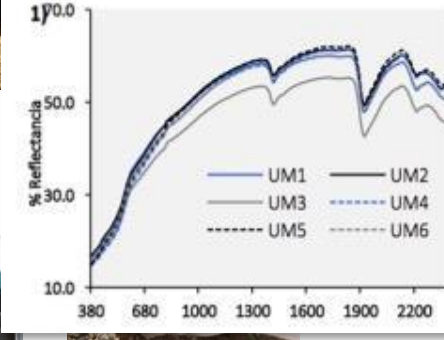
SATELLITE





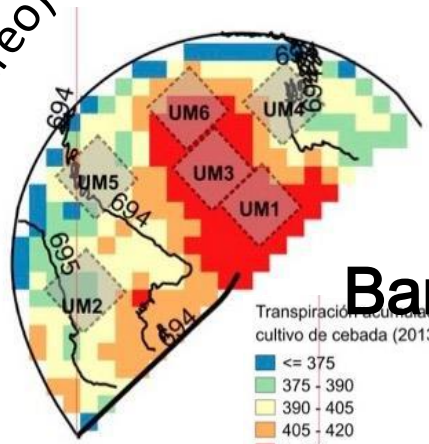
FIELD

DIRECT MEASUREMENT



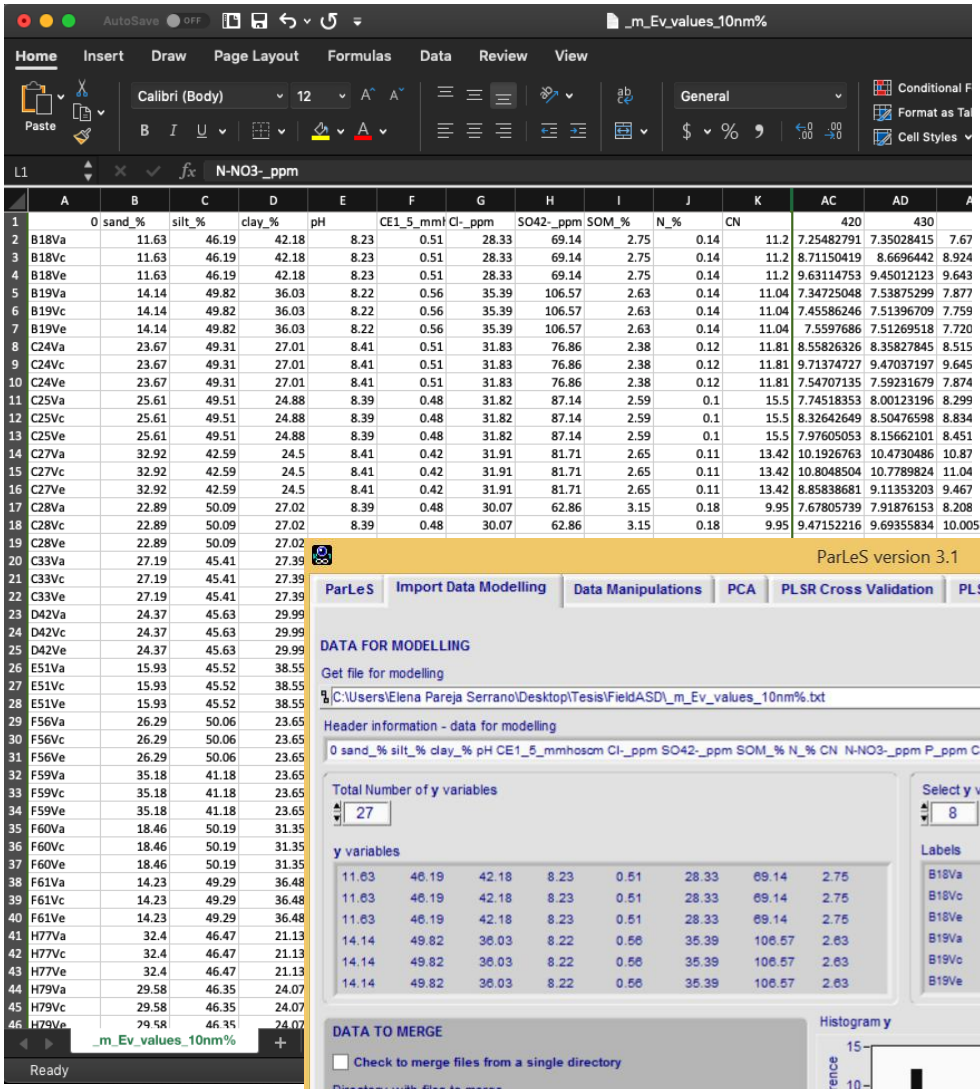
LABORATORY

Áreas 1 ha: 6 **UM** (Unidades de Muestreo)

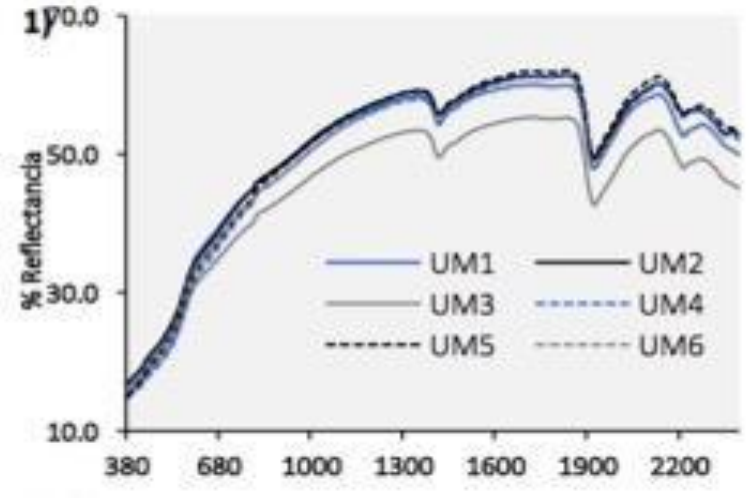


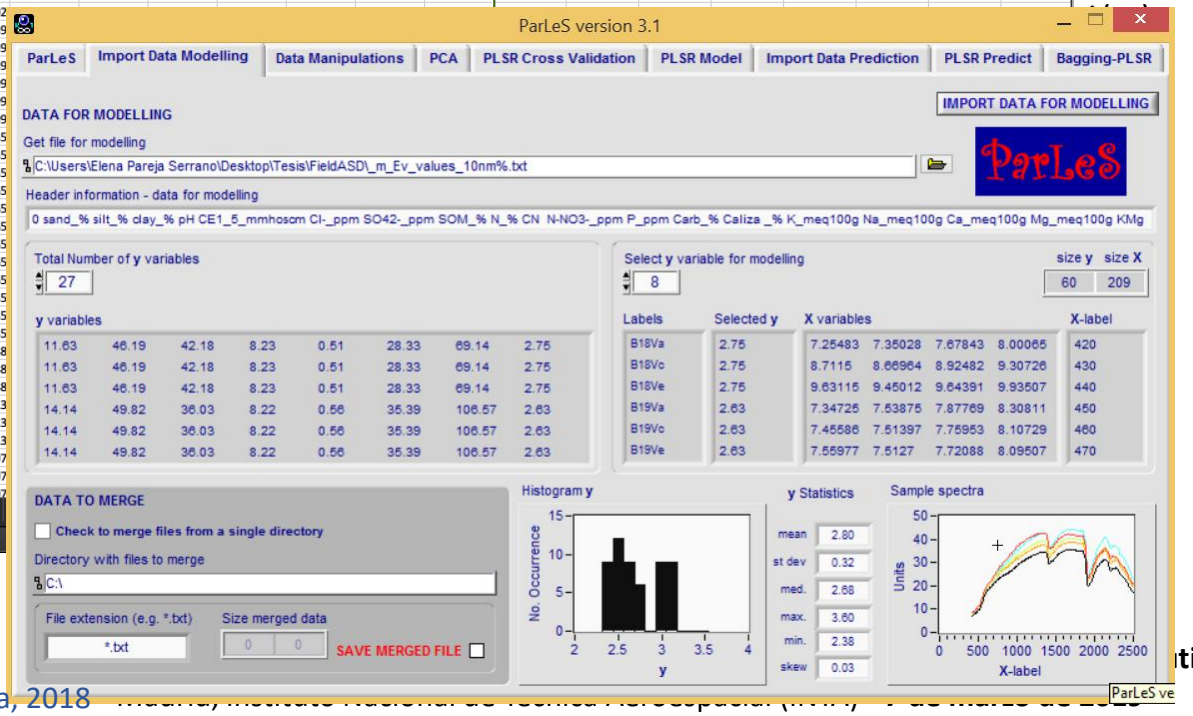
Barley

DATA PROCESS: SOIL



	A	B	C	D	E	F	G	H	I	J	K	AC	AD
1		0 sand_%	silt_%	clay_%	pH	CE1_5_mmh	Cl-_ppm	SO42-_ppm	SOM_%	N_%	CN	420	430
2	B18Va	11.63	46.19	42.18	8.23	0.51	28.33	69.14	2.75	0.14	11.2	7.25482791	7.35028415
3	B18Vc	11.63	46.19	42.18	8.23	0.51	28.33	69.14	2.75	0.14	11.2	8.71150419	8.6696442
4	B18Ve	11.63	46.19	42.18	8.23	0.51	28.33	69.14	2.75	0.14	11.2	9.63114753	9.45012123
5	B19Va	14.14	49.82	36.03	8.22	0.56	35.39	106.57	2.63	0.14	11.04	7.34725048	7.53875299
6	B19Vc	14.14	49.82	36.03	8.22	0.56	35.39	106.57	2.63	0.14	11.04	7.45586246	7.51396709
7	B19Ve	14.14	49.82	36.03	8.22	0.56	35.39	106.57	2.63	0.14	11.04	7.5597686	7.51269518
8	C24Va	23.67	49.31	27.01	8.41	0.51	31.83	76.86	2.38	0.12	11.81	8.55826326	8.35827845
9	C24Vc	23.67	49.31	27.01	8.41	0.51	31.83	76.86	2.38	0.12	11.81	9.71374727	9.47037197
10	C24Ve	23.67	49.31	27.01	8.41	0.51	31.83	76.86	2.38	0.12	11.81	7.54707135	7.59231679
11	C25Va	25.61	49.51	24.88	8.39	0.48	31.82	87.14	2.59	0.1	15.5	7.74518353	8.00123196
12	C25Vc	25.61	49.51	24.88	8.39	0.48	31.82	87.14	2.59	0.1	15.5	8.32642649	8.50476598
13	C25Ve	25.61	49.51	24.88	8.39	0.48	31.82	87.14	2.59	0.1	15.5	7.97605053	8.15662101
14	C27Va	32.92	42.59	24.5	8.41	0.42	31.91	81.71	2.65	0.11	13.42	10.1926763	10.4730486
15	C27Vc	32.92	42.59	24.5	8.41	0.42	31.91	81.71	2.65	0.11	13.42	10.8048504	10.7789824
16	C27Ve	32.92	42.59	24.5	8.41	0.42	31.91	81.71	2.65	0.11	13.42	8.85838681	9.11353203
17	C28Va	22.89	50.09	27.02	8.39	0.48	30.07	62.86	3.15	0.18	9.95	7.67805739	7.91876153
18	C28Vc	22.89	50.09	27.02	8.39	0.48	30.07	62.86	3.15	0.18	9.95	9.47152216	9.69355834
19	C28Ve	22.89	50.09	27.02									
20	C33Va	27.19	45.41	27.39									
21	C33Vc	27.19	45.41	27.39									
22	C33Ve	27.19	45.41	27.39									
23	D42Va	24.37	45.63	29.99									
24	D42Vc	24.37	45.63	29.99									
25	D42Ve	24.37	45.63	29.99									
26	E51Va	15.93	45.52	38.55									
27	E51Vc	15.93	45.52	38.55									
28	E51Ve	15.93	45.52	38.55									
29	F56Va	26.29	50.06	23.65									
30	F56Vc	26.29	50.06	23.65									
31	F56Ve	26.29	50.06	23.65									
32	F59Va	35.18	41.18	23.65									
33	F59Vc	35.18	41.18	23.65									
34	F59Ve	35.18	41.18	23.65									
35	F60Va	18.46	50.19	31.35									
36	F60Vc	18.46	50.19	31.35									
37	F60Ve	18.46	50.19	31.35									
38	F61Va	14.23	49.29	36.48									
39	F61Vc	14.23	49.29	36.48									
40	F61Ve	14.23	49.29	36.48									
41	H77Va	32.4	46.47	21.13									
42	H77Vc	32.4	46.47	21.13									
43	H77Ve	32.4	46.47	21.13									
44	H79Va	29.58	46.35	24.07									
45	H79Vc	29.58	46.35	24.07									
46	H79Ve	29.58	46.35	24.07									



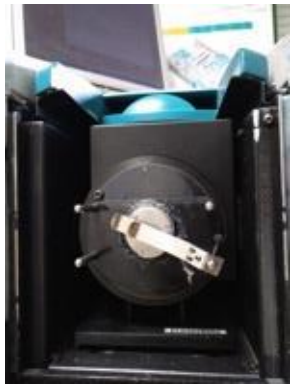


Protocolos y **tilidad de los datos**

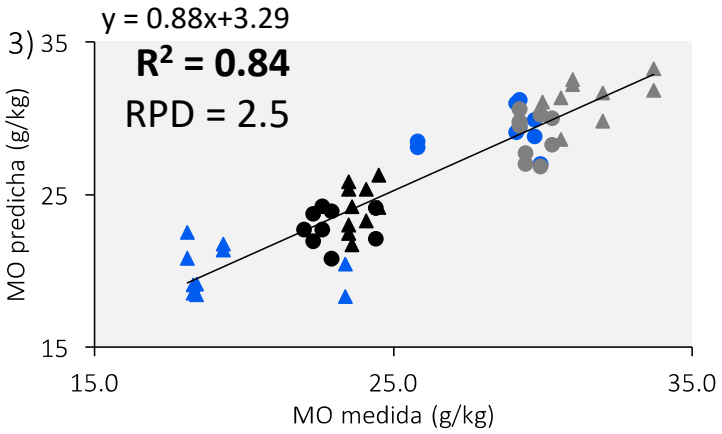
DATA PROCESS: SOIL

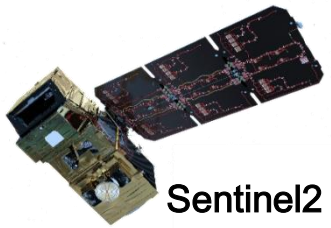
Field Spectroscopy to Support Precision Agriculture

MO: Organic Matter



Integrating Sphere-Laboratory

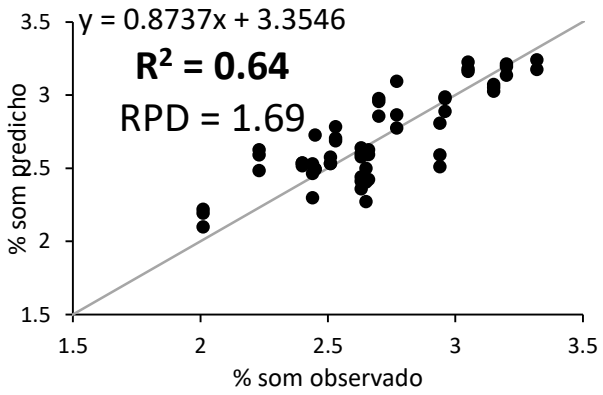




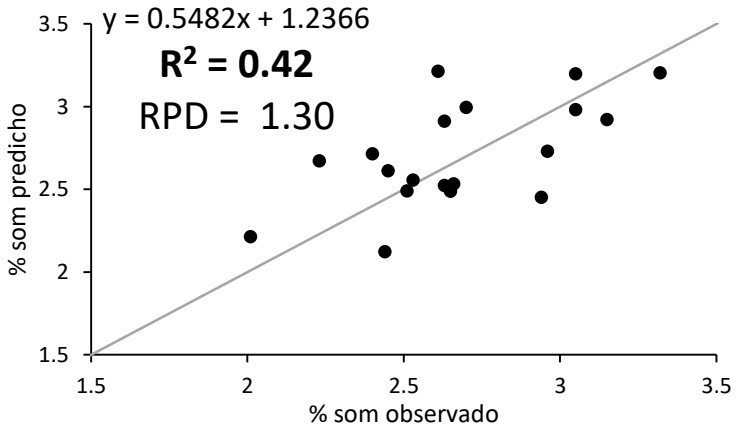
Sentinel2 – remoto

Radiómetro-En campo

ASD field

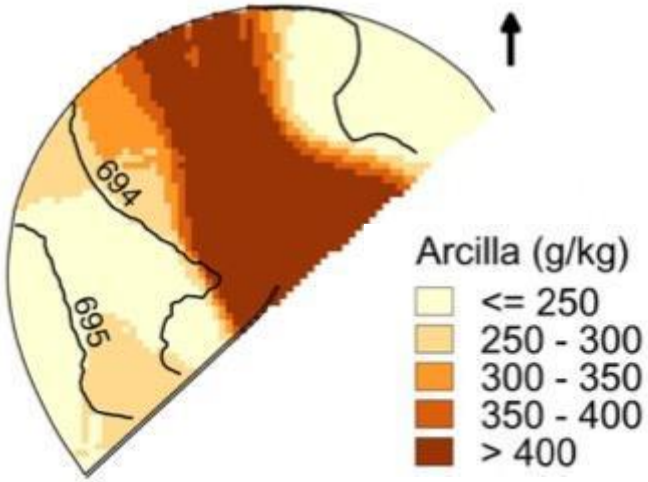


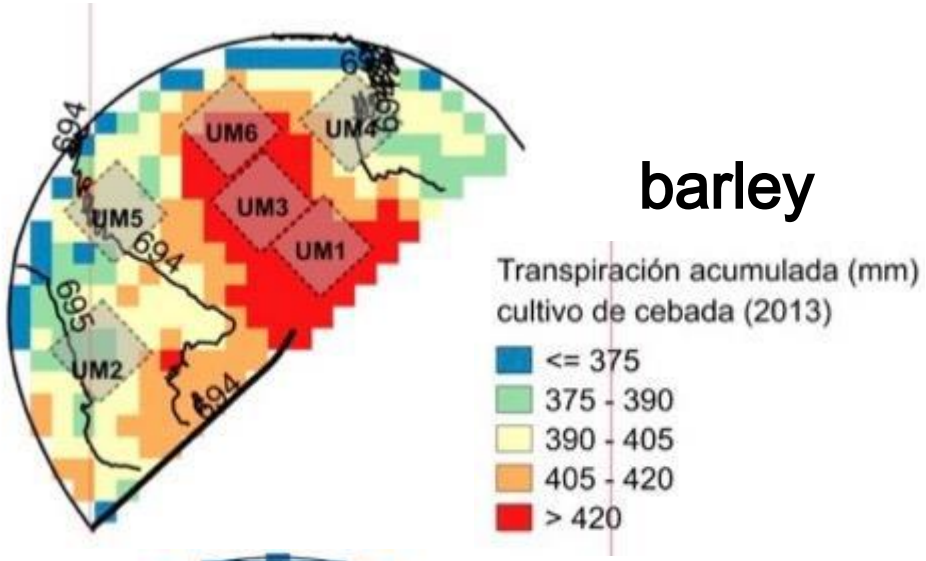
7 nov. 2017

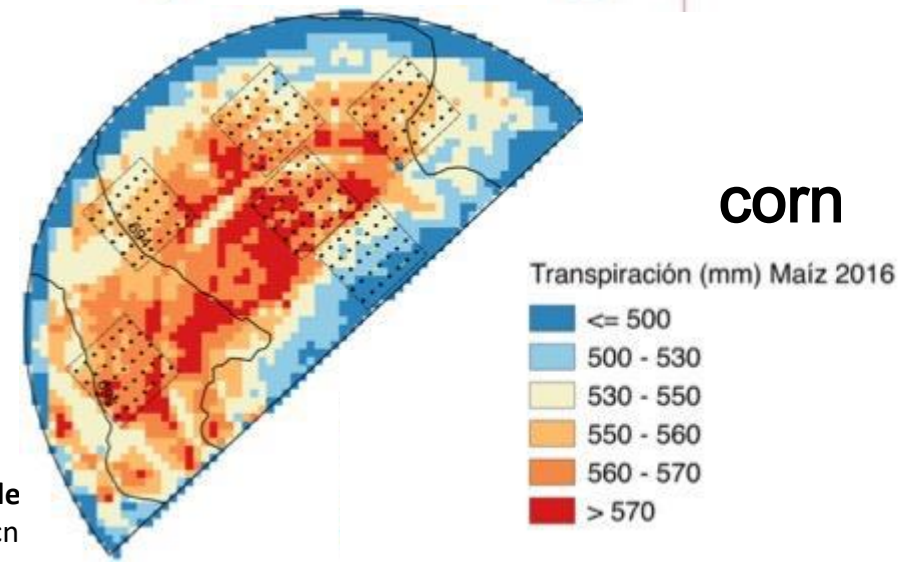


DATA PROCESS: SOIL

Clay– transpiration







CONCLUSIONS

- Provide reliable (guarantee quality) data to users (UAV & Satellite).
- Instruments at field are operational.
- Radiometry is implemented in the information supplied to the users.

AKNOWLEDGEMENTS

FATIMA

(**FA**rming **T**ools for external nutrient **I**nputs and water **MA**nagement)

European Union´s Horizon 2020 (G. A. Nº 633945).

Unión Europea

HERMANA

(**HER**ramienta para el **M**Anejo de fertilización **N**itrogenada y **A**gua sostenible)

Spanish Ministry of Economy and Competitiveness (AGL2015-68700-R)

Unión Europea
Fondo Europeo de Desarrollo Regional
"Una manera de hacer Europa"

MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

ANIATEL

[Optimización en el uso del agua y del nitrógeno en el cultivo del almendro a través de prácticas agronómicas y técnicas de teledetección]

SBPLY/17/180501/000357

Castilla-La Mancha

Unión Europea