3rd European Conference on
Xylella fastidiosa and XF-ACTORS final meeting

Progress and achievements on the early detection of *Xylella fastidiosa* infection and symptom development with hyperspectral and thermal remote sensing imagery

Zarco-Tejada, P.J., Poblete, T., Calderon, R., Hornero, A., Hernández-Clemente, R., Kattenborn, T., Montes-Borrego, M., Román-Écija, M., Velasco-Amo, M.P., Susca, L., Morelli, M., Gonzalez-Dugo, V., Landa, B.B., Beck, P.S.A., Boscia, D., Saponari, M., Navas-Cortes, J.A.

Objectives

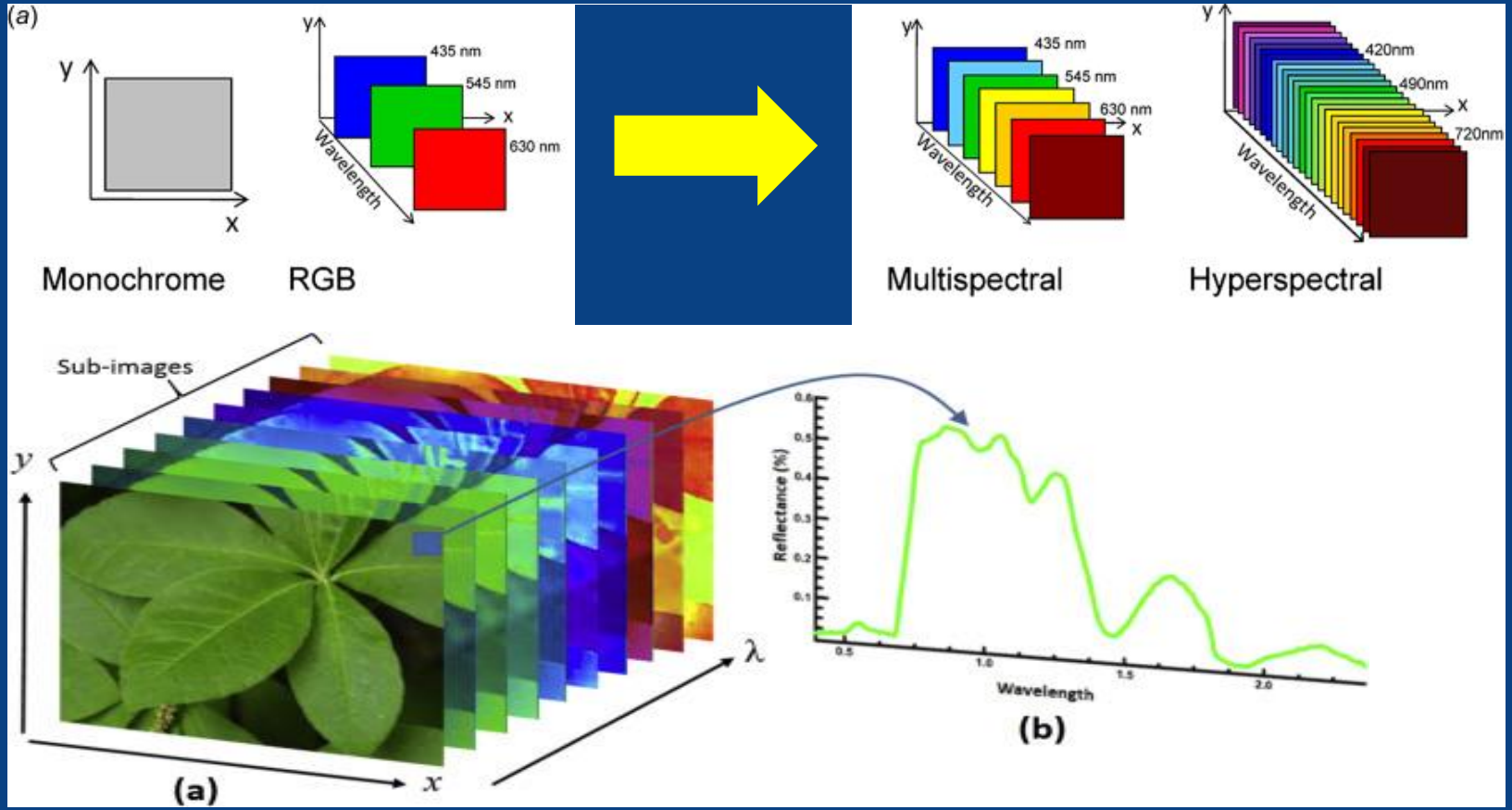
1. To assess hyperspectral and thermal imaging methods for the early detection of *Xf*-induced symptoms

The ***role*** of Remote Sensing in *Xf* detection

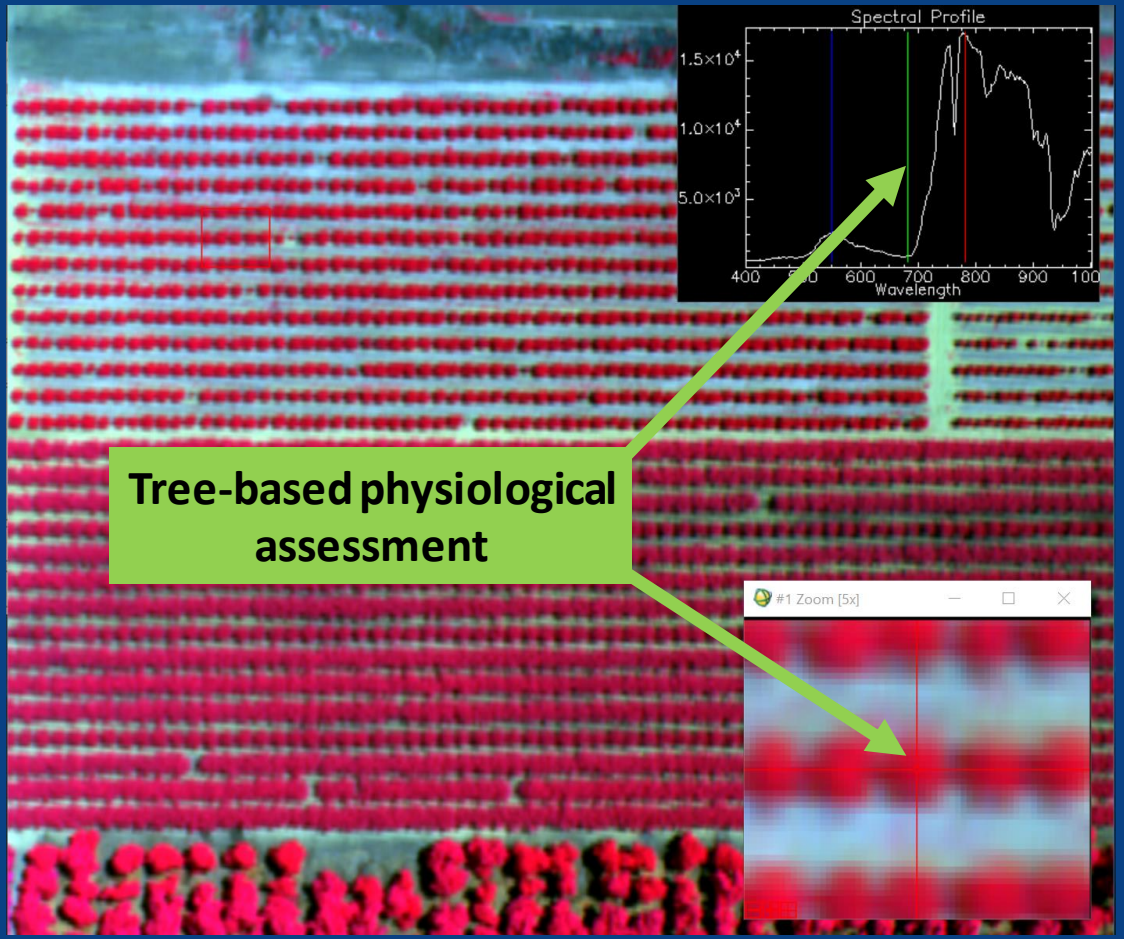
Asymptomatic **Initial** **Severe**

Physiological changes

Imaging Spectroscopy



Hyperspectral flightline



The ***role*** of Remote Sensing in *Xf* detection

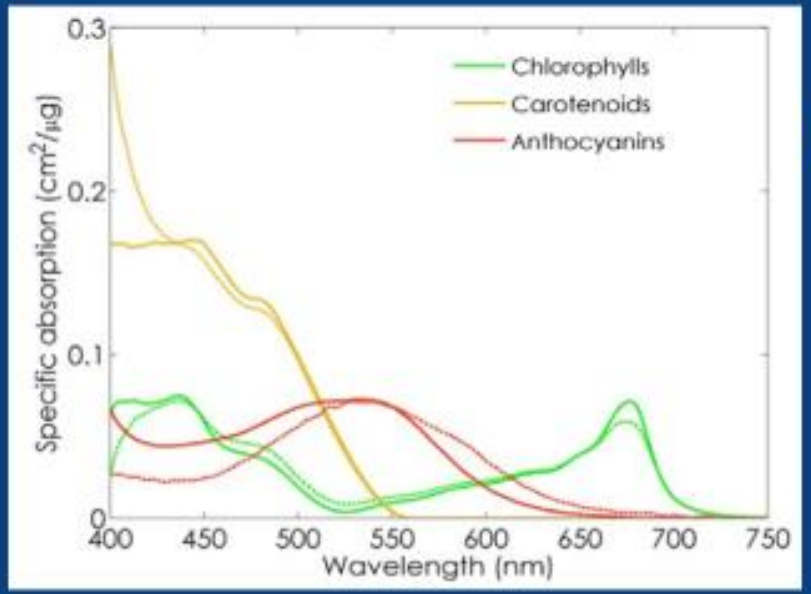
Asymptomatic **Initial** **Severe**

Structural changes

THE UNIVERSITY OF MELBOURNE

The ***role*** of Remote Sensing in *Xf* detection: pigments

Asymptoma



Chlorophyll *a+b* / Carotenoids
Anthocyanins / Xanthophylls

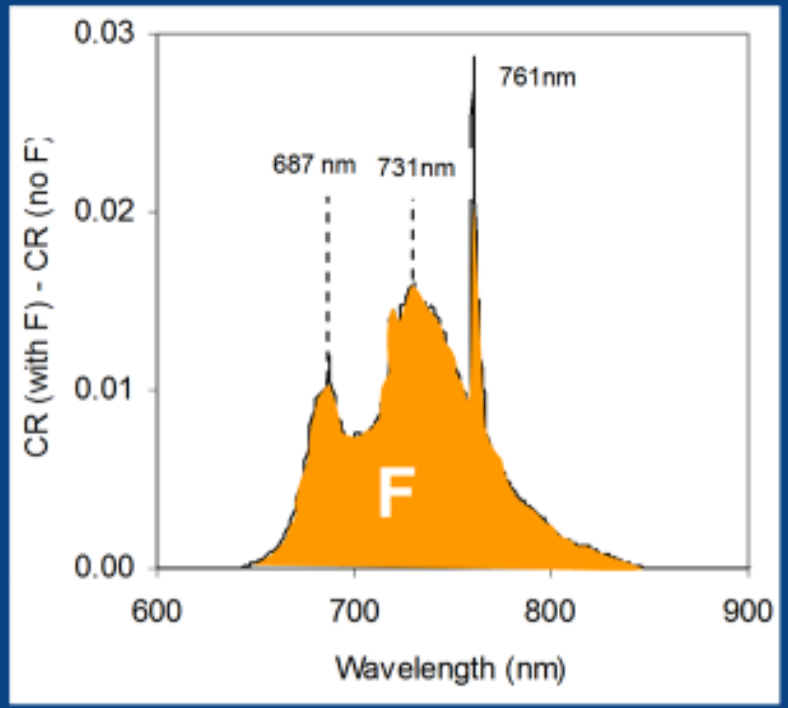
Indicators of biotic stress

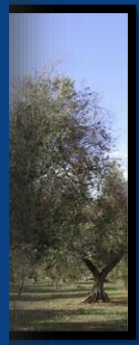
ere

Asymptomat

Solar-induced Chlorophyll Fluorescence quantification

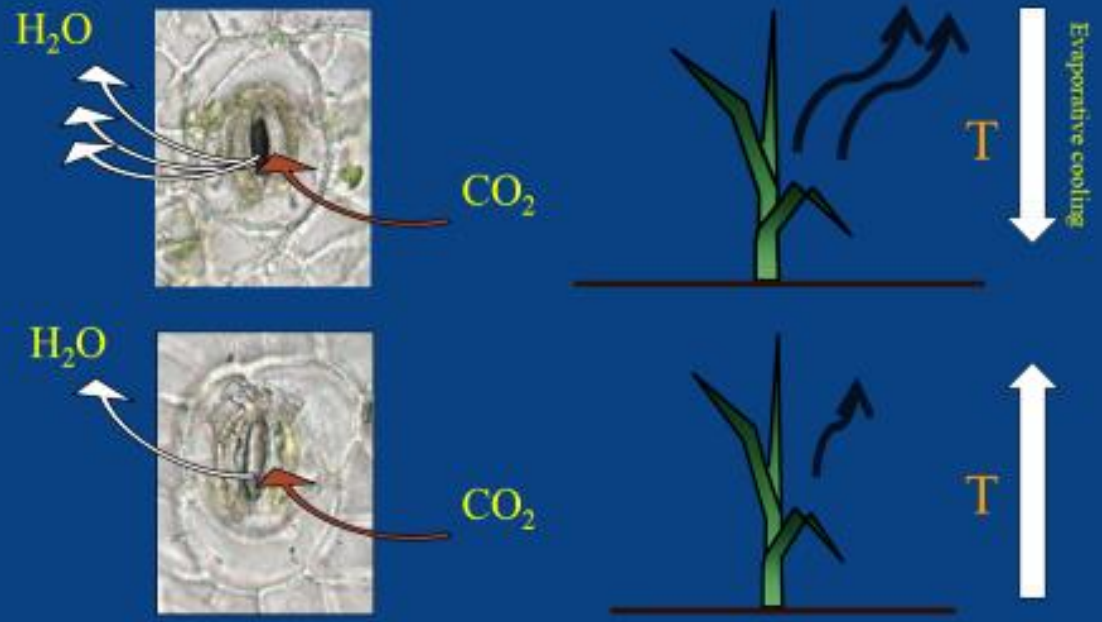
→ ~2% of the total incoming radiation
→ Linked to photosynthesis
→ High spectral resolution required
→ Early indicator of stress





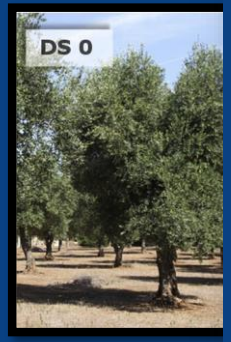
THE UNIVERSITY OF MELBOURNE

The *role* of Remote Sensing in *Xf* detection: transpiration



Asymptom

re



Transpiration

The ***role*** of Remote Sensing in *Xf* detection

Asymptomatic **Initial** **Severe**

Structural changes

Photosynthetic pigments

Fluorescence emission

Transpiration

The ***role*** of Remote Sensing in *Xf* detection

Asymptomatic **Initial** **Severe**

Structural changes

Photosynthetic pigments

Fluorescence emission

Transpiration

The ***role*** of Remote Sensing in *Xf* detection

Asymptomatic **Initial** **Severe**

Structural changes

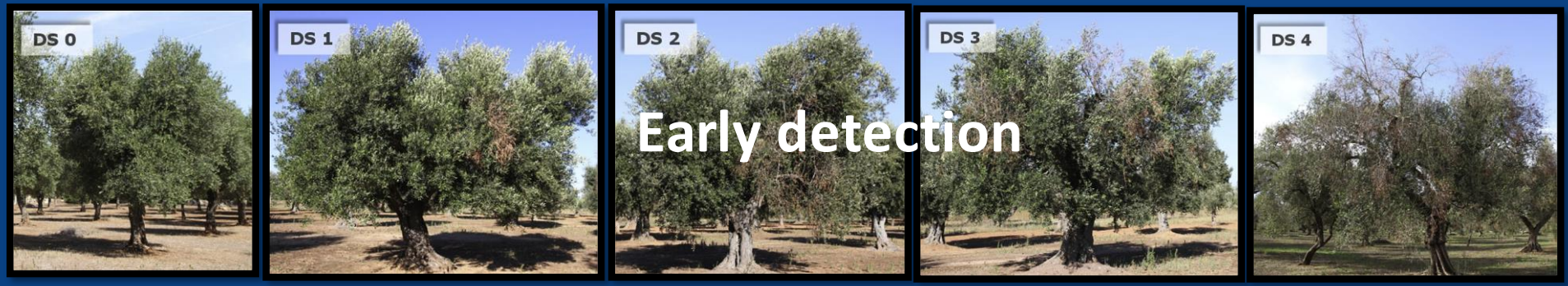
Photosynthetic pigments

Fluorescence emission

Transpiration

The ***role*** of Remote Sensing in *Xf* detection

Asymptomatic **Initial** **Severe**



Structural changes

Photosynthetic pigments

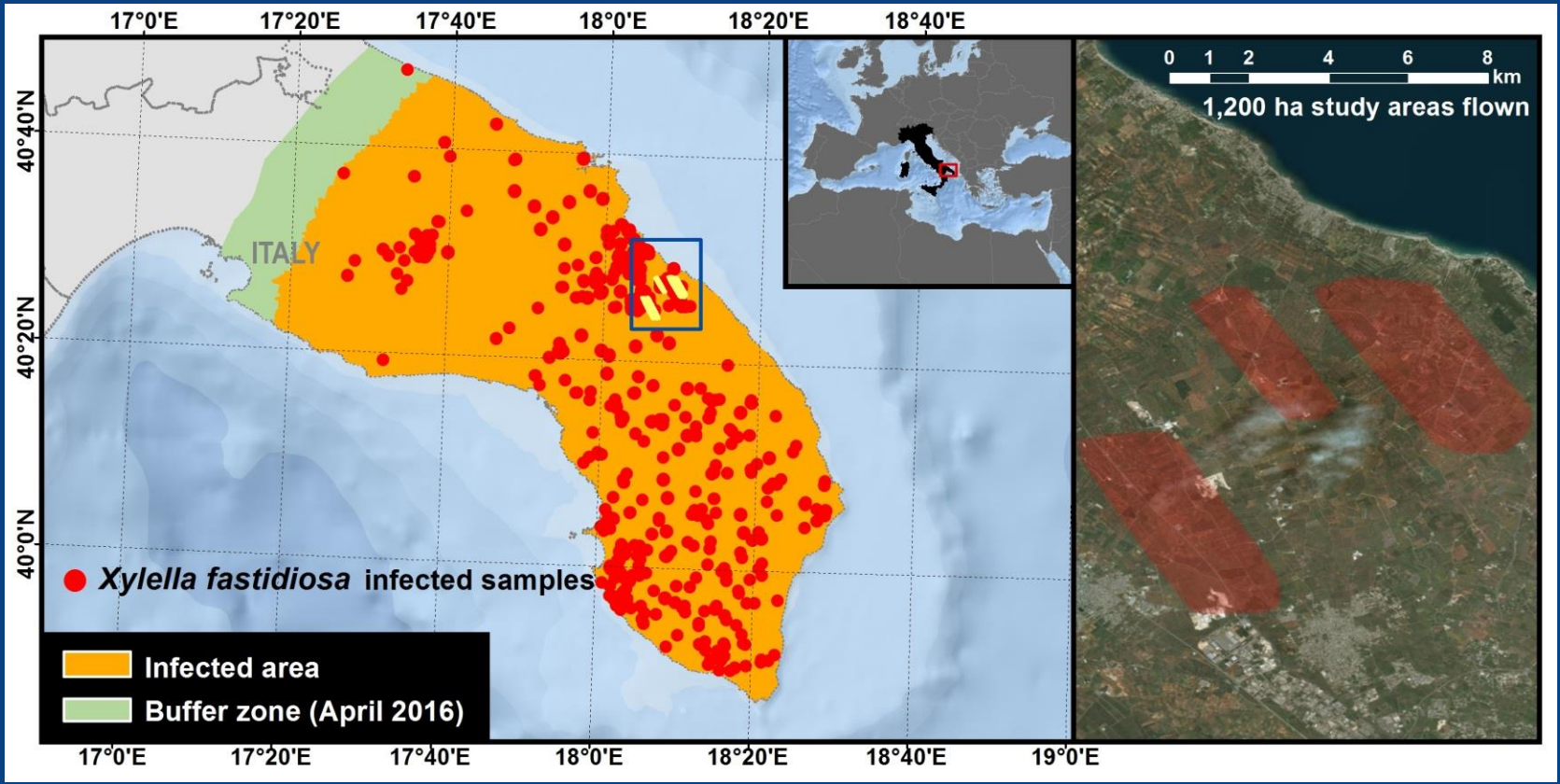
Fluorescence emission

Transpiration

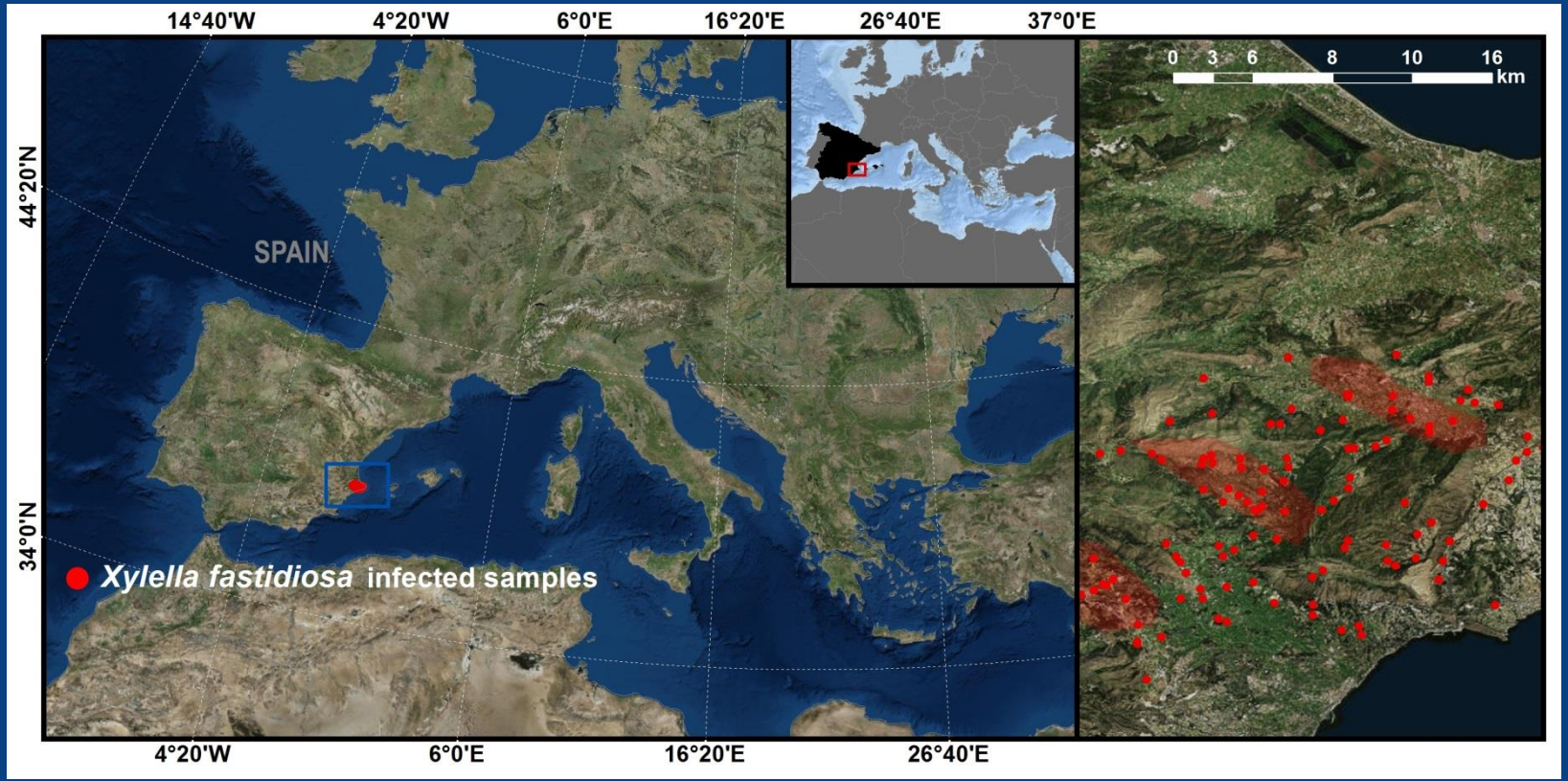
Spain

Italy

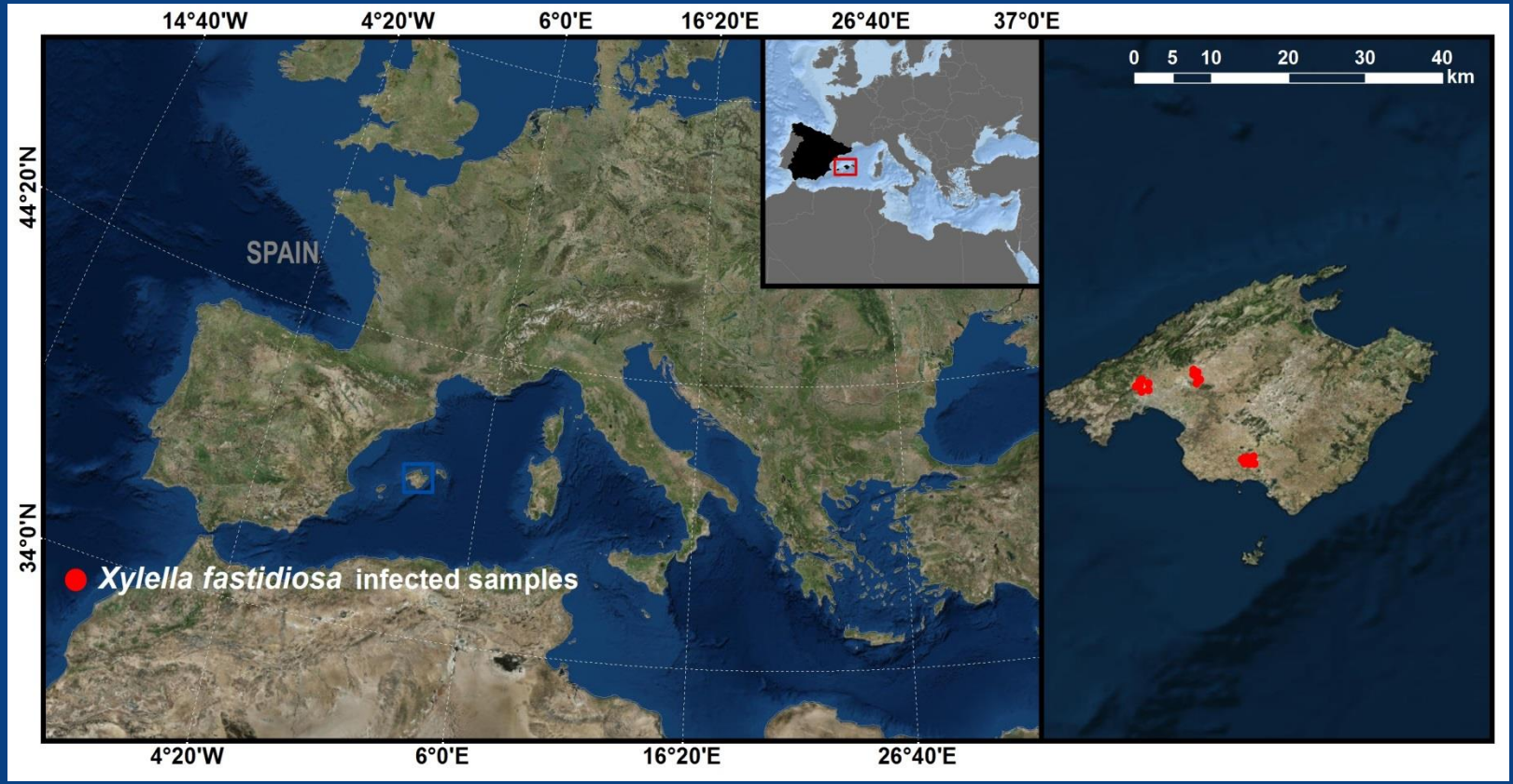
Airborne campaigns in the Puglia region, Italy



Airborne campaign in Alicante region, mainland Spain



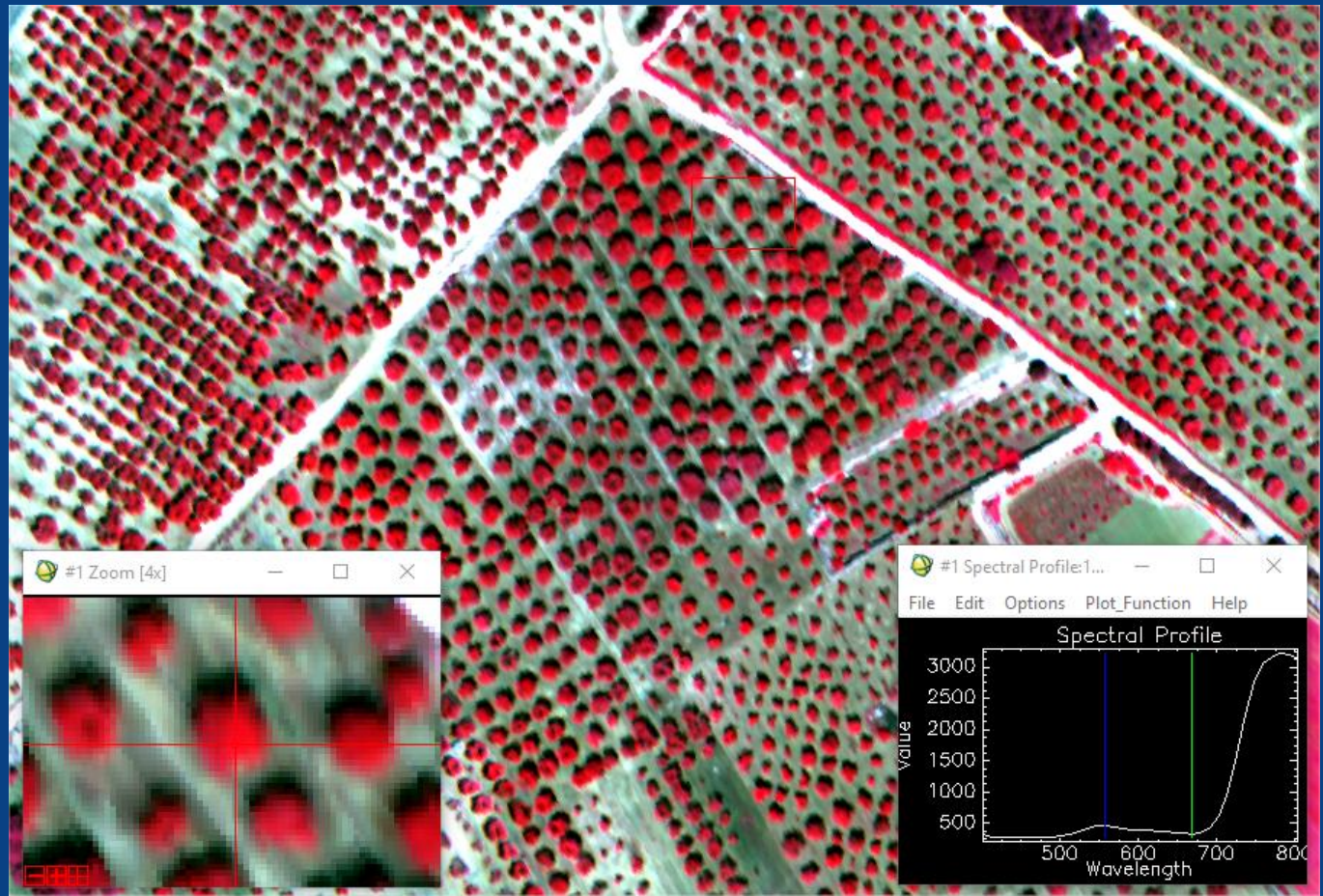
Airborne campaigns in the Balearic Islands, Spain



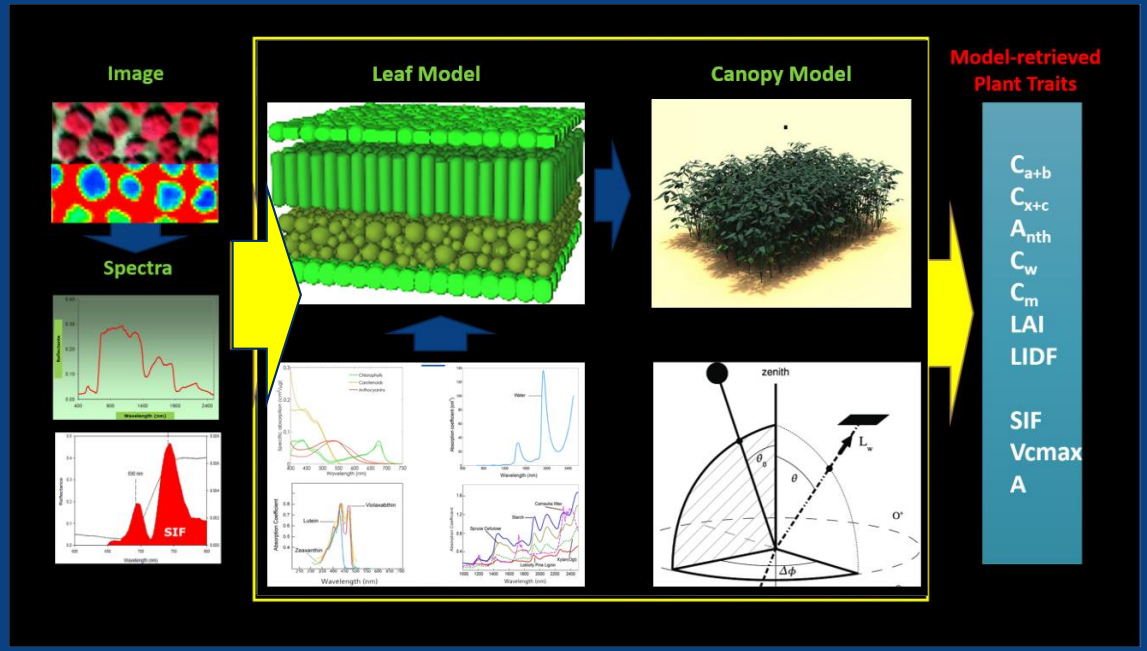
Field surveys

+ qPCR

High resolution Hyperspectral imagery



Linked leaf-canopy simulation models

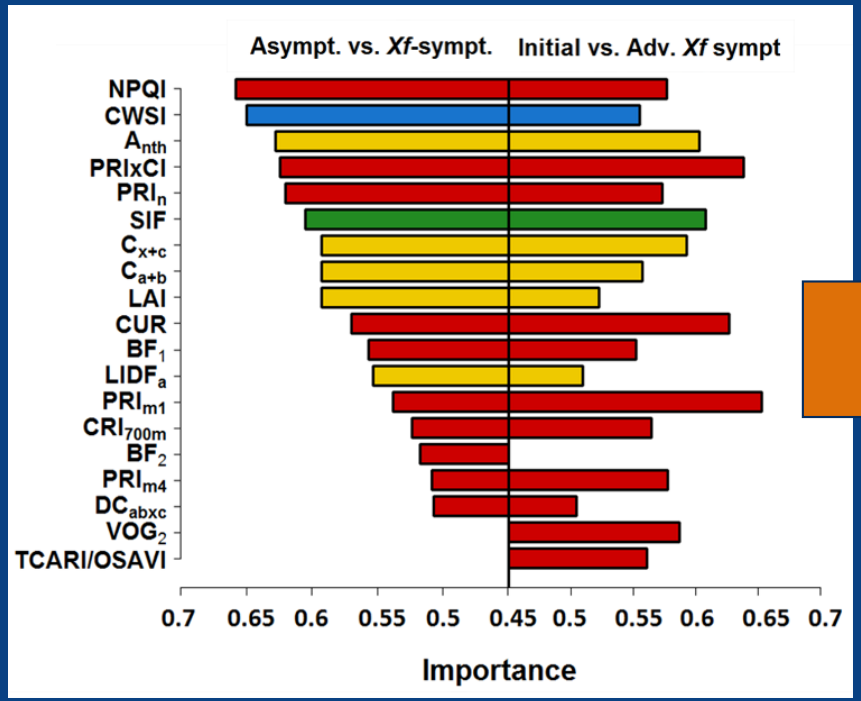


Machine learning

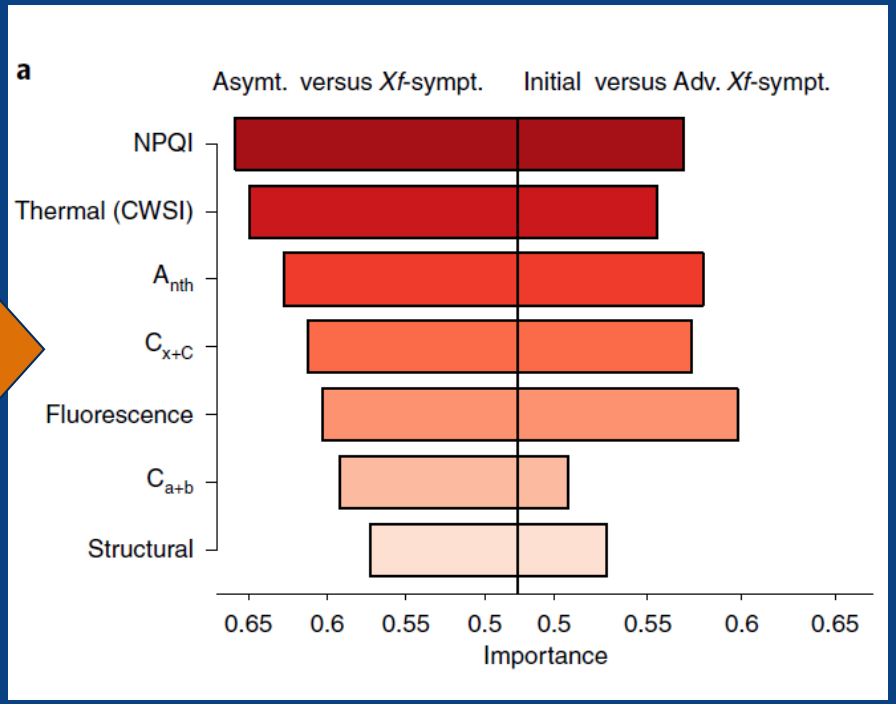
Disease detection

Sensitivity of Plant Traits to *Xf* symptoms - olive

Spectral plant traits



Spectral functional groups



Objectives

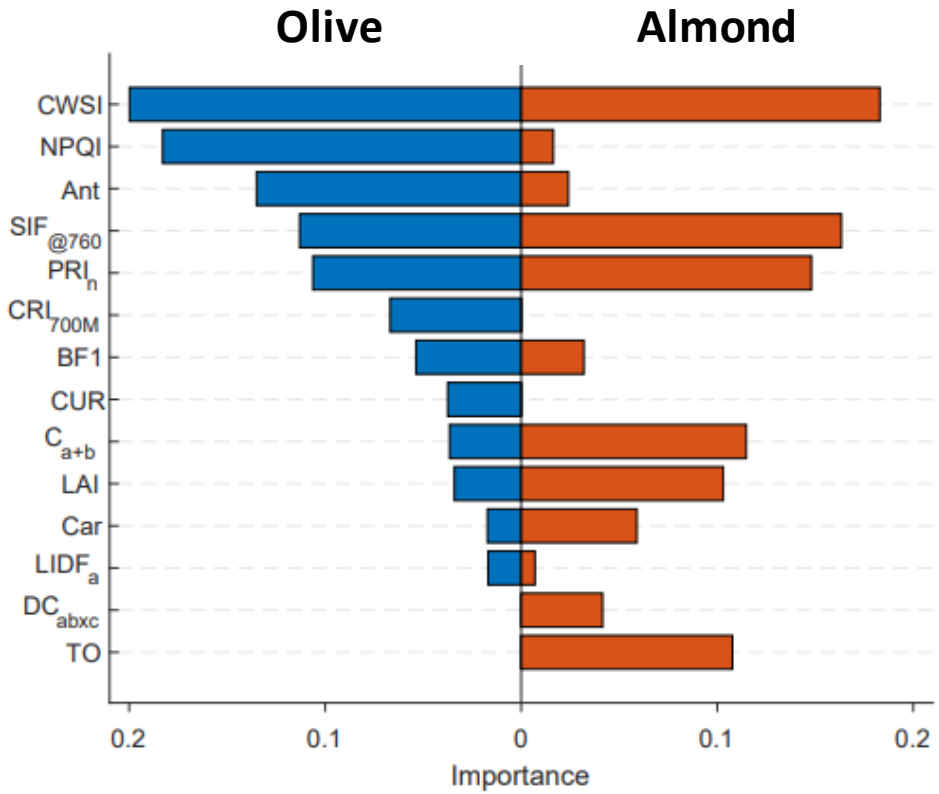
1. To assess hyperspectral and thermal imaging methods for the early detection of *Xf*-induced symptoms

2. To evaluate spectral plant traits sensitive to *Xf* across species (olive / almond)

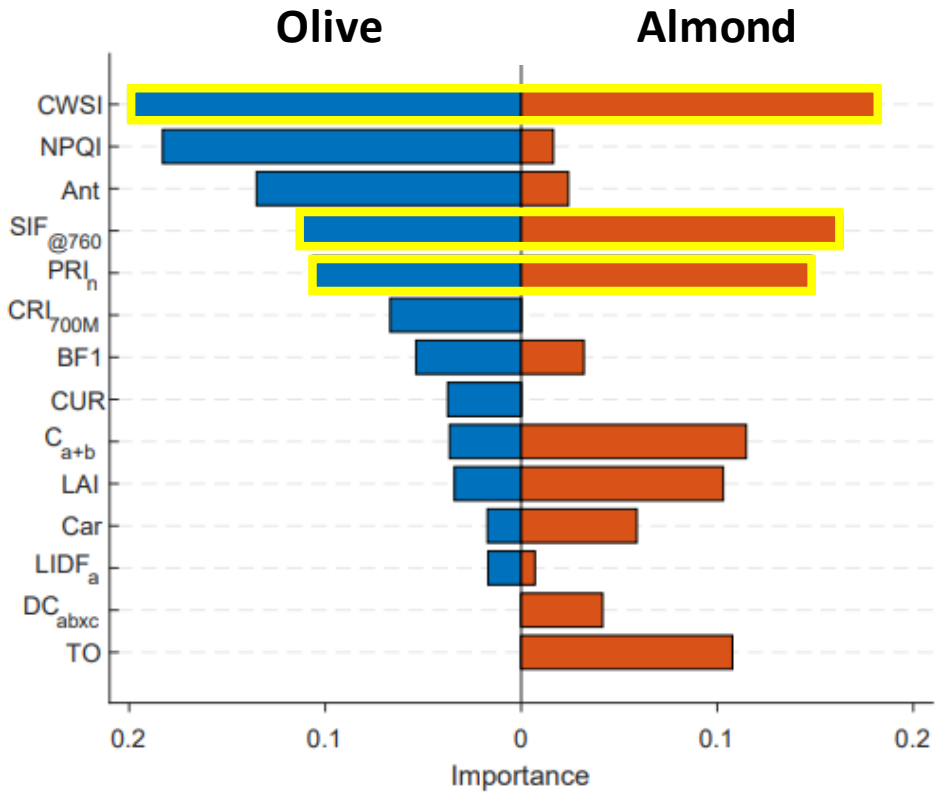
3. To quantify the influence of the abiotic condition on the detection of *Xf*

THE UNIVERSITY OF MELBOURNE

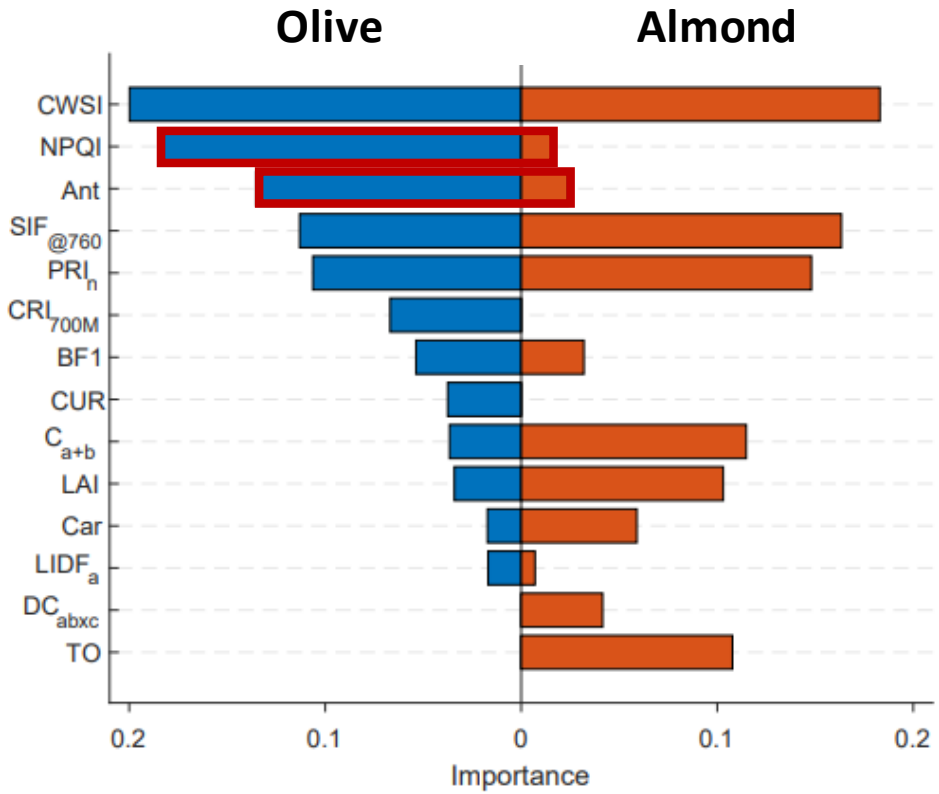
Importance of *Xf*-sensitive spectral traits in olive vs. almond



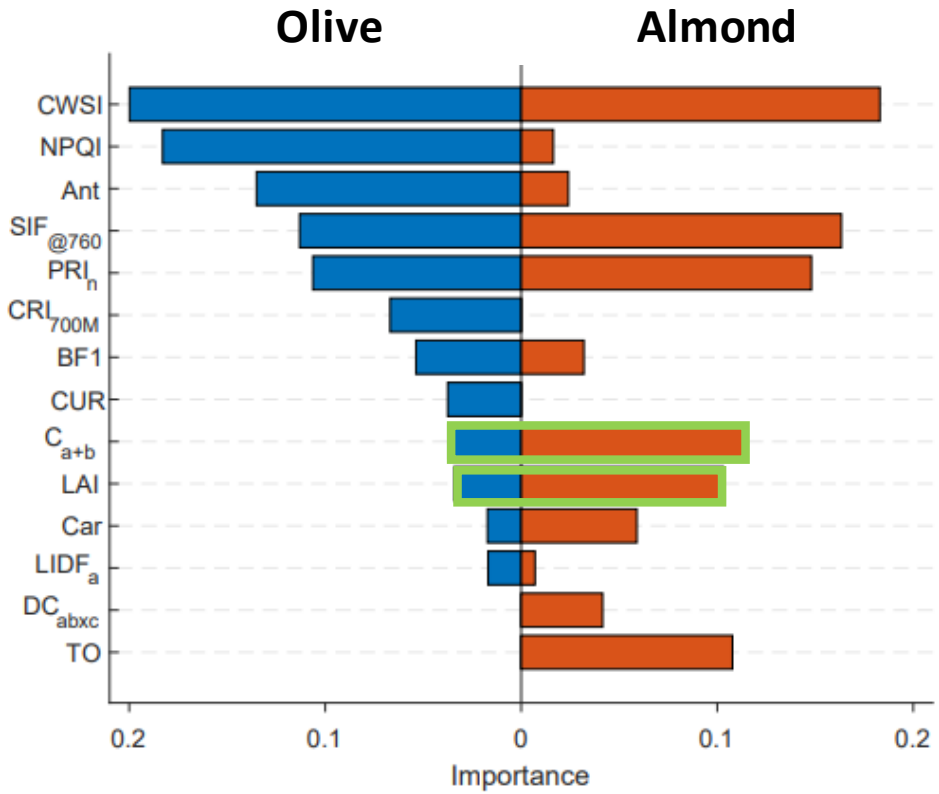
Importance of *Xf*-sensitive spectral traits in olive vs. almond



Importance of *Xf*-sensitive spectral traits in olive vs. almond

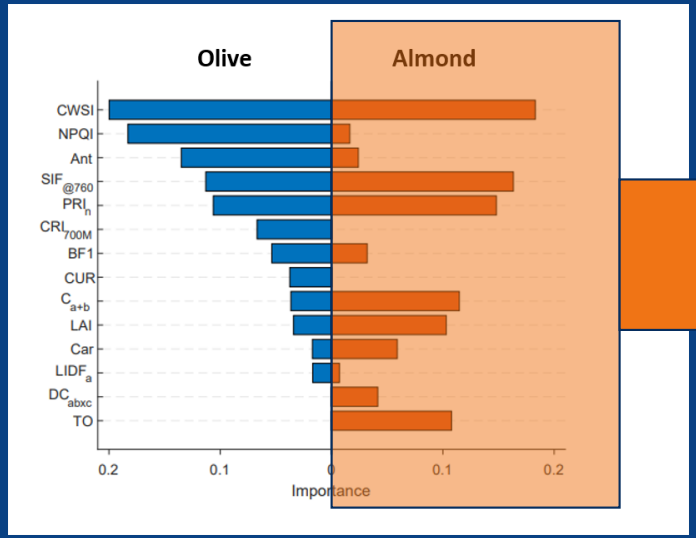


Importance of *Xf*-sensitive spectral traits in olive vs. almond

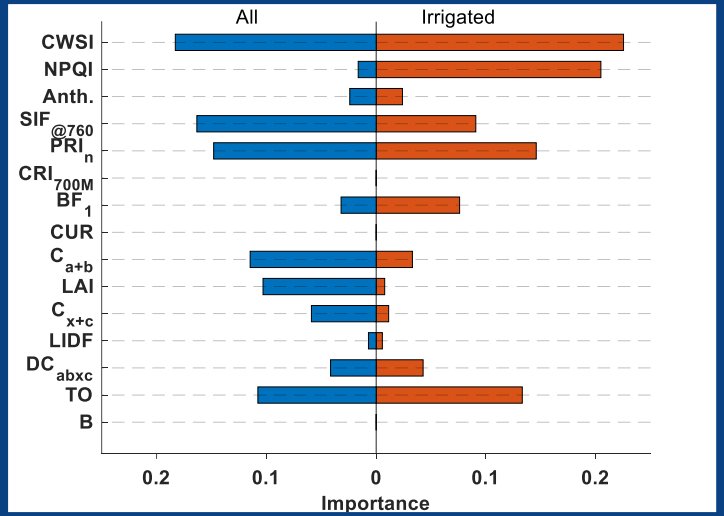


Water status effects on the spectral plant traits

Olive vs Almond

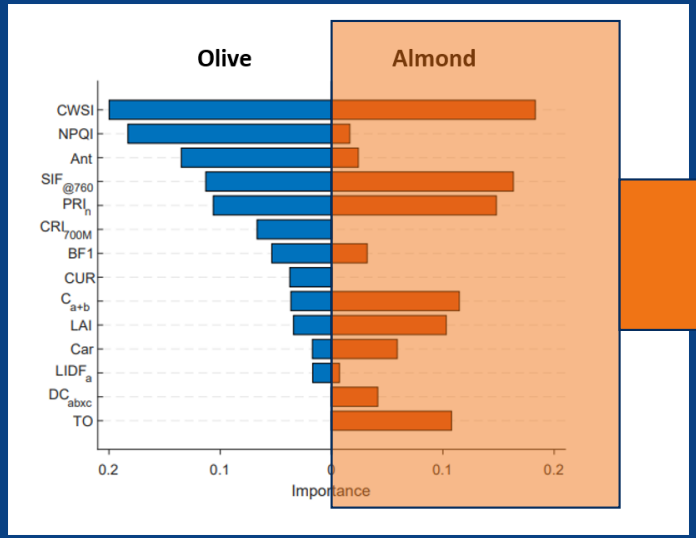


All vs. irrigated

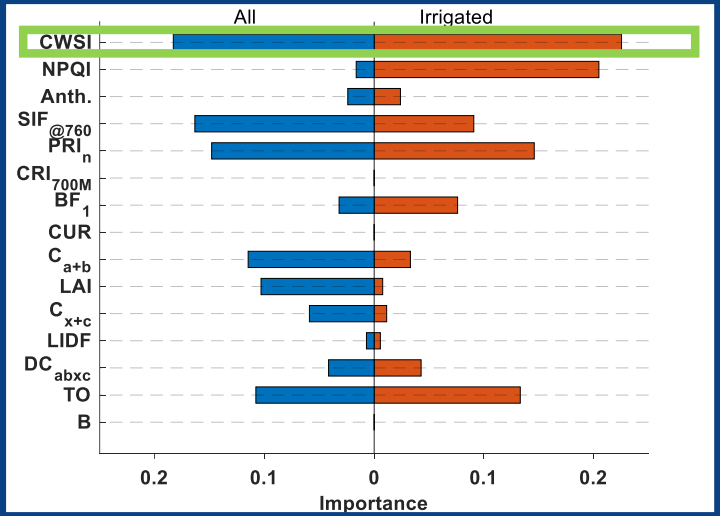


Water status effects on the spectral plant traits

Olive vs Almond

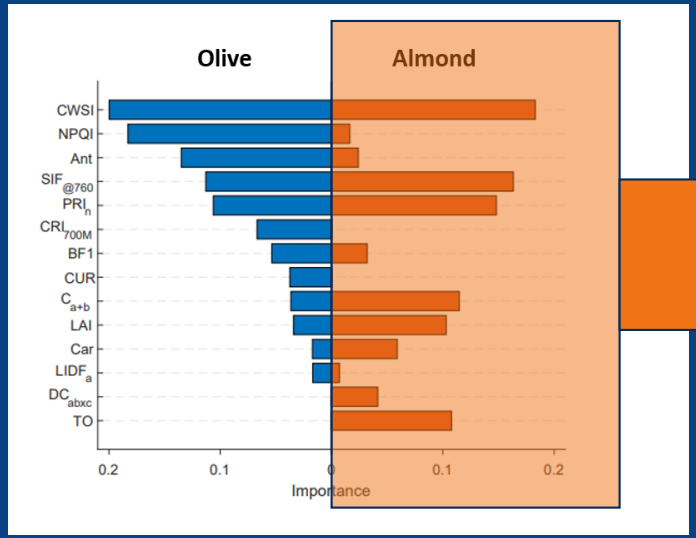


All vs. irrigated

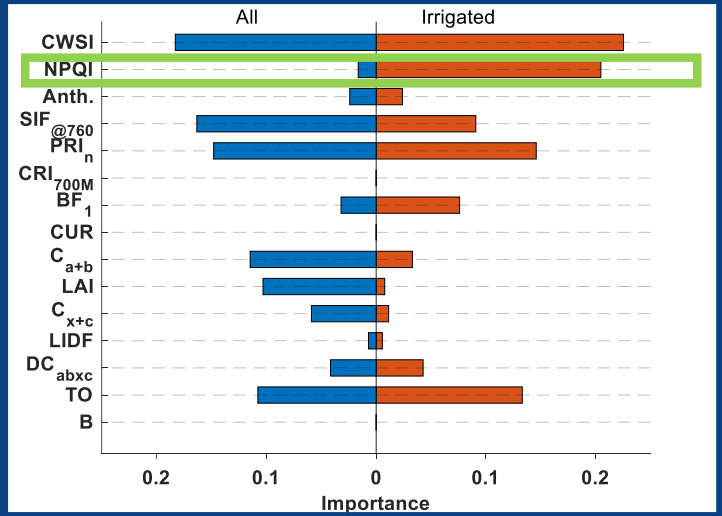


Water status effects on the spectral plant traits

Olive vs Almond

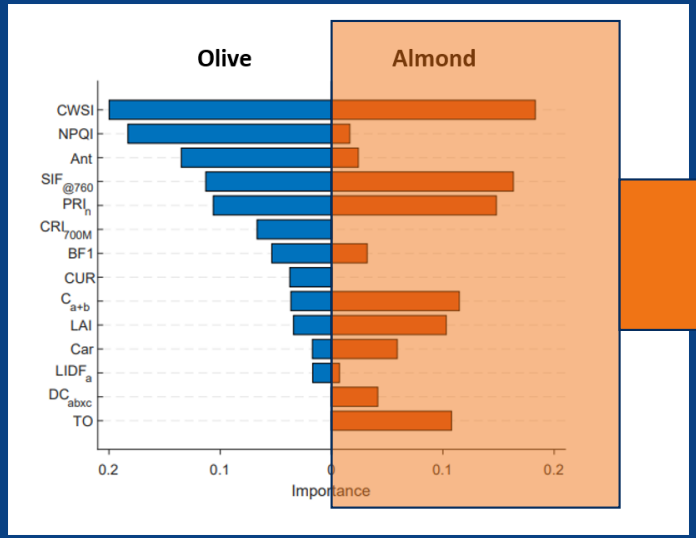


All vs. irrigated

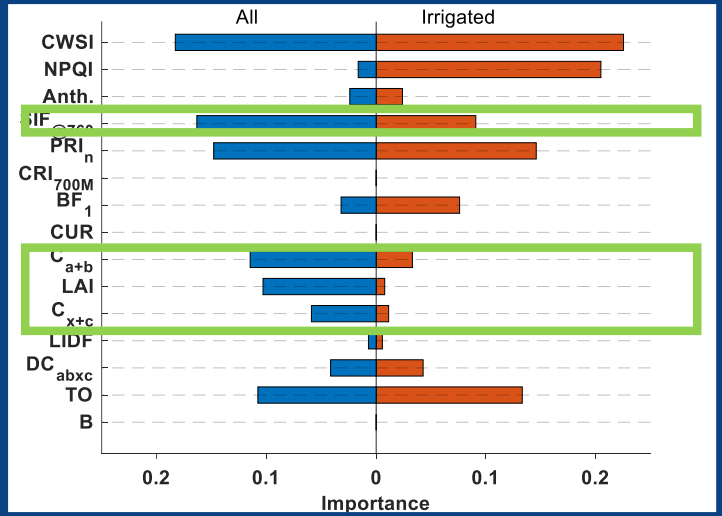


Water status effects on the spectral plant traits

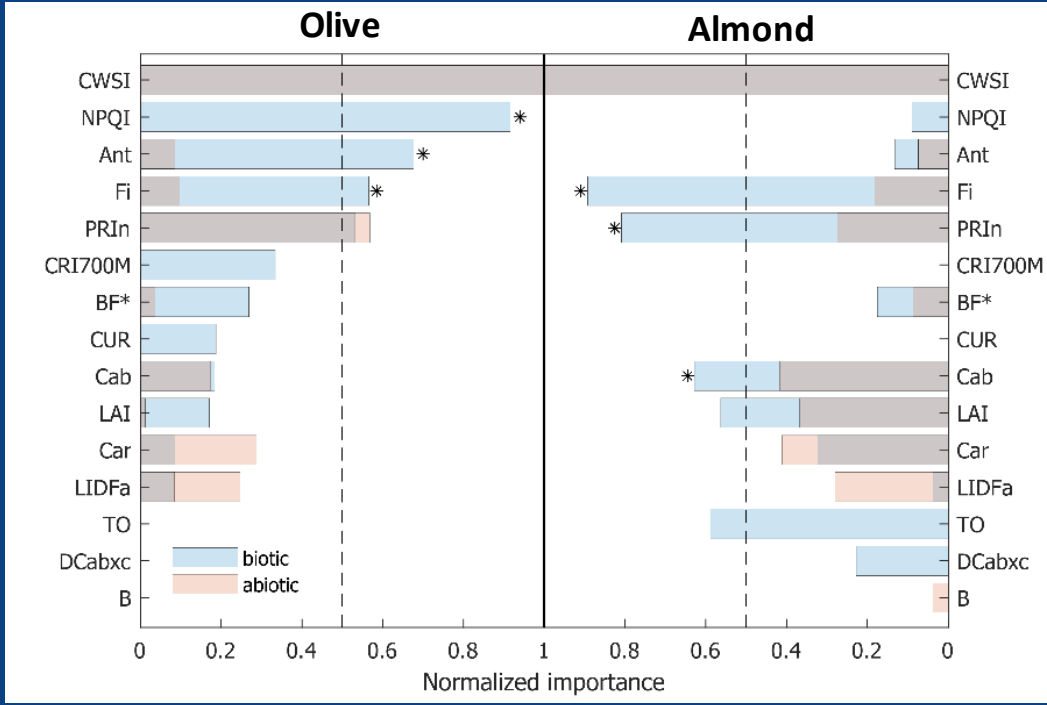
Olive vs Almond



All vs. irrigated

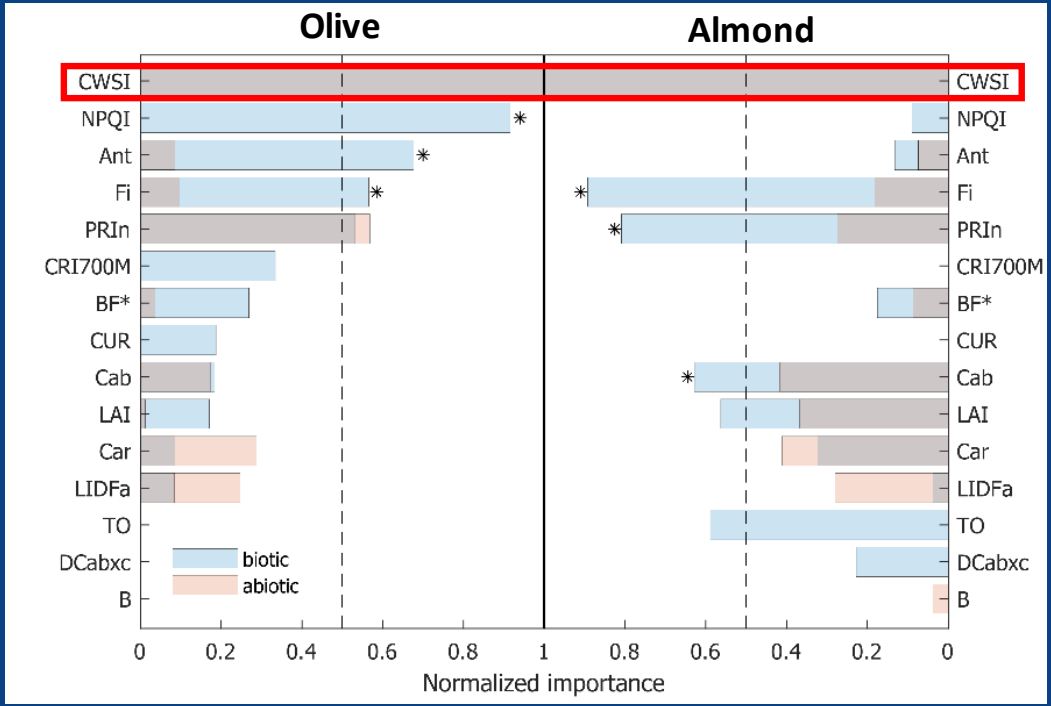


Xf – abiotic plant trait interactions for olive vs almond



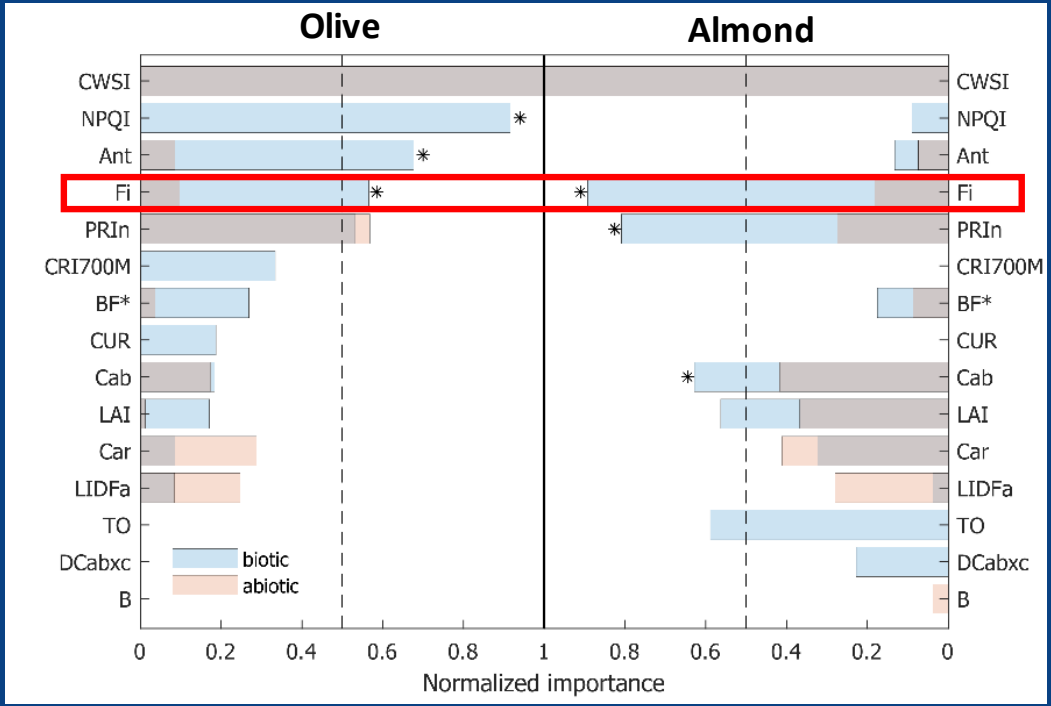
- CWSI common indicator of *Xf* and water stress
- Fluorescence emission important for *Xf* across olive and almond
- NPQI and anthocyanins are olive specific
- PRI_n and C_{a+b} are almond specific

Xf – abiotic plant trait interactions for olive vs almond



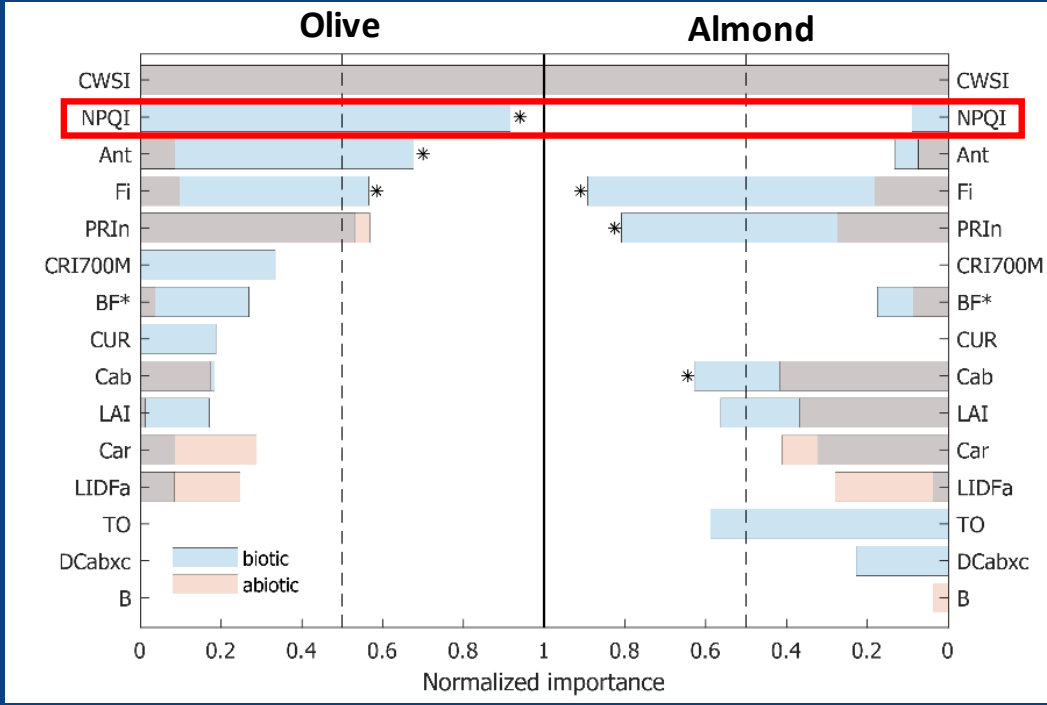
- CWSI common indicator of *Xf* and water stress
- Fluorescence emission important for *Xf* across olive and almond
- NPQI and anthocyanins are olive specific
- PRI_n and C_{a+b} are almond specific

Xf – abiotic plant trait interactions for olive vs almond



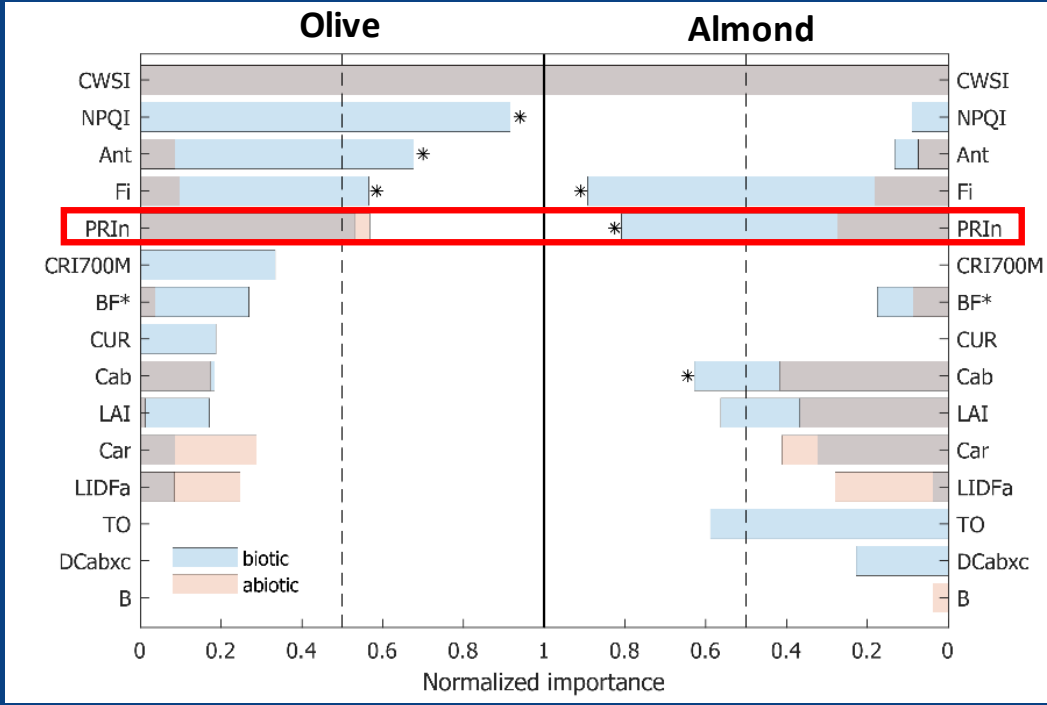
- CWSI common indicator of *Xf* and water stress
- Fluorescence emission important for *Xf* across olive and almond
- NPQI and anthocyanins are olive specific
- PRI_n and C_{a+b} are almond specific

Xf – abiotic plant trait interactions for olive vs almond



- CWSI common indicator of *Xf* and water stress
- Fluorescence emission important for *Xf* across olive and almond
- NPQI and anthocyanins are olive specific
- PRI_n and C_{a+b} are almond specific

Xf – abiotic plant trait interactions for olive vs almond



- CWSI common indicator of *Xf* and water stress
- Fluorescence emission important for *Xf* across olive and almond
- NPQI and anthocyanins are olive specific
- PRI_n and C_{a+b} are almond specific

Conclusions

1. Progress made on assessing hyperspectral and thermal remote sensing for *Xf* detection across olive and almond species (OA>0.8-0.9; k>0.6)

2. Specific spectral plant traits have been identified to successfully detect *Xf*-induced symptoms in olive and almond species (CWSI, NPQI, Anth, SIF and PRI_n)

3. Quantifying the water status (i.e. abiotic-induced stress level) is critical for improved *Xf* detection in almond and olive:
   - Almond: OA: 83% (κ=0.65) → 94% (κ=0.87)
   - Olive: OA: 77% (κ=0.43) → 92% (κ=0.83)

4. Airborne / drone hyperspectral and thermal imagery can be used for orchard scale *Xf* detection and monitoring (Poblete *et al.,* 2020; Camino *et al.,* 2021)

5. Satellite monitoring of *Xf* can be used for damage mapping, i.e. advanced severity levels (Hornero *et al.,* 2020)

3rd European Conference on
Xylella fastidiosa and XF-ACTORS final meeting

Progress and achievements on the early detection of *Xylella fastidiosa* infection and symptom development with hyperspectral and thermal remote sensing imagery

Zarco-Tejada, P.J., Poblete, T., Calderon, R., Hornero, A., Hernández-Clemente, R., Kattenborn, T., Montes-Borrego, M., Román-Écija, M., Velasco-Amo, M.P., Susca, L., Morelli, M., Gonzalez-Dugo, V., Landa, B.B., Beck, P.S.A., Boscia, D., Saponari, M., Navas-Cortes, J.A.