

The CERBERUS project: Multiplatform remote surveillance for integral crop health, early detection and actuation



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<https://cerberusproject.eu/cerberus-concept/>

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Main Objectives



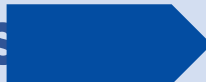
Early detection of pests

+



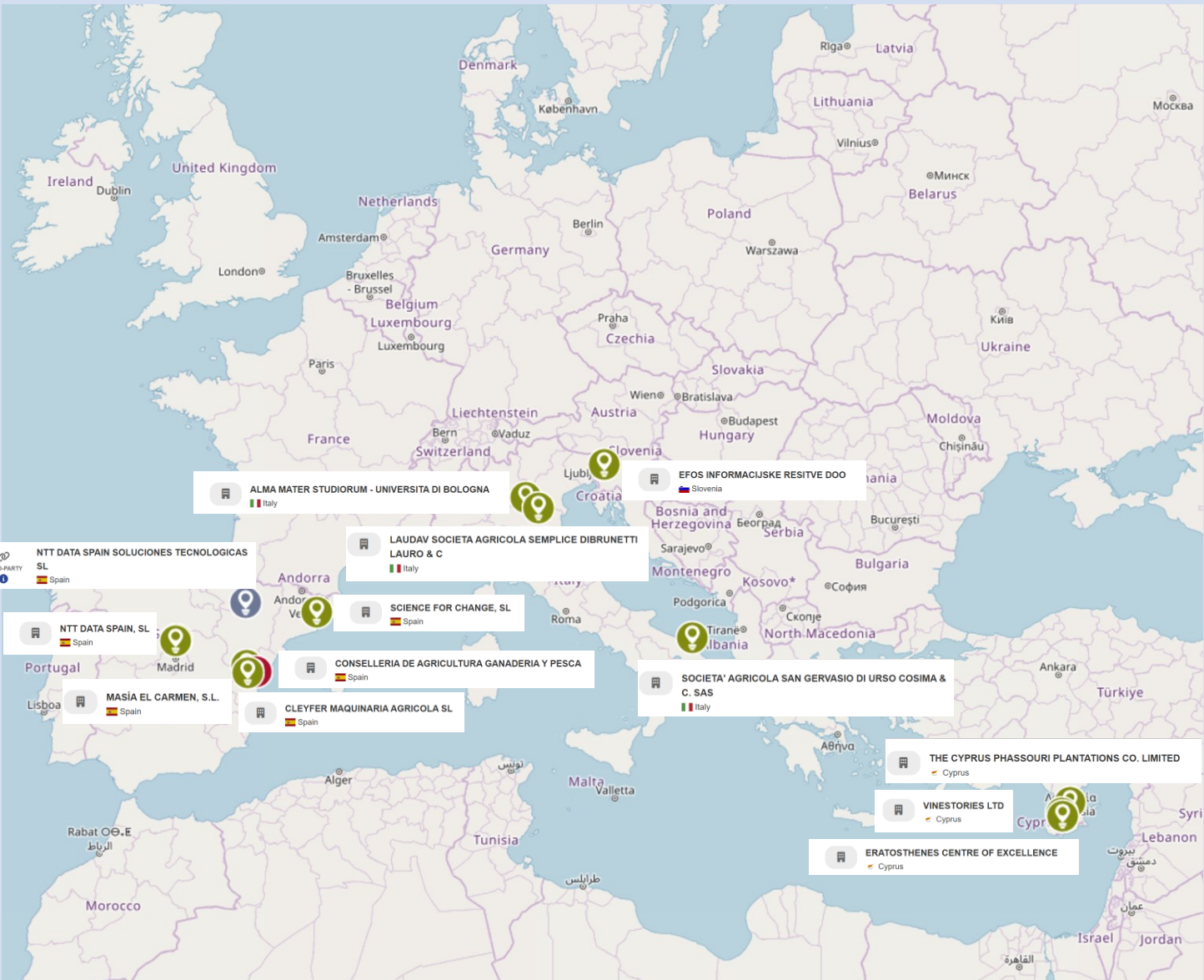
Efficient and sustainable spraying

Crop	Production area	EU Producing Countries	Target common pest	Target quarantine pest
Vine	3.2 M ha	ES, FR, IT, RO, PT, GR, DE, HR	<u>Lobesia botrana</u>	<u>Flavescence dorée</u>
Olive	4.6 M ha	ES, IT, GR, PT, FR, SI, CR, CY, MT	<u>Bactrocera oleae</u>	<u>Xylella fastidiosa</u>
Citrus	1.3 M ha	ES, IT, GR, PT, CY, FR	<u>Ceratitis capitata</u>	<u>Bactrocera dorsalis</u>

Strategy: Individual Farms  Large-scale productive zones



Consortium



CERBERUS

Grant agreement ID: 101134878

EC signature date

7 November 2023

Start date

1 January 2024

End date

31 December 2027

Funded under

Food, Bioeconomy Natural Resources, Agriculture and Environment

Total cost

€ 4 891 830,00

EU contribution

€ 4 891 830,00

Coordinated by

UNIVERSITAT POLITECNICA DE VALENCIA

Spain

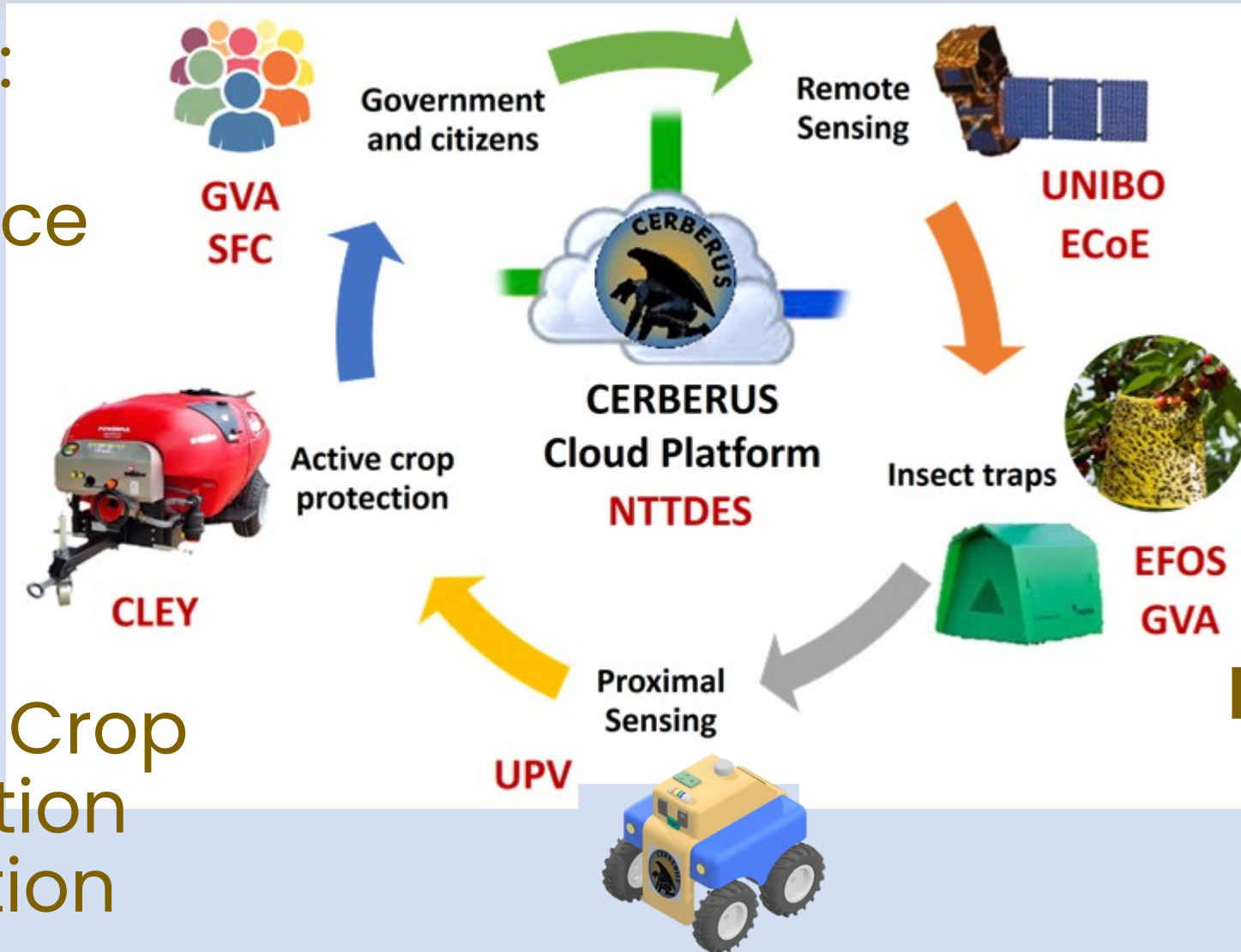




Concept and partner role

Level III:
Citizen
surveillance
(large
scale)

Level IV: Crop
protection
actuation



Level I:
Large-scale
surveillance

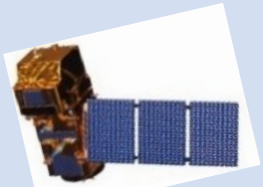
Level II: Ground
surveillance

Complete Solution: detects and fixes



Multi-platform architecture

Satellites



Sentinel - 2A



Sentinel - 2B

Copernicus

Level I

Ground Platforms



Robots

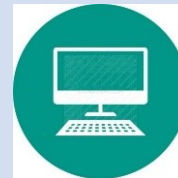
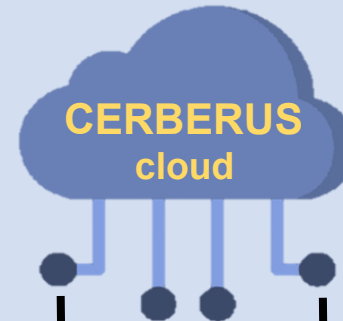
IoT
Traps



Smart
sprayer

Levels II & IV

Virtual Platform



Computer
Terminal



Mobile
Terminal

User interface

Public outreach



Plant Health Service



Citizens



EIP-Agri
Operational
Groups

Level III

WP2: Large scale remote surveillance through Copernicus observation data

- Leader: ECoE
- Focal crops: Citrus, Olives (ECoE), Vines (UNIBO)





Monitoring fruit flies and developing an infestation risk index for citrus

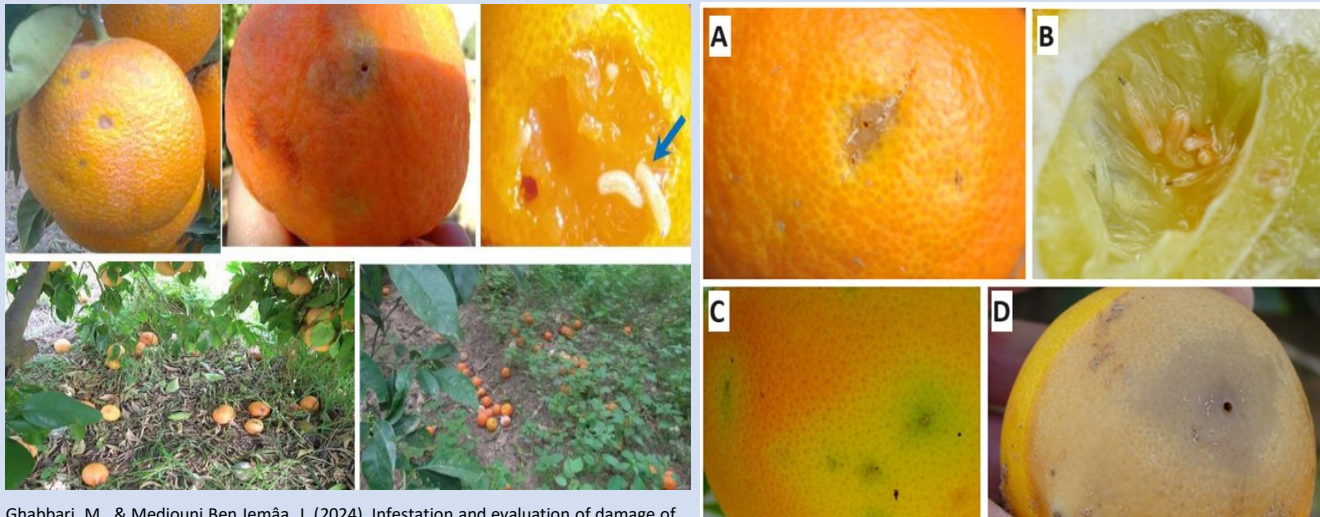


Both CERBERUS citrus pests attack the fruits

Ceratitis capitata (Mediterranean Fruit Fly)



Bactrocera dorsalis (Oriental Fruit Fly)



Ghabbari, M., & Mediouni Ben Jemâa, J. (2024). Infestation and evaluation of damage of the Mediterranean fruit fly (Medfly), *Ceratitis capitata* (Wied.) (Diptera: Tephritidae) on Citrus in Southern Tunisia. JOURNAL OF OASIS AGRICULTURE AND SUSTAINABLE DEVELOPMENT, 6(01), 101–110. <https://doi.org/10.56027/JOASD.112024>, 10/12/2024





Infestation symptoms on fruits not visible from satellite images



Fruits not visible in 10 x 10 m Sentinel 2 image – not even in 3 x 3 m Planet Labs

Need to develop an infestation pressure index based on medfly population size and other risk factors



Conceptual infestation pressure index for the medfly

Important risk factors:

✓ **Fruit maturity:** Color break

✓ **Medfly population size**

✓ **Temperature**

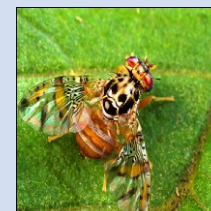


Kim, S.S.; Kim, H.-J.; Park, K.J.; Kang, S.B.; Park, Y.; Han, S.-G.; Kim, M.; Song, Y.H.; Kim, D.-S. Metabolomic Profiling of *Citrus unshiu* during Different Stages of Fruit Development. *Plants* **2022**, *11*, 967. <https://doi.org/10.3390/plants11070967>, 10/12/2024

↑ Maturity of the fruit → ↑ RISK

↑ High pop. size → ↑ RISK

Temperature → ∩ RISK



Monthei, Derek & Mueller, Scott & Lockwood, Jeffrey & Debboun, Mustapha. (2010). Entomological Terrorism: A Tactic in Asymmetrical Warfare. U.S. Army Medical Department Journal. 11-21., 10/12/2024



IoT traps installed:
Cyprus plot



Monitoring fruit maturity using satellite data (Sentinel 2)

Aim: Identify the key *phenological stages* of citrus with emphasis on color break and fruit maturation

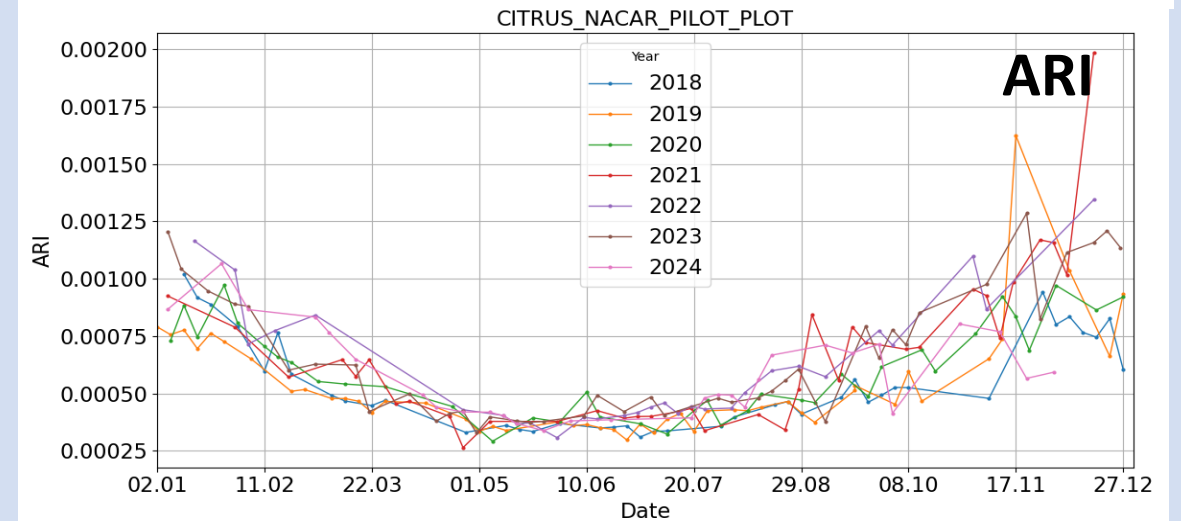
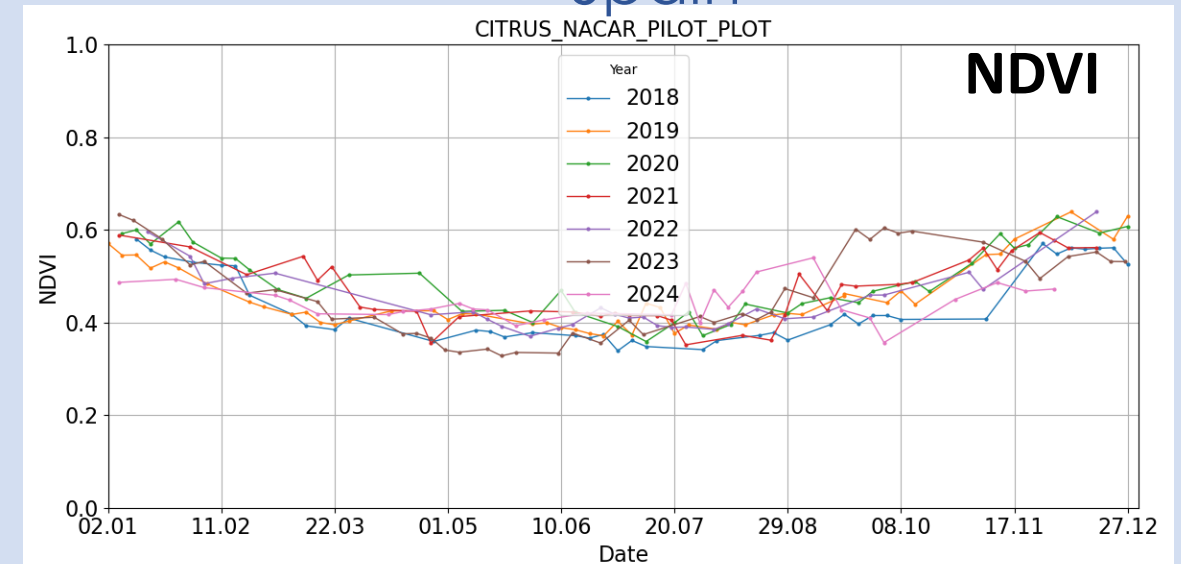
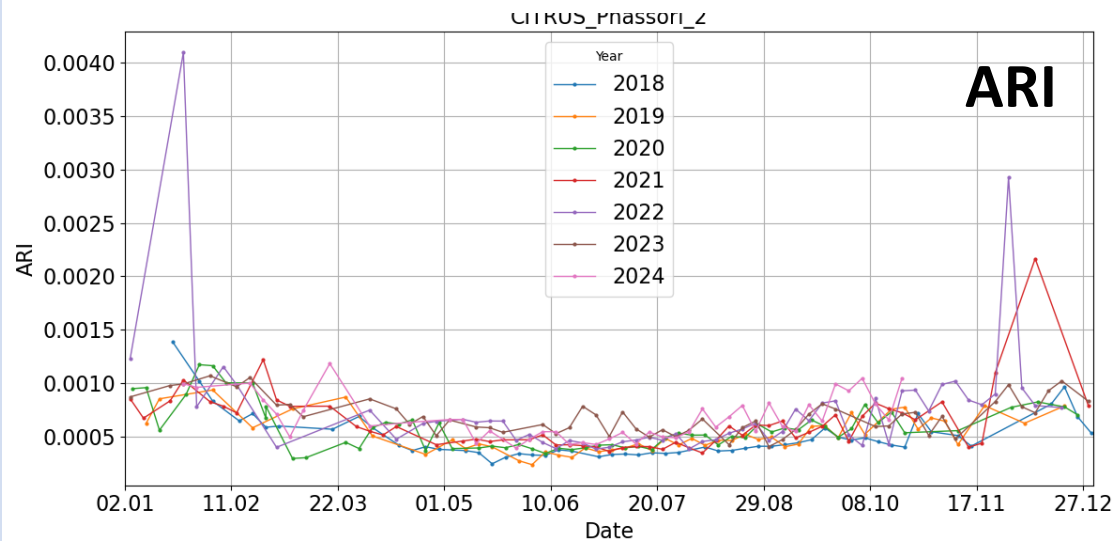
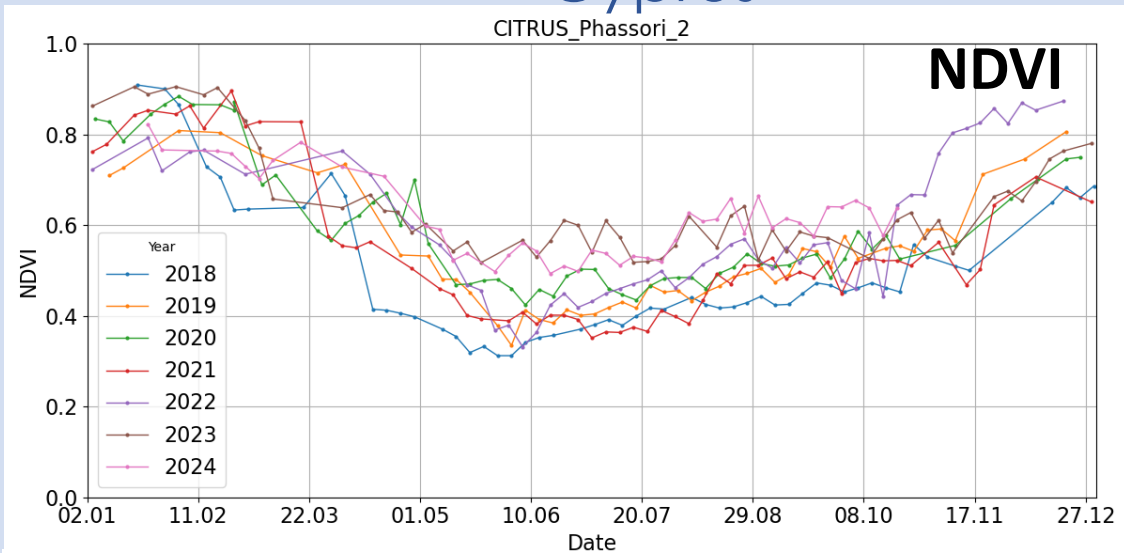


Index	Name	Formula
NDVI	Normalized Difference Vegetation Index	$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$
LAI	Leaf area index	$LAI = 3.618 \cdot EVI - 0.118$
EVI	Enhanced Vegetation Index	$EVI = \frac{2.5 \cdot (NIR - RED)}{(NIR + 6 \cdot RED - 7.5 \cdot BLUE + 1)}$
ARI	Anthocyanin Reflectance Index (accurate estimation of anthocyanin accumulation)	$ARI = \left(\frac{1}{(GREEN)} + \frac{1}{REDEGE} \right)$
NDMI	Normalized Difference Moisture Index	$NDMI = \frac{(NIR - SWIR)}{(NIR + SWIR)}$
CI	Chlorophyll Index	$CI = \left(\frac{NIR}{(GREEN)} - 1 \right)$



Satellite indices values show variation through the year

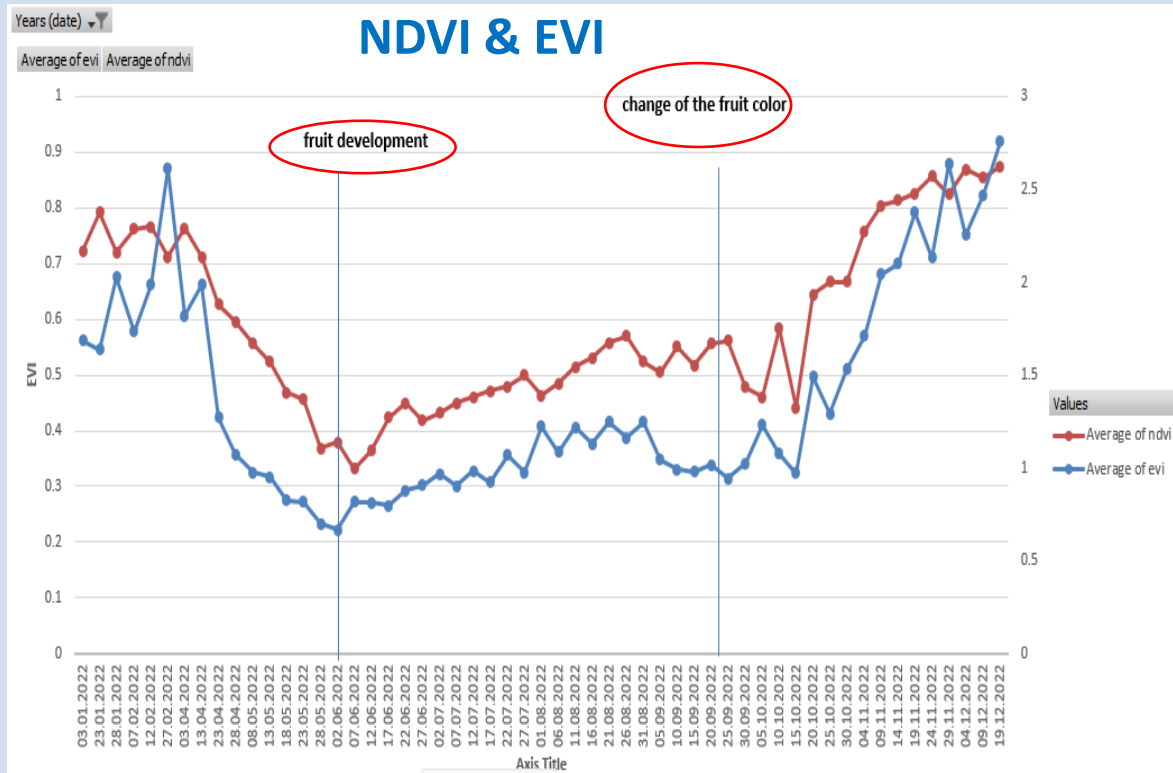
- Pick the most informative indices for crop phenology and fruit maturation
 - Cyprus
 - Spain





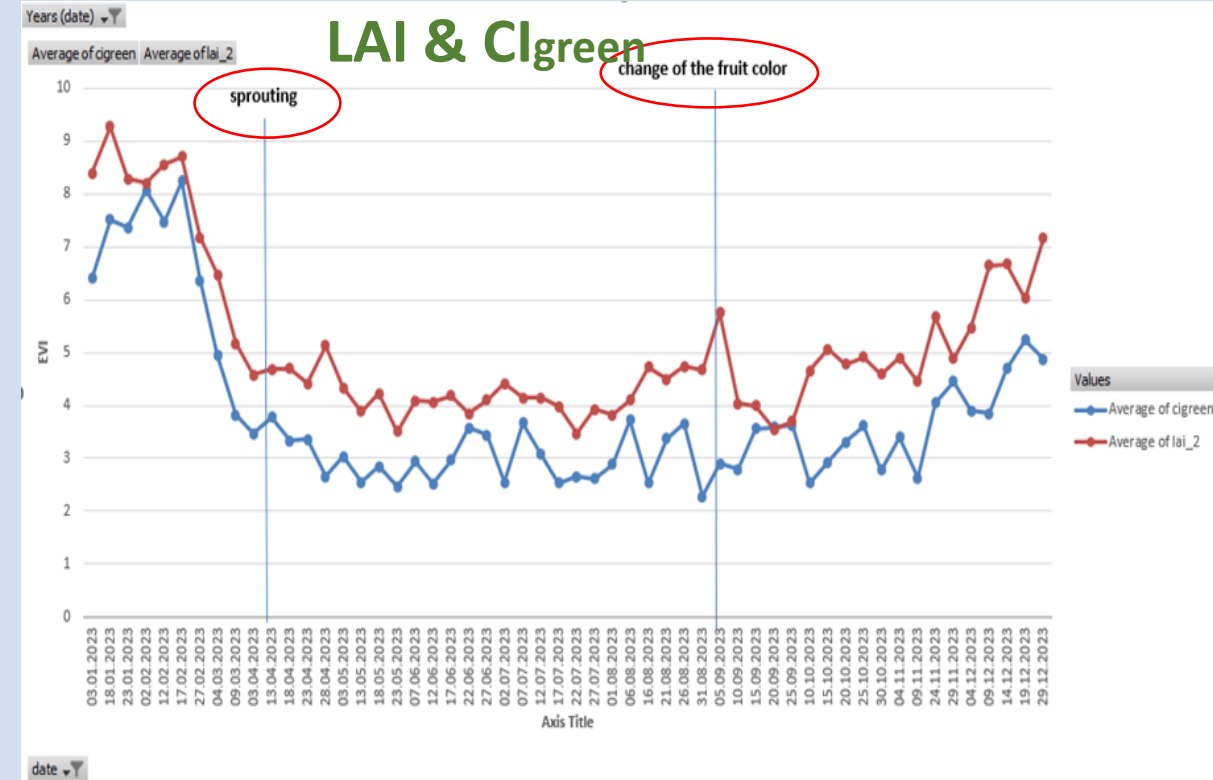
Phenology monitoring using satellite data

Preliminary identification of 4 phenological stages for citrus orchards using Cyprus plot (Phassouri plot 1)



Explanation: NDVI and EVI possible indications:
Changes in:

- fruit developmental stages
- June: fruit development
- September: change of the fruit colour.



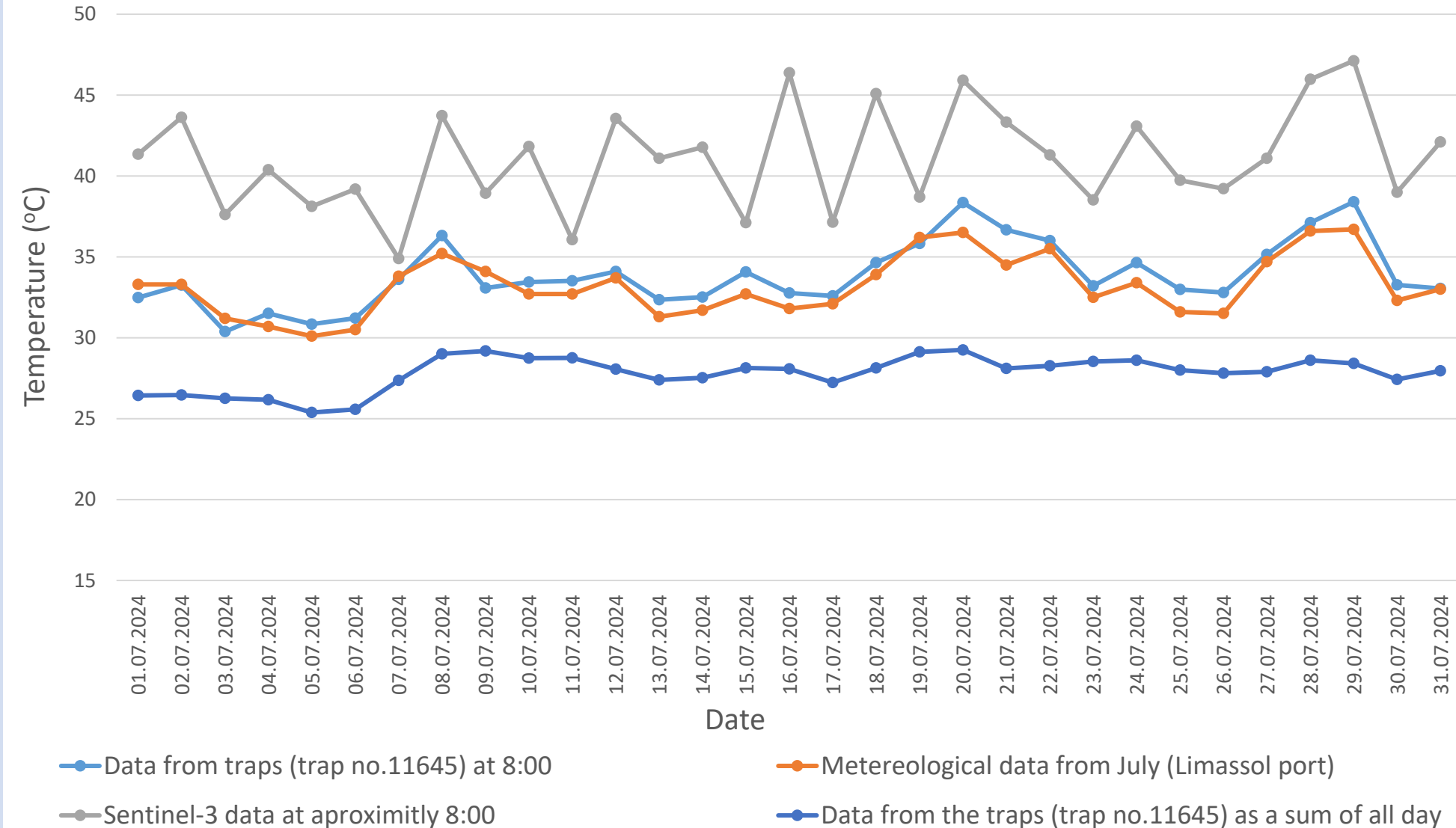
Explanation: LAI and Clgreen possible indications:
Similarities in:

- March: Flashes and possible Sprouting
- Changes in:
- September: color breaking of the fruit



Temperature layers with in-field and Sentinel 3 sensors

Diferent temperature data from different data sources



Dataset

- Satellite: Sentinel-3 Land Surface Temperature (LST) → Resolution 1km
- Trap temperature data
- Meteorological station data → 6-7km



Medfly infestation pressure index

Variable	Role of importance in this stage of the project
Temperature	High dependence of fly growth on a specific temperature range
Fruit maturity stage	Fruit flies attack fruits after the color-break
Fly population size in traps	The risk for infestation increases with higher population size

Temperature, °C	Scale layer of risk (1-10)
10-15	0
15-20	1
20-25	2
25-30	3
30-35	5
35-40	4
40-45	0

Number of flies in traps, pc (new medfly counts/day)	Scale for layer of risk (1-5)
0-5	0
5-10	1
10-15	2
15-20	3
20-25	4
25-30	5
30-35	5
More than 35	5

Maturity stage	Scale for layer of risk (1-5)
Green	0
Color break	1
1/3 changes to orange	2
2/3 changes to orange	3
Full surface orange	4
Fully mature fruit	5

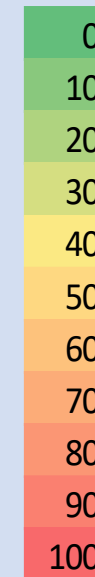


Medfly infestation pressure map example

CPPC Citrus Plots

92	67	14	96	41
6	41	11	68	52
38	46	70	5	63
97	33	34	60	26
96	1	75	92	12
40	69	95	39	69
94	19	100	3	90
54	0	3	78	35
92	5	99	24	28
21	4	70	37	87
92	22	90	31	56
13	20	43	11	27
18	75	11	97	10
34	86	38	32	64
40	19	24	31	10
93	21	31	3	42
5	84	43	44	50
22	54	60	97	64
15	28	94	69	54
58	5	9	78	35

Infestation pressure



***Xylella fastidiosa* satellite- based detection in olives**



Overview of *Xylella fastidiosa*

- *Xylella fastidiosa* (Xf) is a bacterial plant pathogen that inhabits the xylem tissue of plants and triggering water-stress
- Trees die
- Initially detected in Salento in 2013
- The main vector of Xf is the insect *Philaenus spumarius*
- Xf can infect over a hundred different plant species





Symptom Stages of *Xylella fastidiosa* in olive groves



Stages of *Xylella fastidiosa* in olive groves:
leaf symptoms (A)
expanding to
twigs (B-C),
small branches
(D)



Symptom Stages of *Xylella fastidiosa* in olive groves



Subsequently at the top of the canopy (E)

Expanding to lower parts of the canopy (F)



Finally, to the entire tree (G)

leading to the tree to death (H)



Early Symptoms of *X. fastidiosa*

Chlorotic
Halo



“Burned”
leaves
rolling
inwards



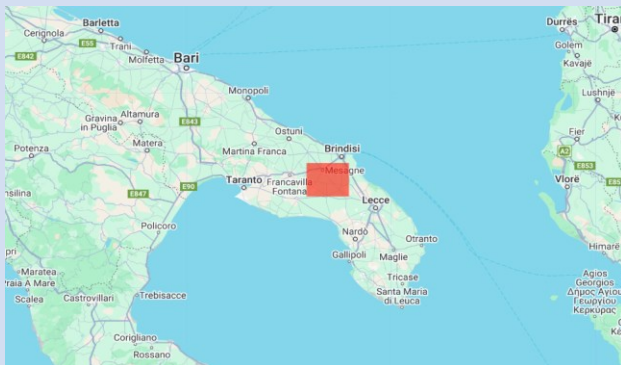
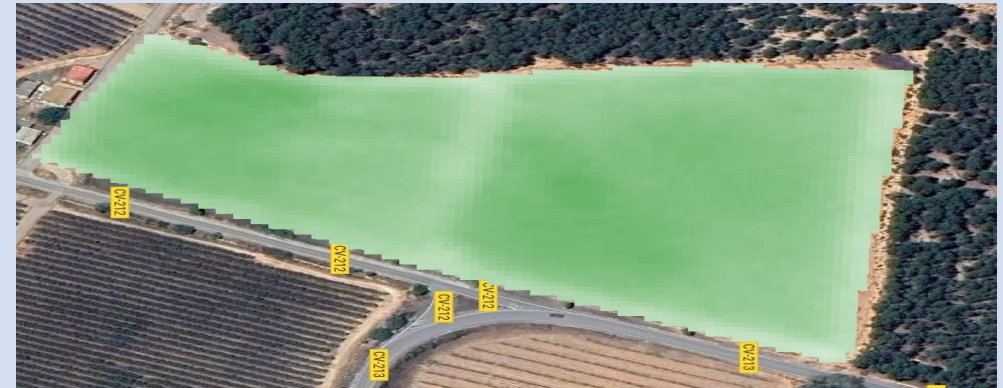
Symptoms of dieback





Olive groves dataset

Work presented here focuses on two olive orchards, one in Apulia, Italy (SAN plot) -infected by Xf and one in the province of Valencia, Spain (NACAR plot) – free from pathogen.



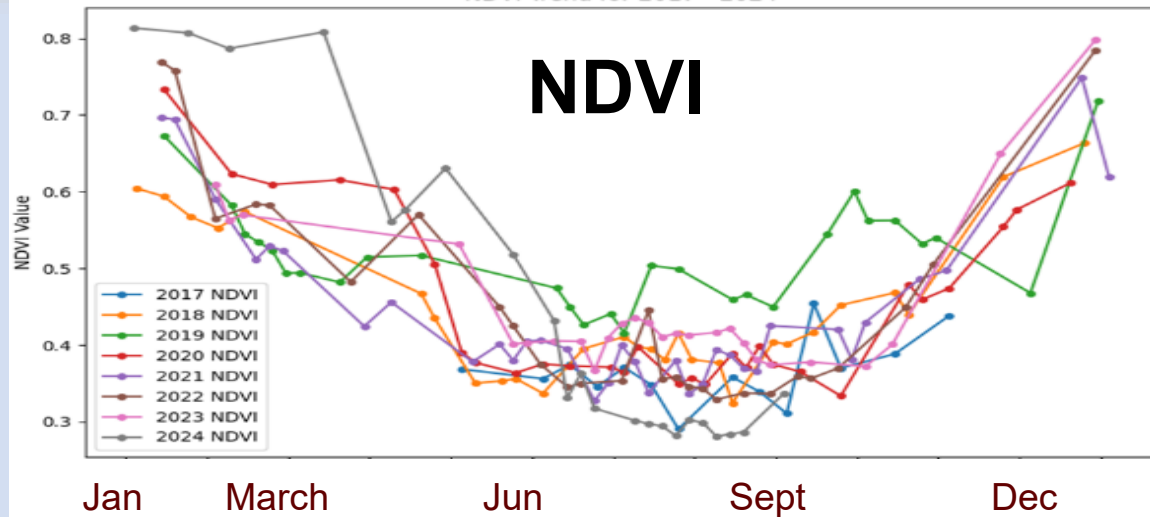


SAN Plot – IT, Infected by *Xf*

SAN Plot

NDVI Trend for 2017 - 2024

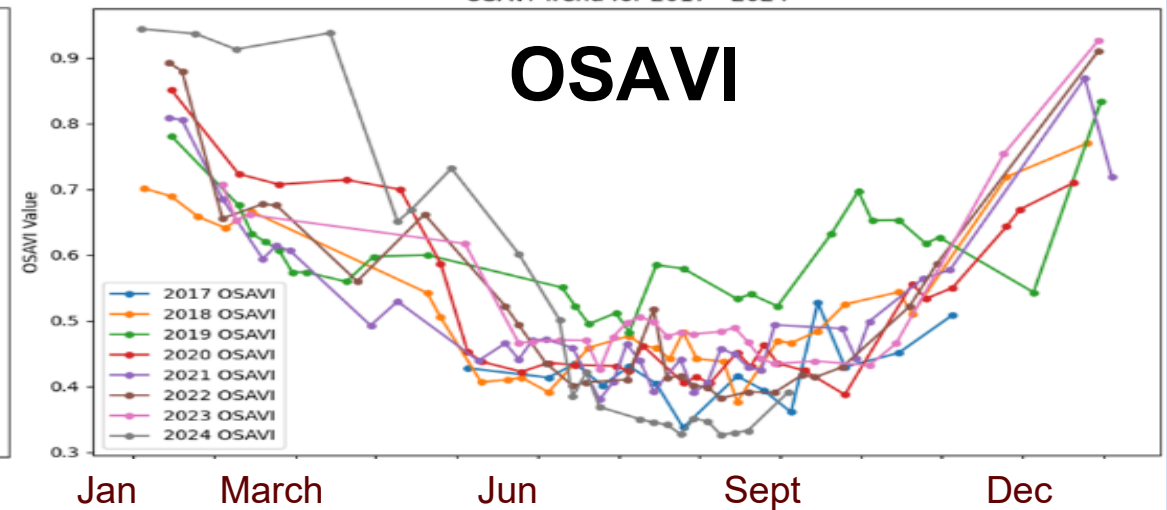
NDVI



SAN Plot

OSAVI Trend for 2017 - 2024

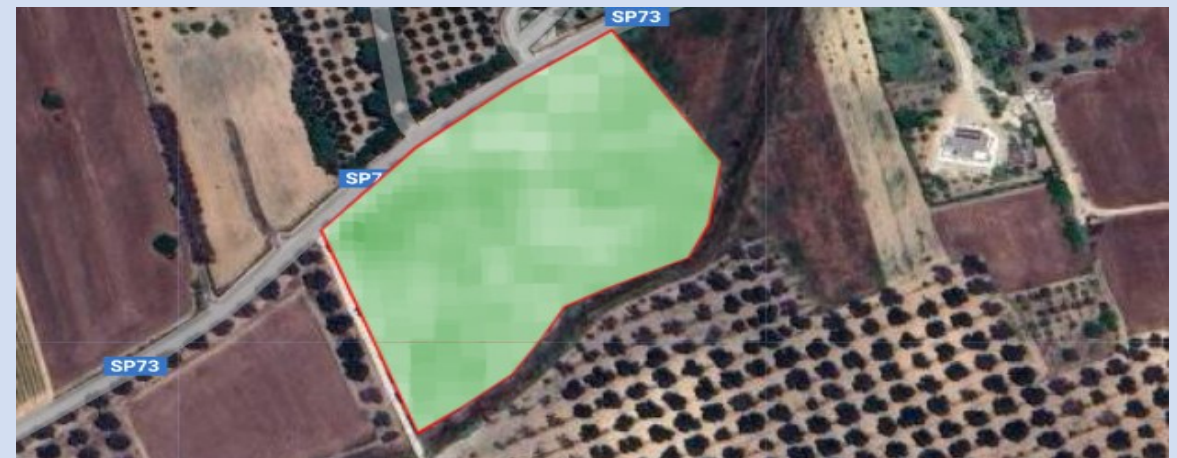
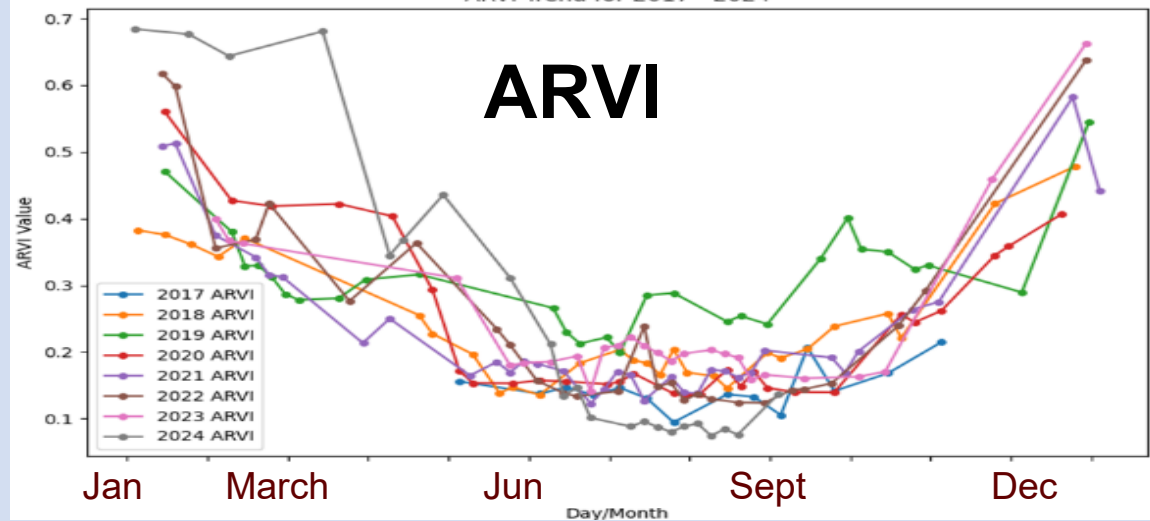
OSAVI



SAN Plot

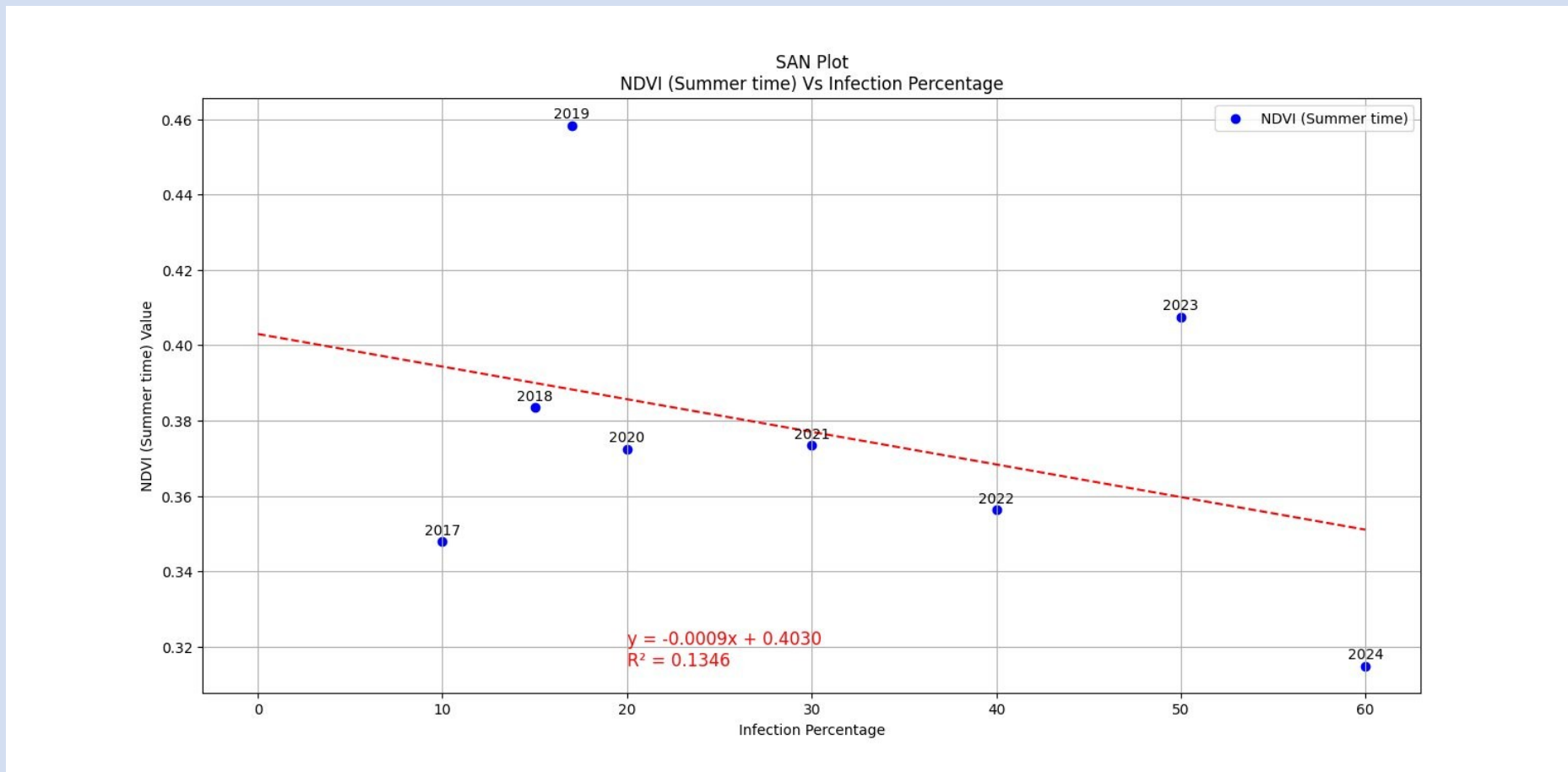
ARVI Trend for 2017 - 2024

ARVI





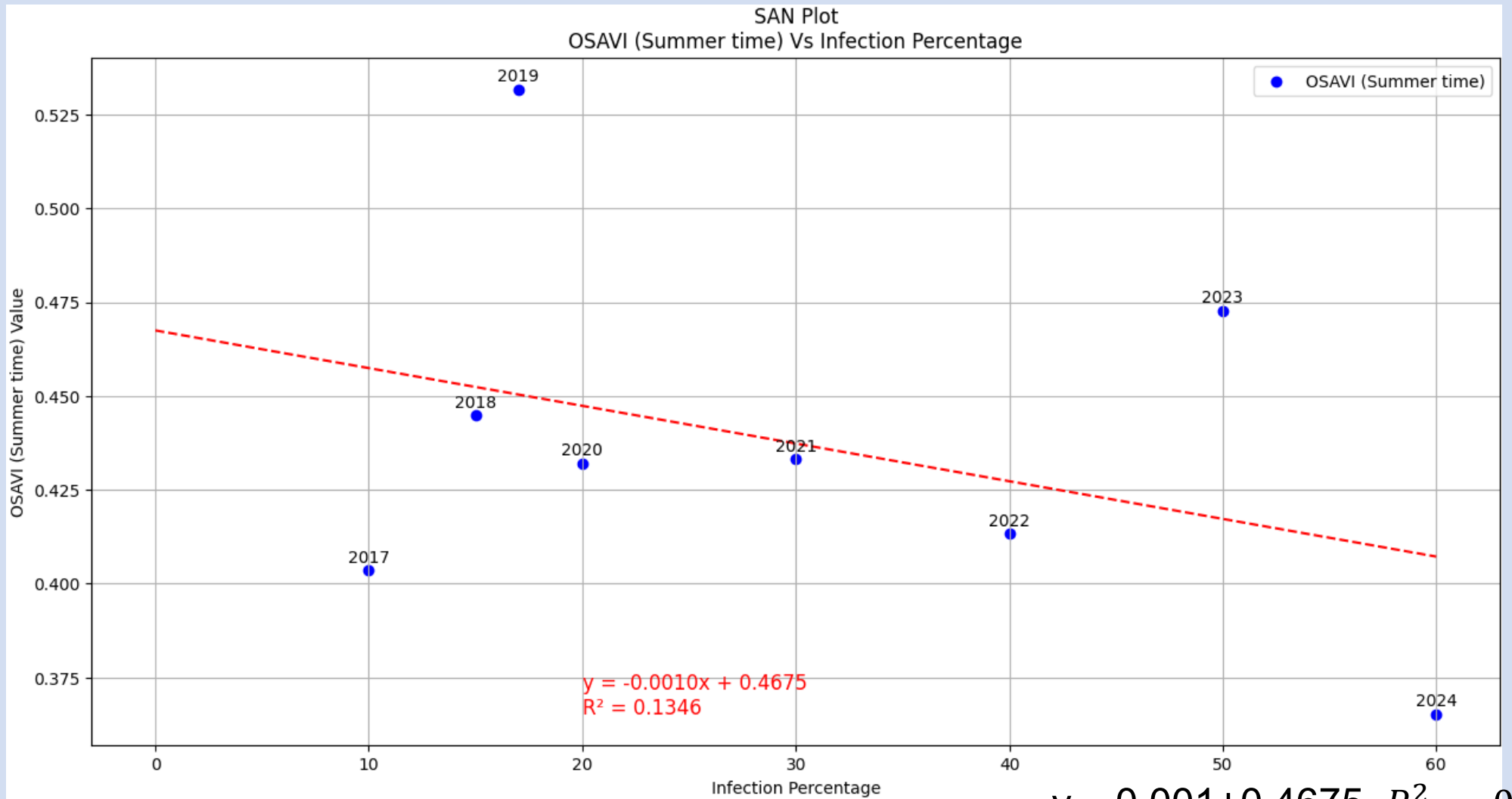
Relationship between NDVI and Xylella infection percentage (SAN plot)



$$y = -0.0009x + 0.4030, R^2 = 0.134$$



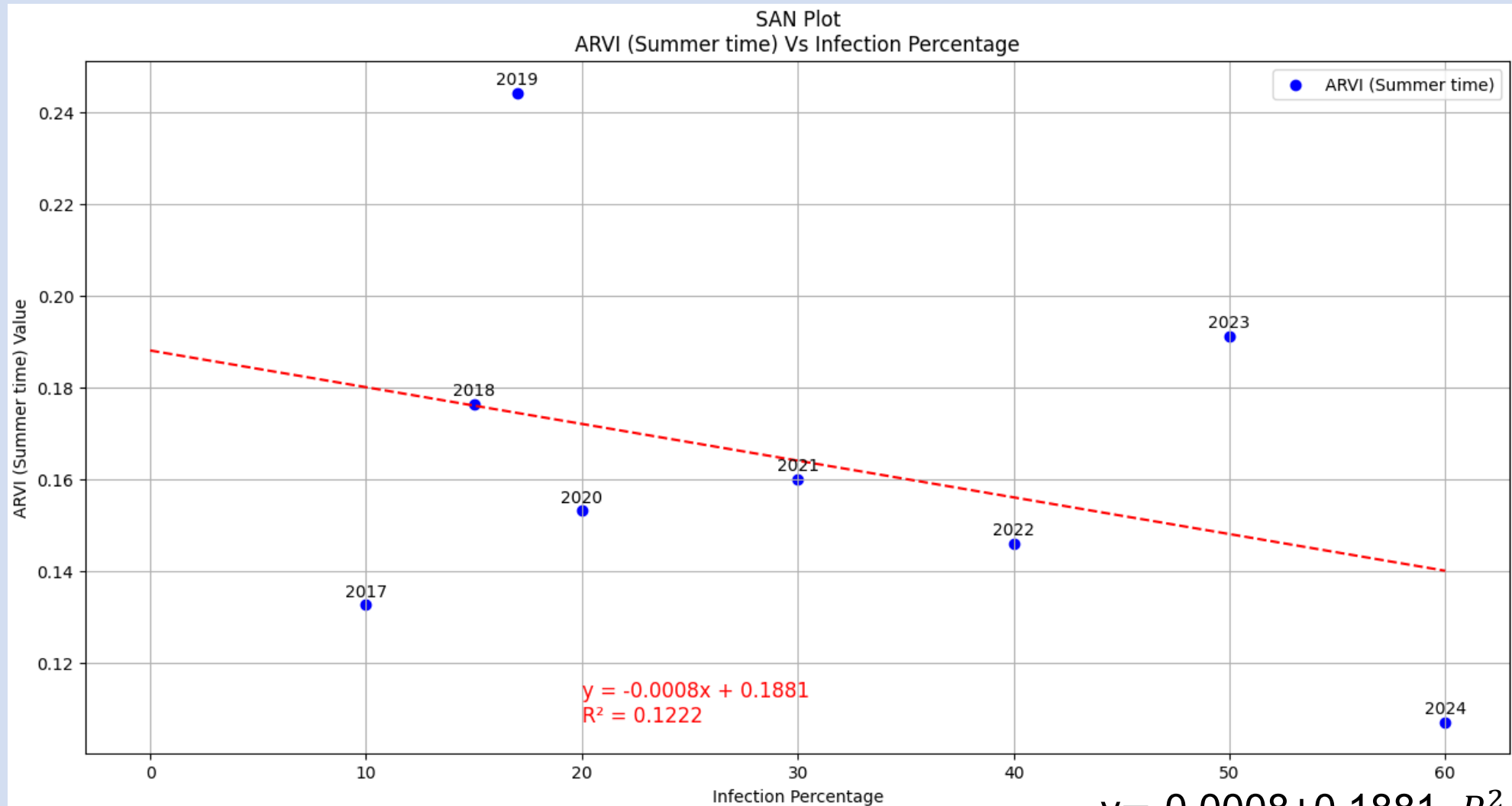
Relationship between OSAVI and Xylella infection percentage (SAN plot)



$$y = -0.001x + 0.4675, R^2 = 0.134$$



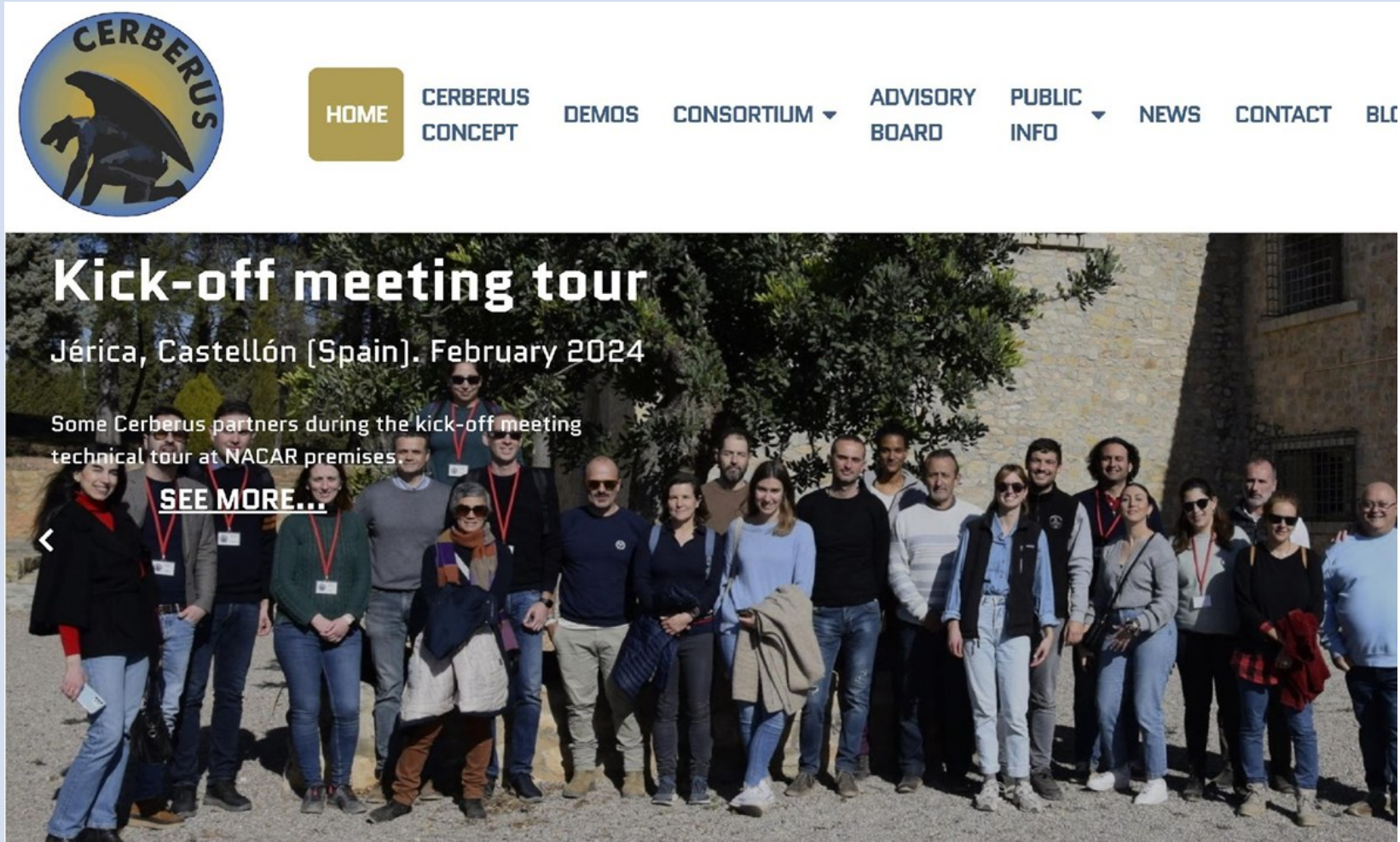
Relationship between ARVI and Xylella infection percentage (SAN plot)



$$y = -0.0008x + 0.1881, R^2 = 0.122$$



CERBERUS platform



Access through the web ... <https://cerberusproject.eu>



Structure and content

CERBERUS DATA TYPES & SOURCES

CERBERUS CLOUD PLATFORM

PUBLIC area

Earth
Observation map

Pest incidence
Map

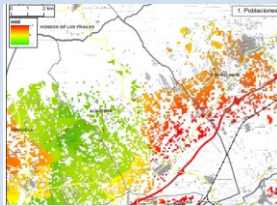
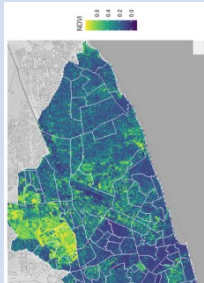
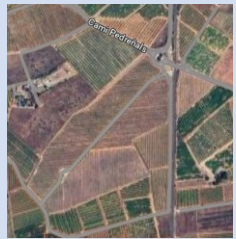
Recommendation
report

Aerial view

Spectral index

Treatment date

Product & rate



Large Scale

PRIVATE area

Field stress

Field ground-
based map

Pest incidence in
field

Prescription rate
map

Spray treatment
map

Abiotic stress

Biotic stress

Spectral indices

Regular traps

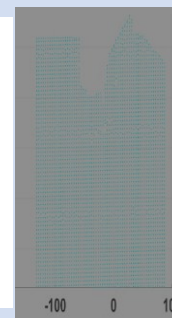
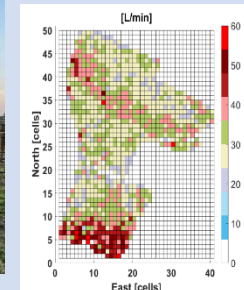
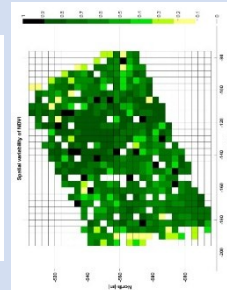
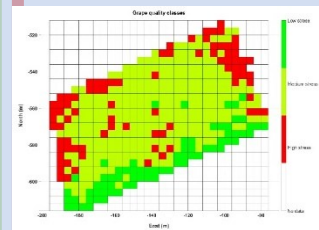
IoT Traps

Smart sprayer

Regular sprayer

Private report

Digital farmbook



Local scale: private farm

Phasouri citrus plot

Target pests:

Mediterranean fruit fly (*Ceratitis capitata*)

Oriental fruit fly (*Bactrocera dorsalis*)

CPPC

Location: Lat: 34.629997870418734, Lon: 32.95011061887146

Description: This is the sixth pilot crop of Cerberus project.

Country: CY

Region: Asomatos

Area: 120 hectares

Irrigation: Dripping-sprinkl

Crop Type: Citrus

Crop Variety: Orange

Crop Image:



Weather Forecast

2025-03-17



2025-03-18



2025-03-19



2025-03-20

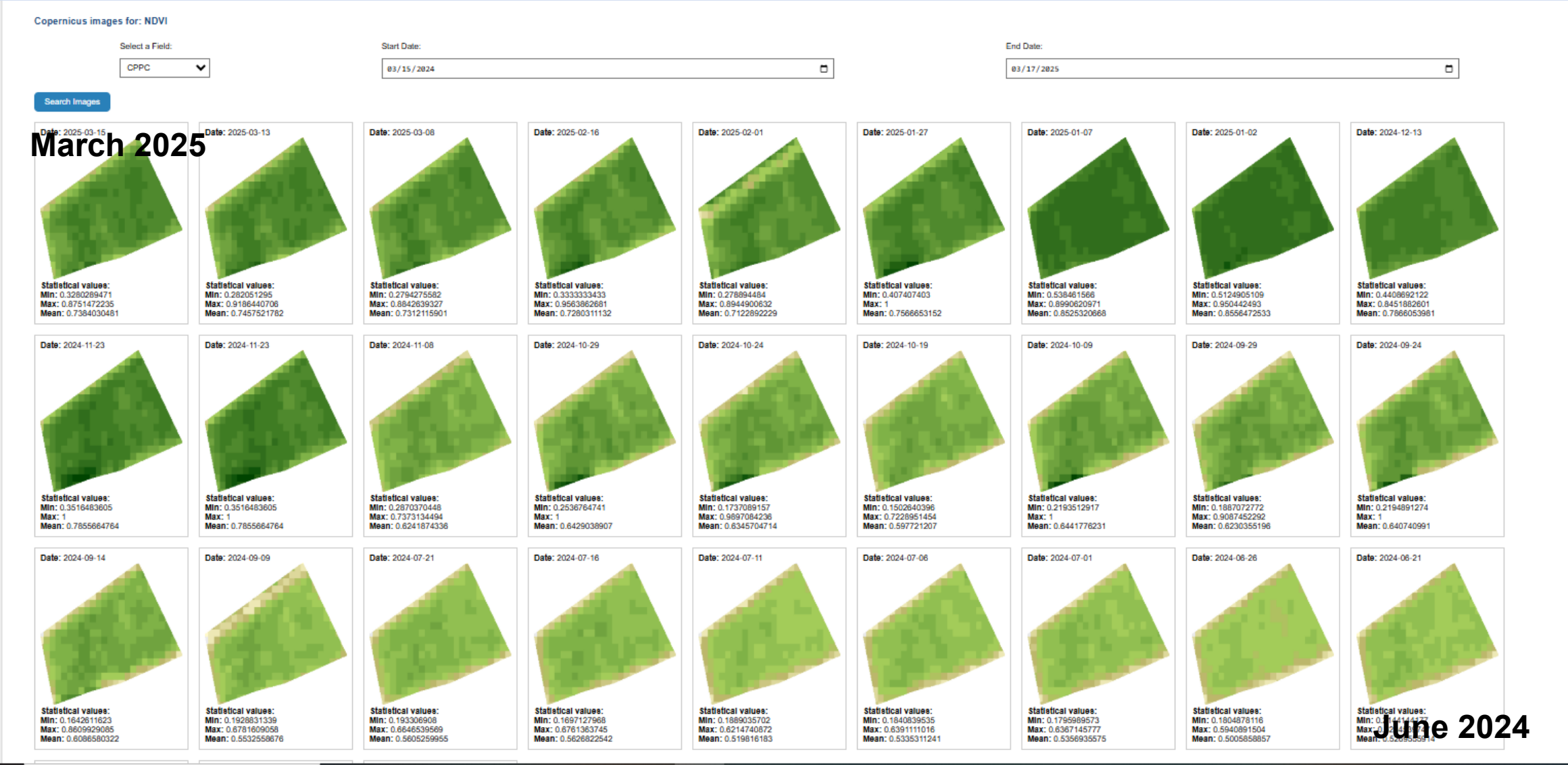


2025-03-21





Phasouri Citrus: NDVI values June 2024 to March 2025

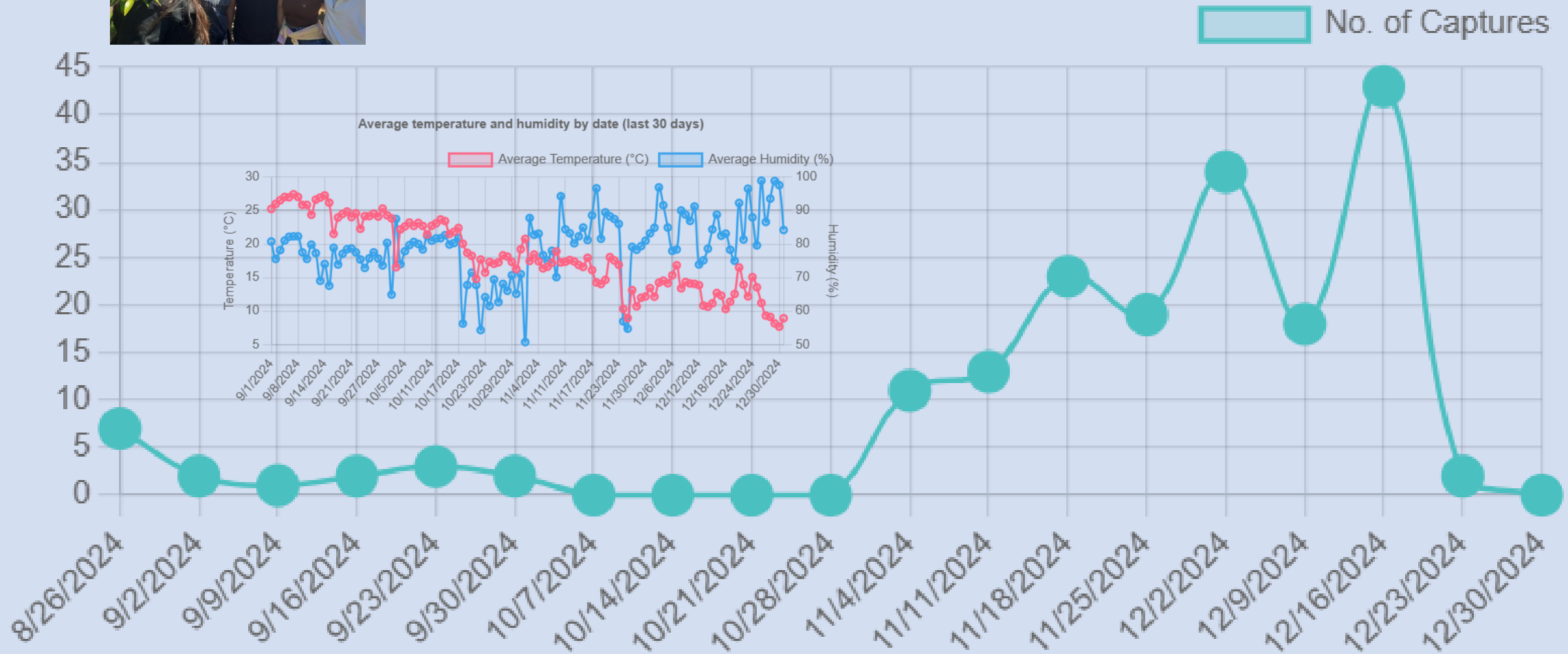




Phasouri: Medfly captures in smart traps



Captures by week



Olive Plot: SAN, IT

Target pests:

Olive fruit fly (*Bactrocera dorsalis*)

Olive quick decline syndrome
(*Xylella fastidiosa*)

SAN

Location: Lat: 40.54563694827874, Lon: 17.78846789650007

Description: This is the fifth pilot crop of Cerberus project.

Country: IT

Region: Brindisi

Area: 2 hectares

Irrigation: Dry farmed

Crop Type: Olives

Crop Variety: Arbequina

Crop Image:



Weather Forecast

2025-03-17



2025-03-18



2025-03-19



2025-03-20



2025-03-21



SAN Olive: NDVI values June 2024 to March 2025

Search Images

Date: 2025-03-09
March 2025



Statistical values:
Min: 0.3825338185
Max: 0.7715575895
Mean: 0.5624672072

Date: 2025-03-04



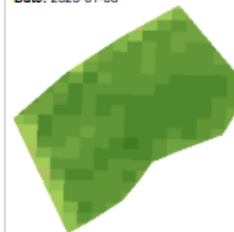
Statistical values:
Min: 0.344276458
Max: 0.8093492389
Mean: 0.7202207764

Date: 2025-02-22



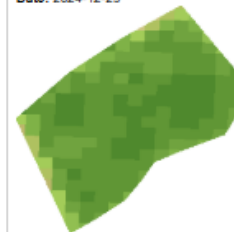
Statistical values:
Min: 0.3719378326
Max: 0.8169096112
Mean: 0.721907675

Date: 2025-01-08



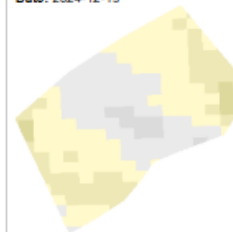
Statistical values:
Min: 0.3779443204
Max: 0.8006952405
Mean: 0.7142172435

Date: 2024-12-29



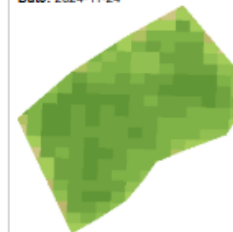
Statistical values:
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Max: 0.7953696847
Mean: 0.7064469516

Date: 2024-12-19



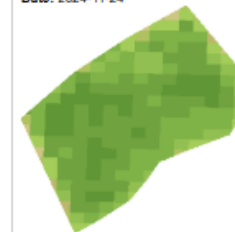
Statistical values:
Min: 0.1272141635
Max: 0.3269016743
Mean: 0.2186872222

Date: 2024-11-24



Statistical values:
Min: 0.3550185859
Max: 0.7429367304
Mean: 0.6418594588

Date: 2024-11-24



Statistical values:
Min: 0.3550185859
Max: 0.7429367304
Mean: 0.6418594588

Date: 2024-11-19



Statistical values:
Min: 0.2895188928
Max: 0.5573560596
Mean: 0.476897996

Date: 2024-11-04



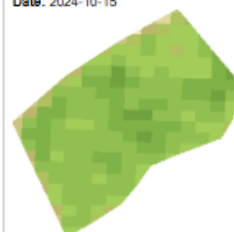
Statistical values:
Min: 0.2288557142
Max: 0.7442295551
Mean: 0.6227971521

Date: 2024-10-30



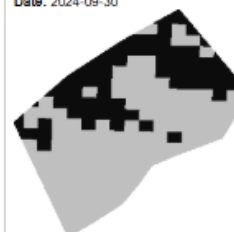
Statistical values:
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Max: 0.6317016482
Mean: 0.4896468633

Date: 2024-10-15



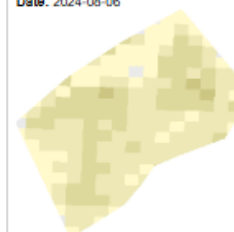
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Mean: 0.5684592066

Date: 2024-09-30



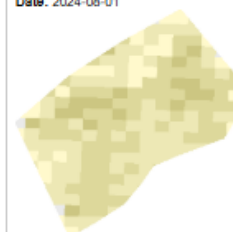
Statistical values:
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Max: 0.0944510028
Mean: 0.0558102534

Date: 2024-08-06



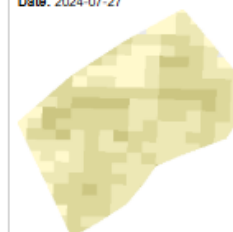
Statistical values:
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Max: 0.3969543278
Mean: 0.2808015538

Date: 2024-08-01



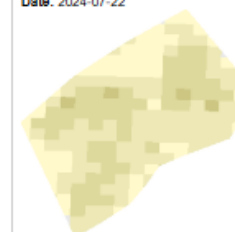
Statistical values:
Min: 0.1886198704
Max: 0.5013668537
Mean: 0.2988423492

Date: 2024-07-27



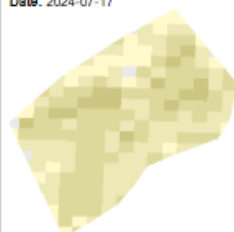
Statistical values:
Min: 0.1793650836
Max: 0.4024691284
Mean: 0.3015543477

Date: 2024-07-22



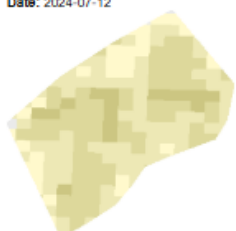
Statistical values:
Min: 0.1634024936
Max: 0.3686760698
Mean: 0.280771987

Date: 2024-07-17



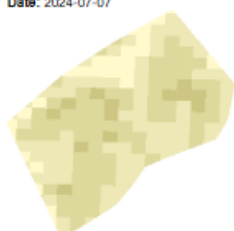
Statistical values:
Min: 0.1763696582
Max: 0.421377182
Mean: 0.2955197035

Date: 2024-07-12



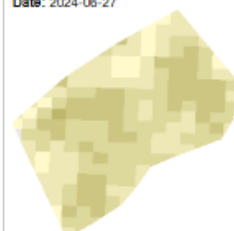
Statistical values:
Min: 0.1863517016
Max: 0.3981160223
Mean: 0.2968343434

Date: 2024-07-07



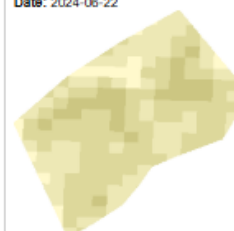
Statistical values:
Min: 0.204047218
Max: 0.3834880292
Mean: 0.29798292

Date: 2024-06-27



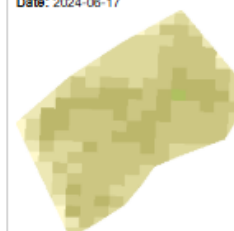
Statistical values:
Min: 0.192085743
Max: 0.4549849033
Mean: 0.3166176748

Date: 2024-06-22



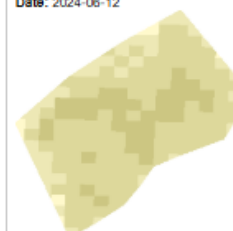
Statistical values:
Min: 0.1986899849
Max: 0.4252261817
Mean: 0.3102512967

Date: 2024-06-17



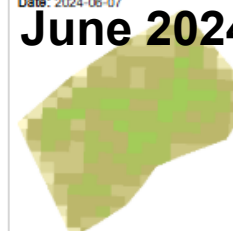
Statistical values:
Min: 0.2009456307
Max: 0.4522968233
Mean: 0.3671703804

Date: 2024-06-12



Statistical values:
Min: 0.1967545599
Max: 0.3759469688
Mean: 0.3248050357

Date: 2024-06-07



Statistical values:
Min: 0.2040374875
Max: 0.528061986
Mean: 0.4306288342

June 2024

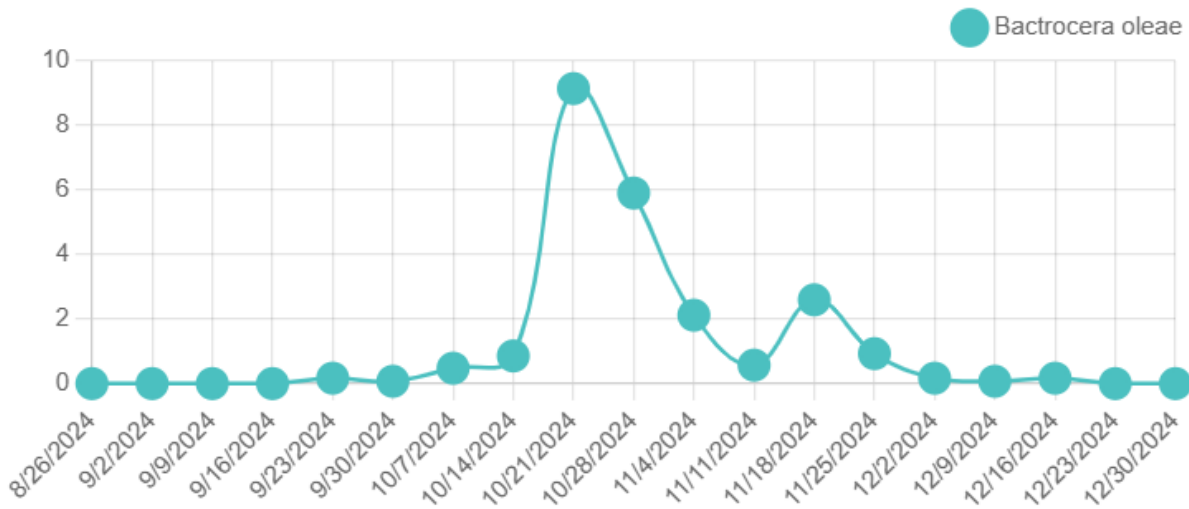
Olive Plot: SAN, IT

Olive fruit fly captures

Philaenus spumarius captures

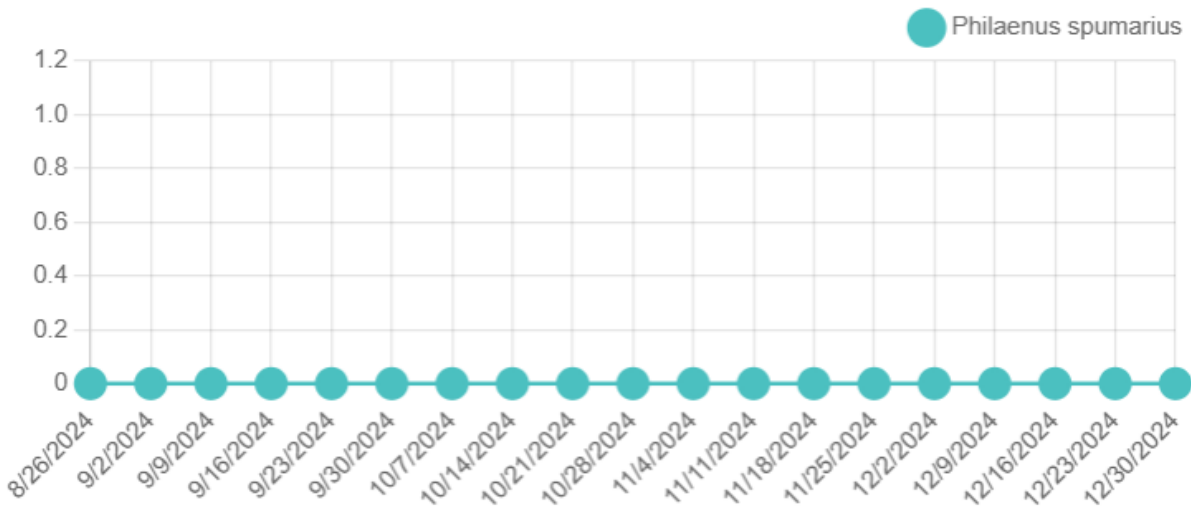
Records shown: All

Bactrocera oleae - MTD (Average Captures by Date)



Records shown: All

Philaenus spumarius - MTD (Average Captures by Date)



Historical Devices - SAN



Thanks!



Coordinator



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