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D2.1. Evaluation of the use of black light traps to collect spittlebug adults and estimate their *Xylella fastidiosa*-infection status.

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ABSTRACT

Xylella fastidiosa is a xylem-limited bacterium causing severe diseases in several crops. In southern Italy, *Philaenus spumarius* is the main vector spreading the bacterium in olives, with *Neophilaenus campestris* playing a secondary role. Efficient vector monitoring is essential to support timely control strategies. Sweep netting and yellow sticky traps are commonly used to estimate adult populations, with good efficiency when their use is combined across different vegetation layers and phenological stages.

This study aimed to evaluate the attractiveness of **UV-A LED-enhanced traps** for monitoring adult spittlebugs under field conditions. A portable prototype combining yellow or tinfoil sticky traps with UV-A LED lights and solar panels was developed and tested across six olive orchards from 2023 to 2025.

Overall, standard yellow sticky traps consistently captured more *P. spumarius* and *N. campestris* adults than those equipped with UV-A LEDs. The different LED-based traps performed similarly, compared to standard traps no significant increase of the attractiveness was recorded, nevertheless they prove to be less efficient to capture insects when a peak is recorded with the conventional traps. Whereas, tinfoil LED traps were the least attractive.

These findings suggest that UV-A wavelengths are suboptimal for attracting spittlebug vectors and that most likely the colour of the trap remains the dominant signal driving the insects. Standard yellow sticky traps remain the most effective and reliable method for monitoring *X. fastidiosa* vectors in olive groves.

However, further improvements should consider insect visual sensitivity to blue–green wavelengths.

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1. INTRODUCTION

Xylella fastidiosa (*Xf*) is a gram-negative bacterium that colonizes the xylem vessels of plants, causing serious diseases in crops of major socio-economic importance. In Europe it was first detected in Italy in 2013 in olive orchards in the Apulia region, where soon after the spittlebug species *Philaenus spumarius* was identified as the predominant vector (Saponari et al., 2014) responsible for the bacterial spread in olive groves. Afterwards, numerous studies have demonstrated that the meadow spittlebug, *P. spumarius* (L.) (Hemiptera: Aphrophoridae), is currently the predominant vector species of *X. fastidiosa* subsp. *pauca* ST53 in the Apulia region, being widely distributed, reaching high populations density and showing high transmission efficiency (Cornara et al, 2017, Bodino et al., 2019, Cavalieri et al., 2019).

Other spittlebug species, such as *Philaenus italosignus* and *Neophilaenus campestris*, have also been confirmed as *Xf* vectors in Europe. However, *P. italosignus* is restricted to environments where *Asphodelus* plants are present, as its nymphs develop exclusively on them. *N. campestris*, although widespread, is less abundant in olive orchards, and its transmission efficiency is lower. Therefore, its role in the epidemic dynamics on olive trees is considered negligible (Cavalieri et al., 2019; Bodino et al., 2021, Dongiovanni et al., 2023). Spittlebugs appear to be also involved in the outbreak of *Xf* subsp. *fastidiosa* recently detected in the same region, affecting grapes and almonds (Cornara et al., 2024).

Likewise other vector-borne diseases, controlling and reducing the vector population is one of the most effective measures to prevent the rapid spread of the disease (Bodino et al., 2023). To this end, monitoring the populations of *Xf*-vectors in the target crops is critical for planning effective management strategies. This is one of the pillars of the containment plan enforced in Apulia to manage the *Xf*-olive epidemics.

More specifically, the annual Regional Action Plan include a systematic survey program carried out from March to October, in the riskiest areas: encompassing the forefront of the infected demarcated areas and bordering *Xf*-free areas. The aim of this program is to provide precise local-based information on the life stage development and population dynamics of the spittlebugs for implementing targeted interventions for the juveniles (i.e., mechanical interventions on the ground vegetation) and for the adults (i.e., insecticides applications). These control management strategies are mandatory in specific high risky areas, with applications for adults in olive, almond and vineyards.

In parallel, the Apulian monitoring program includes the diagnostic tests for *Xf* on representative collected adults. Ultimately, thanks to this program the outbreak of *Xf* subsp. *fastidiosa* was recently discovered by intercepting *Xf*-positive insects prior to discover infected host-plants.

So, monitoring the occurrence and abundance of adult vector populations is essential to determine the most appropriate timing for targeting adults and to develop effective management strategies to mitigate disease outbreaks and prevent their spread to new areas.

Sweep nets is the most widely applied sampling method for capturing adults of spittlebugs (Cruaud et al., 2018, Cornara et al. 2018, Antonatos et al., 2019, Bodino et al, 2019, Di Serio et al., 2019, Vos et al., 2019) but, as reported by Purcell et al. (1994), although this

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method is highly effective for the evaluation of insects on ground cover, it is less effective on canopies.

The use of sticky traps to monitor adult spittlebugs is still controversial and the efficiency depends on several factors, mainly the population dynamic during the season when adults occur in the orchard (Cornara et al, 2018; Di Serio et al., 2019; Morente et al., 2018).

However, as reported by Purcell (1994), an accurate estimation of the presence and abundance of spittlebugs can be obtained by combining different sampling methods. Recently, Dongiovanni et al. (2023) showed that sweep nets are particularly useful at the beginning of the adult season, shortly after their emergence, to monitor adults insects on ground covers, whereas yellow sticky traps proved to be more efficient for capturing insects individuals on tree canopies during the later stages of the adult lifespan. These studies highlight the importance of integrating complementary techniques to optimize vector monitoring.

In addition to these traditional approaches, trap designs that exploit insect visual ecology offer promising alternatives. Short wavelengths are generally attractive for insects, which can perceive ultraviolet (UV), blue, and green light (Sun et al., 2014; Park and Lee, 2017; Kamei et al., 2021). Black light traps emitting within the UV-A spectrum have been successfully used to collect a wide range of insect species, including certain spittlebugs and other hemipteran pests (Yang et al., 2014).

Building on this evidence, the aim of this Deliverable was to develop and tests a prototype UV-A LED light trap designed for the massive capture of adult spittlebugs. he goal was to improve current surveillance, early detection, and monitoring strategies for *Xf*-vectors, and to increase capture efficiency for *P. spumarius* adults under filed conditions.

2. MATERIALS AND METHODS

2.1 Prototype development

A prototype trap was designed by integrating a solar panel with a stand that supported both the LED light source and the trapping device. Sticky panels combined with the LED lamp were mounted on handcrafted wooden supports, positioned at two different heights to capture insects moving through different vegetation layers and across seasons:

- **Close to ground vegetation (spring):** to capture early emerging vectors soon after their appearance.
- **Higher positions (summer and late season):** to intercept *Xf* vectors during flight activity.

The LED lamps were powered by a small solar panel, which was mounted either on the upper part or to the side of the top rung of the handcrafted wooden support, and remained continuously switched on during operation.

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2.2 Field trials

Between 2023 and 2025, surveys of *Xf* vectors were conducted in six olive groves previously identified as sites with high *Philaenus spumarius* population densities in the preceding year. At each site, ten LED light traps, mounted on wooden supports and equipped with solar panels and sticky panels, were installed along the field margin with the highest recorded *P. spumarius* density. From late spring to late summer, two to four surveys were carried out per site to assess vector presence and capture abundance, while also comparing the performance of different types of LED light lamps as described below (Table 1).

Table 1: *Details of the sites monitored in the framework of the project.*

Field location	Coordinates GPS	Year of planting	Cultivar	Planting Density (m)	Altitude (m) s.l.m	Period of survey
Santeramo in colle (Ba)	40°46'48.12"N 16°41'27.20"E	2000	Nociara	5 x 5	397	2023
Cisternino (Br)	40°45'25.5"N 17°27'19.3"E	1940	Oliva rossa	10 x 10	323	2023
Casarano (Le)	40°01'38"N 18°12'37"E	2020	Favolosa	2.5 x 5	157	2024
Cisternino (Br)	40°45'25.5"N 17°27'19.3"E	1940	Oliva rossa	10 x 10	323	2024
Casarano (Le)	40°01'38"N 18°12'37"E	2020	Favolosa	2.5 x 5	157	2025
Casarano (Le)	40°01'35"N 18°12'08"E	2020	Leccino	7 x 7	153	2025

In 2023, assessments were conducted in two olive groves. Each wooden support was equipped with a LED black light lamp (ca. 365 nm) powered by a small solar panel, combined with two types of sticky traps designed to capture vector spittlebugs: commercial yellow sticky traps and handcrafted silver traps coated with insect glue. Both trap types were positioned at different heights to account for variations in vector flight activity (Figure 1). Sticky traps without a light source served as controls.

In 2024 and 2025, the study was expanded to two additional experimental fields per year. In 2024, strip blue LED lamps (395–405 nm; Figure 2) were installed around the wooden supports and tested for their effectiveness in attracting and capturing spittlebugs. In this case, only yellow sticky traps were used in association with the strip LED lamps, and their performance was compared with yellow sticky traps without a light source.

In 2025, the efficacy of a UV-A LED light source (415 nm; Figure 2) positioned at the base of yellow sticky traps was evaluated, in comparison with yellow sticky traps without a light

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source. As in previous years, the sticky traps were adjusted to different heights to account for seasonal variation in adult vector flight patterns.

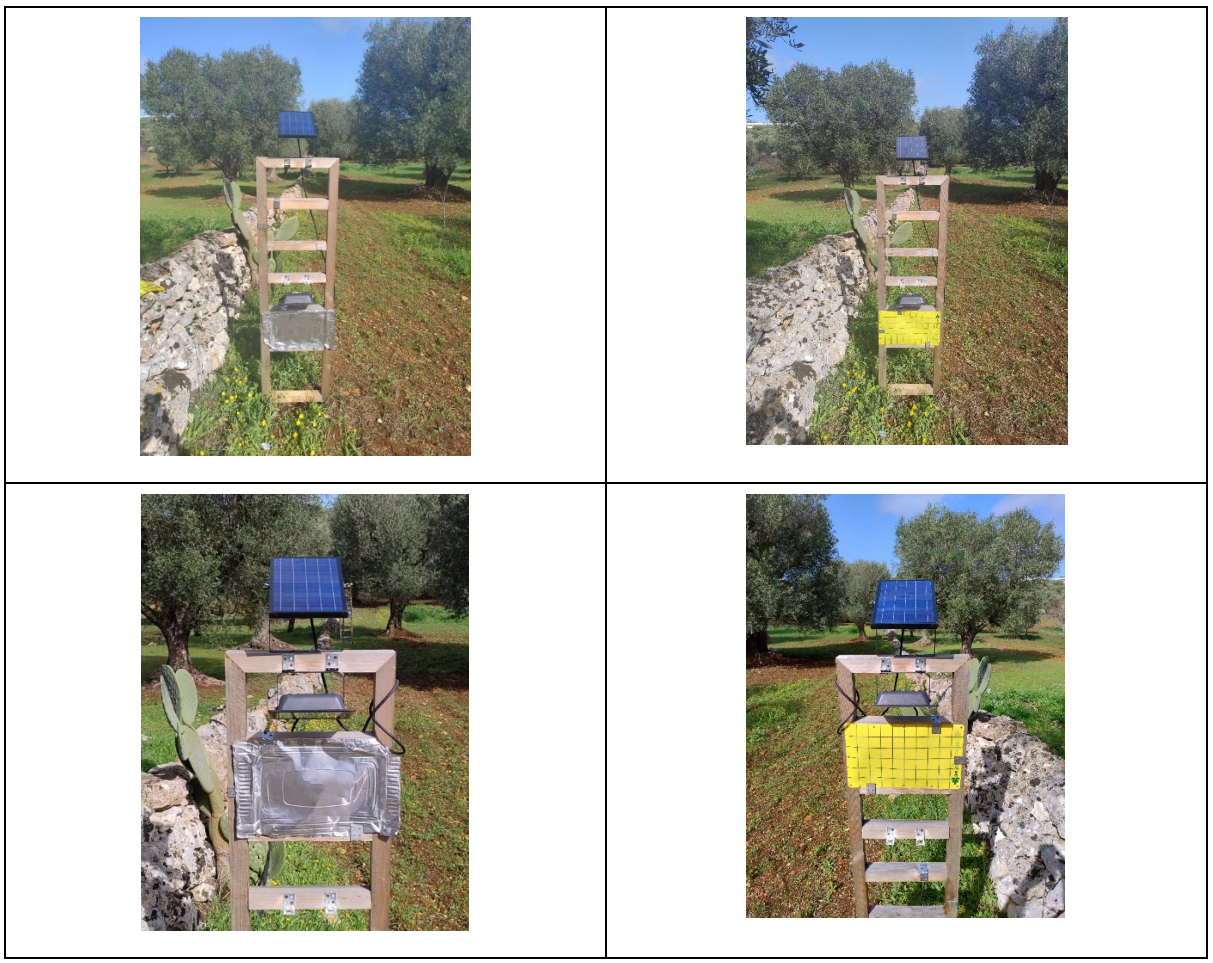


Figure 1: *LED black light lamp tested during 2023, combined with sticky traps (yellow or silver trap) placed at different heights on the wooden support structure according to the monitoring period.*

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Figure 2: *Strip LED installed around the wooden support and violet-UV-A LED lamp installed at the base of the sticky traps, as tested in 2024 and 2025.*

3. RESULTS

3.1. Prototype development

3.1.1. Component of a handcrafted wooden support

The handcrafted wooden support was designed to accommodate sticky traps, LED light lamps, and a solar panel. It was constructed from fir wood (5 × 5 cm) and consisted of two parallel vertical beams (2.0 m high) joined by six horizontal rungs (40 cm wide) placed at heights of 35, 55, 80, 100, 120, and 150 cm above the ground (Figure 3).

Steel angles were installed between the first (35 cm) and second (55 cm) rungs, and between the fourth (100 cm) and fifth (120 cm) rungs, to allow flexible placement of sticky traps at different heights. This configuration enabled captures during distinct seasonal phases: in spring, when vectors move from ground vegetation soon after emergence, and in summer through late season, when they migrate to the canopies of host plants.

The LED light lamp could be repositioned between the third (80 cm) and top (150 cm) rungs, depending on trap placement, to directly illuminate the sticky panels during different capture periods. The solar panel was mounted either above or to the side of the top rung and connected to the LED lamp via a cable, ensuring continuous power supply.

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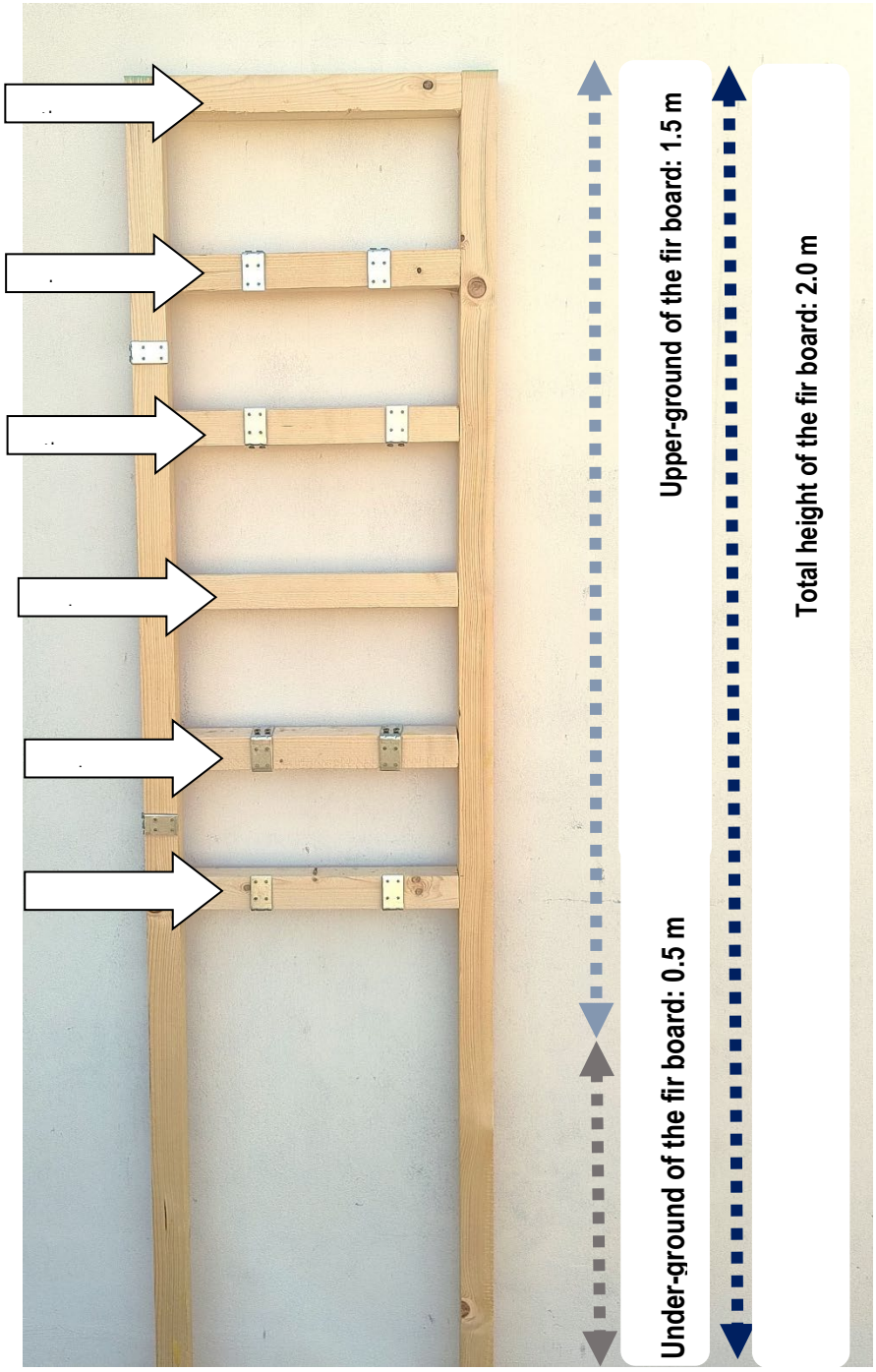


Figure 3: *Handcrafted wooden support constructed from parallel fir boards, holding six horizontal rungs at different heights to allow the placement of sticky traps, LED lamps, and a solar panel.*

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3.1.2. Electronic components

Each device was equipped with an LED light lamp and a small solar panel. During 2024 and 2025, these components were further integrated with a lead-acid battery, serving as an electric current generator to ensure stable operation.

3.1.3. LED light lamps

Different types of LED light lamps were evaluated between 2023 and 2025 (Figure 4), with their main technical characteristics summarized in Table 2.

Table 2: *Technical characteristics of the LED light lamps evaluated between 2023 and 2025.*

Lamp overview	LED light lamp	Strip LED	Verty UVA
Projector material	Aluminum		Polymethylmethacrylate
Colour	Black	UV Blacklight	Violet
Wavelenght (nm)	365-370	395-405	415
Beam angle	180°	-	120°
Watt projector (W)	50	36	14
Voltage	3.2V	12 V	12 Vdc
Protection degree	IP 66	IP 65	IP 65
Projector dimension	205x158x34 (mm)	8 mm x 5 m	500x28.6x26 (mm)

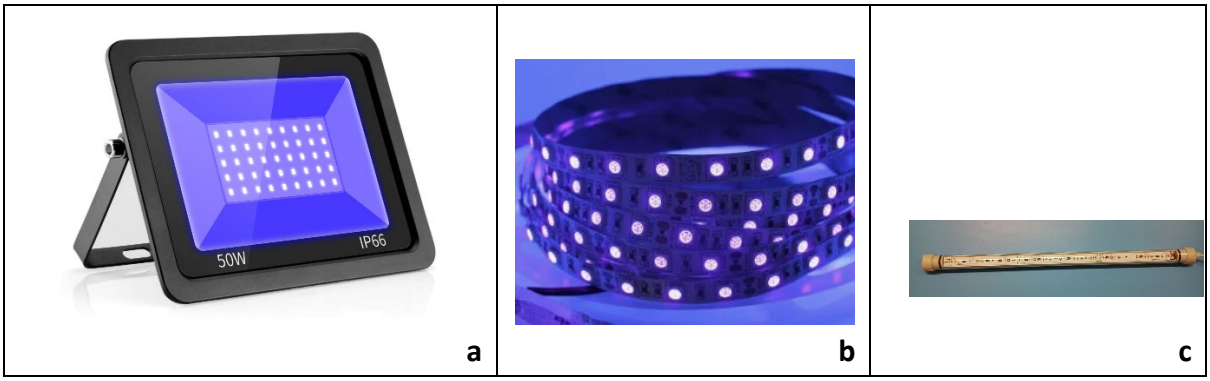


Figure 4: *Types of LED light lamps evaluated: (**a**) LED black light lamp; (**b**) strip LED black light lamp; and (**c**) violet UV-A LED light source.*

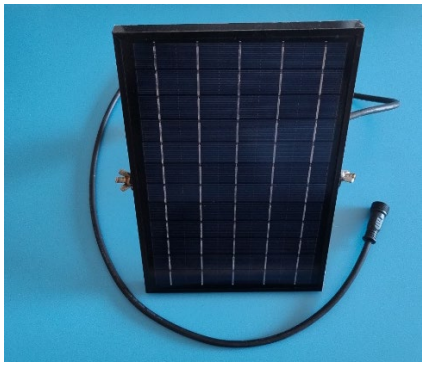
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3.1.4. Solar Panel

To enable the use of LED light lamps under open-field conditions without access to an external power supply, each device was equipped with a small solar panel (Figure 5), whose technical specifications are provided in Table 3.

Table 3: *Technical specifications of the solar panels used to power LED light lamps in open-field conditions.*

Solar Panel overview	2023	2024-25
Solar panel material	Polysilicon	Glass
Colour	Black	Violet
Usage environment	Outside	Outside
Certifications	CE	CE
Watt solar panel (W)	12	10
Solar Panel Voltage	Vmp 6V - Imp 2A - VOC 7.2V - ISC 5A	12 Volt
Protection degree	IP 65	IP 65
Panel dimension (mm)	290x210x21,5 (mm)	350x260x25



a



b

Figure 5: *Solar panels used to power LED light lamps in field experiments: (**a**) model used in 2023; (**b**) model used in 2024–2025.*

3.1.5. Lead-acidity battery

To ensure continuous operation of the solar-powered system, including during night-time, the solar panels were connected to a lead-acid battery in 2024 and 2025. This configuration allowed electricity generated during daylight hours to be stored for later use (Figure 6). The technical characteristics of the battery are summarized below in Table 4.

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Table 4: *Technical specifications of the lead-acid battery used to store solar energy for continuous operation of LED light traps.*

Solar charge controller overview	
Material:	Absorbent fiberglass mesh construction with no acid leakage
Type:	Sealed Lead Acid (SLA) Battery
Voltage:	12 V
Operating temperature range:	-20 +60°C
Dimension	151 x 65 x 97.5 mm.



Figure 6: *Lead-acid battery used to store electricity generated by the solar panels during daylight hours for continuous operation of the LED light traps.*

3.2. Field trials

3.2.1. Evaluation of LED light lamp in 'Nociara' olive grove in Santeramo (BA) during 2023

Standard yellow sticky traps consistently captured the highest numbers of *P. spumarius* adults across all monitoring periods. Among traps equipped with LED lights, yellow LED traps were generally more attractive than tinfoil LED traps in nearly all surveys. However, the addition of LED light to yellow traps did not increase their attractiveness compared to standard yellow traps. In July, yellow traps, regardless of whether the LED was activated, performed similarly and were significantly more effective than tinfoil traps (Table 5).

For *N. campestris*, which occurred at very low population densities, no significant differences in captures among trap types were observed in most surveys. The only exception occurred in September, when standard yellow sticky traps were significantly more attractive than both yellow and tinfoil LED traps (Table 6).

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Table 5: *Repeated-measures ANOVA for* Philaenus spumarius *captures on sticky traps, with or without LED light, in 'Nociara' olive grove (Santeramo, BA) during 2023*

Traps	June	July	August	September	Mean months
Yellow	1.6 a	2.8 a	1.8 a	1.0 a	1.8 a
Yellow plus black LED light	0.2 b	1.7 a	0.5 b	1.0 a	0.9 b
Tinfoil plus black LED light	0.1 b	0.1 b	0.0 b	0.1 a	0.1 c
***F*-value**	8.68	11.66	11.60	2.61	8.68
***P*-value**	0.002	0.0006	0.0006	0.10	0.023

Table 6: *Repeated-measures ANOVA for* Neophilaenus campestris *captures on sticky traps, with or without LED light, in 'Nociara' olive grove (Santeramo, BA) during 2023*

Traps	June	July	August	September	Mean months
Yellow	0.0 a	0.3 a	0.3 a	0.9 a	0.4 a
Yellow plus black LED light	0.0 a	0.4 a	0.0 a	0.5 ab	0.2 a
Tinfoil plus black LED light	0.1 a	0.0 a	0.0 a	0.1 b	0.1 a
***F*-value**	0.03	1.52	1.0	4.60	1.0
***P*-value**	0.39	0.25	0.39	0.02	0.39

3.2.2. Evaluation of LED light lamp on 'Oliva Rossa' olive grove in Cisternino (BR) during 2023

Across all sampling periods, mean captures of *P. spumarius* and *N. campestris* adults were consistently low. Under these conditions, tinfoil traps equipped with LED lights proved less attractive to *P. spumarius* than yellow sticky traps, irrespective of LED activation. For *N. campestris*, no significant differences among trap types were detected in any sampling period (Tables 7 and 8).

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Table 7: *Repeated-measures ANOVA for* Philaenus spumarius *captures on sticky traps, with or without LED light, in* 'Oliva Rossa' *olive grove in Cisterino (BR), during 2023*

Traps	June	July	August	September	Mean months
Yellow	0.4 a	0.6 a	0.1 a	0.3 a	0.4 a
Yellow plus black LED light	0.8 a	0.2 ab	0.1 a	0.4 a	0.4 a
Tinfoil plus black LED light	0.1 a	0.0 b	0.0 a	0.1 a	0.1 b
***F*-value**	1.56	4.84	0.47	1.19	4.82
***P*-value**	0.24	0.02	0.63	0.32	0.21

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Table 8: *Repeated-measures ANOVA for* Neophilaenus campestris *captures on sticky traps, with or without LED light, in* 'Oliva Rossa' *olive grove in Cisterino (BR), during 2023*

Traps	June	July	August	September	Mean months
Yellow	0.3 a	0.0 a	0.0 a	0.0 a	0.1 a
Yellow plus black LED light	0.3 a	0.0 a	0.0 a	0.0 a	0.1 a
Tinfoil plus black LED light	0.0 a	0.0 a	0.0 a	0.1 a	0.002 a
***F*-value**	1.59	0.01	0.01	0.03	1.0
***P*-value**	0.23	0.39	0.39	0.39	0.39

3.2.3. Evaluation of LED light lamp on 'Fs17' olive grove in Casarano (LE) during 2024

In May, shortly after adult emergence, standard yellow sticky traps were generally more effective than yellow sticky traps equipped with LED lights for capturing both *P. spumarius* and *N. campestris.* No significant differences among trap types were observed in June or July. Overall, activation of yellow sticky traps with LED lights did not enhance *P. spumarius* captures. Across all sampling periods, the mean number of *P. spumarius* and *N. campestris* adults caught on standard yellow traps was consistently higher than on yellow traps combined with LED lights (Tables 9 and 10).

Table 9: *Repeated-measures ANOVA for* Philaenus spumarius *captures on sticky traps, with or without LED light, in* 'Fs17' *olive grove in Casarano (LE), during 2024*

Traps	May	June	July	Mean months
Yellow	3.0 a	0.9 a	2.3 a	2.1 a
Yellow plus black LED light	0.6 b	0.8 a	1.8 a	1.1 b
***F*-value**	31.60	0.13	1.10	11.9
***P*-value**	0.0003	0.73	0.32	0.0073

Table 10: *Repeated-measures ANOVA for* Neophilaenus campestris *captures on sticky traps, with or without LED light, in* 'Fs17' *olive grove in Casarano (LE), during 2024*

Traps	May	June	July	Mean months
Yellow	2.3 a	0.3 a	3.5 a	2.0 a
Yellow plus black LED light	0.0 b	0.3 a	2.7 a	1.0 b
***F*-value**	21.54	0.01	0.72	5.12
***P*-value**	0.0012	0.39	0.42	0.050

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3.2.4. Evaluation of LED light lamp on 'Oliva Rossa' olive grove in Cisternino (BR) during 2024

P. spumarius adults were occasionally captured in both yellow sticky traps, with or without strip LED lights. However, no statistically significant differences were observed between the two trap types in any survey (Table 11). *N. campestris* was absent from all samples, preventing any meaningful statistical evaluation (Table 12).

Table 11: *Repeated-measures ANOVA for* Philaenus spumarius *captures on sticky traps, with or without LED light, in 'Oliva Rossa' olive grove in Cisterino (BR), during 2024*

Traps	June	July	August	Mean months
Yellow	0.0 a	0.7 a	0.3 a	0.3 a
Yellow plus black LED light	0.1 a	0.1 a	0.2 a	0.1 a
***F*-value**	1.0	5.06	0.18	2.61
***P*-value**	0.34	0.05	0.68	0.14

Table 12: *Repeated-measures ANOVA for* Neophilaenus campestris *captures on sticky traps, with or without LED light, in 'Oliva Rossa' olive grove in Cisterino (BR), during 2024*

Traps	June	July	August	Mean months
Yellow	0.0	0.0	0.0	0.0
Yellow plus black LED light	0.1	0.0	0.0	0.0
***F*-value**	---	---	---	---
***P*-value**	---	---	---	---

3.2.5. Evaluation of LED light lamp on 'Fs17' olive grove in Casarano (LE) during 2025

In the June survey, standard yellow sticky traps were significantly more attractive than yellow sticky traps combined with UV-A LED lights for capturing both *P. spumarius* and *N. campestris*. In contrast, no differences between trap types were observed in May or July. Overall, the addition of LED lights did not enhance the effectiveness of yellow sticky traps compared to the standard version (Tables 13 and 14).

Table 13: *Repeated-measures ANOVA for* Philaenus spumarius *captures on sticky traps, with or without LED light, in 'Fs17' olive grove in Casarano (LE), during 2025*

Traps	May	June	July	Mean months
Yellow	0.6 a	5 a	0.9 a	2.2 a
Yellow plus black LED light	0.1 a	0.4 b	0.6 a	0.4 b
***F*-value**	2.14	51.3	0.50	33.2
***P*-value**	0.18	0.0001	0.49	0.0003

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Table 14: *Repeated-measures ANOVA for* Neophilaenus campestris *captures on sticky traps, with or without LED light, in 'Fs17' olive grove in Casarano (LE), during 2025*

Traps	May		June		July		Mean months	
Yellow	0.3	a	2.6	a	4.4	a	2.4	a
Yellow plus black LED light	0.1	a	0.1	b	3,9	a	1.4	a
***F*-value**	0.64		12.6		0.64		3.59	
***P*-value**	0.44		0.006		0.44		0.09	

3.2.6. Evaluation of LED light lamp on 'Leccino' olive grove in Casarano (LE) during 2025

In both surveys, yellow sticky traps equipped with UV-A LED lights did not increase the mean number of *P. spumarius* and *N. campestris* adults captured compared to standard yellow sticky traps (Tables 15 and 16).

Table 15: *Repeated-measures ANOVA for* Philaenus spumarius *captures on sticky traps, with or without LED light, in 'Leccino' olive grove in Casarano (LE), during 2025*

Traps	July		August		Mean months	
Yellow	1.1	a	1.0	a	1.1	a
Yellow plus black LED light	0.7	a	0.7	a	0.7	a
***F*-value**	1.72		1.98		3.64	
***P*-value**	0.23		0.19		0.09	

Table 16: *Repeated-measures ANOVA for* Neophilaenus campestris *captures on sticky traps, with or without LED light, in 'Leccino' olive grove in Casarano (LE), during 2025*

Traps	July		August		Mean months	
Yellow	0.2	a	0.3	a	0.3	a
Yellow plus black LED light	0.2	a	0.2	a	0.2	a
***F*-value**	0.01		0.31		0.31	
***P*-value**	0.39		0.59		0.59	

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4. SUMMARY OF RESULTS AND CONCLUSIONS

The need for efficient monitoring of the presence, abundance and infectivity of *Xf* vectors has been constrained by the low efficiency of currently available techniques for collecting and monitoring spittlebugs. These insects are polyphagous and ubiquitous, exhibit significant dispersal capacity and are particularly difficult to collect, especially during the summer season in Mediterranean regions. The development of an effective trapping method, ideally incorporating some attractant, would not only improve the use of insect vectors as "spy-sentinels" for early detection of the bacterium in a given area but also enable more accurate estimations of vector population densities.

Insects such as leafhoppers and planthoppers rely on a range of stimuli for host plant recognition and localization, including visual cues, acoustic signals, and chemical stimuli (Anastasaki et al., 2021; Bullas-Appleton et al., 2004; Fereres and Moreno, 2009; Todd et al., 1990).

Germinara et al. (2017) investigated the olfactory sensitivity of *P. spumarius* to different volatile organic compounds (VOCs) from various chemical classes. All tested compounds elicited measurable antennal responses that varied with compound concentration, carbon chain length and molecular structure. These findings provide a foundational olfactory profile of *P. spumarius* and support future efforts to identify behaviorally active VOCs for the development of semiochemical-based pest control strategies. However, up to now, no pheromones, typically the most effective attractants for many insect species, have been identified for *Xf*-vectors or for direct use in the field.

Although sweep netting is time-consuming, it remains the standard method for collecting spittlebugs. The effectiveness of yellow sticky traps has been widely debated in the literature (Cornara et al., 2018; Di Serio et al., 2019; Morente et al., 2018). However, recent long-term field studies conducted in Mediterranean areas by Dongiovanni et al. (2023) demonstrated that coloured sticky traps, particularly yellow traps, are highly effective for detecting spittlebugs in various crops such as cherry, olive and almond. Their efficiency even exceeded that of sweep nets, especially during summer, when spittlebugs are more frequently located in the tree canopy.

Black light traps emitting radiation in the UV-A spectrum have long been used to monitor the occurrence and abundance of various insect species (Weissling et al., 1994). Their efficiency has been demonstrated for some spittlebugs and other Hemipteran pests (Yang et al., 2014). *P. spumarius* exhibits its highest flight activity at night, while related species are particularly active at dusk (around 9–10 p.m.) (Fagan and Kuitert, 1969; Lago et al., 2021).

Building on this evidence, the BeXyl project evaluated three different types of UV-A black light traps to enhance trapping efficiency for spittlebugs. In a preliminary phase, a wooden prototype was developed to facilitate transport and field installation. The prototype integrated yellow sticky panels with UV-A LED lights and a solar panel, allowing autonomous operation under field conditions.

Across three consecutive years of field trials conducted in different olive cultivars and locations, UV-A LED light traps did not significantly improve the efficiency of capturing *P.*

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spumarius or *N. campestris* compared with conventional yellow sticky traps. Among the LED-enhanced designs, traps with yellow backgrounds were consistently more attractive than those with tinfoil surfaces. In some cases, yellow LED traps performed comparably to standard yellow traps for *P. spumarius*, but during peak activity periods they were generally less effective, indicating that trap color remains the primary determinant of visual attraction.

For *N. campestris*, the addition of LED lights had little impact on capture efficiency, likely reflecting the low population densities observed during the sampling period. Overall, these results demonstrate that, under the tested field conditions, the integration of LED lights—irrespective of wavelength—into yellow sticky traps did not provide an advantage for monitoring spittlebug populations in olive groves.

Unexpectedly, traps equipped with UV-A LEDs frequently captured fewer adults than standard yellow sticky traps. This reduced efficacy may be explained by a spectral mismatch between the emission wavelengths of the LEDs and the visual sensitivity of the target species. Contrary to expectations derived from phototactic responses observed in other Hemiptera (Yang et al., 2014), UV-A wavelengths may lie at or beyond the sensitivity thresholds of *P. spumarius* and *N. campestris*, or may interfere with their orientation mechanisms. Under field conditions, the UV-A light might therefore have acted not as an attractant but as a deterrent.

These results support the conclusion that standard yellow sticky traps remain the most effective and reliable tool for monitoring both *P. spumarius* and *N. campestris* under diverse environmental conditions. Approaches involving UV-A lighting to improve trap performance should therefore be reconsidered or redesigned based on a more comprehensive understanding of the visual ecology of *Xf*-vectors. Future developments should take into account not only the physical properties of light (e.g., intensity, directionality, spectral bandwidth) but also the behavioral and physiological visual responses specific to the target species. Recent studies suggest that certain hemipteran insects may be more sensitive to green–blue wavelengths (490–560 nm) than to UV-A (Pan et al., 2021; Hao et al., 2023), indicating that future research should prioritize alternative spectral ranges.

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