Monitoring maize N status with airborne and ground level sensors

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Outline

I. Introduction:
   - Maize N dynamic
   - Available N sensors

II. Experimental setup

III. Results:
   - Fertiliser rate vs. N uptake
   - Remote sensor predicting N content
   - Scale resolution effect

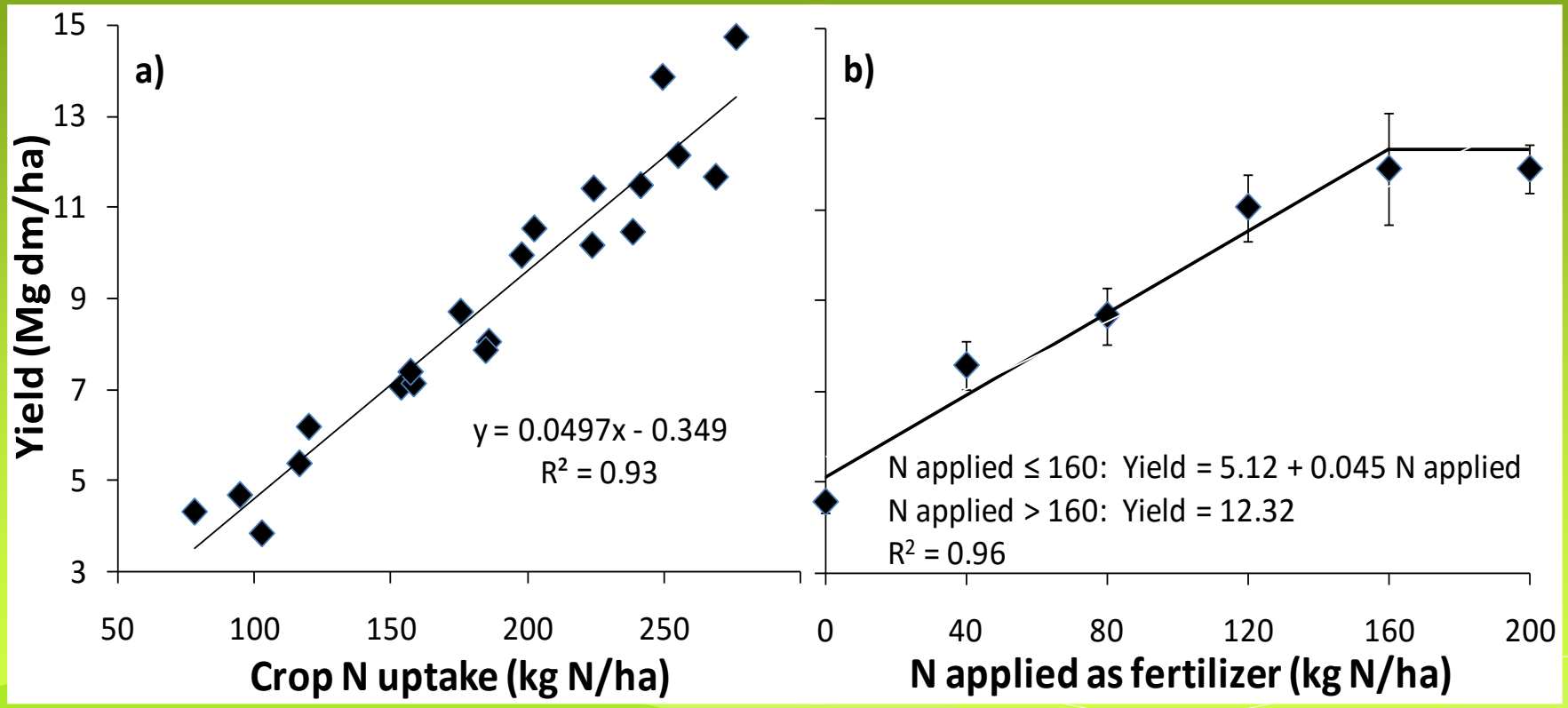
IV. Conclusions

I. Maize N dynamic

Maize yield:

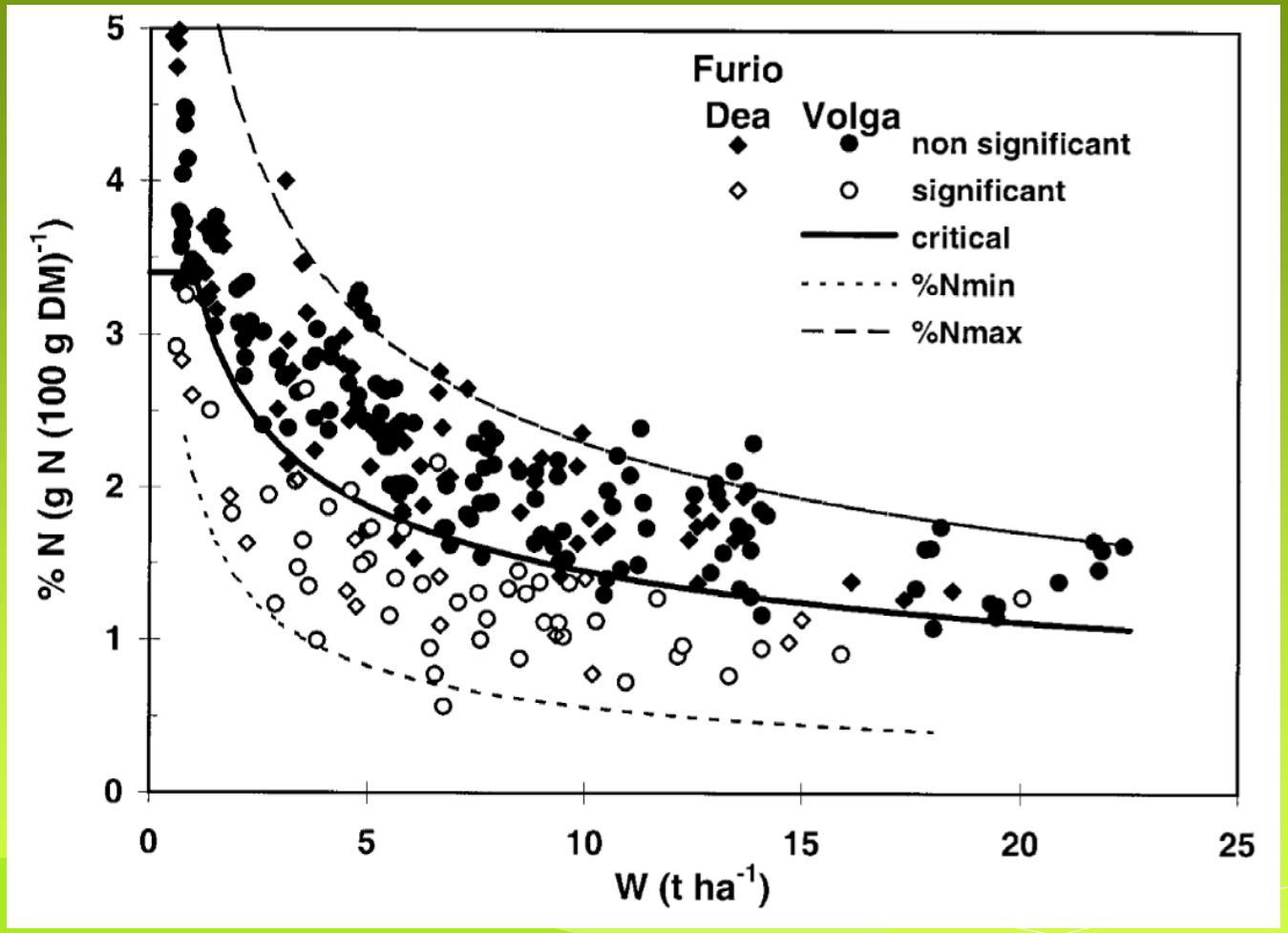
vs. crop N uptake

vs. N applied as fertilizer



From: Quemada et al. 2014. Remote Sensing 6, 2940-2962

I. Maize N dynamic



From: Plénet & Lemaire, 2000. Plant and Soil 216, 65-82

I. Available N sensors

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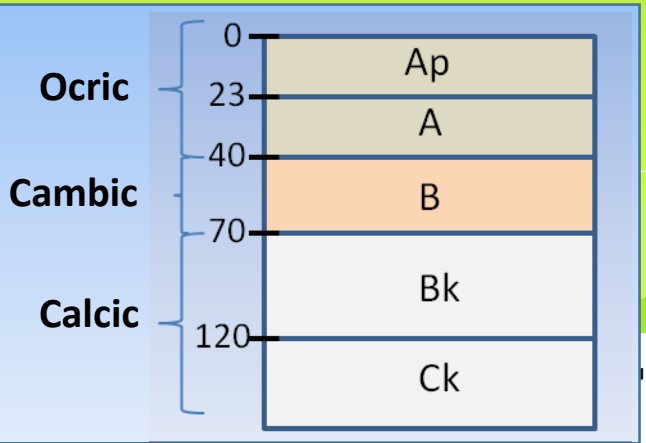
II. Experimental setup

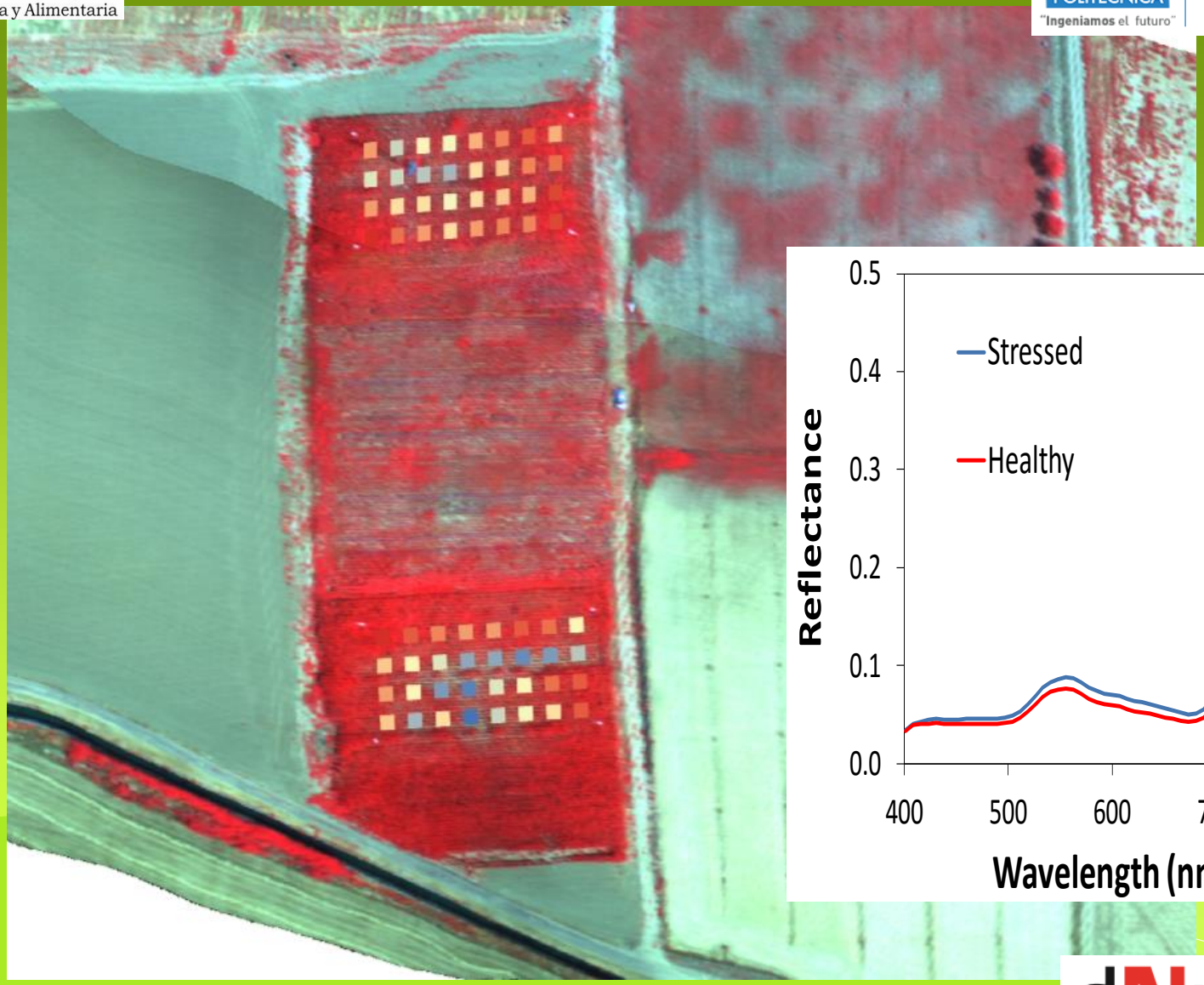
- **Field Station "La Chimenea"**
- **Zone: Tajo river basin**
- **Climatic conditions:**
  - Mediterranean semiarid
  - Monoxeric with 4 dry months (June to September)
  - Average annual temperatures:
    - 20.5 ºC maximum
    - 14 ºC mean
    - 6.5 ºC minimum
  - Average annual rainfall: 350 mm
  - ETo 753 mm

Clasification { **Typic calcixerept** (Soil Survey Staff, 2003) / **Haplic calcisol** (FAO-UNESCO, 1988)

- Silty clay loam texture pH≈8 OM≈2%
- Polygenic origin soil appropriate for irrigation
- Friable structure and porous along the profile
- Without erosion, compactation, inundation, and with low stone content throughout the profile



II. Experimental setup

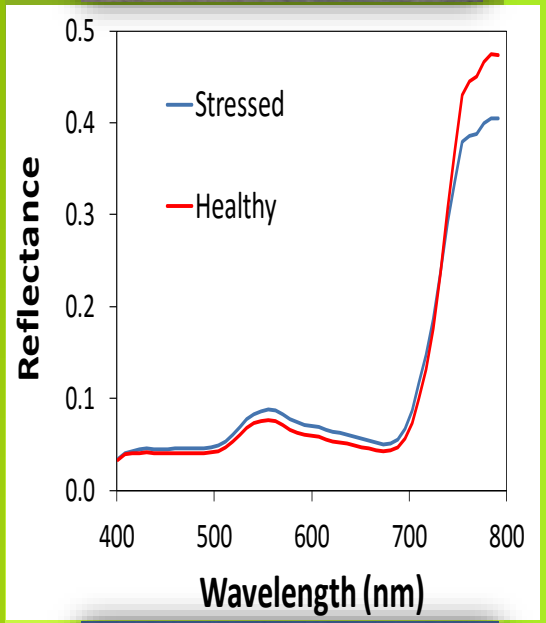


II. Experimental setup

Index	Definition
	SPAD
SPAD	Ratio of transmitted light at the red and infrared wavelengths
	Dualex® Scientific
Chl	Ratio of transmitted light at two infrared wavelengths
Flav	Log of the fluerescence emission ratio at the red and UV wavelengths
NBI	Nitrogen Balance Index = Chl / FlavI

II. Experimental setup

Index	Equation
Structural indices	
**Normalized difference vegetation index (NDVI)	$NDVI = (R_{800} - R_{670})/(R_{800} + R_{670})$
**Renormalized difference vegetation index (RDVI)	$RDVI = (R_{800} - R_{670})/(R_{800} + R_{670})^{.5}$
**Optimized soil-adjusted vegetation index (OSAVI)	$OSAVI = (1 + 0.16) \times (R_{800} - R_{670})/(R_{800} + R_{670} + 0.16)$
Chlorophyll indices	
Red edge reflectance index	R_{750}/R_{710}
Double peak canopy nitrogen index (DCNI)	$DCNI = (R_{720} - R_{700})/(R_{700}-R_{670})/(R_{720} - R_{760}+0.16)$
**Transformed Chlorophyll absorption in reflectance index (TCARI)	$TCARI = 3 [(R_{700} - R_{670}) - 0.2 (R_{700} - R_{550})/(R_{700}/R_{670})]$
**Combined TCARI/OSAVI	TCARI/OSAVI
Xanthophyll indices	
Photochemical reflectance index (PRI)	$PRI = (R_{570} - R_{539})/(R_{570} + R_{539})$
Normalized photochemical reflectance Index (PRI norm)	$PRI\ norm = (R_{515} - R_{531})/(R_{515} + R_{531})$
Blue/green/red ratio índices	
BGI1	$BGI_1 = R_{400}/R_{550}$
BGI2	$BGI_2 = R_{450}/R_{550}$
Fluorescence retrieval	
Fluorescence (SIF760)	FLD3 method using 2 reference bands (750; 762; 780)



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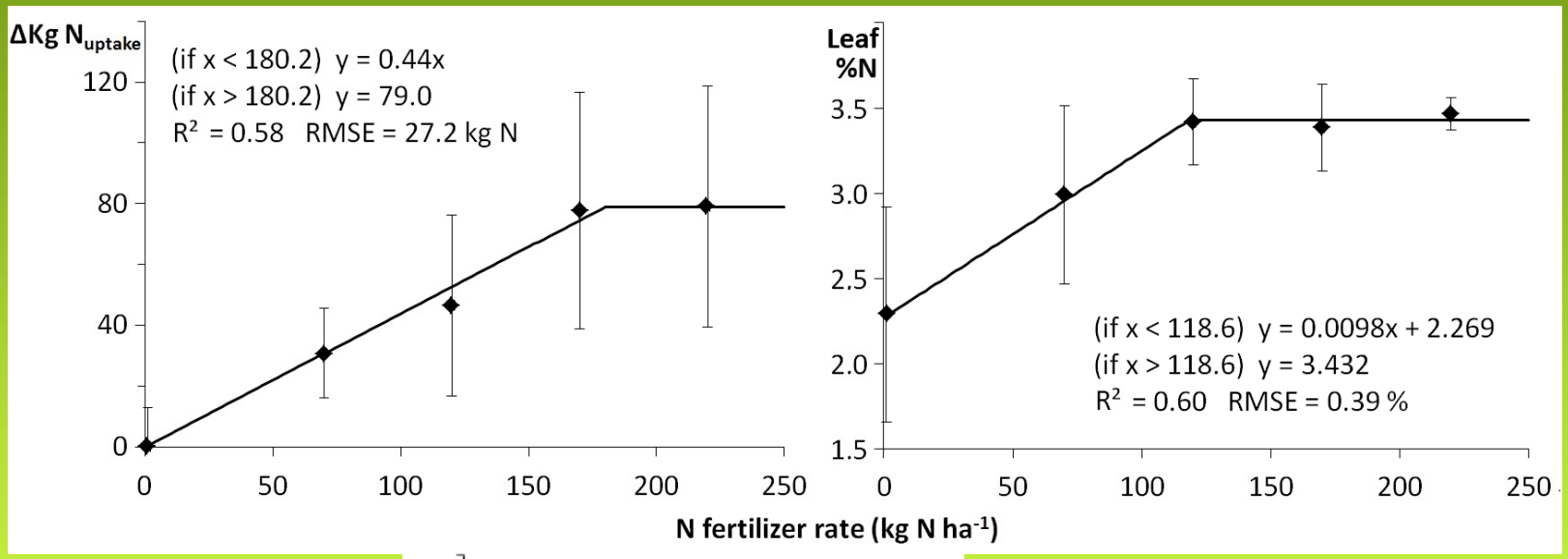
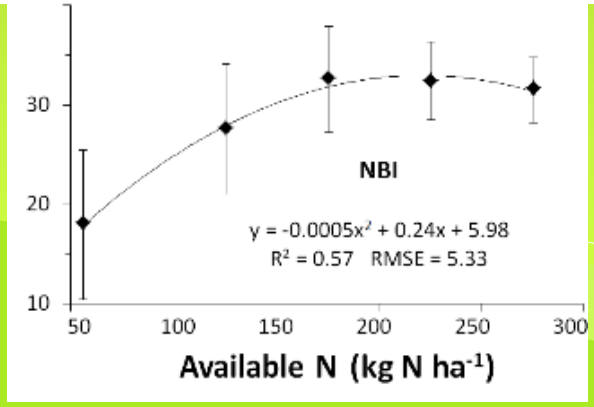
III. Fertiliser rate vs. N uptake





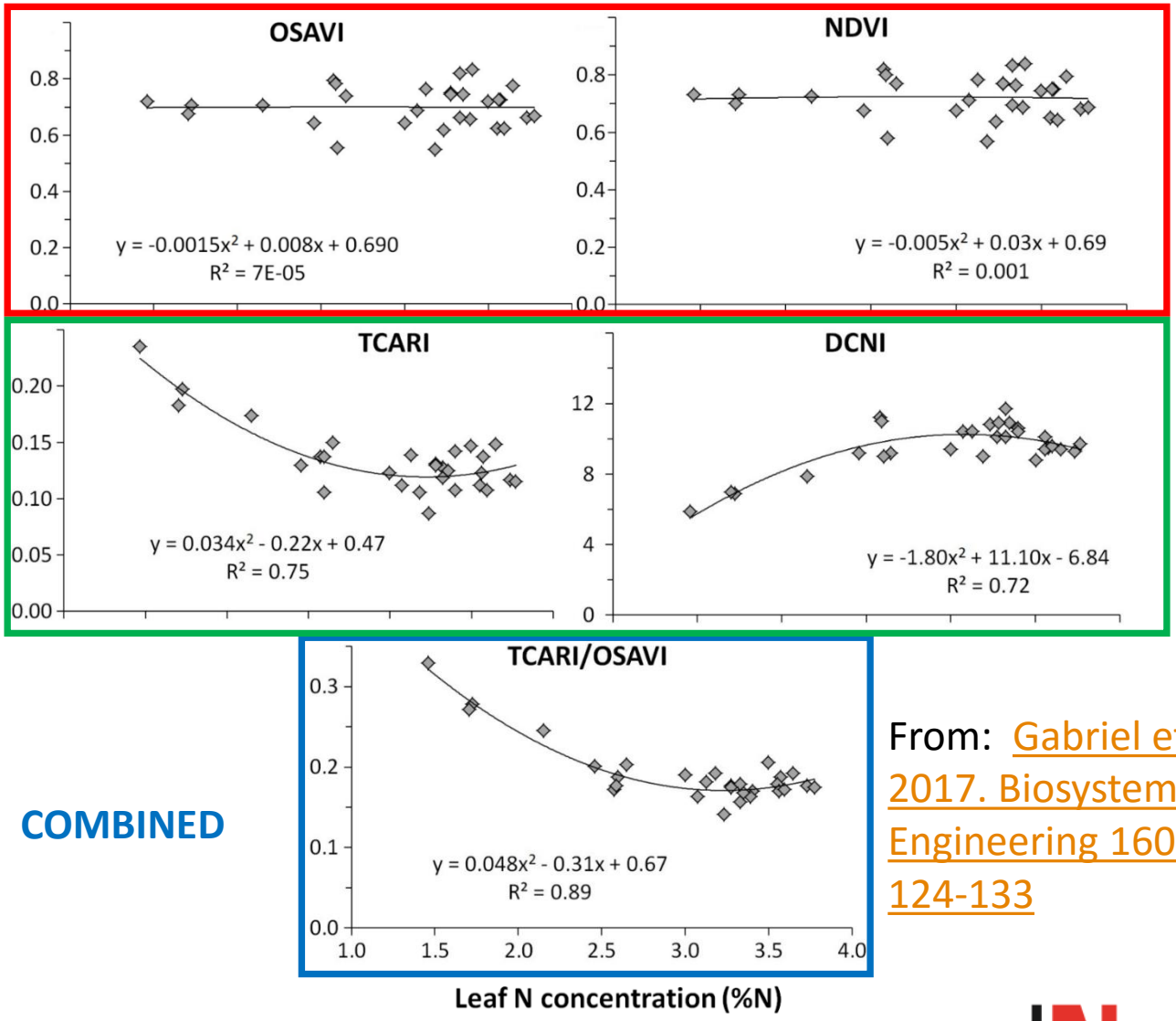
From: Gabriel et al. 2017. Biosystems Engineering 160, 124-133

III. Remote sensor predicting N content

ESTRUCTURAL

PIGMENT

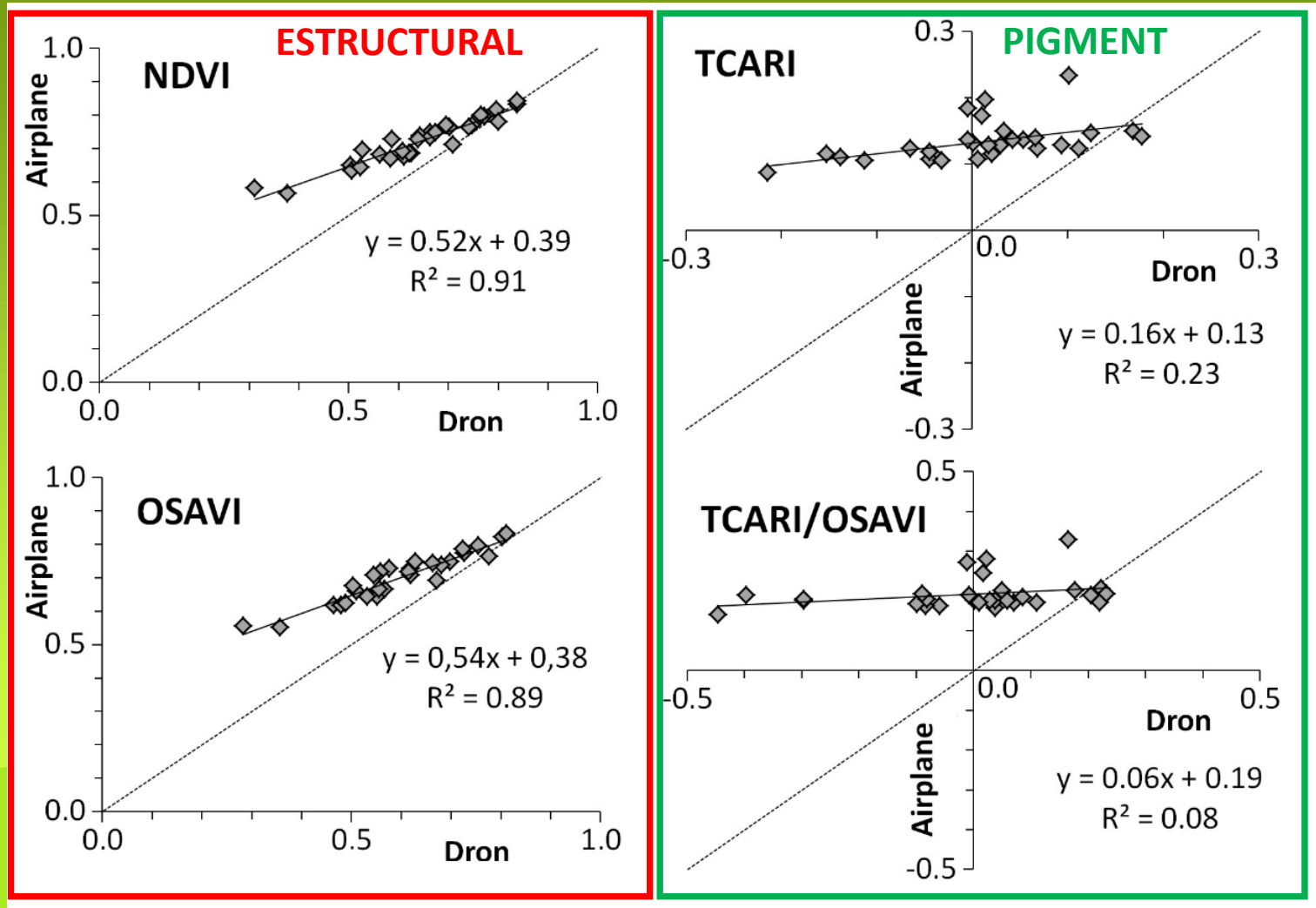
COMBINED



From: Gabriel et al. 2017. Biosystems Engineering 160, 124-133

III. Scale resolution effect

From: Gabriel et al. 2017. Biosystems Engineering 160, 124-133



IV. CONCLUSIONS

- Proximal and airborne sensors provided useful information for the assessment of maize N nutritional status.
- Higher accuracy was obtained with indexes combining chlorophyll estimation with canopy structure (i.e. TCARI/OSAVI for airborne sensors) or with polyphenol indexes (NBI for proximal sensors, avoiding index saturation).
- The spatial resolution (SR) of the acquired image had an effect on the indexes performance: Structural indexes (NDVI, RDVI or OSAVI) presented low dependency of image SR, whereas pigment indexes (as TCARI) were highly influenced by SR because of the background and shadow effect.
- Further research is needed to identify robust indexes across species and stress levels related to plant N concentration for better monitoring crop N nutritional status.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