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Article

Planting System and Cultivar Influence Olive Key-Pests Infestation in an Olive-Growing Vocated Area

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Abstract: Traditional and intensive planting systems have paved the way for the phenomenon of intensification, with the super high-density (SHD) system being the most prominent. This system has demonstrated high levels of profitability due to both the reduction in production costs achieved through complete mechanization and a significant increase in olive oil production per hectare, stemming from the more efficient utilization of resources such as light, water, and nutrients. The aim of this study was to evaluate, in a vocated olive-growing area, the phytosanitary status of a SHD olive orchard compared to a traditional one (TRD). The research focused on six key olive pests, considering the interaction between planting systems and eight cultivars in a semi-arid environment. The comparative analysis of pest infestations across the two planting systems revealed significant and complex patterns in pest population distribution and intensity. Overall, the planting system appeared to be the main factor influencing pest dynamics. The SHD olive orchard exhibited the highest infestation levels of *Otiorhynchus cribricollis*, *Palpita unionalis*, and *Bactrocera oleae*. Conversely, in the TRD system, the highest infestation levels of *Saissetia oleae*, *Euphyllura olivina*, and *Prays oleae* were observed. Moreover, the study highlighted a less pronounced effect of cultivars on the prevalence of all monitored key pests. These findings underscore the potential for developing more sustainable and effective pest management strategies tailored to specific planting systems. Furthermore, the results contribute to advancing eco-friendly control approaches and improving pest infestation management practices. Additional research will be necessary to deepen the understanding of these key pests and their interactions within different olive-growing systems.

Keywords: phytosanitary status; traditional orchard; superintensive orchard; *Bactrocera oleae*; *Euphyllura olivina*; *Otiorrhyncus cribricollis*; *Palpita unionalis*; *Prays oleae*; *Saissetia oleae*

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1. Introduction

The olive tree *Olea europaea* L. var. *sativa* (Lamiales, Oleaceae) is a globally significant fruit tree, playing a crucial role in the economies of many countries. It has a rich history and cultural heritage, particularly in the Mediterranean basin, where it has been cultivated for thousands of years [1,2]. Spain, Italy, and Greece are the leading producers, although countries such as Tunisia, Morocco, Turkey, and Syria have recently increased their production [3]. Olive cultivation has also expanded beyond the Mediterranean to regions including California, Australia, South Africa, and South America [4]. The olive tree is long-lived and highly adaptable to diverse environmental conditions, thriving in Mediterranean climates characterized by hot dry summers and mild winters. It is tolerant to drought and poor soils [5] and contributes to soil conservation and biodiversity by providing habitats for numerous animal and plant species [6].

Over time, olive growing has evolved significantly, with major changes in cultivation practices and technological advancements. The traditional olive industry in the Mediterranean region relies on production systems that are centuries old, marked by low yields and high production costs [7], largely due to limited mechanization [8] and reliance on rainfed conditions [9]. To address rising production costs and labor shortages, olive cultivation began transitioning approximately 25 years ago to super high-density (SHD or super-intensive) planting systems [10], a trend that has also been adopted for other crops [11,12]. The SHD system is characterized by higher planting densities, ranging from 1200 to 2200 trees per hectare, and is designed to achieve full mechanization and enhance orchard profitability [10,13]. This innovative approach to olive production includes hedgerow-style tree shaping and tree spacing of less than 4 m × 2 m, which has become a global standard. This uniform spacing is essential for enabling the optimal performance of fully mechanized cultivation practices [13]. Currently, olive-growing systems are moving toward intensification to improve agronomic and economic sustainability, aiming to produce high-quality oils while preserving their cultural and environmental heritage. This trend is spreading not only throughout the Mediterranean region but also globally [14,15].

However, it is essential to assess the environmental impact of different olive-growing systems [16]. As the agricultural industry faces new challenges, environmental concerns have become increasingly prominent [17]. One of the main challenges lies in the management of pests and diseases, which can significantly impact productivity levels, olive and olive oil quality, and, consequently, human health and the environment [18]. Integrated pest management (IPM) strategies, which combine various techniques to control pests and diseases, have been developed to reduce pesticide usage and enhance the sustainability of olive cultivation [19–22].

The complex interactions between planting systems and varietal susceptibility in influencing the infestation levels of key phytophagous organisms in olive orchards remain an ongoing area of research [23]. Planting systems can directly affect the presence and abundance of these organisms by altering habitats and resources essential for their life cycles [24]. For instance, soil management practices can influence the dynamics of phytophagous populations, either facilitating or inhibiting their growth. Currently, the trend in olive orchards is to avoid plowing and adopt no-tillage practices due to their benefits in mitigating water stress [25]. Moreover, functional biodiversity within agricultural ecosystems can affect the presence of natural enemies of phytophagous organisms, thereby enhancing biological control [24].

Different olive cultivars exhibit significant variations in their morphological and biochemical characteristics, such as volatile compound composition, leaf structure, and the presence of repellent or attractive substances for phytophagous organisms. These cultivar-specific traits can influence pest settlement, nutrition, and reproduction [26].

The combination of optimal agronomic practices and the selection of resistant cultivars represents a key strategy in integrated pest management. Recent studies suggest that exploiting the interaction between planting systems and varietal susceptibility can lead to innovative and sustainable approaches to crop protection [24].

This study aimed to monitor the infestation levels of various olive key pests to assess the influence of planting systems and cultivars in eight different olive cultivars, grown in both traditional and super high-density orchards in the Apulia region (southern Italy). The research focused on addressing two key questions: (1) the differential behavior of each cultivar against specific phytophagous organisms and (2) whether the impact of each phytophagous organism on each cultivar is modified by the planting system.

2. Material and Methods

2.1. Experimental Site and Orchards

The research was conducted at the experimental farm of the University of Bari, "Centro Didattico-Sperimentale P. Martucci", located in Valenzano, Bari (Apulia region, Southern Italy; 41°01′ N, 16°45′ E, 110 m a.s.l.), within one of the most extensive olive-growing areas in Apulia. The experimental fields were surrounded by other fruit crops, primarily fruit trees and grapevines, also managed under IPM protocols. The study was carried out over a year, from December 2022 to November 2023. Two adjacent olive orchards were selected for the research. The first is a traditional rainfed orchard (TRD) with a spacing of 6.0 × 6.0 m (277 trees hectare^{-1}). This orchard comprised 36-year-old vase-shaped trees (Figure 1a). The second orchard was a super high-density (SHD) irrigated system, with a spacing of 4.0 × 1.5 m, (1666 trees hectare^{-1}). The SHD orchard, planted 16 years ago, featured north–south oriented rows with central leader-shaped trees. The rows were supported by a trellis system made of wooden poles and two stainless steel wires (Figure 1b). All orchards were established on a homogeneous sandy clay soil (sand: 630 g kg^{-1}; silt: 160 g kg^{-1}; clay: 210 g kg^{-1}), classified as a Typic Haploxeralf according to USDA taxonomy or a Chromi-Cutanic Luvisol according to the FAO classification.

Figure 1. The traditional rainfed orchard ((**a**) TRD; 6.0 × 6.0 m; 277 trees ha^{-1}) 36-year old, with vase-shaped trees. The super high-density irrigated orchard ((**b**) SHD; 4.0 m × 1.5 m; 1666 trees ha^{-1}) with a north–south row orientation, 16-year old, with central leader-shaped trees.

The average canopy volumes per hectare were similar between the two orchards (11.2 m^3 ha^{-1} and 12.5 m^3 ha^{-1} for TRD and SHD orchard, respectively). Both orchards hosted the same eight olive cultivars: ‘Carolea’, ‘Cima di Bitonto’, ‘Coratina’, ‘Frantoio’, ‘Leccino’, ‘Maurino’, ‘Nociara’, and ‘Peranzana’. The olive trees were arranged in fully randomized rows within each grove; in the TRD orchard, each cultivar was represented by four trees, while in the SHD orchard, each cultivar was represented by 35 trees. No soil fertility gradient was detected in either orchard. Routine cultural practices, including weed control and fertilization, were applied. Specifically, a pre-emergence herbicide was used in spring, complemented by two mechanical weedings throughout the year. Both orchards were pruned in February, with 30% of the vegetation removed from the canopy. The irrigation season for the SHD orchard began in June and ended in September, with an average irrigation interval of 10 days and a seasonal irrigation volume of 1590 m^3 ha^{-1}. The drip line was installed along the soil surface of each row. Copper-based spraying was performed in March in both orchards, combined with a 20-20-20 NPK foliar fertilizer, to control peacock eye disease. Additionally, two treatments targeting *Bactrocera oleae* (Rossi) (Diptera, Tephritidae) were conducted: one in late August, using acetamiprid, and another in late September, using flupyradifurone. While neonicotinoid compounds can have adverse effects on beneficial pollinators and natural enemies, with limited significant impact on generalist predators [27,28], these treatments were deemed necessary to contain the pest's proliferation. Moreover, the same treatments were uniformly applied to all cultivars and both cropping systems. The harvest occurred in November in both years, coinciding with the end of the pest monitoring period.

2.2. Pests Monitoring

To accurately and statistically validate pest monitoring in both planting systems, a standardized monthly visual sampling methodology was employed. This involved measuring the occurrence of adult pests or their signs of infestation, as specified for each pest. The number of sampled trees varied between the two orchards due to the significant differences in canopy volume per tree: an average of 40.5 m^3 per tree in the TRD orchard and 7.5 m^3 per tree in the SHD orchard. The sampling units consisted of 1-year-old shoots, each with an average length of 50 cm, approximately 20 leaves and 10 drupes. This methodology is well-established in the literature and has been applied to other pests and fruit tree species [20,29–31]. In the TRD orchard, two homogeneous trees per cultivar were selected, and 30 randomly chosen shoots per tree were labeled for monitoring. In the SHD orchard, six trees per cultivar were selected, with 10 randomly chosen shoots per tree monitored—five from each side of the row. The selected trees were distributed randomly along the rows, with extreme trees excluded to avoid the "edge effect". In total, the same number of shoots per cultivar (60) were assessed in both orchards. This resulted in 1440 data points collected per cultivar (60 shoots × 2 planting systems × 12 months), with 120 cumulative data points per pest and per cultivar. Considering all six pests monitored, a total of 8640 data points (720 cumulative) were recorded for each cultivar.

Monitoring involved recording the increment of specific symptoms or individual pests each month compared to the previous month on the labeled shoots. For *B. oleae*, monitoring included inspecting drupes for infestation by the pest, as well as identifying those containing larvae of the olive fruit fly. Regarding *Euphyllura olivina* (Costa) (Hemiptera, Liviidae), the presence of adults and pre-imaginal stages was recorded on the designated shoots, contributing to a comprehensive understanding of the pest's seasonal dynamics. For *Otiorhynchus cribricollis* Gyllenhal (Coleoptera, Curculionidae), characteristic "half-moon" damage on leaves was counted, quantifying the number of damaged leaves per shoot. In the case of Jasmine moth *Palpita unionalis* Hubner (=*P. vitrealis* (Rossi) (Lepidoptera, Crambidae)), the number of damaged vegetative tips was recorded on each shoot. *Prays oleae* Bernard (Lepidoptera, Praydidae) infestations were monitored by counting the number of infested shoots showing leaf mines. For *Saissetia oleae* Olivier (Hemiptera, Coccidae), the focus was on counting the number of individuals present on each shoot, providing quantitative data on the pest's population levels. Additionally, fresh fruit weight was measured during harvest using a precision balance. This was determined on a sample of 50 olives per cultivar from both orchards.

2.3. Statistical Analysis

To evaluate the significance of the main effects considered in the experimental design (cultivar, planting system, and their interaction) for each phytophagous pest, cumulative field data—calculated as the sum of all damage or occurrences for each pest observed across the months during the study period—were analyzed using a two-way analysis of variance (ANOVA). The factor "cultivar" was considered a fixed effect, while "planting system" and the interaction "planting system × cultivar" were treated as random effects. Regarding the error term, the general error was used to test the "planting system × cultivar" interaction, while the mean square of this interaction was used to test the effects of "planting system" and "cultivar". Before conducting the statistical analysis, normality tests (Shapiro–Wilk and Kolmogorov–Smirnov) were performed on the quantitative dependent variables used in the study, and normality was confirmed in all cases. When analyzing the evolution of damage throughout the year, monthly data were used, and the new term "month" was included in the ANOVA model. The time effect (quantitative and uniformly distributed) was explored using orthogonal contrast analysis, testing linear, quadratic, or quartic trends depending on the shape of the damage curve. A linear trend was tested for *O. cribricollis*, as this pest's damage started in July and reached its peak in January of the following year. A quadratic trend was tested when damage exhibited a single ascending and descending pattern over the year, as observed for *B. oleae*, *E. olivina*, *P. unionalis*, and *S. oleae*. A quartic trend was tested when a double curve was observed over the year, which was the case for *P. oleae*.

The response variables considered in the analysis included cultivar (cv), planting system (PS), time (month), and the interaction PS × cv (along with the general error). PS and its interaction PS ×cv were treated as random effects due to the high variability associated with the planting system. This variability stems from numerous agronomic and environmental factors that can influence results, even within a specific system. Conversely, cultivar and month were treated as fixed effects. When necessary, mean values were compared using the Student–Newman–Keuls (SNK) test. Both mean values and standard errors (SE) were reported in the tables and figures.

All statistical analyses were performed using SAS software (v9.4, Cary, NC, USA) with the GLM procedure.

2.4. Climatic Pattern

Monthly rainfall and temperature were monitored throughout the experimental period for both years (Figure 2). Agro-climatic data were provided by the Regional Agency for Irrigation and Forestry Activities (ARIF) and recorded at the nearest weather station, located just a few kilometers from the experimental site. During the 2022–2023 monitoring period, monthly temperature and rainfall values aligned with the typical patterns of a Mediterranean climate.

In 2022, the highest mean temperature was observed in July (26.6 °C), which was 3.4 °C lower than the 30-year average. The lowest mean temperature was recorded in March (7.9 °C), which was 2.9 °C higher than the 30-year average. In 2023, the highest mean temperature was again recorded in July (28.4 °C), 1.6 °C lower than the 30-year average, while February showed the lowest mean temperature (8.5 °C), 3.5 °C higher than the 30-year average. Rainfall in 2022 was relatively well-distributed, with the highest value recorded in November (118 mm), 42 mm higher than the 30-year average, and the lowest in April (11.6 mm), 45.4 mm higher than the historical average for that month. However, in 2023, a significant deviation was noted, with rainfall concentrated in the spring months: 85.4 mm in March, 72.8 mm in April, and 150.3 mm in May. These values exceeded the 30-year averages by 26.4 mm, 15.8 mm, and 106.3 mm, respectively. Additionally, the summer of 2023 experienced a more pronounced drought compared to 2022, with five consecutive drought months from June to October.

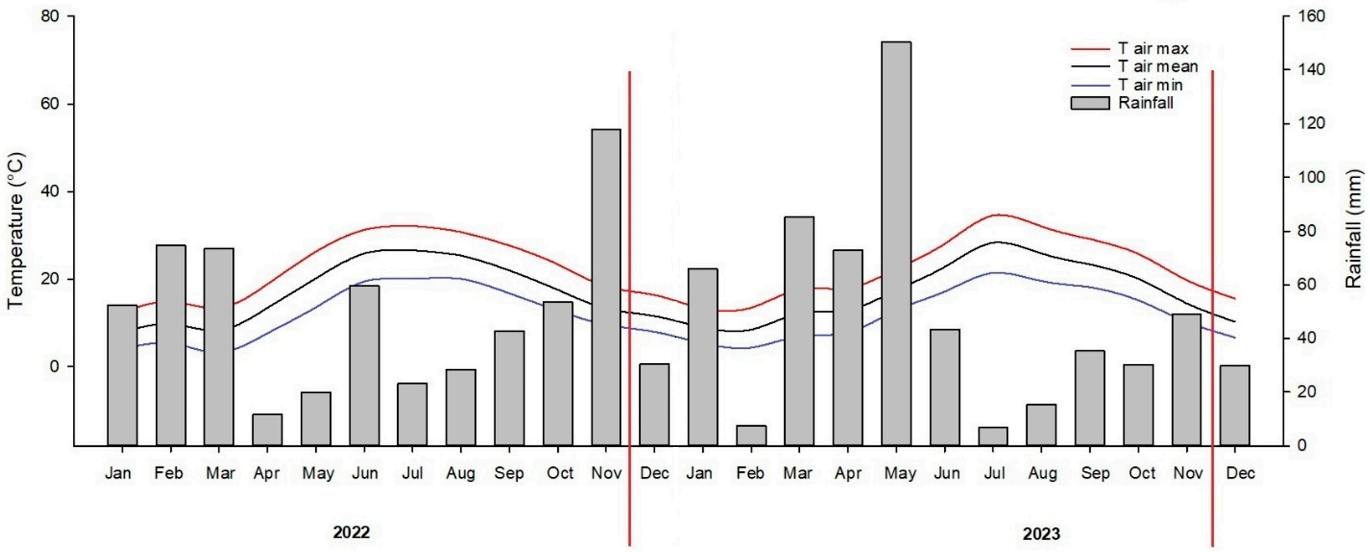

Figure 2. Monthly rainfall and temperature patterns during the monitoring period (2022–2023). Vertical red bars indicate the pest monitoring period.

3. Results

3.1. Planting System Influence

The planting system significantly influenced insect infestations (Table 1). *B. oleae* exhibited substantially higher infestation levels in SHD orchards (1.52 olives/shoot) compared to TRD systems (0.38 olives/shoot) (F = 64.0, $p < 0.001$; Table 1). However, the interaction between the planting system and cultivar was not significant (F = 0.52, $p = 0.820$; Table 2). For *E. olivina*, a moderately significant response to planting systems was observed, with higher infestation levels in TRD orchards (0.90 infested shoots) compared to SHD systems (0.11 infested shoots) (F = 50.5, $p = 0.0002$; Table 1). There was no significant effect of cultivar (F = 0.87, $p = 0.571$), but the interaction between the planting system and cultivar was significant (F = 4.36, $p < 0.0001$; Tables 1 and 2).

O. cribricollis exhibited markedly higher infestation levels in SHD (5.60 leaves/shoot) compared to TRD (3.81 leaves/shoot), suggesting a strong preference for host plants within the SHD system. However, a significant interaction between the planting system and cultivar was observed (F = 11.9, $p < 0.0001$). Notably, 'Carolea' displayed different behavior under TRD conditions in December and January, with higher infestation levels compared to SHD, whereas the other cultivars followed the opposite trend.

P. unionalis infestations were significantly higher (F = 5.51, $p < 0.05$) in SHD (0.36 vegetative tips/shoot) compared to TRD (0.19 vegetative tips/shoot). There were no significant differences among cultivars (F = 0.21, $p = 0.38$), but a notable interaction between the planting system and cultivar was detected (F = 2.13, $p < 0.05$).

Table 1. Comparison of the cumulative infestation of six different phytophagy during a whole annual cycle in two different planting systems: rainfed traditional (TRD; 277 trees ha^{-1}) and irrigated superintensive (SHD; 1666 trees ha^{-1}). By rows, letters denote the statistical difference between planting systems for each phytophagous ($p < 0.05$; SNK test).

Phytofagous	**Infestation**	**TRD**	**SHD**
Bactrocera oleae	n. olives damaged/shoot	0.38 ± 0.03 b	1.52 ± 0.06 a
Euphyllura olivina	n. infested shoots	0.90 ± 0.05 a	0.11 ± 0.02 b
Otiorhynchus cribricollis	n. damaged leaves/shoot	3.81 ± 0.27 b	5.60 ± 0.17 a
Palpita unionalis	n. damaged vegetative tips/shoot	0.19 ± 0.02 b	0.36 ± 0.03 a
Prays oleae	n. infested shoots	0.45 ± 0.04 a	0.29 ± 0.03 b
Saissetia oleae	n. of adult females/shoot	0.28 ± 0.04 a	0.00 ± 0.00 b

Table 2. Statistical significance (F values and significance; degrees of freedom are presented in the bottom line since they are the same for every phytophagous) for the influence of planting system, cultivar, interaction, and polynomic trends on phytophagous insects' infestation. Each cell shows the correlation coefficient associated with the interaction.

Phytofagy	Planting System	Cultivar	PS × cv	Linear	Quadratic	Quartic
Bactrocera oleae	64.0 ***	1.04 NS	0.52 NS	--	101 ***	--
Euphyllura olivina	50.5 ***	0.87 NS	4.36 ***	--	121 ***	--
Otiorhynchus cribricollis	12.2 **	0.62 NS	11.9 ***	911 ***	--	--
Palpita uniolalis	5.51 *	0.21 NS	2.13 *	--	63.5 ***	45.4 ***
Prays oleae	1.12 NS	0.67 NS	6.25 ***	--	24.7 ***	18.2 ***
Saisetia oleae	7.25 *	1.00 NS	19.7 ***	--	0.32 NS	--
Degrees of freedom	1	7	7	1	1	1

'NS' = not significant; * = $p < 0.05$; ** = $p < 0.001$; *** = $p < 0.0001$ from GLM statistical analysis.

P. oleae did not show significant differences between planting systems. However, the interaction between planting system and cultivar (PS × cv) explained a substantial portion of the variability and will be explored further.

S. oleae demonstrated a notable presence in TRD (0.28 adult females/shoot) but was entirely absent in SHD (F = 7.25, $p < 0.05$). The interaction between the planting system and cultivar accounted for most of the variability (F = 19.7, $p < 0.0001$).

3.2. Cultivar Influence

3.2.1. *Bactrocera oleae*

All cultivars experienced approximately uniform attacks from *B. oleae*, indicating a widespread susceptibility (Figure 3). A comparison between SHD and TRD olive orchards revealed a significant difference in infestation levels (Table 2), with no interaction observed between the planting system and cultivar (PS × cv). Infestation rates were consistently higher in the SHD orchard compared to the TRD grove, reaching a peak of nearly six times higher for 'Coratina' (Table 3). There were no significant differences among cultivars in overall infestation levels, except for 'Nociara', which exhibited significantly lower infestation rates (0.48 damaged olives/shoot) compared to the other cultivars.

Table 3. *Bactrocera oleae* infestation expressed as a cumulative number of olives damaged per shoot during a whole annual cycle for eight cultivars grown in two different planting systems: rainfed traditional (TRD; 277 trees ha^{-1}) and irrigated superintensive (SHD; 1666 trees ha^{-1}). Lowercase letters denote statistical differences among interactions between the planting system and cultivar ($p < 0.05$; SNK test); uppercase letters denote statistical differences among cultivar averages ($p < 0.05$; SNK test).

Cultivar	TRD	SHD	Mean
'Carolea'	0.40 ± 0.07 a	1.77 ± 0.17 a	1.06 ± 0.11 A
'Cima di Bitonto'	0.40 ± 0.09 a	1.45 ± 0.14 a	0.93 ± 0.10 A
'Coratina'	0.30 ± 0.07 a	1.67 ± 0.19 a	1.02 ± 0.12 A
'Frantoio'	0.43 ± 0.07 a	1.48 ± 0.15 a	0.96 ± 0.09 A
'Leccino'	0.33 ± 0.06 a	1.65 ± 0.18 a	0.99 ± 0.12 A
'Maurino'	0.43 ± 0.09 a	1.75 ± 0.14 a	1.09 ± 0.10 A
'Nociara'	0.37 ± 0.10 a	0.58 ± 0.09 a	0.48 ± 0.12 A
'Peranzana'	0.40 ± 0.08 a	1.87 ± 0.17 a	1.13 ± 0.12 A

In TRD, infestation levels were low and consistent across cultivars, ranging from 0.30 to 0.43 damaged olives per shoot. In contrast, in SHD, 'Peranzana' exhibited the highest infestation rate (1.87 damaged olives/shoot), while 'Nociara' recorded the lowest (0.58 damaged olives/shoot). In TRD, infestations began in August and gradually increased, with peak infestation levels observed in October, following the typical progression of infestation in the area. This pattern aligned with a quadratic trend.

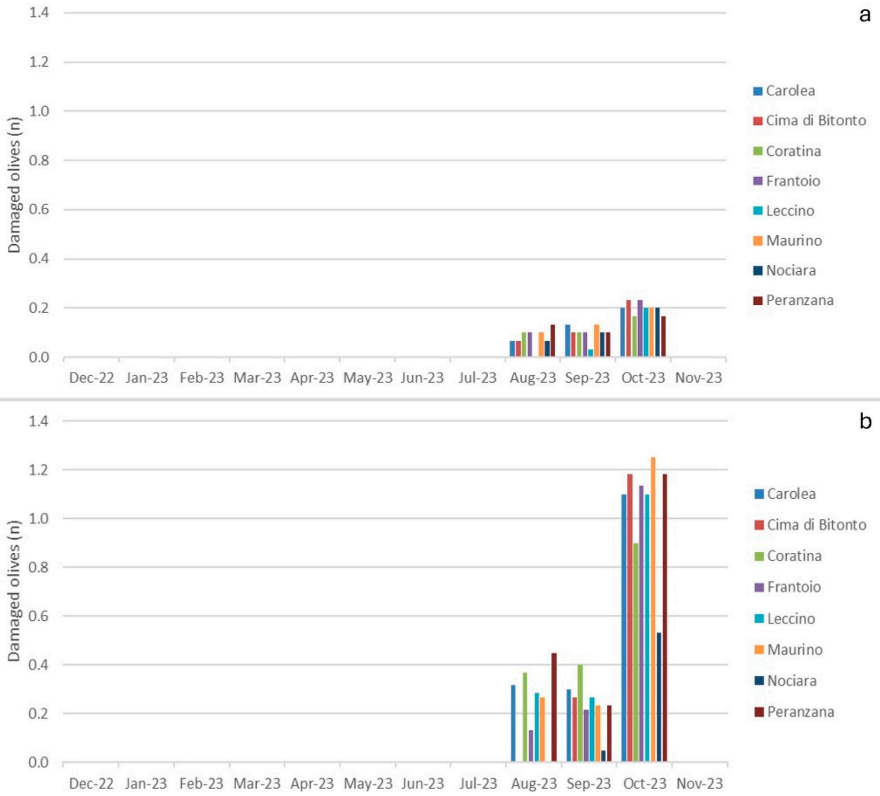

Figure 3. *Bactrocera oleae* infestation expressed as a monthly number of olives damaged per shoot during a whole annual cycle for eight cultivars grown in two different planting systems: rainfed traditional ((**a**) TRD; 277 trees ha^{-1}) and irrigated superintensive ((**b**) SHD; 1666 trees ha^{-1}).

The highest infestation levels in TRD were recorded in 'Carolea' and 'Cima di Bitonto', reaching up to 0.2 damaged olives per shoot. In contrast, SHD exhibited a much more pronounced infestation pattern. Infestations followed a quadratic trend (Table 3), beginning similarly in August but increasing sharply and peaking in October. 'Carolea', 'Maurino', and 'Peranzana' showed the highest infestation levels, reaching up to 1.2 damaged olives per shoot, whereas 'Nociara' remained below 0.6 damaged fruits. This discrepancy could be attributed to the different sizes of the olives from the two systems. Olives from SHD were nearly twice the weight of those from TRD (3.25 g and 1.85 g, respectively; Table S1).

3.2.2. *Euphyllura olivina*

The infestation pattern of *E. olivina* was found to be very similar across all analyzed cultivars (Figure 4), following a quadratic trend (Table 2). In TRD, infestations began appearing in December, with 'Coratina' exhibiting the earliest signs of infestation. From March onward, 'Maurino', 'Leccino', 'Carolea', 'Peranzana', 'Nociara', and 'Frantoio' showed increasing infestation levels. The highest infestation levels were recorded for all cultivars in the TRD (Figure 4a).

Peak infestation levels occurred in May and June, with 'Maurino' reaching up to 0.5 infested shoots, followed closely by 'Carolea' and 'Peranzana'. In contrast, SHD exhibited much lower infestation levels, with only minor infestations observed in May and June, primarily in 'Peranzana' and 'Cima di Bitonto'. Notably, 'Maurino' was the most affected cultivar under the TRD system, whereas it was not affected at all under the SHD system. Overall, 'Coratina' showed the highest infestation levels (0.77 infested shoots), while 'Nociara' had the lowest (0.24 infested shoots) (Table 4). In the TRD orchard, 'Coratina' had the highest infestation levels (1.53 infested shoots), while 'Peranzana' showed lower levels (0.35 infested shoots). Under the SHD system, 'Coratina', 'Leccino', and 'Maurino' showed no infestation.

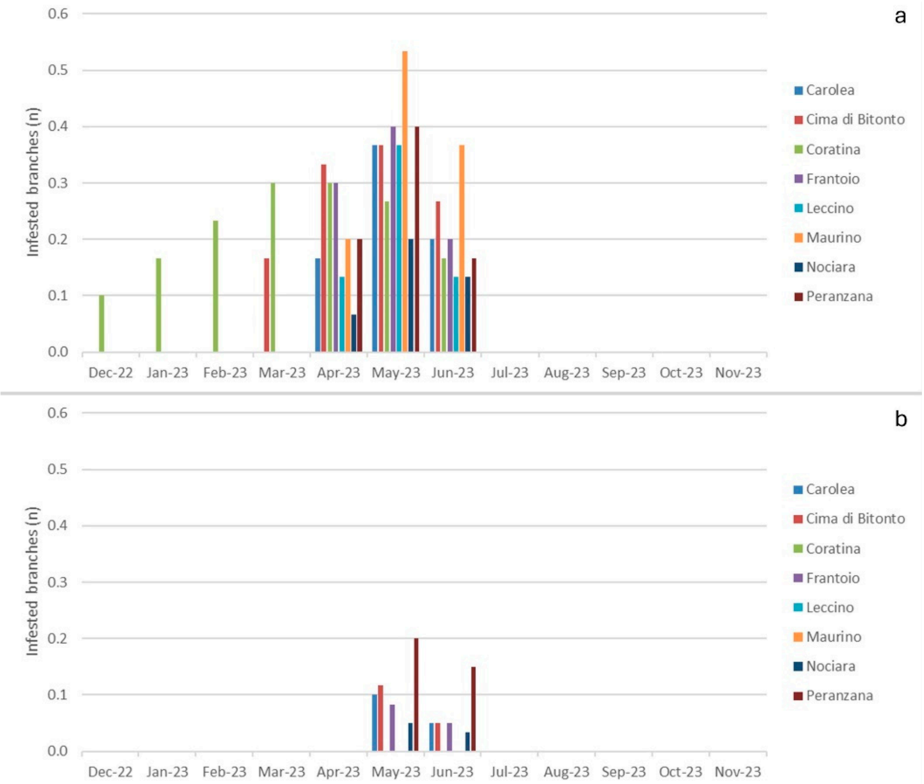

Figure 4. *Euphyllura olivina* infestation expressed as a monthly number of infested shoots during a whole annual cycle for eight cultivars grown in two different planting systems: rainfed traditional ((**a**) TRD; 277 trees ha^{-1}) and irrigated superintensive ((**b**) SHD; 1666 trees ha^{-1}).

Table 4. *Euphyllura olivina* infestation expressed as a cumulative number of infested shoots during a whole annual cycle for eight cultivars grown in two different planting systems: rainfed traditional (TRD; 277 trees ha^{-1}) and irrigated superintensive (SHD; 1666 trees ha^{-1}). Lowercase letters denote statistical differences among interactions between the planting system and cultivar ($p < 0.05$; SNK test); uppercase letters denote statistical difference among cultivar averages ($p < 0.05$; SNK test).

Cultivar	TRD	SHD	Mean
'Carolea'	0.73 ± 0.11 d	0.15 ± 0.06 fi	0.44 ± 0.07 A
'Cima di Bitonto'	1.13 ± 0.14 bd	0.17 ± 0.05 fh	0.65 ± 0.09 A
'Coratina'	1.53 ± 0.17 a	0.00 ± 0.00 hij	0.77 ± 0.11 A
'Frantoio'	0.90 ± 0.14 cd	0.13 ± 0.06 fj	0.52 ± 0.08 A
'Leccino'	0.63 ± 0.11 df	0.00 ± 0.00 hij	0.32 ± 0.06 A
'Maurino'	1.10 ± 0.17 bc	0.00 ± 0.00 hij	0.55 ± 0.10 A
'Nociara'	0.40 ± 0.09 f	0.08 ± 0.04 ghi	0.24 ± 0.05 A
'Peranzana'	0.77 ± 0.12 de	0.35 ± 0.09 fgi	0.56 ± 0.08 A

3.2.3. *Otiorhynchus cribricollis*

The infestation pattern of *O. cribricollis* demonstrated a significant interaction between the planting system and cultivar (PS × cv), with a markedly different linear trend in the second half of the year (Table 2). All cultivars exhibited an initial infestation peak on old leaves in January, which gradually decreased toward February before rising again significantly from July onward. In TRD, 'Carolea' showed the highest number of damaged leaves in January, reaching up to eight damaged leaves per shoot (Figure 5). In contrast, the SHD system exhibited a more dispersed infestation pattern with lower peaks, not exceeding four damaged leaves per shoot. New infestations on fresh leaves were observed beginning in April, primarily in 'Coratina', 'Cima di Bitonto', 'Nociara', and 'Frantoio'. Notably, 'Nociara' exhibited an earlier onset of infestation in March, preceding the other cultivars.

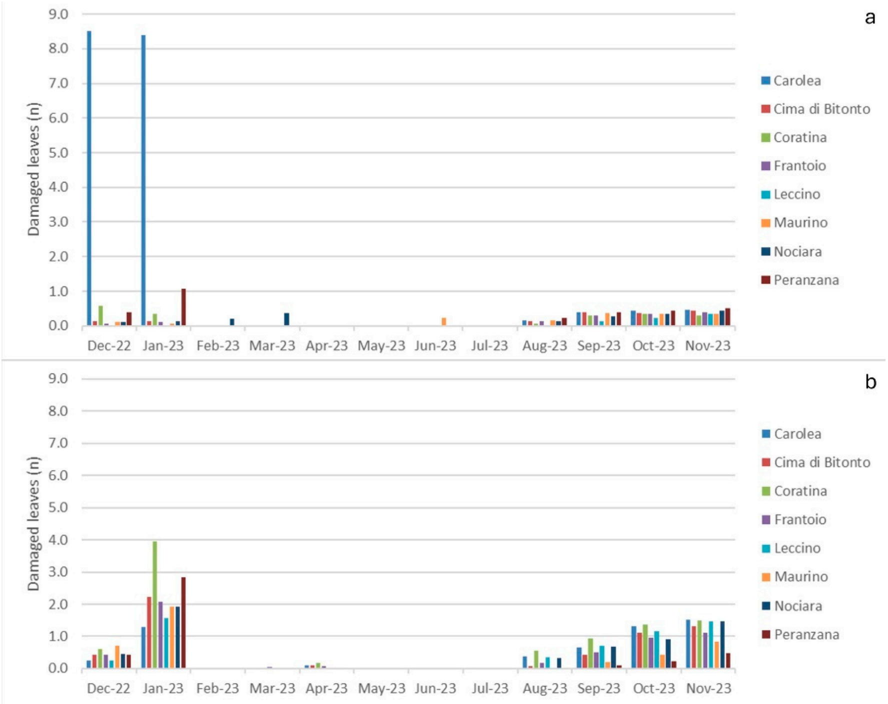

Figure 5. *Otiorhynchus cribricollis* infestation expressed as monthly number of damaged leaves per shoot during a whole annual cycle for eight cultivars grown in two different planting systems: rainfed traditional ((**a**) TRD; 277 trees ha^{-1}) and irrigated superintensive ((**b**) SHD; 1666 trees ha^{-1}).

A later increase in infestation levels was observed across all cultivars starting in July. This final phase followed a linear trend with significant differences depending on the interaction between the planting system and cultivar (PS × cv). In SHD, most cultivars exhibited a linear slope between 0.3 and 0.4, while 'Maurino' and 'Peranzana' had lower slopes of 0.21 and 0.11, respectively. Conversely, in TRD, 'Carolea', 'Cima di Bitonto', 'Frantoio', 'Nociara', and 'Peranzana' showed slopes between 0.10 and 0.12, whereas 'Coratina', 'Leccino', and 'Maurino' displayed slopes between 0.08 and 0.09. Apart from 'Peranzana', SHD generally exhibited higher infestation levels than TRD, particularly toward the end of the year, from September to November, as evidenced by the consistent presence of damaged leaves. 'Carolea' exhibited the highest overall infestation (11.93 damaged leaves/shoot), followed by 'Coratina' (5.49 damaged leaves/shoot), while other cultivars showed lower and relatively similar levels (Table 5). Most cultivars showed higher infestation levels in SHD compared to TRD. However, in TRD, 'Carolea' had an exceptionally high infestation (18.37 damaged leaves/shoot), whereas in SHD, 'Coratina' recorded the highest infestation (9.08 damaged leaves/shoot).

Table 5. *Otiorhynchus cribricollis* infestation expressed as the cumulative number of damaged leaves per shoot during a whole annual cycle for eight cultivars grown in two different planting systems: rainfed traditional (TRD; 277 trees ha^{-1}) and irrigated superintensive (SHD; 1666 trees ha^{-1}). Lowercase letters denote statistical differences among interactions between the planting system and cultivar ($p < 0.05$; SNK test); uppercase letters denote statistical differences among cultivar averages ($p < 0.05$; SNK test).

Cultivar	TRD	SHD	Mean
'Carolea'	18.37 ± 0.49 a	5.50 ± 0.34 c	11.93 ± 0.66 A
'Cima di Bitonto'	1.60 ± 0.15 fg	5.65 ± 0.49 c	3.63 ± 0.32 A
'Coratina'	1.90 ± 0.19 fg	9.08 ± 0.64 b	5.49 ± 0.47 A
'Frantoio'	1.33 ± 0.13 fg	5.38 ± 0.45 c	3.36 ± 0.30 A
'Leccino'	0.70 ± 0.14 g	5.48 ± 0.42 c	3.09 ± 0.31 A
'Maurino'	1.60 ± 0.22 fg	4.10 ± 0.43 d	2.85 ± 0.27 A
'Nociara'	1.97 ± 0.21 f	5.77 ± 0.36 c	3.87 ± 0.27 A
'Peranzana'	3.03 ± 0.36 e	4.07 ± 0.44 d	3.55 ± 0.29 A

3.2.4. *Palpita unionalis*

The results revealed a significant difference in the distribution of *P. unionalis* among cultivars based on the interaction between the planting system and cultivar (PS × cv; Table 2). The significant infestation observed in August may have been triggered by summer weather changes, as ideal temperatures for the development of the insect facilitated its spread (Figures 2 and 6). The first signs of the phytophagous insect were detected as early as February and March but only on 'Carolea', 'Cima di Bitonto', and 'Peranzana'. In February, 'Cima di Bitonto' exhibited minimal infestations, while 'Carolea' and 'Peranzana' showed the first signs of damage in March (Figure 6).

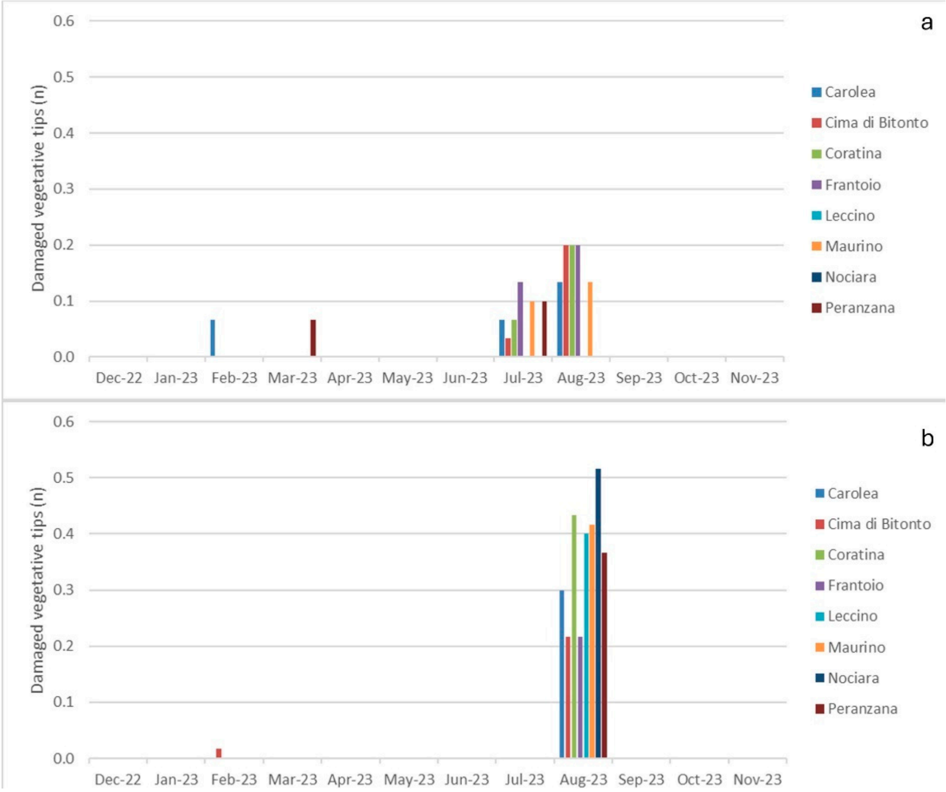

Figure 6. *Palpita unionalis* infestation expressed as a monthly number of damaged vegetative tips per shoot during a whole annual cycle for eight cultivars grown in two different planting systems: rainfed traditional ((**a**) TRD; 277 trees ha^{-1}) and irrigated superintensive ((**b**) SHD; 1666 trees ha^{-1}).

Subsequently, infestations intensified in August, coinciding with climatic conditions that favored the insect development and the abundant presence of tender vegetative tips, which are its preferred substrate. The insect activity followed the typical flight curve for the area, with trends characterized by a significant quadratic (one peak) or quartic (two peaks) pattern. In TRD, infestations remained relatively low until July, with noticeable increases in August, particularly in the cultivars 'Frantoio' and 'Cima di Bitonto'. In contrast, SHD recorded the highest absolute infestation levels across all cultivars (Figure 6b). During the August peak, infestation levels reached up to 0.5 damaged vegetative tips per shoot in 'Carolea' and 'Coratina,' which were significantly higher than those observed in TRD. Overall, *P. unionalis* infestation levels were relatively low and did not show significant differences among cultivars, with values ranging from 0.20 to 0.35 vegetative tips per shoot (Table 6). However, the genotypes responded differently to planting systems. 'Coratina', 'Leccino', 'Maurino', 'Nociara', and 'Peranzana' showed significantly higher infestation levels in SHD compared to TRD. Conversely, 'Carolea', 'Cima di Bitonto', and 'Frantoio' exhibited no significant differences between planting systems. Within the TRD system, 'Frantoio' exhibited the highest infestation levels (0.33 vegetative tips per shoot). In SHD, 'Nociara' recorded the highest infestation levels (0.52 vegetative tips per shoot).

Table 6. *Palpita unionalis* infestation expressed as the cumulative number of damaged vegetative tips per shoot during a whole annual cycle for eight cultivars grown in two different planting systems: rainfed traditional (TRD; 277 trees ha^{-1}) and irrigated superintensive (SHD; 1666 trees ha^{-1}). Lowercase letters denote statistical differences among interactions between the planting system and cultivar ($p < 0.05$; SNK test); Uppercase letters denote statistical differences among cultivar averages ($p < 0.05$; SNK test).

Cultivar	TRD	SHD	Mean
'Carolea'	0.27 ± 0.07 bcdeh	0.30 ± 0.07 cdeg	0.28 ± 0.05 A
'Cima di Bitonto'	0.23 ± 0.06 dei	0.23 ± 0.06 dei	0.23 ± 0.04 A
'Coratina'	0.27 ± 0.07 bcdehB	0.43 ± 0.08 abg	0.35 ± 0.05 A
'Frantoio'	0.33 ± 0.08 bcdef	0.22 ± 0.06 ej	0.28 ± 0.05 A
'Leccino'	0.00 ± 0.00 kl	0.40 ± 0.09 ad	0.20 ± 0.05 A
'Maurino'	0.23 ± 0.06 dei	0.42 ± 0.08 ac	0.33 ± 0.05 A
'Nociara'	0.00 ± 0.00 kl	0.52 ± 0.09 a	0.26 ± 0.05 A
'Peranzana'	0.17 ± 0.05 fghijk	0.37 ± 0.06 ae	0.27 ± 0.04 A

3.2.5. *Prays oleae*

The diffusion pattern of *P. oleae* (Figure 7) revealed two distinct peaks in the field. The first peak occurred in January and February, corresponding to the phyllophagous generation, while the second peak was observed in April and May, corresponding to the anthophagous generation. This pattern aligned with the typical seasonality of the insect in the area and fits significant quadratic (one peak) or quartic (two peaks) trends.

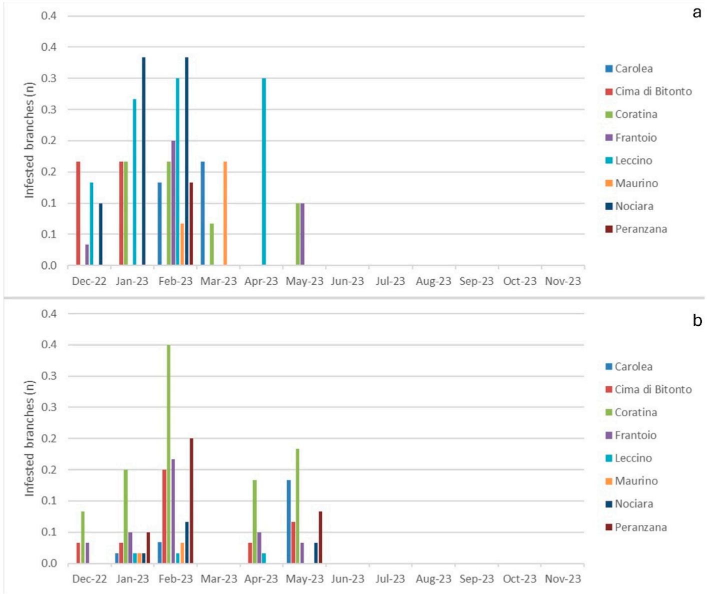

Figure 7. *Prays oleae* infestation expressed as the monthly number of infested shoots during a whole annual cycle for eight cultivars grown in two different planting systems: rainfed traditional ((**a**) TRD; 277 trees ha^{-1}) and irrigated superintensive ((**b**) SHD; 1666 trees ha^{-1}).

The interaction between the planting system and cultivar (PS × cv) was significant, indicating differing damage trends among cultivars depending on the planting system (Table 2). In TRD, the highest infestation levels were observed in 'Nociara', reaching up to 0.33 infested shoots in February, followed by 'Leccino' at 0.3 infested shoots. Other cultivars exhibited initial infestations in January and February, followed by a pause in March and a resurgence in April and May. In contrast, SHD generally showed lower infestation levels for 'Leccino', 'Maurino', and 'Nociara'. However, infestation levels were equivalent for 'Frantoio' and higher for 'Peranzana' (Table 7). The highest infestation in SHD was recorded in 'Coratina', which reached 0.4 infested shoots in February. Infestations in 'Maurino' and

'Carolea' were observed in March, followed by a pause in April, indicating a one-month delay compared to other cultivars.

Table 7. *Prays oleae* infestation expressed as the cumulative number of infested shoots during a whole annual cycle for eight cultivars grown in two different planting systems: rainfed traditional (TRD; 277 trees ha^{-1}) and irrigated superintensive (SHD; 1666 trees ha^{-1}). Lowercase letters denote statistical differences among interactions between the planting system and cultivar ($p < 0.05$; SNK test); uppercase letters denote statistical differences among cultivar averages ($p < 0.05$; SNK test).

Cultivar	TRD	SHD	Mean
'Carolea'	0.30 ± 0.07 be	0.18 ± 0.06 cdeg	0.24 ± 0.04 A
'Cima di Bitonto'	0.33 ± 0.07 bc	0.32 ± 0.08 bd	0.33 ± 0.05 A
'Coratina'	0.50 ± 0.13 b	0.90 ± 0.14 aA	0.70 ± 0.10 A
'Frantoio'	0.33 ± 0.07 bc	0.33 ± 0.07 bc	0.33 ± 0.05 A
'Leccino'	1.00 ± 0.13 a	0.05 ± 0.03 ghij	0.53 ± 0.08 A
'Maurino'	0.23 ± 0.06 cdef	0.05 ± 0.03 fghij	0.14 ± 0.03 A
'Nociara'	0.77 ± 0.16 a	0.12 ± 0.05 cdei	0.44 ± 0.09 A
'Peranzana'	0.13 ± 0.04 cdeh	0.33 ± 0.08 bce	0.23 ± 0.05 A

This delay could be attributed to specific factors, such as the genetic characteristics of these cultivars. In May, an increase in infestations of the anthophagous generation was observed, particularly in cultivars 'Cima di Bitonto' and 'Carolea', suggesting a potential correlation between climatic conditions and the phenology of *P. oleae* in these cultivars. 'Coratina' exhibited the highest overall infestation (0.70 infested shoots), while 'Maurino' had the lowest (0.14 infested shoots) (Table 7). The effect of the planting system varied among the cultivars: 'Leccino' and 'Nociara' showed significantly higher infestation levels in TRD, 'Peranzana' had higher infestation levels in SHD, and other cultivars showed no significant differences between planting systems.

3.2.6. *Saissetia oleae*

Infestations of *S. oleae* began in December in 'Coratina', 'Maurino', and 'Peranzana' (Figure 8). Notably, infestation levels in 'Peranzana' reached a significant peak in January, with up to 0.3 adult females per shoot observed. Similarly, 'Maurino' and 'Coratina' also exhibited increased infestation levels in January (Figure 8a). Infestations in 'Cima di Bitonto' and 'Leccino' began in February, while 'Frantoio' showed signs of infestation starting in March. Throughout the observation period, 'Peranzana' consistently exhibited the highest infestation rates (Figure 8).

Interestingly, a pruning intervention in February led to a significant decrease in infestation percentages in 'Coratina', 'Maurino', and 'Cima di Bitonto'. However, 'Peranzana' exhibited a slower decline in infestation levels, indicating a higher resilience to *S. oleae* in these cultivars. In general, the insect followed the typical trend observed in the area. However, the significant differences among cultivars and the pronounced interaction between the planting system and cultivar (PS × cv) resulted in a non-significant quadratic trend (Table 2), indicating that each case was highly specific. 'Peranzana' showed the highest overall infestation (0.47 adult females per shoot), significantly higher than all other cultivars (Table 8). 'Coratina', 'Cima di Bitonto', 'Frantoio', 'Leccino', and 'Maurino' formed a second group, with no significant differences among them, exhibiting infestation levels ranging from 0.10 to 0.18 adult females per shoot. 'Carolea' and 'Nociara' showed no infestation in either planting system. In TRD, 'Peranzana' had the highest infestation level (0.93 adult females per shoot), followed by 'Coratina' (0.37 adult females per shoot), while 'Nociara' and 'Carolea' recorded the lowest infestation levels (0.00 adult females per shoot).

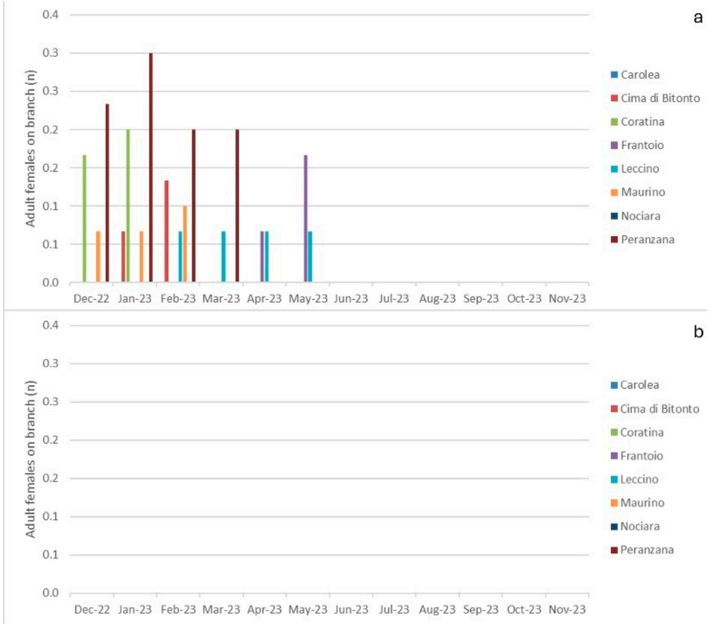

Figure 8. *Saissetia oleae* infestation expressed as the monthly number of adult females per shoot during a whole annual cycle for eight cultivars grown in two different planting systems: rainfed traditional ((**a**) TRD; 277 trees ha^{-1}) and irrigated superintensive ((**b**) SHD; 1666 trees ha^{-1}).

Table 8. *Saissetia oleae* infestation expressed as the cumulative number of adult females per shoot during a whole annual cycle for eight cultivars grown in two different planting systems: rainfed traditional (TRD; 277 trees ha^{-1}) and irrigated superintensive (SHD; 1666 trees ha^{-1}). Lowercase letters denote statistical differences among interactions between the planting system and cultivar ($p < 0.05$; SNK test); Uppercase letters denote statistical differences among cultivar averages ($p < 0.05$; SNK test).

Cultivar	TRD	SHD	Mean
'Carolea'	0.00 ± 0.00 c	0.00 ± 0.00 c	0.00 ± 0.00 A
'Cima di Bitonto'	0.23 ± 0.08 b	0.00 ± 0.00 c	0.10 ± 0.04 A
'Coratina'	0.37 ± 0.13 b	0.00 ± 0.00 c	0.18 ± 0.07 A
'Frantoio'	0.23 ± 0.06 b	0.00 ± 0.00 c	0.12 ± 0.03 A
'Leccino'	0.27 ± 0.09 b	0.00 ± 0.00 c	0.13 ± 0.05 A
'Maurino'	0.23 ± 0.06 c	0.00 ± 0.00 c	0.12 ± 0.03 A
'Nociara'	0.00 ± 0.00 c	0.00 ± 0.00 c	0.00 ± 0.00 A
'Peranzana'	0.93 ± 0.22 a	0.00 ± 0.00 c	0.47 ± 0.12 A

4. Discussion

The comparative analysis of phytophagous pest infestations between TRD and SHD revealed significant and complex patterns in pest population distribution and intensity. Overall, a marked difference in infestation dynamics between the two planting systems was observed. Certain phytophagous species, such as *O. cribricollis*, *P. unionalis*, and *B. oleae*, exhibited significantly higher infestation levels in SHD to TRD. This trend suggested a strong preference for SHD systems, likely due to factors such as higher planting density, altered microclimatic conditions, or differences in management practices typical of SHD orchards. Conversely, *S. oleae*, *E. olivina*, and *P. oleae* showed a higher or exclusive presence in TRD. This distribution may reflect the adaptability of these pests to the more variable environmental conditions and less intensive management practices characteristic of traditional systems. The absence or reduced presence of these species in SHD orchards could be attributed to specific limiting factors associated with this cultivation system or the effectiveness of control measures implemented within it. Landi et al. [23] demonstrated that the cropping system significantly influences the prevalence and impact of various phytophagous pests in olive trees. For instance, SHD was found to reduce total *B. oleae* infestation by nearly 50%, while negatively affecting other pests, such as *E. olivina*. However, SHD also favored pests like *P. unionalis* and *O. cribricollis*.

The significant difference in *B. oleae* infestation levels between SHD and TRD highlighted the influence of cultivation practices and environmental factors on *B. oleae* dynamics (Figure 3, Table 2). The SHD system, characterized by larger olive size and higher water availability, created more favorable conditions for olive fly infestations (Table S1). Conversely, the TRD orchard, with smaller olives and presumably lower water availability, exhibited lower infestation levels, emphasizing the importance of system management in controlling *B. oleae* infestations. Olive size emerged as a key factor in understanding olive fly infestation dynamics, underscoring the critical role of water management in influencing the susceptibility of olives to this pervasive pest [26,32]. Moreover, while *B. oleae* maintained moderate infestation levels across the host range in TRD, it demonstrated a strong preference for specific hosts within SHD, leading to significantly higher infestation levels. This suggests that the management practices unique to each planting system, coupled with their interaction with olive cultivars, are crucial factors, as previously reported in the literature [33]. Researchers have increasingly focused on understanding the mechanisms influencing the olive fly's choice of oviposition sites across different cultivars; as such, insights could pave the way for more effective pest management strategies. For example, in central Italy, total infestation levels were significantly higher in traditional orchards compared to SHD, where infestations were reduced by nearly 50% [23]. Despite geographical and temporal variations, there were no significant differences among sites or years in terms of *B. oleae* catches. Additionally, certain cultivars, such as 'Arbequina', may exhibit lower sensitivity to *B. oleae* due to their small fruit size and high oleuropein production. Environmental factors, such as the absence of a pronounced dry season, may also significantly influence infestation levels [23].

The higher infestation levels of *E. olivina* in TRD compared to SHD systems can be attributed to differences in cultivation practices and environmental conditions (Figure 4, Table 3). TRD, with its more open canopy structure, may create less favorable conditions for ventilation and sunlight exposure, thereby fostering the development of *E. olivina* infestations. In contrast, SHD, characterized by trees arranged in thinner hedgerows, provides better ventilation and sunlight exposure, reducing the likelihood of severe infestations [34]. The early infestation of 'Coratina' in December highlighted its susceptibility and aligns with previous reports indicating that attacks by pre-imaginal stages are concentrated near the fruits [35]. 'Maurino', 'Leccino', 'Carolea', 'Peranzana', 'Nociara', and 'Frantoio' exhibited significant infestations starting in March, with 'Maurino' showing the highest peak in May and June. 'Nociara' was the least infested, suggesting potential resistance or less favorable conditions for *E. olivina* development in this cultivar. Landi et al. [23] noted that *E. olivina* was disadvantaged by SHD orchard management, which resulted in negligible damage in some cultivars, such as 'Coratina', 'Leccino', and 'Maurino'. Furthermore, differences in pest frequency were observed across sites, likely influenced by geographic parameters, agronomic practices, and climatic conditions, such as the absence of a dry season [23]. *O. cribricollis* poses a significant threat to both traditional and superintensive olive orchards due to its damaging feeding habits and rapid population growth [23]. Although limited studies are available on olives, larvae of *Otiorhynchus* spp. in other fruit species caused substantial damage by feeding on the fine roots of trees. This resulted in stunted growth, smaller leaves and fruits, and ultimately, plant death if left uncontrolled [36]. The damage is further exacerbated by adult beetles, which feed on foliage, creating round cuts along the leaf edges and adding stress to the plants. Infestations of *O. cribricollis* are becoming increasingly relevant in the context of olive pests. In this study, infestation levels were generally higher in SHD, except for 'Carolea', which showed higher infestations in TRD (Table 4, Figure 5). These elevated infestation levels in SHD orchards were likely due to the vegetative canopy continuity, which facilitates the spread of this pest, along with the tension structures typical of SHD systems that act as bridges for the insect [37]. Notably, 'Carolea' recorded the highest infestation levels among the cultivars, representing an exception as its highest infestations were observed in TRD (Table 4). This anomaly can be attributed to two factors: (i) unlike other cultivars in SHD, 'Carolea' has a columnar growth habit that does not create the same vegetative continuity as other cultivars [38]; (ii) in TRD, 'Carolea' had a higher number of suckers, which are known to be particularly appealing to this pest [37]. The significant differences in *P. unionalis* infestations between TRD and SHD systems underscore the influence of irrigation and vegetative growth on pest distribution (Figure 6, Table 5). Weather conditions appeared to exacerbate these infestations, particularly in August, aligning with the findings of Caselli et al. [39]. Early infestations in 'Cima di Bitonto', 'Coratina', and 'Peranzana' suggested that these genotypes may be more susceptible to early-season pest activity. The uniformity of infestation levels in the SHD system highlighted how intensive cultivation practices can influence pest dynamics, supporting the observations of González-Zamora et al. [40]. The role of tender vegetative tips as a preferred substrate for *P. unionalis* is corroborated by previous studies [41–43]. These findings suggested that managing vegetative growth through pruning and irrigation practices could be key strategies for controlling *P. unionalis* infestations in olive orchards. In central Italy, SHD olive orchard systems were found to favor *P. unionalis* infestations compared to traditional systems. The increased vegetative growth in SHD, primarily due to pruning, contributed to this heightened infestation. However, in that experimental site, infestations on shoots of 'Arbequina' remained low and showed no differences between SHD and TRD, likely due to the low total tree biomass produced [23]. The observed seasonality of *P. oleae* infestations across different cultivars highlights the impact of climatic conditions and genetic characteristics on pest dynamics. Two distinct infestation peaks aligned with the typical regional seasonality of *P. oleae* (Figure 7, Table 6). Higher infestation levels in TRD, linked to the crop load of the previous year, suggested that past agricultural practices significantly influence current pest levels, with 'Coratina' being the most infested cultivar. The delayed infestations observed in 'Maurino' and 'Carolea' indicated that genetic factors may influence the timing of pest activity. Meanwhile, increased infestations in 'Cima di Bitonto' and 'Carolea' in SHD underscored the importance of both environmental and genetic factors in developing effective pest management strategies. The higher infestations observed in TRD can be attributed to environmental conditions favoring *S. oleae* development, particularly due to wider pruning cycles [44,45]. Infestations began earlier, in December, for 'Coratina', 'Maurino', and 'Peranzana', with 'Maurino' and 'Peranzana' showing increased infestation levels in January (Table 7, Figure 8). This suggests a population buildup of *S. oleae* during this period. In regions like Apulia and Crete, *S. oleae* exhibits an annual generation cycle, with population peaks during the summer and significant natural mortality due to extreme climatic conditions, such as high summer temperatures and low winter temperatures [46,47]. The delayed infestation observed in 'Cima di Bitonto' and 'Leccino', starting in February, indicates a variation in the seasonality of *S. oleae* activity among cultivars (Table 7, Figure 8). The significant reduction in infestation levels following pruning in February underscores the impact of agronomic practices on pest management. The persistent infestations in 'Peranzana' and stable infestation rates in 'Leccino' highlighted differences in cultivar susceptibility and pest recovery ability. The absence of infestations in 'Carolea' and 'Nociara' throughout the observation period pointed to potential resistance in these genotypes. Pest distribution within the tree is also influenced by microhabitats, with scales preferring sheltered areas and older leaves, which can impact the overall health and productivity of the trees [47,48]. Moreover, these discrepancies in infestation patterns could be influenced by genetic factors, seasonal pest activity, environmental conditions, and the effectiveness of pruning interventions [49]. The impact of more intensive cultivation practices was further emphasized by the higher infestation levels observed in TRD compared to SHD (Table 2). Landscape composition and configuration also play significant roles, as diverse and complex landscapes are associated with lower pest populations. This is attributed to an increased abundance of natural enemies and the presence of herbaceous and woody vegetation adjacent to olive orchards, which help reduce pest abundance [50].

In SHD, intense pruning and high plant biomass production could favor pest infestations due to denser canopies and higher humidity levels. In contrast, TRD often provides less favorable conditions for pests [23]. Additionally, the absence of a dry season can create optimal conditions for pest development, highlighting the importance of regional climatic conditions in devising effective pest management strategies [23]. Long-term studies have underscored the importance of balancing yield and economic losses when deciding on pest control measures, particularly for pests like *P. oleae*. While natural egg predators can significantly reduce pest populations, control measures may still be necessary during years of high infestation to prevent economic losses [51]. Selecting appropriate cultivars for different management systems is also crucial. Some cultivars exhibit lower susceptibility to pests due to specific traits, making them more suitable for certain cultivation systems and aiding in the development of integrated pest management strategies [51].

5. Conclusions

These findings represent the first data on the influence of two planting systems and different cultivars on infestation levels of key olive pests in southern Italy, within the most vocated and extensive olive-growing area. The comprehensive analysis of pest infestations across olive cultivars revealed complex relationships among genetic and agronomic factors. The planting system had a significant impact on the pest dynamics of *B. oleae*, *E. olivina*, and *O. cribricollis* but no significant effect on *P. unionalis*, *P. oleae*, and *S. oleae*. Specifically, the highest infestation levels of *O. cribricollis*, *P. unionalis*, and *B. oleae* were recorded in the SHD olive orchard. Conversely, the highest infestation levels of *S. oleae*, *E. olivina*, and *P. oleae* were observed in the TRD olive orchard. The study also highlighted a generally nuanced effect of different cultivars on pest dynamics and emphasized the potential influence of climatic conditions on the seasonality of pest activity. Factors such as olive size, water availability, and fruit ripeness appeared to play significant roles in *B. oleae* infestations. Moreover, *O. cribricollis* stood out as the only pest for which both cultivar selection and planting system were crucial, underscoring the importance of integrated decision-making in pest management.

Overall, these findings highlight the complexity of olive pest interactions and the importance of a holistic cultivar-specific approach to pest management in olive cultivation. This study provides an in-depth overview of the infestation dynamics of key pests across different olive cultivars and planting systems, contributing valuable insights into the understanding and management of pest infestations in olive growing. The results emphasize the species-specific influence of agricultural practices on phytophagous insects. The distinct patterns observed suggest that effective pest management strategies should consider not only general practices but also the specific interactions between these practices and the biological characteristics of the target pest species. This tailored approach could lead to more sustainable and effective pest management solutions for olive growing. Furthermore, the findings contribute significantly to scientific research in olive cultivation and pest management, promoting the development of eco-friendly control methods and improving current infestation management practices. The collected data are highly useful for farmers and technicians, providing guidance on cultivar selection and aiding in the planning of pest control strategies. Additional research is necessary to deepen the understanding of these key pests. Future studies could include a co-occurrence analysis to explore whether cooperation or synergic interactions among different pest species might be influencing infestation dynamics. Such insights could further refine integrated pest management strategies, enhancing sustainability and productivity in olive cultivation.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/horticulturae10121251/s1, Table S1: Fruits weight for eight cultivars grown in two different planting systems: rainfed traditional (TRD; 277 trees ha^{-1}) and irrigated superintensive (SHD; 1666 trees ha^{-1}). For each mean value the first letter denotes statistical differences among cultivars, while the second one denotes statistical difference between planting systems for each cultivar ($p > 0.05$; SNK test).

Author Contributions: Conceptualization, M.C., S.C. and E.T.; methodology, E.T.; software, A.R. and J.F.H.; validation, M.C., S.C. and E.T.; formal analysis, A.R.; investigation, M.C. and E.T.; resources, S.C.; data curation, A.R. and F.M.; writing—original draft preparation, M.C. and F.M.; writing—review and editing, F.M., F.N., A.R. and S.C.; visualization, F.M.; supervision, S.C.; project administration, S.C. and E.T.; funding acquisition, S.C. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The original contributions presented in the study are included in the article and Supplementary Material, further inquiries can be directed to the corresponding authors.

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Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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