Detection of symptoms induced by *X. fastidiosa* with high-resolution multispectral satellite data: assessment with airborne hyperspectral imagery

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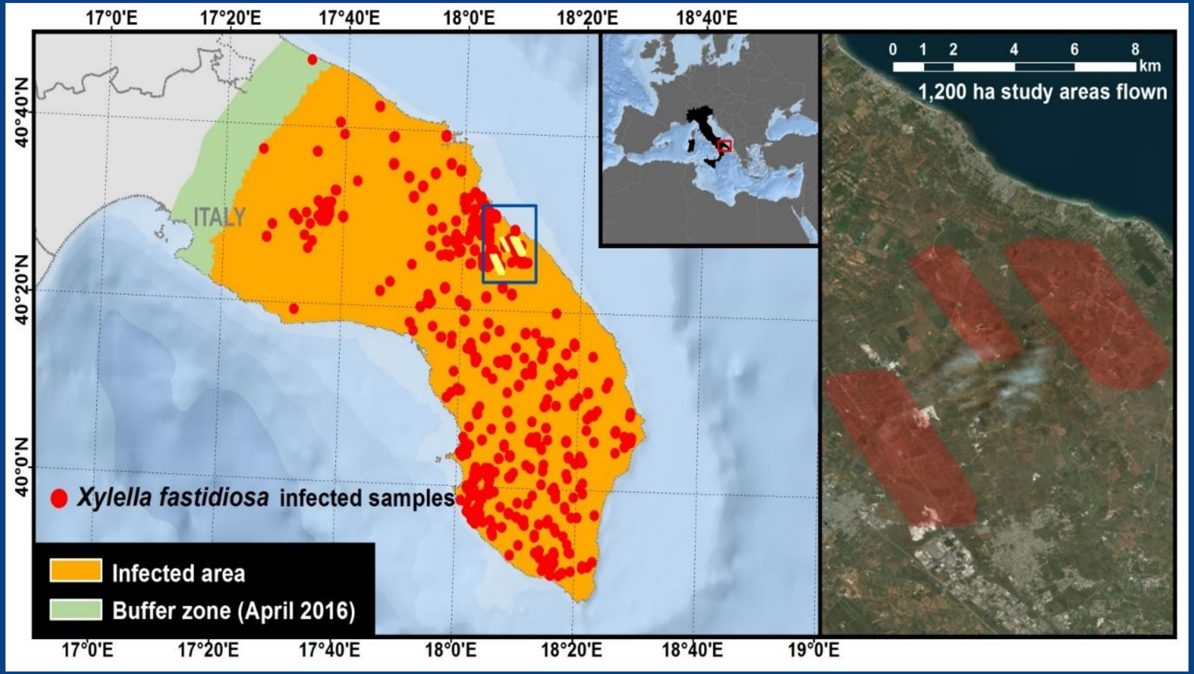
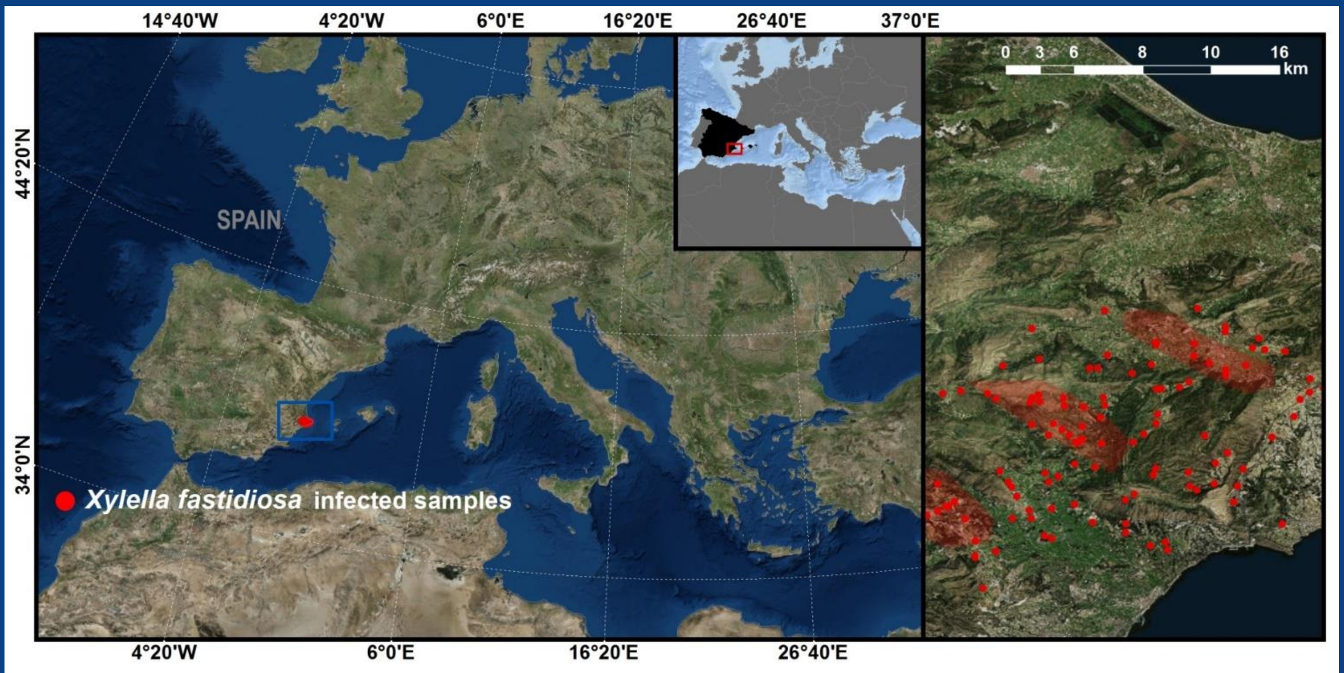
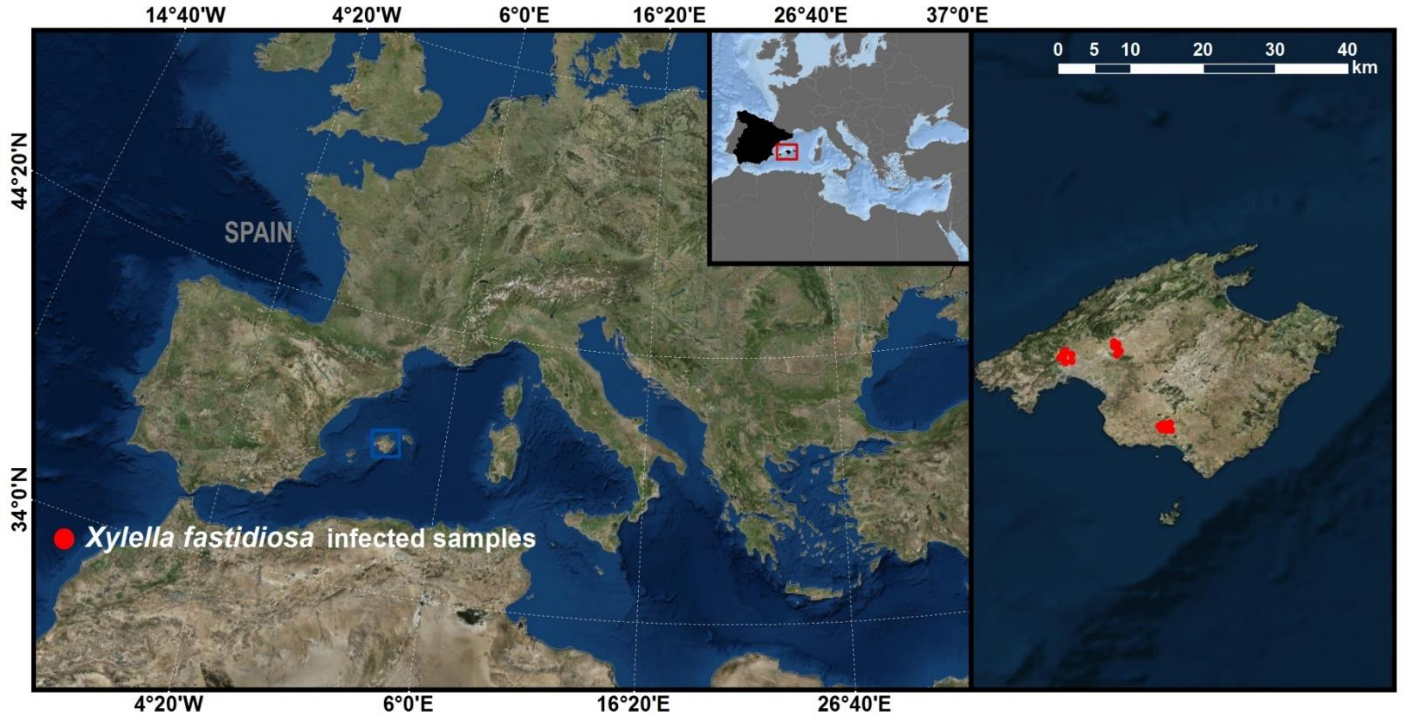




Airborne campaigns in the Puglia region, Italy

Airborne campaigns in Alicante region, mainland Spain

Xf airborne campaigns in Europe – 2016 - 2023

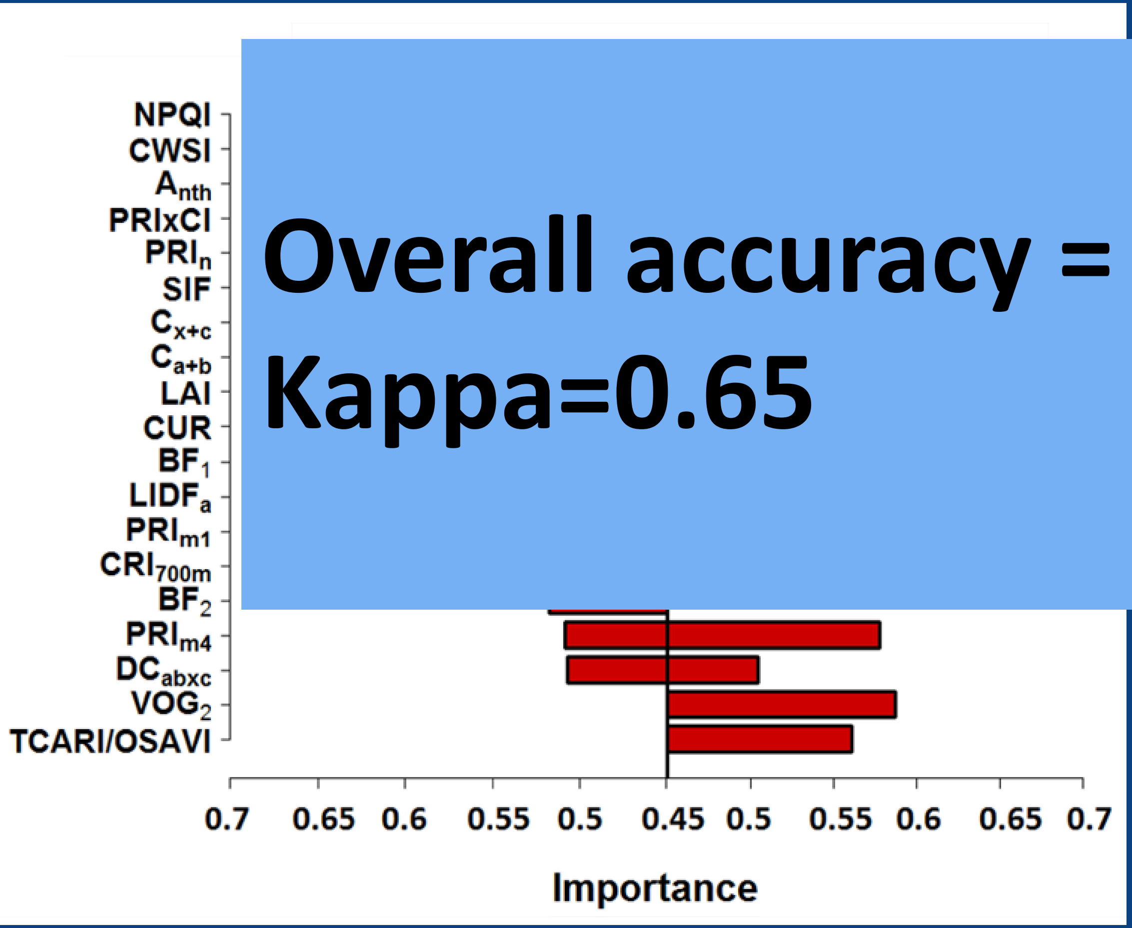


Airborne campaigns in the Balearic Islands, Spain

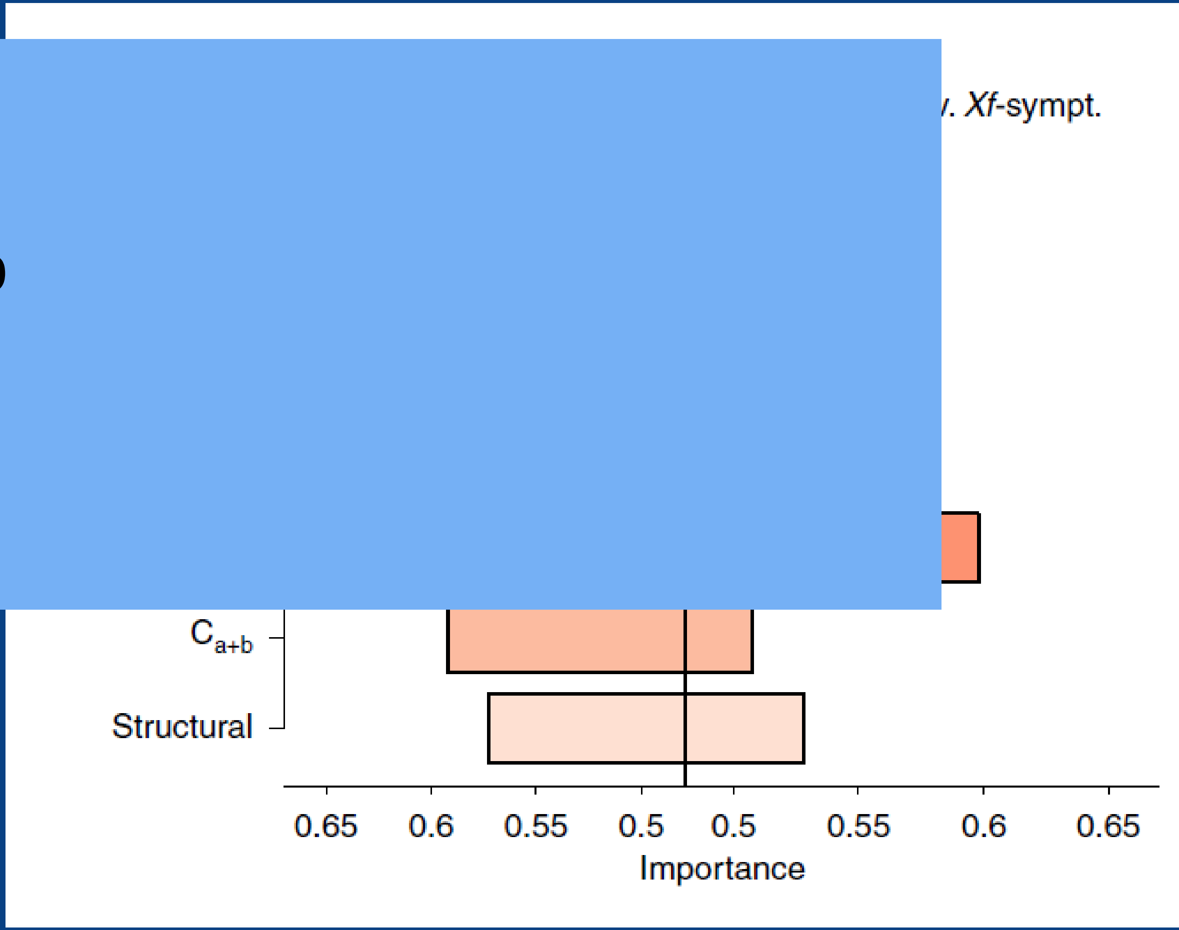
2018

Sensitivity of hyperspectral traits to *Xf* symptoms - olive

Spectral plant traits



Spectral functional groups



Overall accuracy = 80%

Kappa=0.65

Zarco-Tejada *et al.* (2018)

2018

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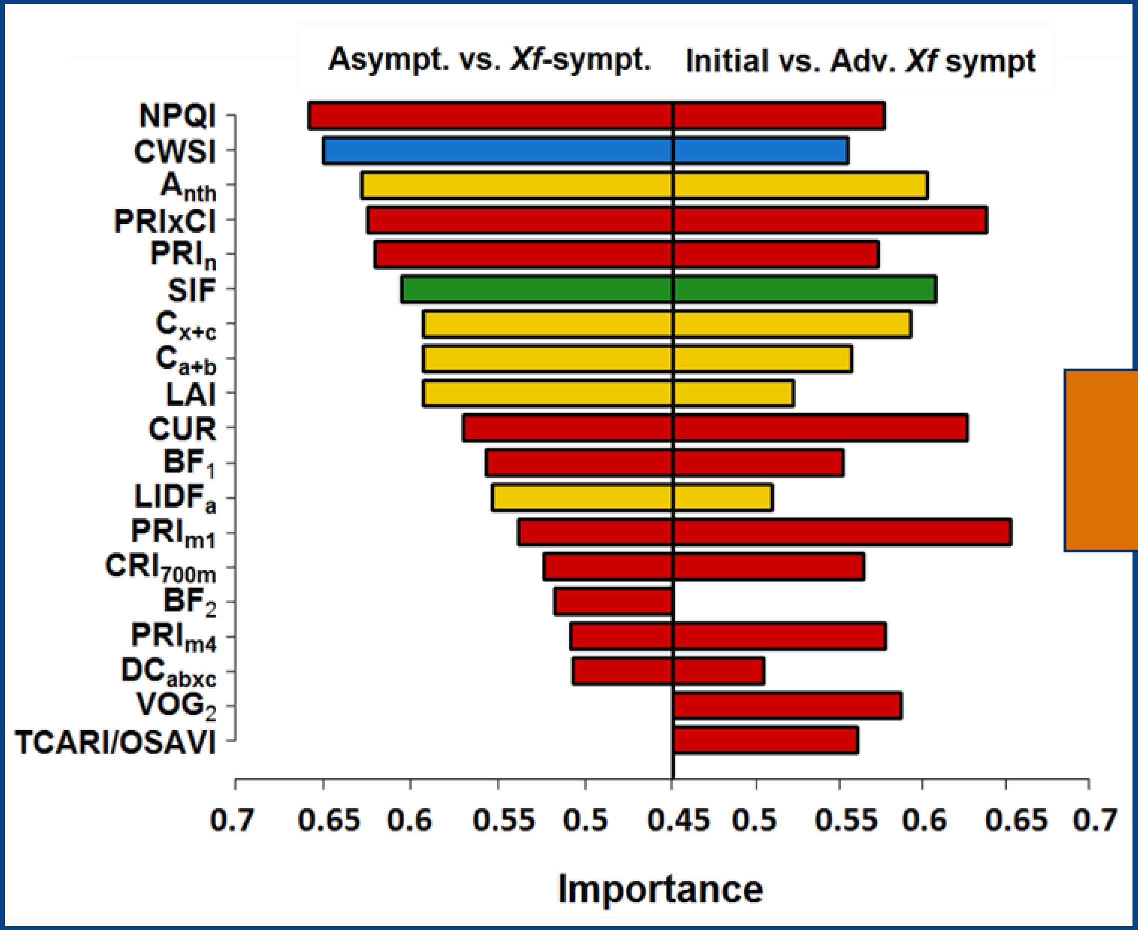

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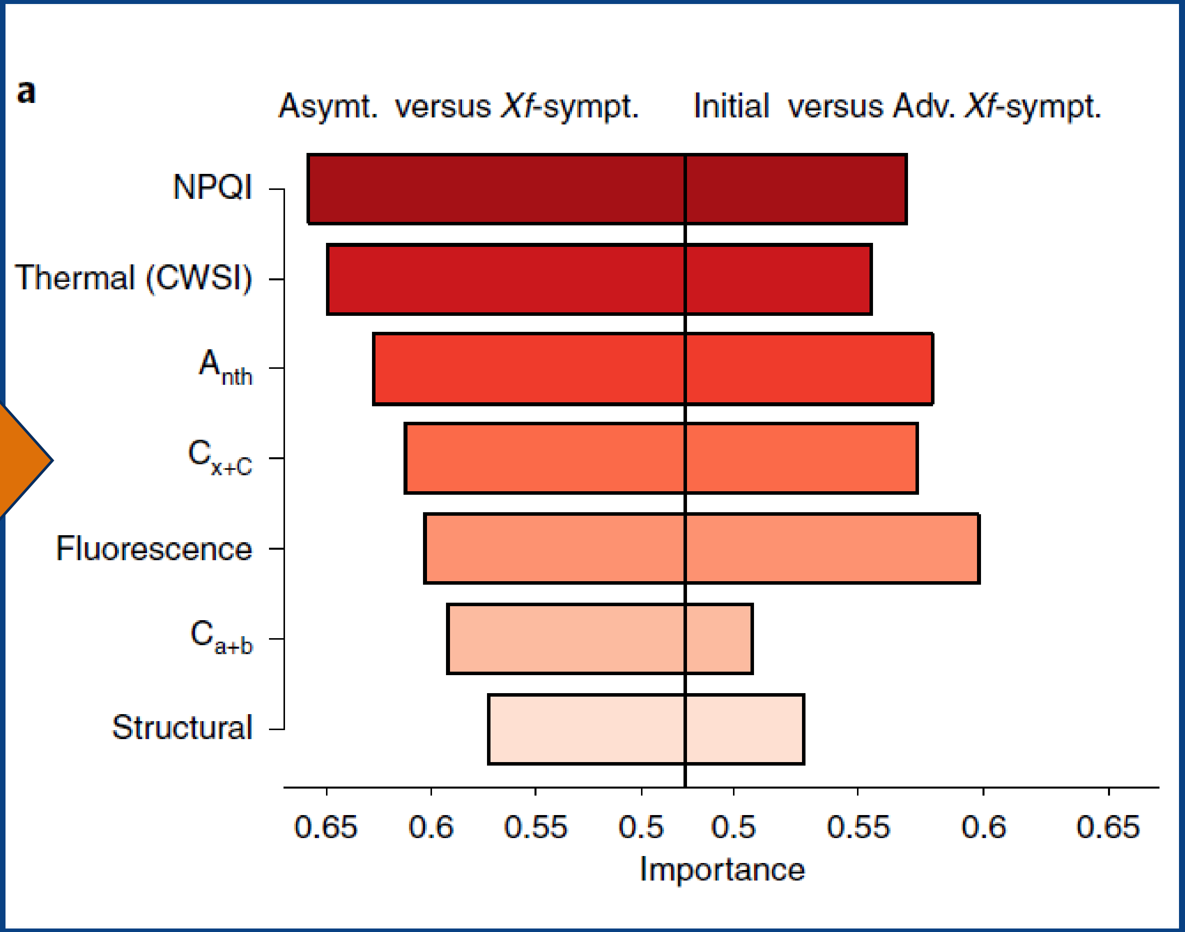

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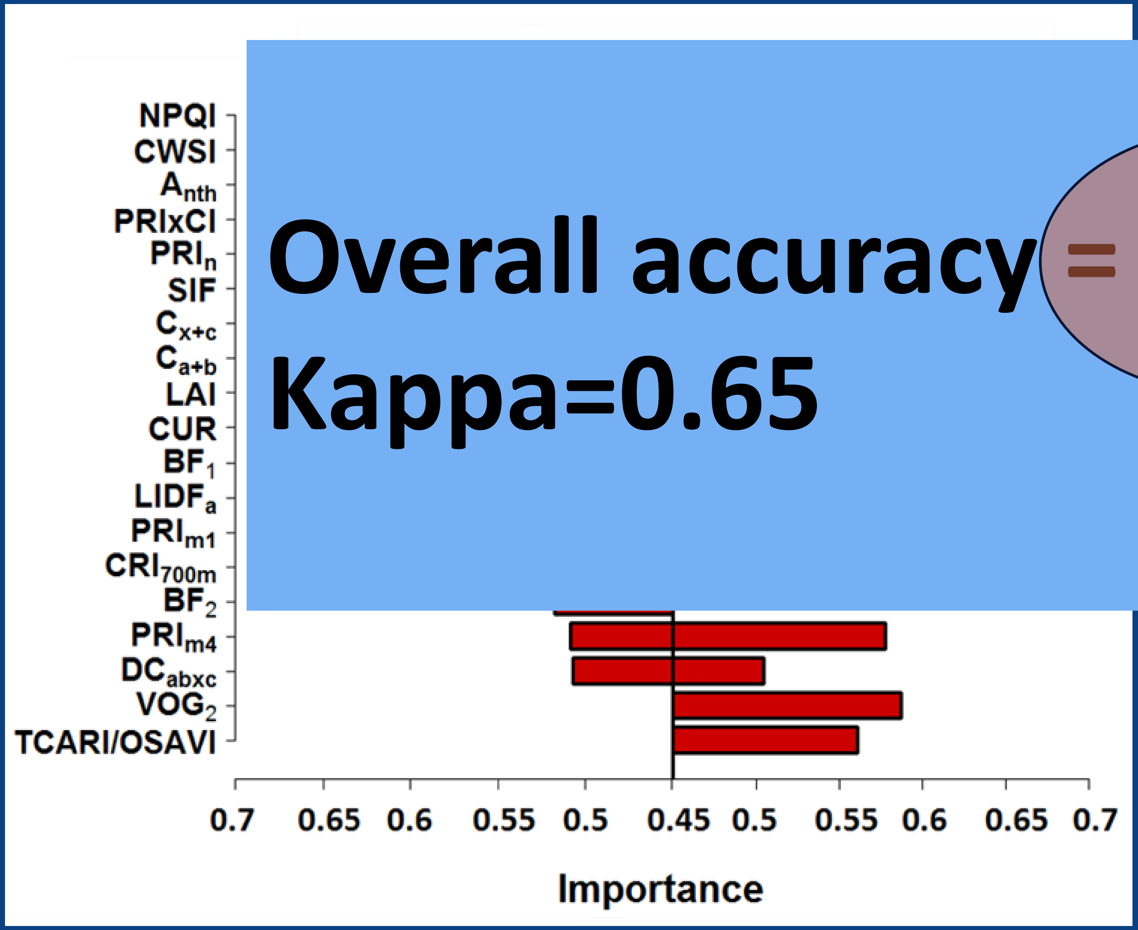

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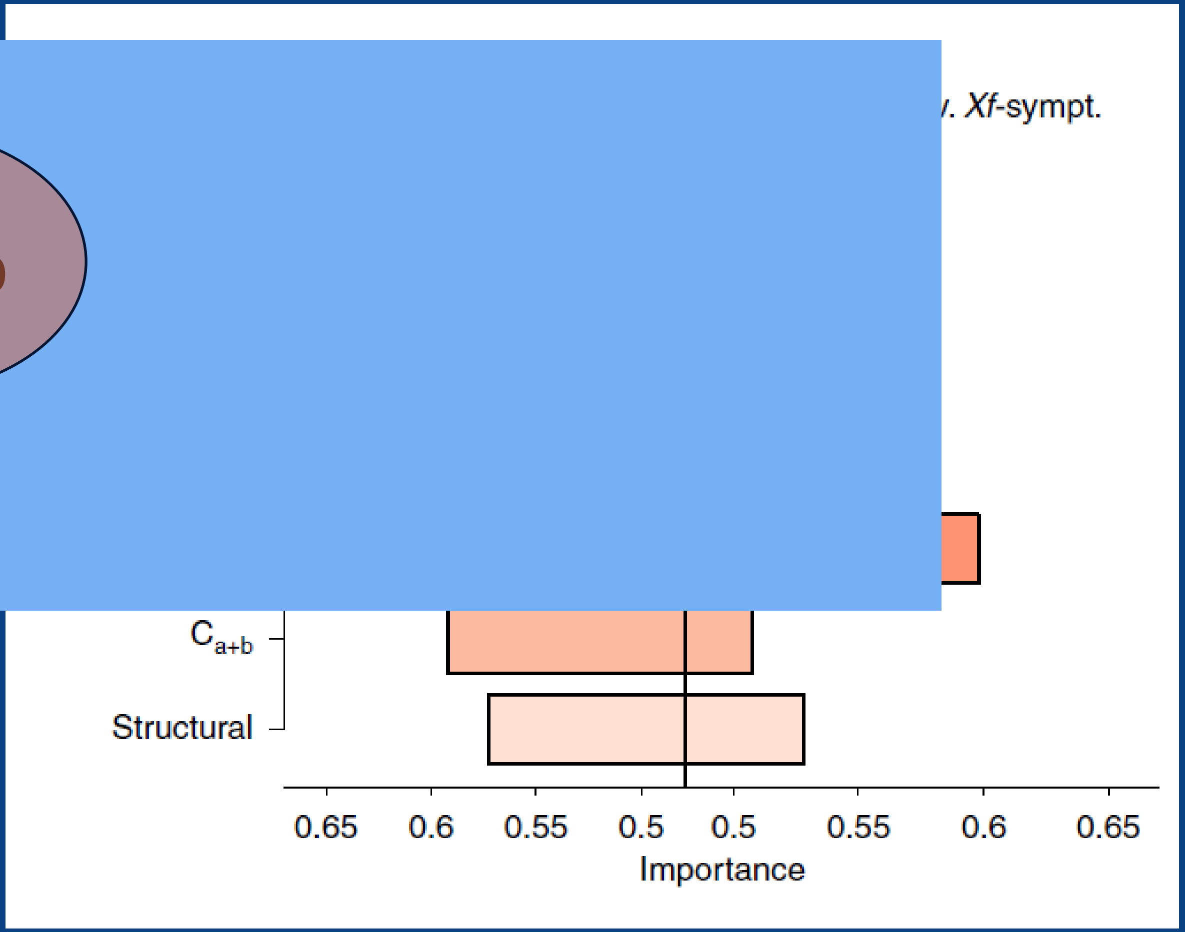

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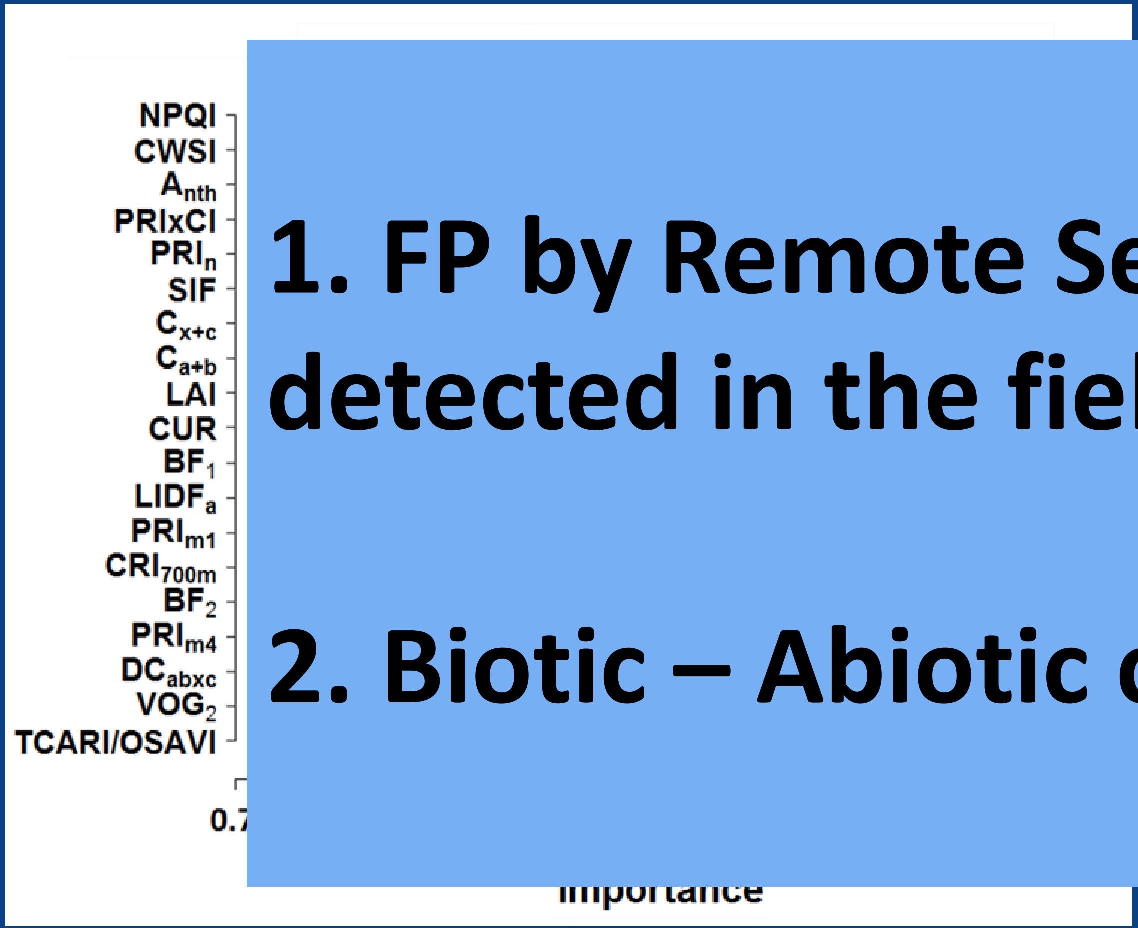
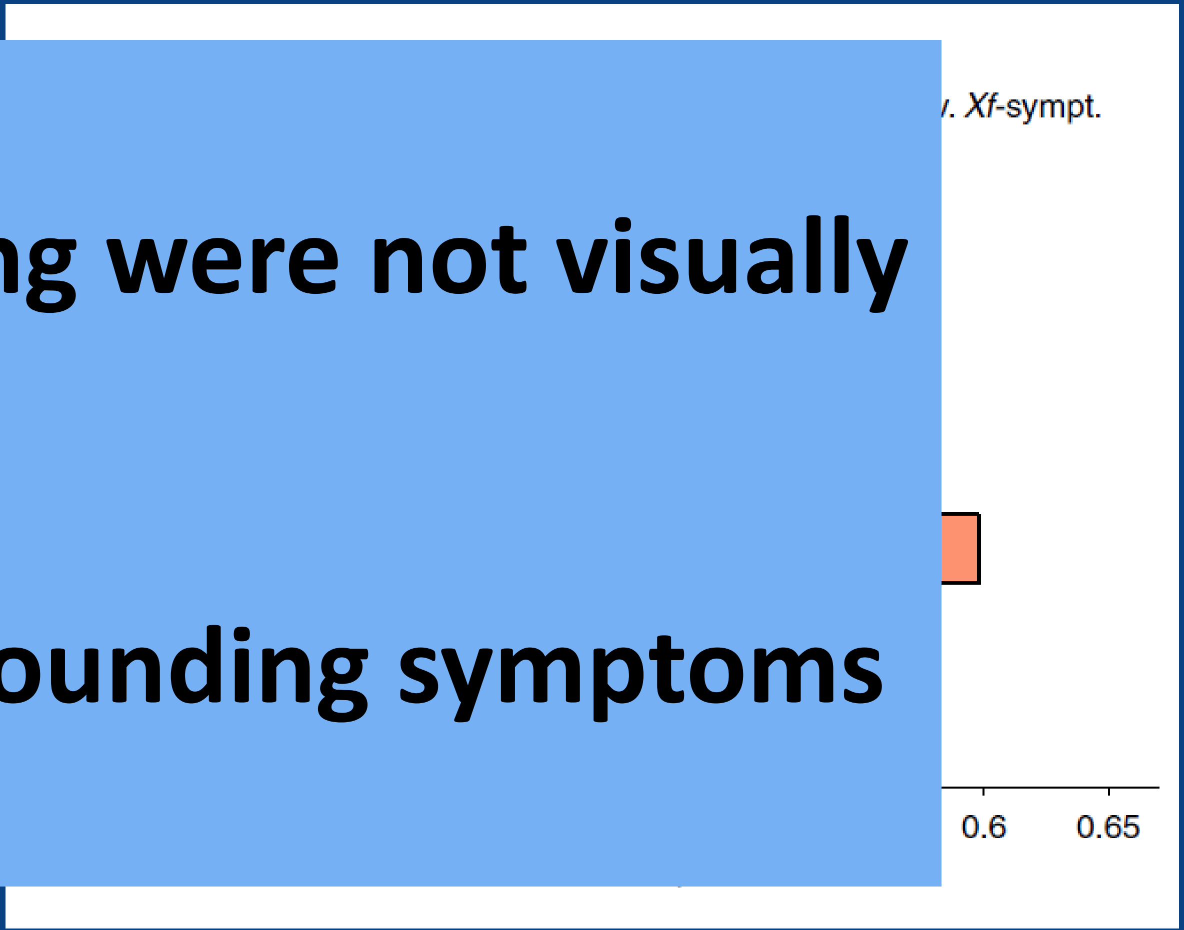


Spectral functional groups

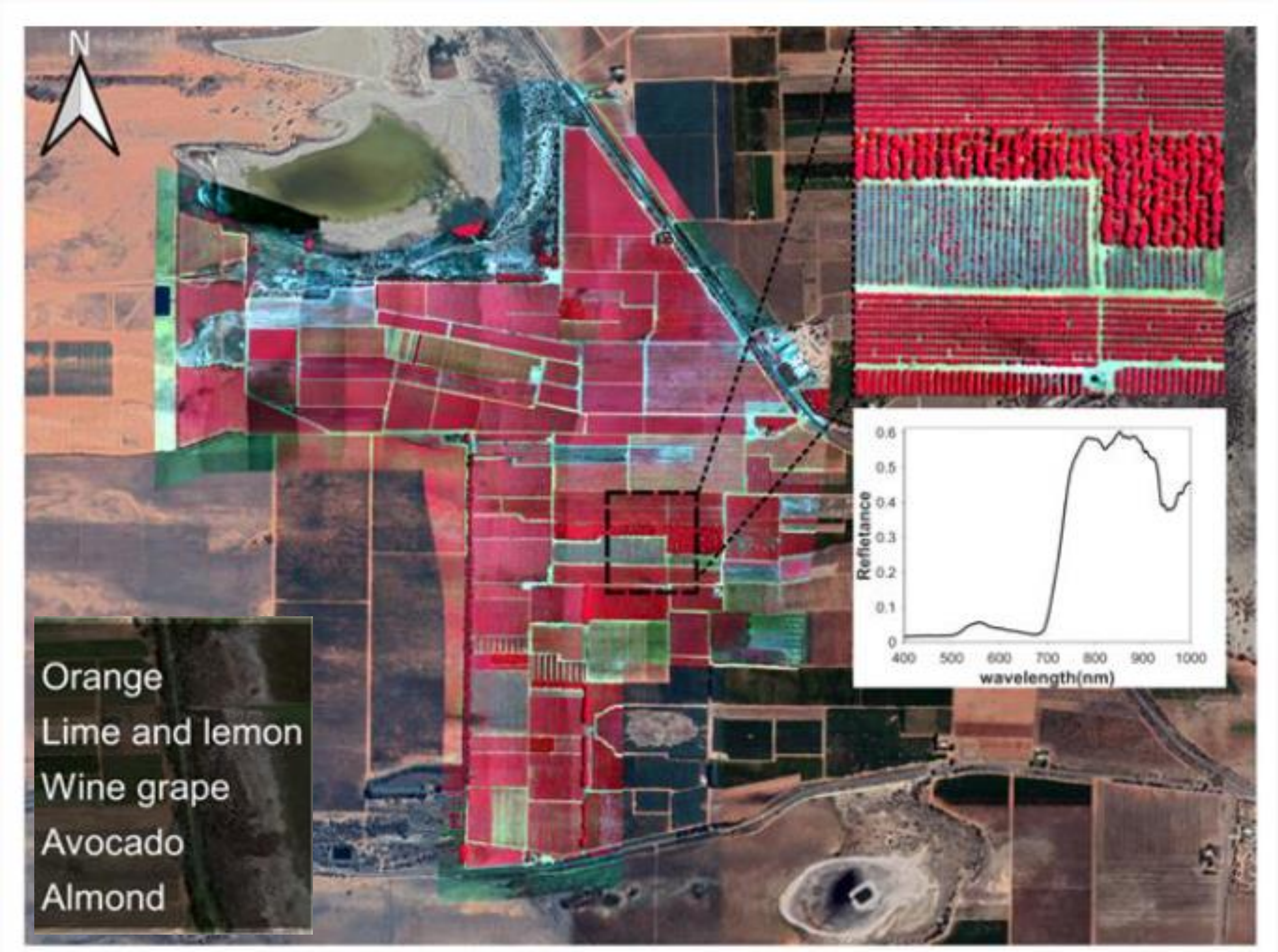


1. FP by Remote Sensing were not visually detected in the field

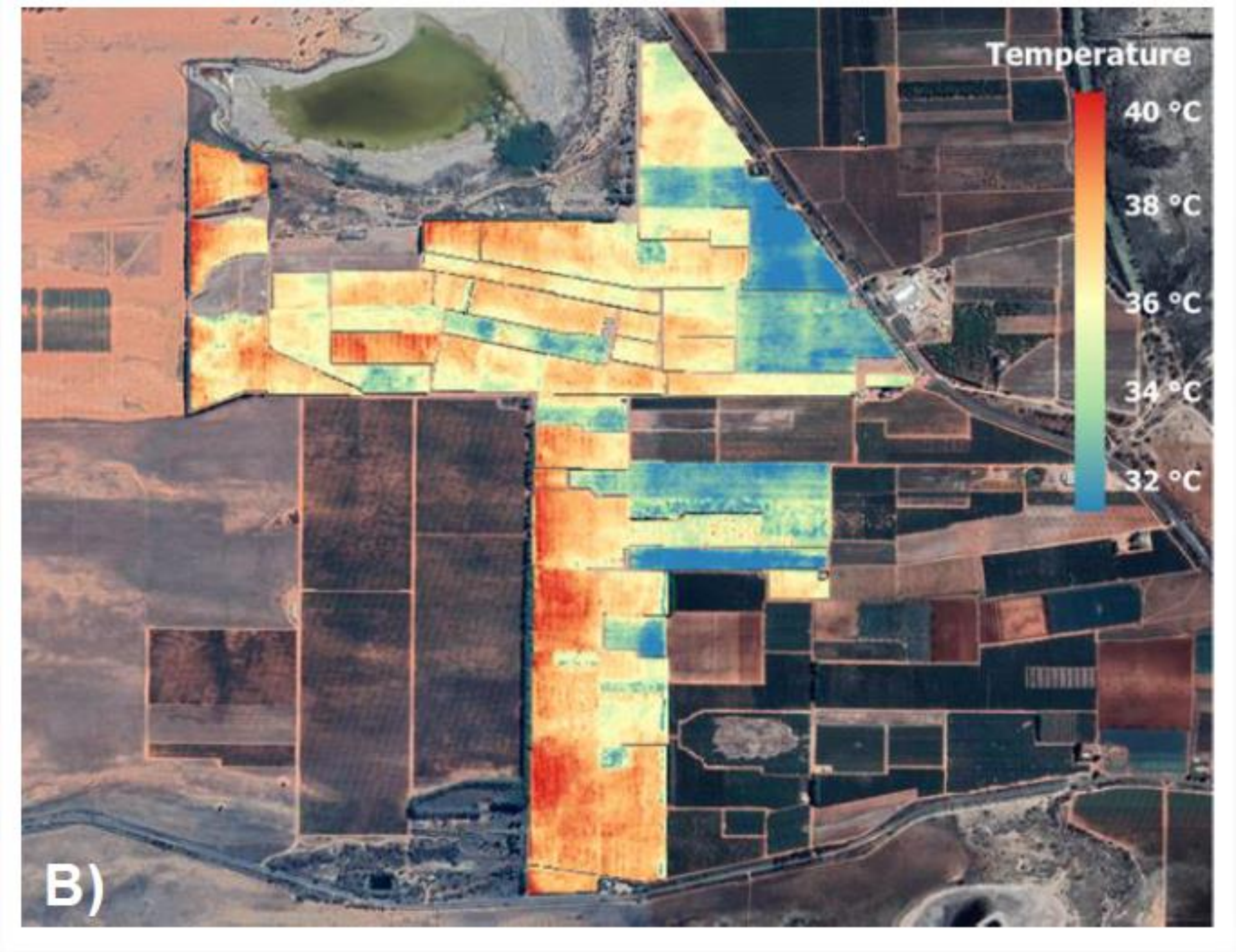
2. Biotic – Abiotic confounding symptoms

Zarco-Tejada *et al.* (2018)

Large natural variability of water and nutrient stress



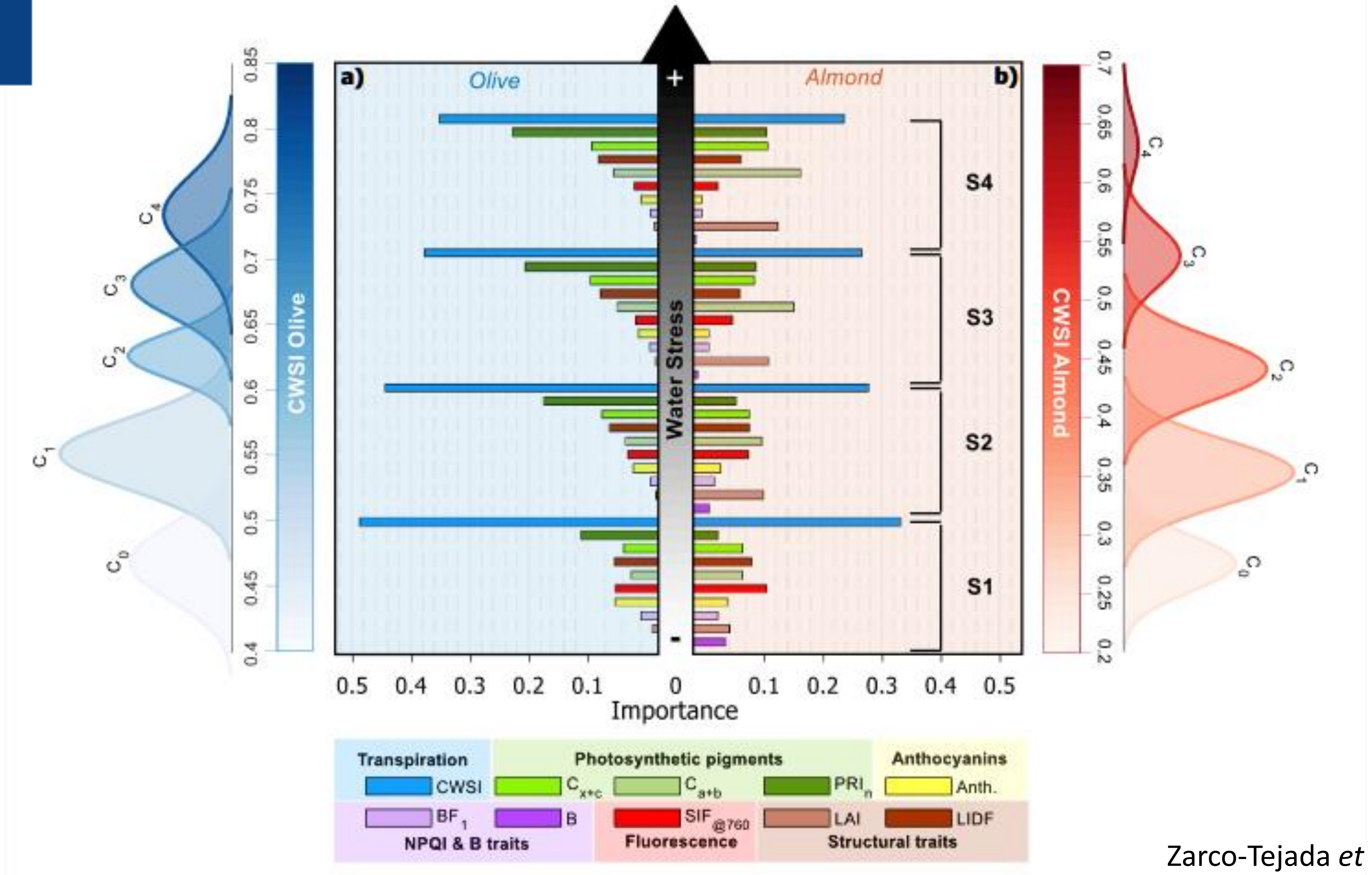
Hyperspectral image



Thermal image

2021

Importance of plant traits to detect water stress as a function of stress levels



Zarco-Tejada *et al.* (2021)

2021

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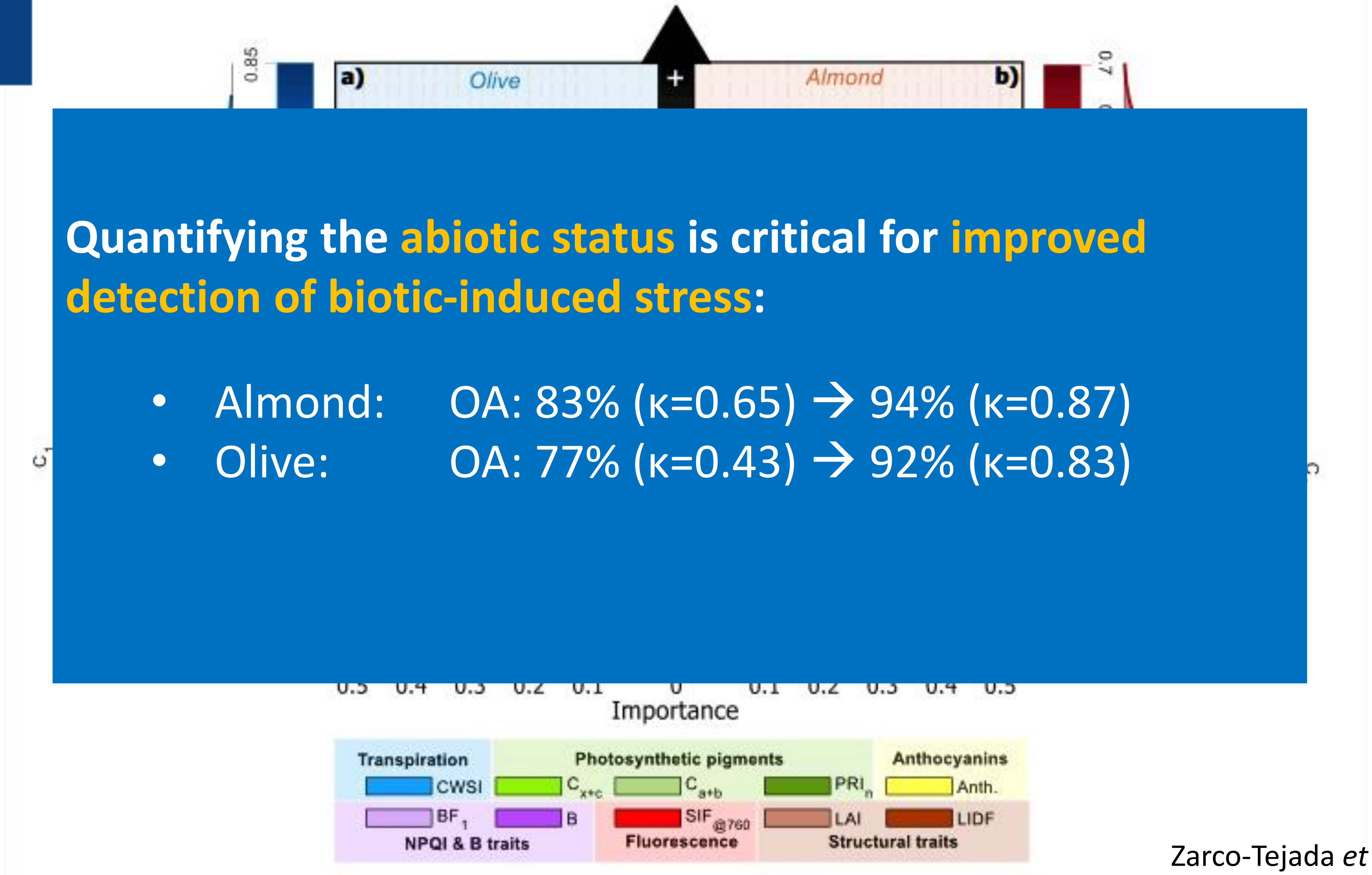


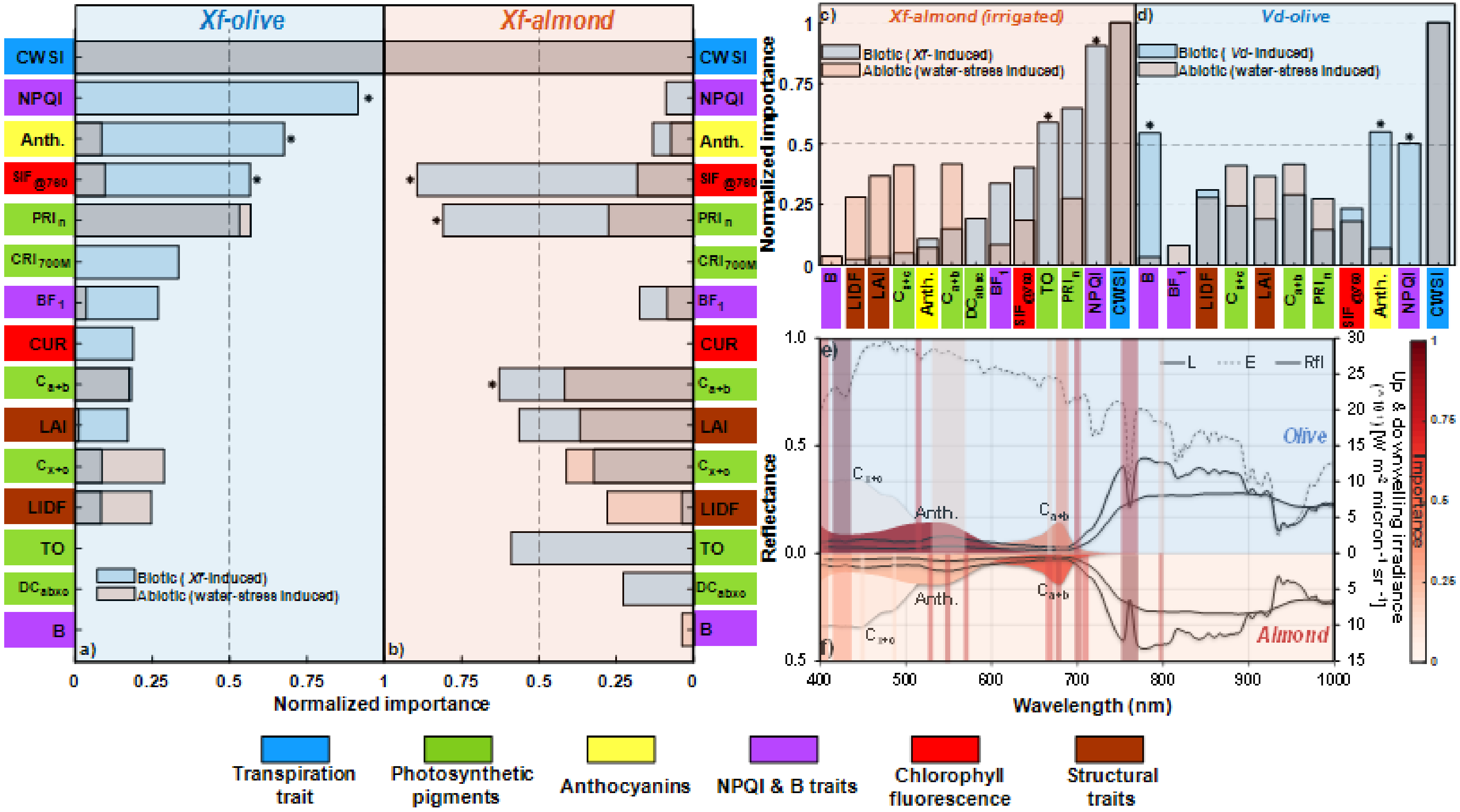
Quantifying the abiotic status is critical for improved detection of biotic-induced stress:

- Almond: OA: 83% (κ=0.65) → 94% (κ=0.87)
- Olive: OA: 77% (κ=0.43) → 92% (κ=0.83)

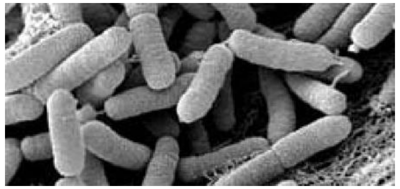
Zarco-Tejada *et al.* (2021)

2021

Disentangling biotic and abiotic stress



Xf



OA=92% (κ=0.83) compared with qPCR

Vd

OA=93% (κ=0.87) compared with qPCR

Zarco-Tejada *et al.* (2021)

New questions

→ Operational *Xf*-induced symptoms detection with existing high-resolution multispectral satellites

→ Operational use of hyperspectral satellites for *Xf* detection

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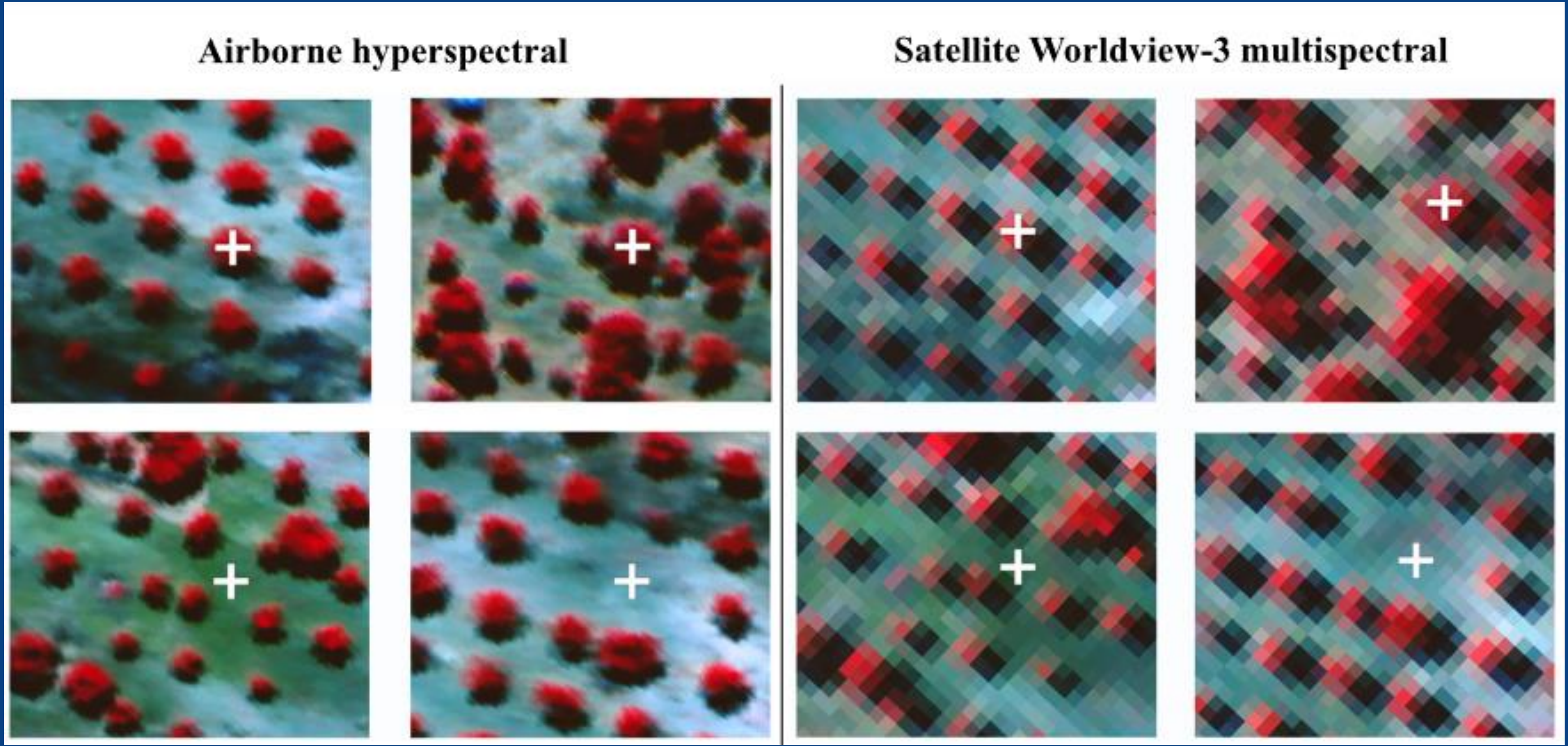
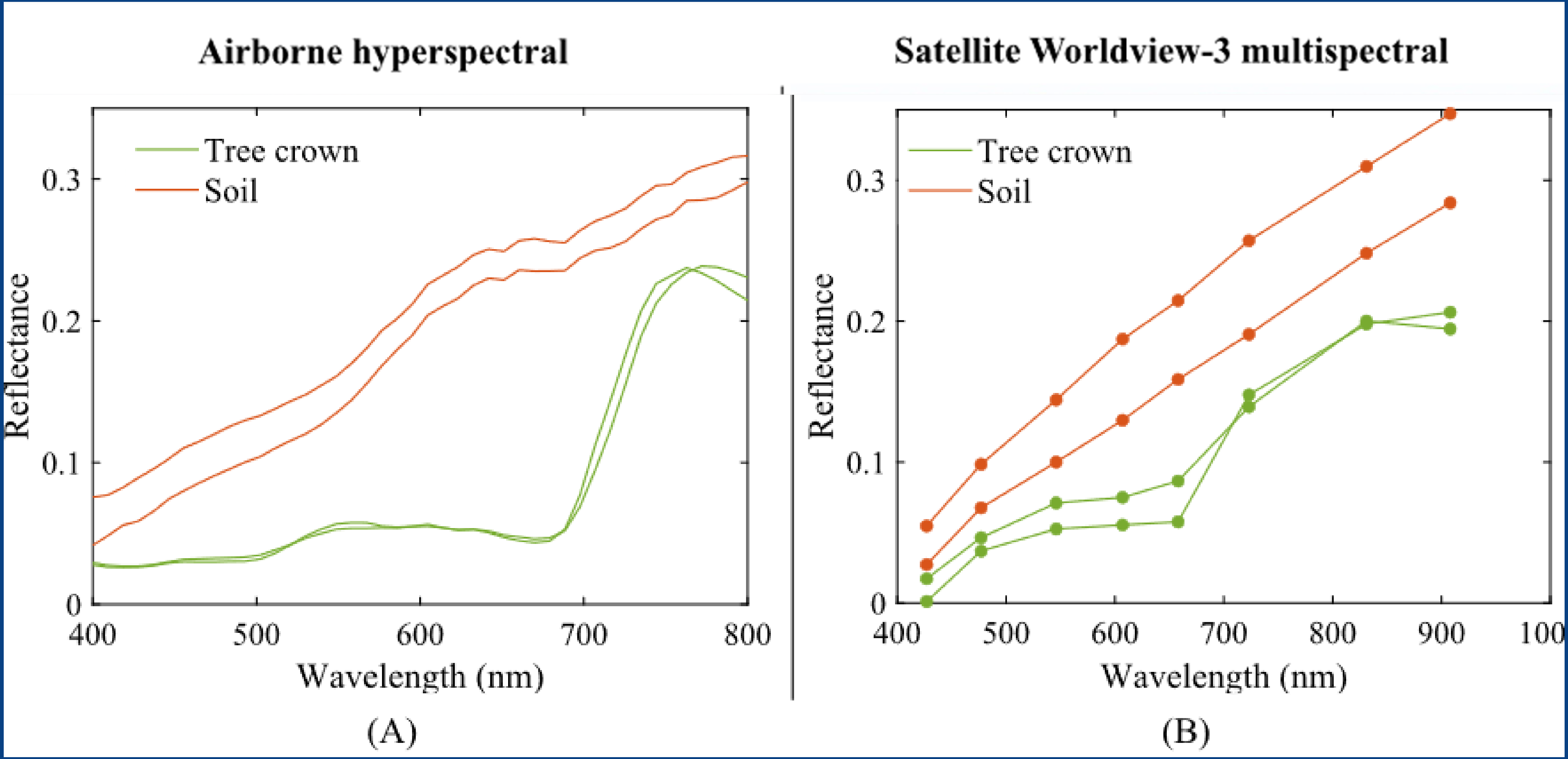
→ Operational *Xf*-induced symptoms detection with existing high-resolution multispectral satellites

→ Sentinel-2, Worldview 2/3

→ Operational use of hyperspectral satellites for *Xf* detection

→ BeXyl


Airborne hyperspectral
Satellite Worldview-3 multispectral


Airborne hyperspectral
Satellite Worldview-3 multispectral
Tree crown
Soil
Reflectance
0
0.1
0.2
0.3
400
500
600
700
800
Wavelength (nm)
(A)
Tree crown
Soil
Reflectance
0
0.1
0.2
0.3
400
500
600
700
800
900
100
Wavelength (nm)
(B)

Disease detection framework from hyperspectral data

THE UNIVERSITY OF MELBOURNE

Structural changes

Photosynthetic pigments

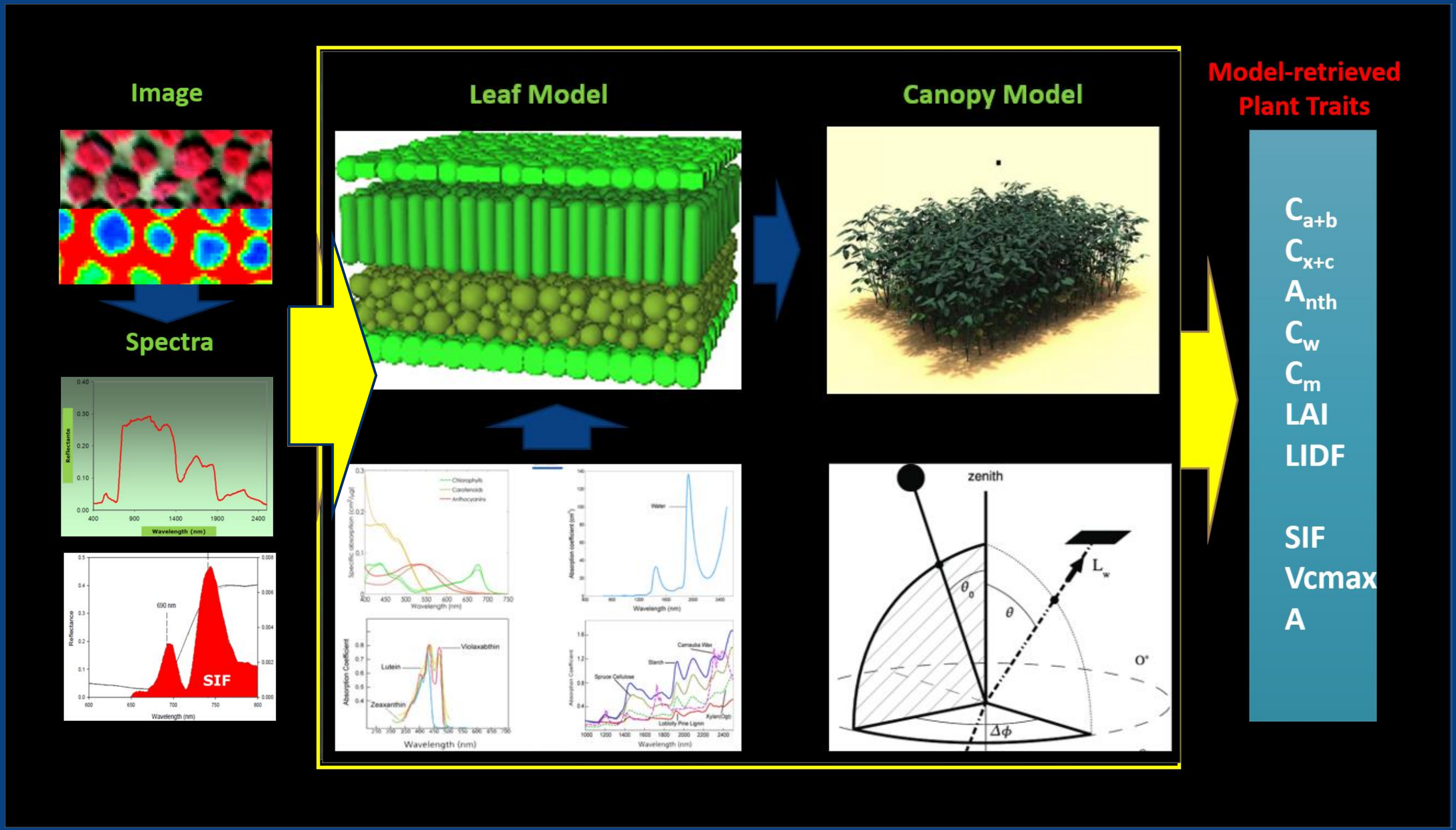
Fluorescence emission

Transpiration

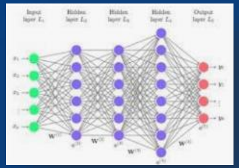
Spectral indicators

Importance of each RS-based indicator

Mechanistic models



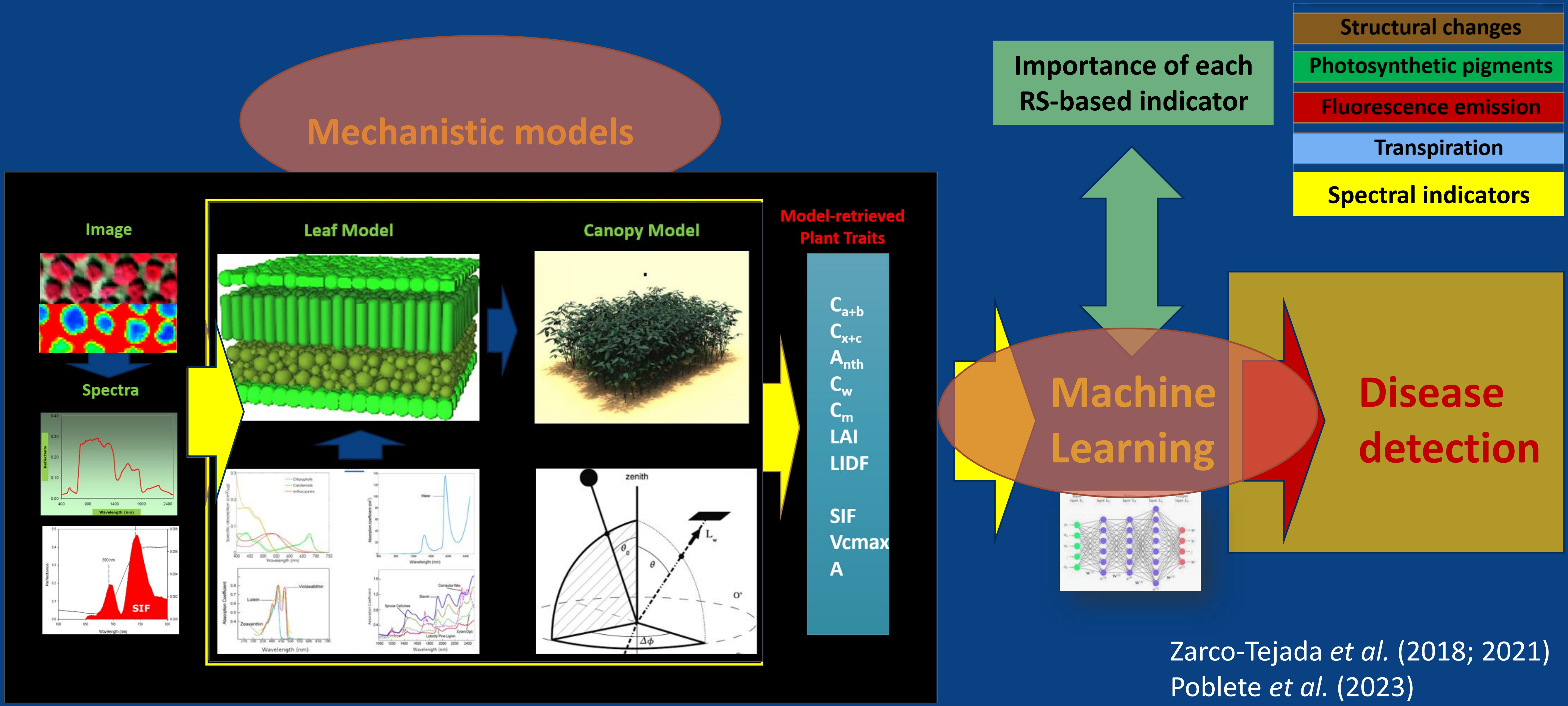
Machine Learning



Disease detection

Zarco-Tejada *et al.* (2018; 2021)
Poblete *et al.* (2023)

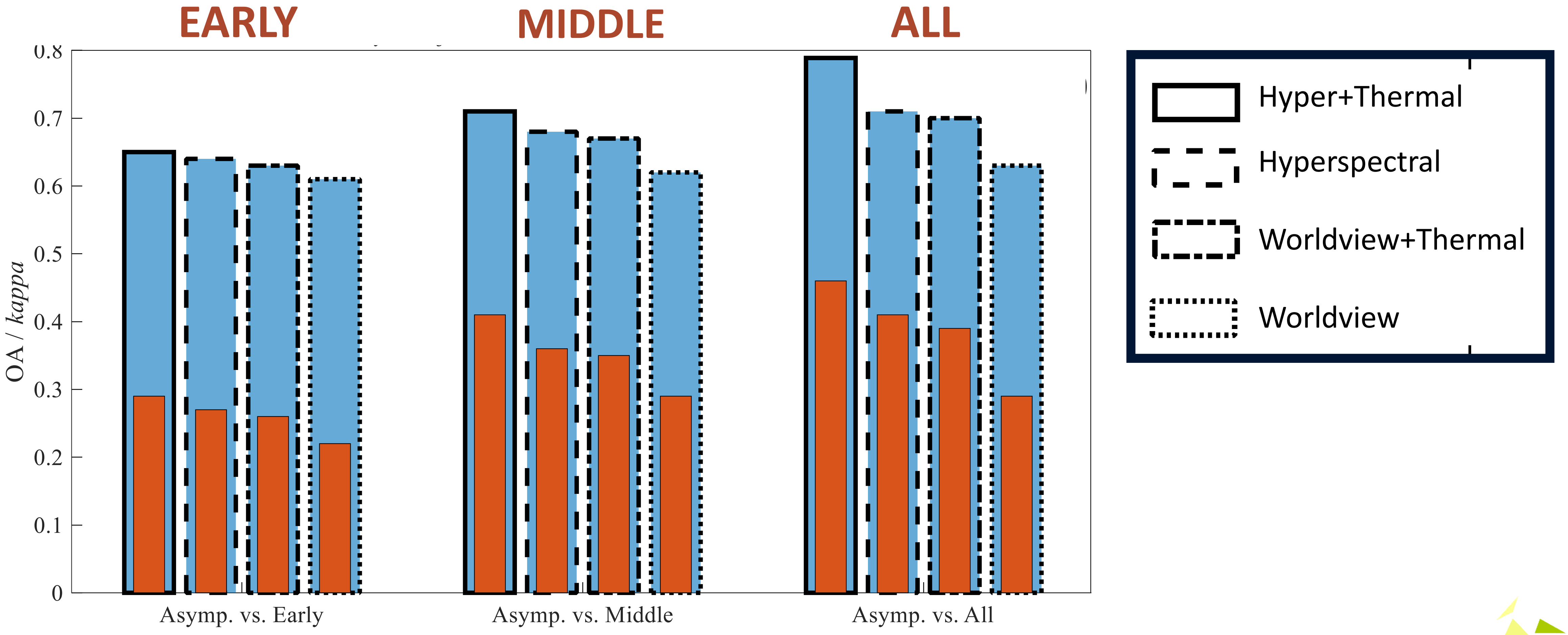
Disease detection framework from hyperspectral data



Zarco-Tejada *et al.* (2018; 2021)
Poblete *et al.* (2023)

2023

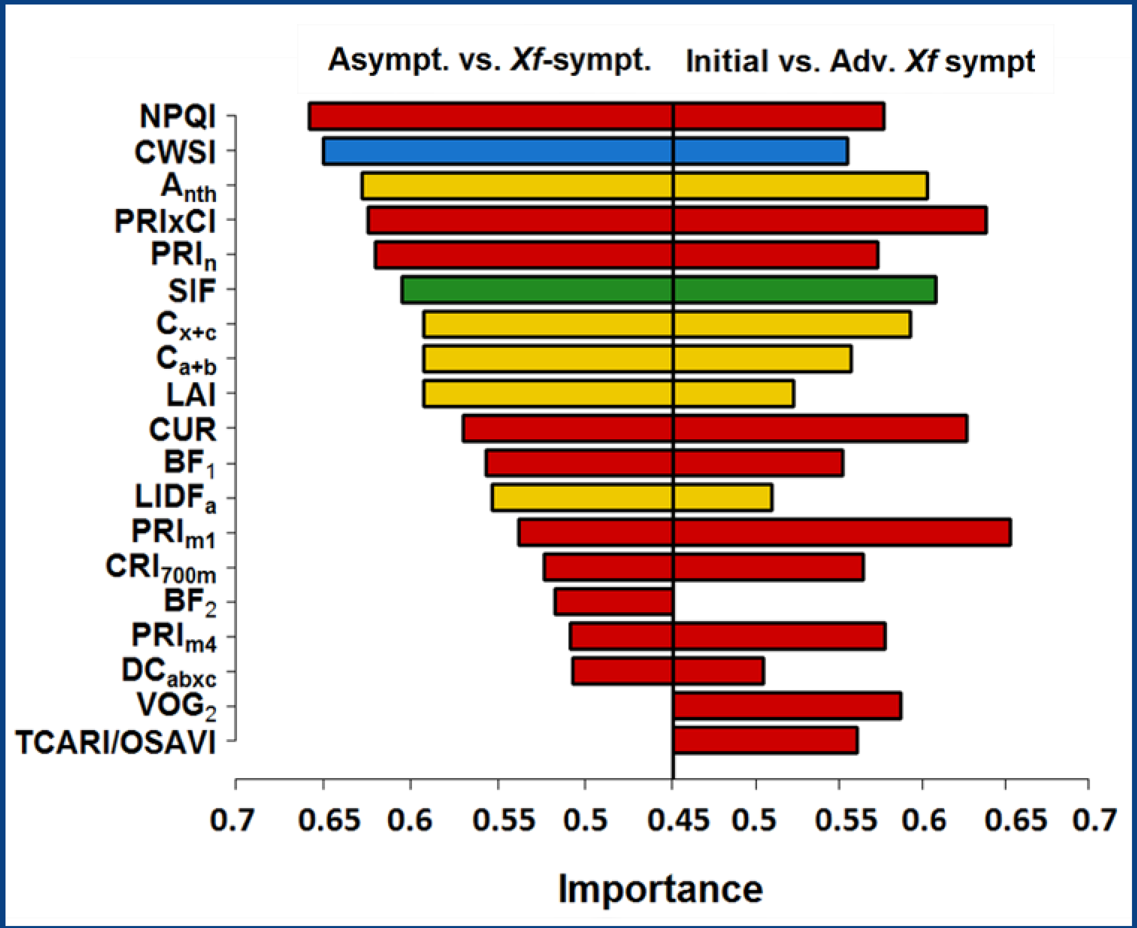
XF DETECTION WITH HIGH-RESOLUTION COMMERCIAL SATELLITES

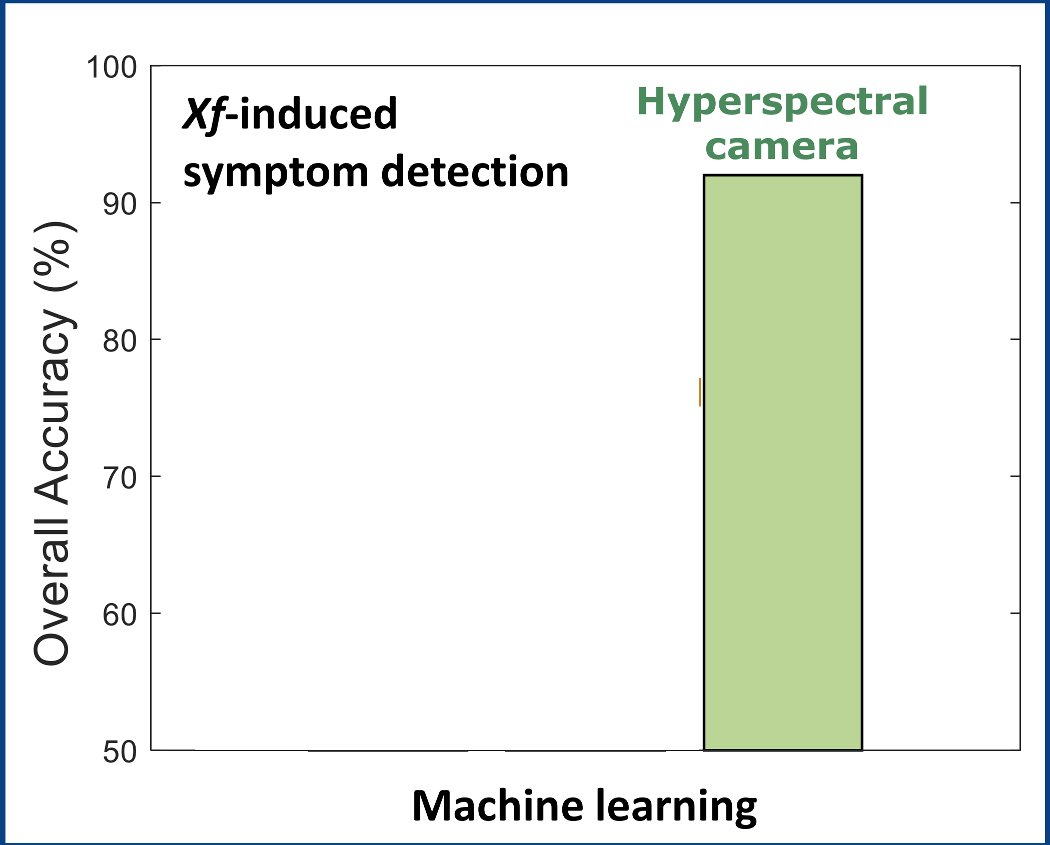


Poblete *et al.* (2023)

Sensitivity of Plant Traits to *Xf* symptoms

Hyperspectral traits





Poblete *et al.* (2020; 2021; 2023)
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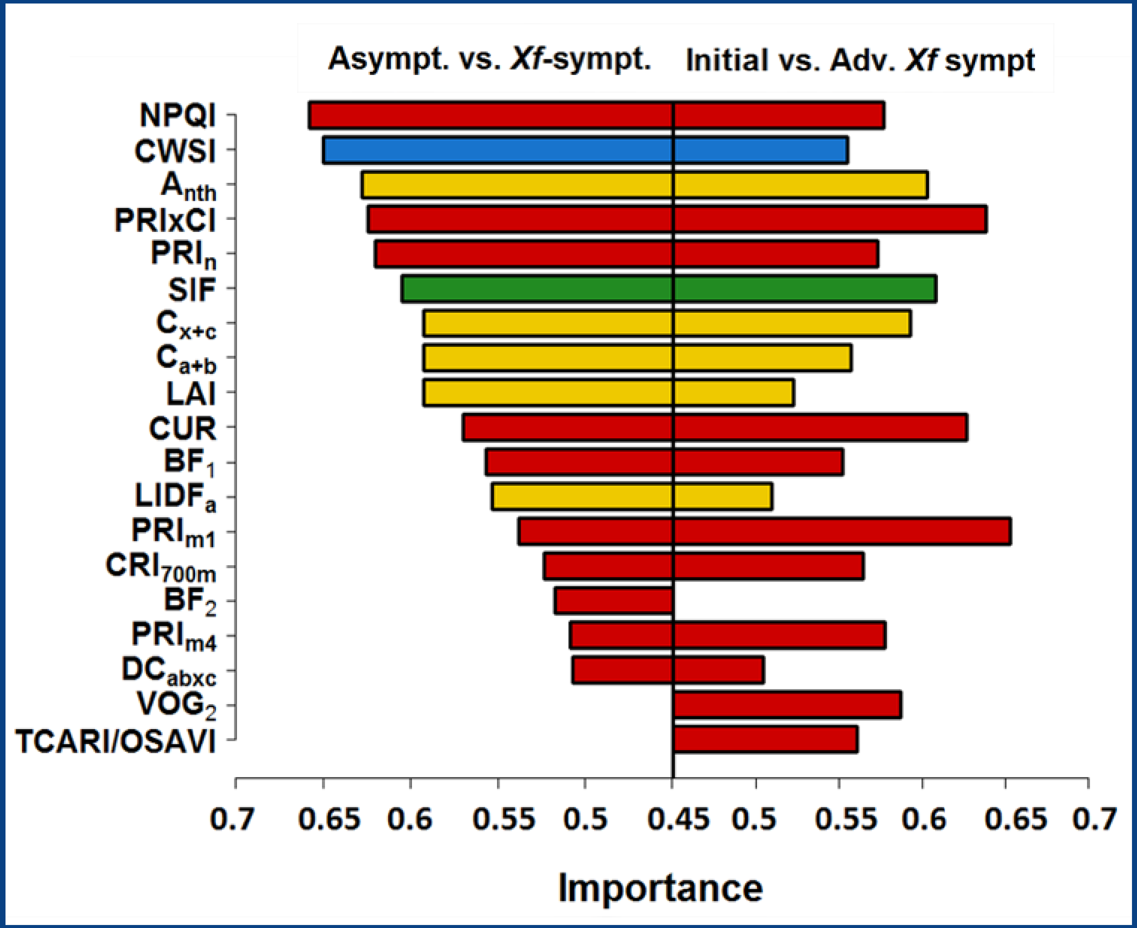

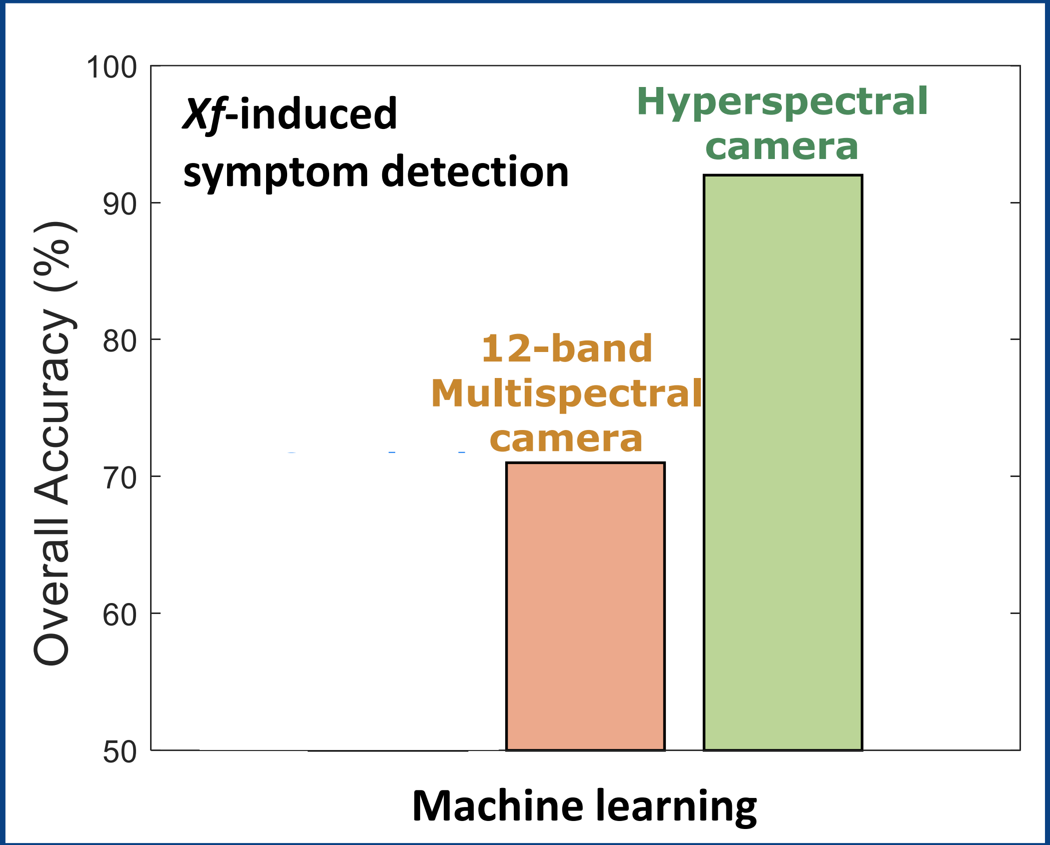

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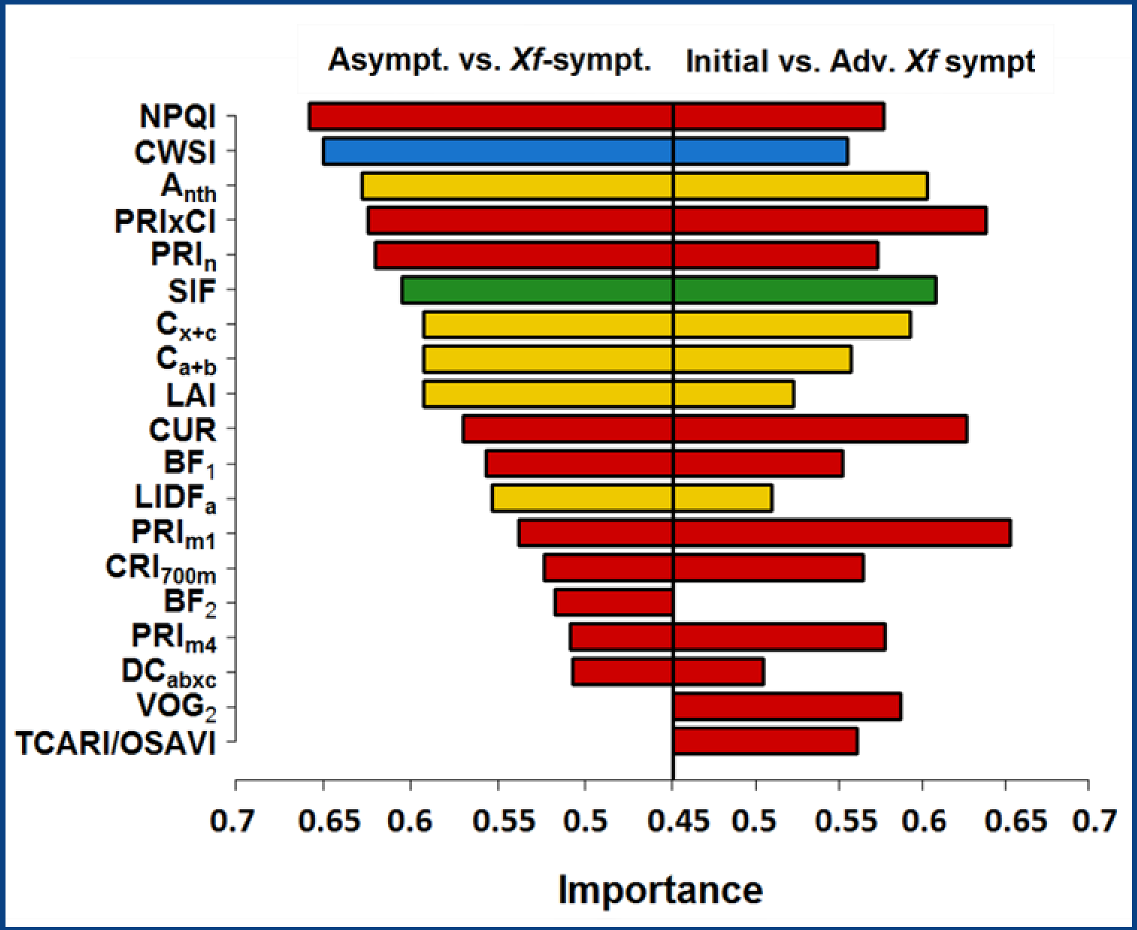

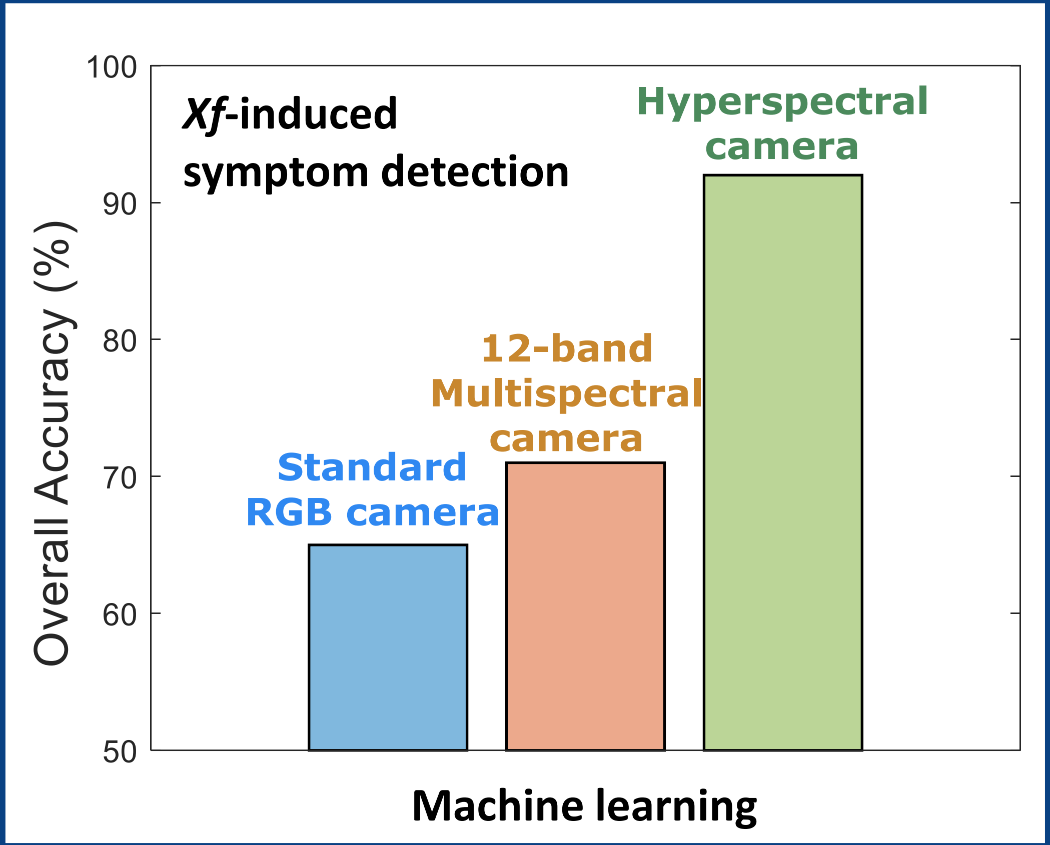

Poblete *et al.* (2020; 2021; 2023)
Zarco-Tejada *et al.* (2018)

CONCLUSIONS

- **Middle** and **Advanced stages** of the disease **can be detected** with multispectral satellite imagery

- **Early** detection of *Xf*-induced symptoms **failed** with multispectral data: hyperspectral required

- Analyses of the disease progression show that **specific spectral bands are required** to detect *Xf* at early stages

  → Highest sensitivity: **SIF, blue NPQI, anthocyanins, and xanthophylls**

- Current work focuses on **new hyperspectral satellites** for mapping early stages of *Xf* infection

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