

Research Article

Efficacy of integrated pest management strategies against Olive psyllid, *Euphyllura straminea* Loginova (Hemiptera: Aphalaridae) in olive orchards of Iran

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Abstract. The olive psyllid (*Euphyllura straminea*) is a major pest affecting olive orchards worldwide, including the principal olive-producing provinces of Iran. Both nymphs and adults cause significant damage by feeding on plant sap, buds, and young branches, weakening trees, premature flower bud abscission, reduced flower numbers, and decrease fertility. This study aimed to evaluate and integrate various pest management strategies to develop an effective control program. The approaches assessed included tree pruning, mineral oil spraying, and insecticide applications, arranged in a completely randomized design with ten treatments, each replicated four times. Results indicated that in Guilan, the most effective treatments were winter oil spraying combined with spring foliar spraying (2.0 ± 0.38 nymphs) and winter oil spraying alone (2.4 ± 0.28 adults). In Zanzan, winter pruning plus spring foliar spraying (2.01 ± 0.4 nymphs) and winter pruning plus mineral oil spraying (2.16 ± 0.9 adults) yielded the best outcomes. In Golestan, mineral oil spraying combined with spring foliar spraying was most effective for egg reduction (2.93 ± 0.91 eggs), while spring pruning plus spring foliar spraying (0.58 ± 0.08 nymphs) and mineral oil spraying with spring foliar spraying (1.33 ± 0.33 adults) were optimal for nymph and adult control, respectively. The highest yields were observed with combined treatments involving pruning and either spring foliar or winter oil spraying. Overall, the findings demonstrate that integrating pruning with targeted spring foliar spraying against nymphs and mineral oil spraying against adults is the most effective strategy for controlling olive psyllid and enhancing olive yield.

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Introduction

The olive, *Olea europaea* L.(Oleaceae) is considered one of the Mediterranean basin bio-indicator species for its historic ecological, economic, and cultural value (Zhang *et al.*, 2024). An evergreen small tree with a broad canopy, *O. europaea*, is widely distributed throughout European Mediterranean islands as well as in countries such as Spain, Italy, France, Greece, Morocco, Tunisia, and Turkey. Additionally, it is present in northern Iran, western Asia, and northern Africa (Ghasemi *et al.*, 2018). Approximately 78,095 hectares of land are dedicated to olive cultivation in Iran, with Zanzan, Gilan, Qazvin, Golestan, and Fars being the primary regions. *Euphyllura*



straminea Loginova (Hemiptera: Aphalaridae) is among the most significant olive pests in Iran and is also reported in Iraq, Jordan, Tunisia, Greece, and Turkey (Marouf *et al.*, 2020a). This pest can cause damageranging from 13% to 40% depending on population density, with average yield reductions up to 58.64% in Guilan and Mazandaran (Marouf *et al.*, 2020b). *E. straminea* is a small hemipteran with piercing-sucking mouthparts. Both adults and nymphs feed on phloem sap from leaves, buds, shoots, flowers, and immature fruits, which can result in significant physiological stress to the host plant. Adults overwinter in protected microhabitats, predominantly on the abaxial surfaces of olive twigs, with a preference for the bases of leaves and buds. The onset of oviposition typically occurs in early spring, marking the initiation of the reproductive cycle (Marouf *et al.*, 2021).

Oviposition typically begins in early spring, with eggs predominantly deposited on the inner surfaces of young, tender leaves of apical buds, where they are attached by short pedicels. Upon hatching, nymphs secrete a characteristic white, waxy substance along with spherical honeydew droplets that coat the infested buds, inflorescences, and other delicate tissues on which they feed. Adult psyllids continue to feed regularly on plant sap throughout diapause and post-diapause quiescence, a behavior critical for their survival during these dormant periods (Tzanakakis, 2008). The olive psyllid, *E. straminea* Loginova, exhibits a variable number of generations annually, primarily influenced by prevailing climatic conditions. Typically, three generations occur per year under optimal temperature ranges of 20–25°C (68–77°F), although in some regions only two generations have been reported. The species overwinters as adults, which seek refuge on buds and leaves of olive trees. These overwintering adults become active by mid-March and initiate oviposition on terminal buds in April. Each female lays an average of approximately 32 eggs, with an embryonic development period ranging from 8 to 10 days (Gupta *et al.*, 2024). Adults of the first generation typically emerge around late May and commence mating activities by early September. The second generation completes its life cycle within approximately 45 to 47 days, with adults generally appearing by late October (Noyes & Fallahzadeh, 2005).

To manage this pest effectively, it is recommended to monitor it in April, May and October to prevent economic losses. Following this, agricultural control measures should be implemented. Research has shown that autumn pruning is usually ineffective, as insects prepare for winter and take shelter on tree trunks. Therefore, spring pruning is recommended, as the insect is primarily in the egg stage during this period. By pruning branches in spring, a significant portion of the pest population can be eliminated, preventing a return to its natural balance. It is also advised to remove infested branches during summer, autumn, and winter. Pruning is crucial for olive trees, as it promotes earlier fruiting, uniform production, and prolongs the tree's productive life. Studies suggest that oil olive cultivars should be pruned every three years. Proper plant nutrition, along with regular and sufficient irrigation, can also help control this pest. Regarding pest control methods, the use of emulsifying oil at 1% is recommended against all wintering insects in the second half of March, as it poses no risk of burning the plant (Zareiyan & Hesami, 2021). Additionally, the use of mineral oil at a dose of 2% is advised against the overwintering population of olive psyllid in March, prior to spawning (Marouf *et al.*, 2020a). Chemical control against wintering olive psyllid in infected gardens (averaging one whole insect per tr etrimfos eatment) in late March, before spawning, should consider preserving natural enemies; thus, the use of etrimfos insecticide at a dose of 1.5 ml/l is recommended. Comparative studies on several insecticides, including fenitrothion, phosmet, imidacloprid, pyriproxyfen, chlorpyrifos, and mineral oil, indicated that fenitrothion provided the best control results (Youssef *et al.*, 2011). Spring pruning of olive trees has also been identified as a non-chemical solution to reduce olive psyllid populations. Research showed that the use of processed kaolin (Surround brand), typically used for olive fly control, had no effect on olive psyllid (Pascual *et al.*, 2010).

Based on the findings of various studies targeting the control of *E. straminea*, several management approaches have been proposed, including mineral oil applications and tree pruning. In light of climatic changes observed over the past two decades, there is an increasing need to develop integrated pest management (IPM) strategies that combine these cultural practices with chemical controls in olive-growing regions. The present study aims to implement a comprehensive set of integrated pest control measures to effectively manage olive psyllid populations.

Material and Methods

Design of Experiment

The field trial was conducted from 2017 to 2018 in olive groves in Zanjan province in northwestern Iran (36° 69' 57.5" N, 48° 54' 97" E), in Guilan province in northern Iran (36° 48' 18.1"N, 49° 24' 45.9"E), at Golestan province in the northeastern of Iran (36° 50' 37" N, 53° 30' 50.3" E). It is important to highlight that the project experienced a one-year suspension due to the outbreak of the COVID-19 pandemic and the associated restrictions, as well as a change in project management. Consequently, the project in Golestan Province was completed within a single year. To ensure a more comprehensive evaluation in this region, egg counts were conducted in addition to the enumeration of nymphs and adult insects. In contrast, the nymph and adult stages were counted in the two other regions, Guilan and Zanjan. In all areas, olive trees of the Zard variety were selected for the project.

Experimental Treatments

A randomized complete block design was used with four blocks (replicates) subdivided into 10 plots (test units) including 40 olive trees, similar in canopy size and height, for each treatment. In arranging the treatments, a row of trees was designated as a buffer to prevent interference between treatments. The treatments included: 1) Winter Oil (mineral oil) Spraying 2% (Zanjan: First week of March, Guilan: Second week of March, Golestan: Third week of February), 2) Spring Pruning: Zanjan and Guilan: Second half of April, Golestan: Second half of April, 3) Foliar Spraying Against Nymphs: Chlorpyrifos at a dosage of 2 ml/l applied before flowering (Zanjan and Guilan: Second week of May, Golestan: First week of May), 4) Combination of winter oil spraying (Volck® Oil 2%) and spring pruning 5) Combination of spring pruning and spring foliar spraying against nymphs. 6) Combination of Winter Oil Spraying and Spring Foliar Spraying. 7) Winter Pruning After Harvest: Zanjan and Guilan (Beginning of December), Golestan (First week of December), 8) Integration of Winter Pruning and Winter Oil Spraying, 9) Integration of Winter Pruning and Spring Spraying Against Nymphs, 10) Control Treatment: No pest control measures applied. In the pruning treatment, 10 to 15% of the branches were selectively removed to achieve balanced vegetative growth and reduce pest damage (Moderate pruning).

For nymph collection, four branches from the four cardinal directions of each tree were selected at a height of 1.5–2 meters within the mid-canopy section. A 30-cm terminal shoot was excised from each branch and immediately sealed in polythene zip lock bags to prevent insect escape or contamination. Samples were transported to the laboratory under controlled conditions and stored at 4°C (39°F) to immobilize the insects. Pest counts were performed on the same day as collection to minimize mortality or behavioral changes, ensuring accurate nymph population quantification.

It is important to emphasize that, due to climatic variability among the study regions, each sampling stage's timing was adjusted according to the olive trees' phenology and the prevailing environmental conditions. After applying treatments, adult and nymph populations were assessed based on the aforementioned sampling protocols, with sampling conducted in alignment with the relevant seasonal periods. Furthermore, the total number of inflorescences on the selected terminal shoots was recorded. Subsequently, the final fruit set was enumerated on the selected trees in mid-July, following the established sampling methodology.

Statistical Analysis of Data

After completing the experiment and sampling, statistical analysis was performed using the software SAS. The data were compared by Analysis of variance (ANOVA) followed by mean comparison by Duncan's test using the SAS program, Version 8.0.

Results

Guilan Province

To better compare the methods of psyllid management in orchards, the data obtained from applying different treatments related to the various life stages of the insect (including nymphs and adults) are presented in [Table 1](#). The mean comparison for psyllid nymphs indicated that treatments such as winter pruning, spring foliar spraying, and winter oil spraying significantly reduced the average number of nymphs in both years. While other treatments also reduced this number compared to the control, they ranked lower statistically.

In both years, the combination of winter oil and spring foliar spraying resulted in the lowest number of nymphs, while the winter oil spraying treatment alone had the highest count. Data analysis showed that over the two years, different treatments led to a decrease in the number of adult insects compared to the control. Specifically, winter oil spraying and the combination of winter and spring foliar spraying were the most effective in reducing the number of adults, whereas spring pruning and early spring foliar spraying had the least impact.

In 2017, the results showed that the lowest yield was significantly observed in the control treatment, while the highest yield in both years was associated with winter oil spraying. Additionally, in the first year, the foliar spraying treatment at the beginning of spring significantly contributed to the high yield.

Zanjan Province

The results showed that in Zanjan province, in both years of the study, the average number of nymphs significantly decreased with the application of different treatments compared to the control. In both years, the spring pruning treatment had the lowest, and the winter pruning treatment had the highest average number of nymphs, significantly compared to the other treatments. The comparison of the average number of adult insects over the two years also showed that in the first year, all treatments significantly reduced the number of insects compared to the control, whereas in the second year, some treatments, such as winter spraying, spring pruning, winter spraying + spring solution, and winter pruning did not show a significant difference in the number of adult insects compared to the control. The lowest number of adult insects in both years was related to winter pruning + spring spraying (Table 2). This table shows that the highest yield in both years was related to winter pruning + spring spraying, and the lowest yield was related to the control group.

Golestan Province

The evaluation of the effectiveness of treatments on different stages of the insect's life cycle showed that in the Golestan province, the highest number of all life stages of the insect (egg, nymph, and adult) was observed in the control treatment, while the lowest number of eggs was found in the winter oil spraying and spring solution spraying treatments, and the highest number of eggs was observed in the winter pruning treatment (Fig.1). Regarding the number of nymphs, the lowest treatment was related to spring pruning + spring spraying, while the highest number of nymphs was observed in the winter pruning treatment. The adults' olive psyllid was observed in the lowest numbers in the winter oil application + spring spraying treatment and the highest in the winter oil application treatment (Fig.1). Ultimately, this province's highest yield of olive trees was associated with the winter pruning + winter oil spraying treatment. In most olive-growing regions of Iran, this pest has affected crop performance and requires fundamental measures for its control.

Discussion

Proper management of pruning fruit trees is important due to its role in improving light penetration into the canopy, enabling the formation and proper distribution of pests, and, ultimately, the tree's fruiting throughout the canopy. It also creates adequate ventilation in the tree's canopy and affects the control of certain pests and diseases, such as psyllids, as well as the control and development of the tree (Marouf *et al.*, 2020a; Dias *et al.*, 2022).

Research has shown that autumn pruning is usually not very effective, as in the fall, adult insects prepare for winter and take refuge on the trunks of trees. Additionally, they can easily relocate due to their flying ability; spring pruning is recommended. Because the insect is mainly in the egg stage in spring, pruning the branches at this time eliminates a significant portion of the pest, preventing it from returning to its natural balance. Removing suckers and shoots in summer, autumn, and winter is recommended. Pruning is one of the important issues in the olive cultivation stage. It causes young trees to bear fruit earlier, results in a uniform product yield, reduces alternate bearing, and increases the tree's lifespan and consequently, its productive period. Pruning usually begins after the harvest. Pruning is done every two years in most olive orchards in Mediterranean regions. Research has shown that olive oil varieties are better pruned every three years (Dias *et al.*, 2022; Amro, 2017).

Table 1. The effect of different treatments on the average number of nymphs and adults of olive psyllid, *Euphyllura straminea* in 2017 and 2018 in Guilan province

Treatments	Nymphs /shoot/week (2017)	Nymphs /shoot/week (2018)	Adults /shoot/week (2017)	Adults /shoot/week (2018)	Yield (Kg/tree) (2017)	Yield (Kg/tree) (2018)
Oil spraying in winter	13.20±2.62 ^b	13.35±2.63 ^b	2.40±0.28 ^b	2.75±0.25 ^b	84.50±3.17 ^a	4.75±0.85 ^a
Spring pruning	8.10±1.56 ^b	7.30±1.43 ^b	4.85±0.41 ^{ab}	5.01±0.42 ^{ab}	59.25±1.75 ^{bc}	4.75±0.47 ^a
Spraying of insecticide in beginning of spring	2.90±0.44 ^c	2.20±0.44 ^c	4.80±0.55 ^{ab}	4.45±0.49 ^{ab}	86.01±2.94 ^a	3.75±0.62 ^{ab}
Oil spraying in winter + Spring pruning	2.25±0.45 ^c	2.95±0.57 ^c	2.55±0.34 ^b	3.05±0.32 ^b	62.75±1.79 ^{bc}	2.75±0.47 ^{bc}
Spring pruning + Spraying of insecticide in beginning of spring	2.20±0.62 ^c	2.60±0.53 ^c	3.20±0.46 ^b	4.25±0.51 ^{ab}	57.50±3.75 ^c	2.37±0.37 ^{bc}
Oil spraying in winter + Spraying of insecticide in beginning of spring	2.10±0.41 ^c	2.00±0.38 ^c	2.75±0.24 ^b	4.15±0.28 ^{ab}	78.75±4.71 ^a	2.75±0.47 ^{bc}
Winter pruning	9.95±2.02 ^b	10.40±2.08 ^b	4.30±0.30 ^b	4.25±0.34 ^{ab}	65.30±2.27 ^{bc}	2.55±0.28 ^{bc}
Winter pruning + Oil spraying in winter	8.55±1.68 ^b	9.30±1.81 ^b	2.95±0.34 ^b	3.25±0.36 ^b	67.22±2.12 ^b	2.75±0.47 ^{bc}
Winter pruning + Spraying of insecticide in beginning of spring	1.97±0.37 ^c	1.80±0.24 ^c	2.60±0.35 ^b	2.81±0.31 ^b	58.16±3.76 ^{bc}	3.25±0.47 ^b
Control	24.80±4.88 ^a	29.65±5.74 ^a	8.02±0.36 ^a	7.05±0.48 ^a	45.25±3.14 ^d	1.75±0.14 ^d

Means with the different letter in each column are significantly different by Duncan's test ($p < 0.05$)

In early spring, the majority of pest populations in olive orchards are present in the egg stage, making this period critical for effective pest management. Pruning at this time not only removes part of the pest population but also disrupts the natural balance of pest density. Pruning trees effectively reduces pest populations by disrupting the microclimatic conditions within the canopy that many pests rely upon for protection and development. By removing branches and thinning foliage, pruning exposes pest eggs to unfavorable environmental factors such as increased light intensity, temperature fluctuations, and enhanced ventilation, which collectively elevate egg mortality. This physical alteration of the habitat not only directly eliminates a portion of the pest population through branch removal but also compromises the survival of remaining individuals by eliminating their sheltered niches. Consequently, pruning serves as a valuable cultural control strategy within integrated pest management programs by decreasing pest pressure and enhancing the efficacy of natural enemies, thereby reducing reliance on chemical interventions. Olive orchards across most regions of Iran are characterized by a rich fauna of beneficial insects. The conservation and support of these beneficial species are essential for successful integrated pest management (IPM). Therefore, combining pruning practices with a single application of dormant oil spray in winter or an early spring spray can contribute to both pest control and the preservation of beneficial insects, aligning with IPM objectives (Goodell *et al.*, 2014; Hougardy *et al.*, 2020).

Table 2. The effect of different treatments on the average number of nymphs and adult insects of olive psyllid, *Euphyllura straminea* in the years 2017 and 2018 in Zanjan province

Treatments	Nymphs/ shoot/week (First year)	Nymphs /shoot/week (Second year)	Adults /shoot/week (First year)	Adults /shoot/week (Second year)	Yield (Kg/tree) (First year)	Yield (Kg/tree) (Second year)
Oil spraying in winter	15.95±5.51 ^b	7.08±1.33 ^c	2.75±0.42 ^c	7.5±0.94 ^a	85.5±6.09 ^{bcd}	81.25±7.48 ^{ab}
Spring pruning	11.33±5.35 ^b	11.16±3.22 ^b	4.83±0.83 ^b	4.08±1.02 ^a	73.01±4.84 ^{cd}	87.35±8.91 ^a
Spraying of insecticide in beginning of spring	2.62±1.04 ^d	2.01±0.41 ^d	4.37±0.85 ^b	2.62±0.76 ^b	101.75±6.88 ^{ab}	90.75±10.15 ^a
Oil spraying in winter + Spring pruning	4.29±1.77 ^c	7.04±1.85 ^c	4.91±0.78 ^b	3.5±0.72 ^{ab}	69.25±5.66 ^d	80.25±8.22 ^{ab}
Spring pruning + Spraying of insecticide in beginning of spring	4.83±1.70 ^c	5.87±2.52 ^c	5.58±0.61 ^{ab}	3.62±0.32 ^{ab}	77.05±4.49 ^{cd}	82.25±4.26 ^{ab}
Oil spraying in winter + Spraying of insecticide in beginning of spring	3.16±1.01 ^c	2.45±0.69 ^d	3.95±0.80 ^c	4.62±0.48 ^a	89.25±5.93 ^{bc}	91.5±11.04 ^a
Winter pruning	15.41±1.07 ^b	12.25±4.08 ^b	4.58±0.94 ^b	4.16±0.8 ^a	73.31±4.65 ^{cd}	86.75±4.71 ^a
Winter pruning + Oil spraying in winter	10.25±3.06 ^b	9.41±3.51 ^b	3.29±0.73 ^c	2.44±0.68 ^b	89.75±6.92 ^{bc}	95.25±4.66 ^a
Winter pruning + Spraying of insecticide in beginning of spring	3.33±0.26 ^c	2.37±0.13 ^d	2.33±0.69 ^c	2.16±0.9 ^b	108.75±9.76 ^a	100.05±12.21 ^a
Control	26.48±8.27 ^a	27.33±9.35 ^a	8.62±1.08 ^a	4.87±1.07 ^a	68.75±4.36 ^d	63.11±4.56 ^b

Means with the different letter in each column are significantly different by Duncan's test ($p < 0.05$)

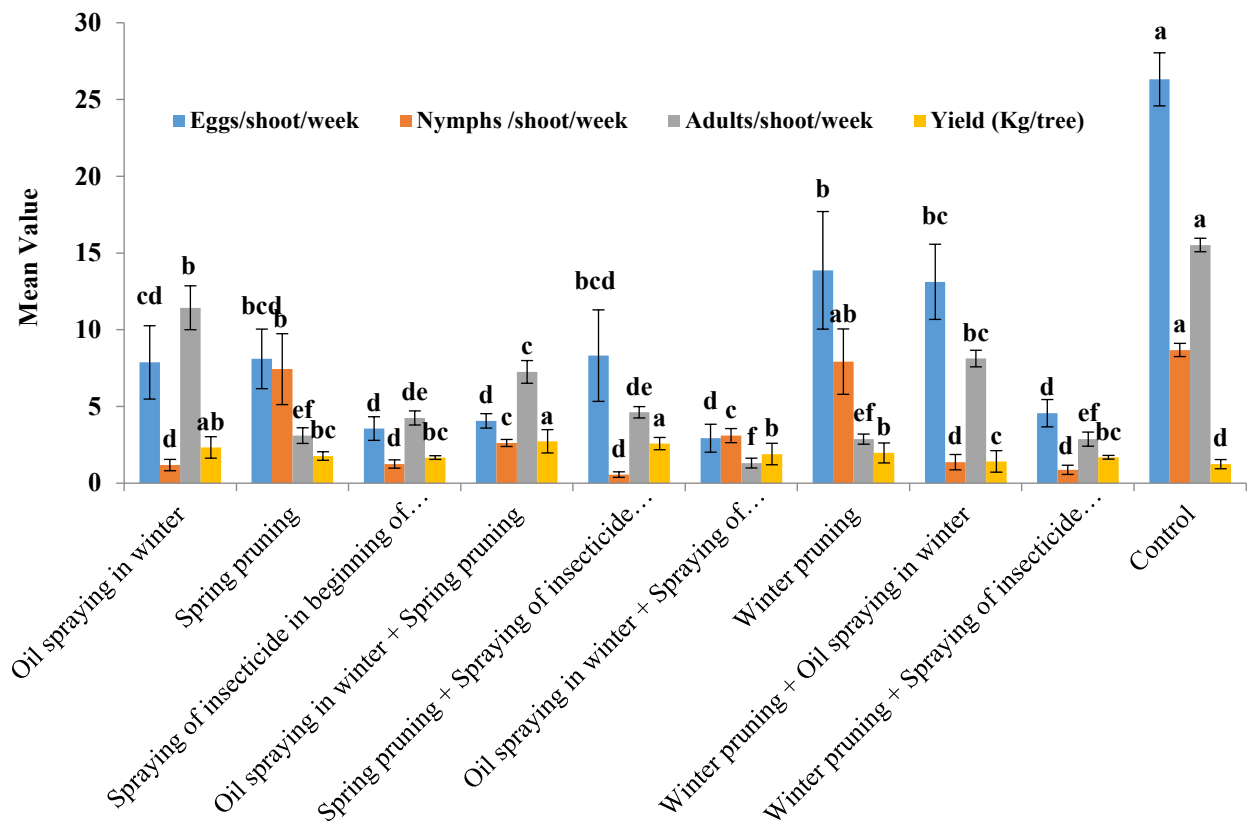


Fig. 1. The effect of different treatments on the average number of nymphs and adult insects of olive psyllid, *Euphyllura straminea* in the year 2018 in Golestan province.

Means with the different letter in each column are significantly different by Duncan's test ($p < 0.05$)

Research indicates that using a 1% emulsifiable oil spray during winter eliminates approximately 80% of the overwintering pest population, while the remaining pests are effectively controlled by natural enemies. Comparative trials between different chemical treatments—including 1% and 2% winter oil, azinphos-methyl (2 per 1000), a mixture of ethion (1.5 per 1000) with 1% oil, and untreated controls—showed no significant difference in efficacy between high-risk chemical insecticides and winter oil.

Considering environmental approaches and the goals of IPM, as well as the preservation of natural enemies, the use of a 1% emulsifiable oil spray in late winter, before pest oviposition and the activity of beneficial insects, is recommended as the best method for pest control in olive orchards. In this study, the mortality of adult olive psyllids in Guilan province due to the application of 2% winter oil treatment was reported to be around 65% (Saeb, 2003). Experiments conducted by researchers have shown that winter spraying with a 1% concentration results in a 77% mortality rate among adult olive psyllids, with no significant differences in mortality observed among the different concentrations of 1%, 2%, and 3% oil (Zareiyan & Hesami, 2021). The reduction in the population of natural enemies due to unplanned spraying has resulted in the remaining pest population after the winter oil spraying being at a level that makes spring control necessary (Marouf *et al.*, 2020b). The use of 1% emulsion oil against overwintering adult insects in the second half of March is recommended without the risk of phytotoxicity. In another study, chemical control of overwintering olive psyllids in infested orchards (averaging one adult per tap) at the end of March, before pest oviposition, was recommended using ethirimol at a concentration of 1.5 g/l (Saeb, 2003). The use of 2% Volck oil against the overwintering population of olive psyllids in March, prior to oviposition, was evaluated with satisfactory results (Marouf *et al.*, 2020a). Most studies observed that the effect of oil on controlling olive psyllids was favorable across all treatments, and the overall results indicated that oil was successful in managing the overwintering population of olive psyllids before oviposition and could serve as a substitute for chemical control methods in spring (Zareiyan & Hesami, 2021).

Applying 1% emulsifiable oil in late March not only does not cause plant burning but also results in a higher percentage of overwintering adult olive psyllids being controlled. In a comparison of several insecticides for controlling the olive psyllid, including fenitrothion, fenthion, imidacloprid, pyroxasulfone, chlorpyrifos, and mineral oil, it was reported that the best control result was achieved with the application of fenitrothion (Youssef *et al.*, 2011). Based on the results of applying the treatment of winter oil (at a concentration of 1.5%) + chlorpyrifos insecticide (at a concentration of 2 per thousand) in two winter and spring stages, complete control of the olive psyllid was achieved (Marouf *et al.*, 2020b).

Other researchers also observed the highest mortality rates of adult olive psyllids due to applying the oil + insecticide treatment (Moheisni *et al.*, 2013). In line with these results, which are consistent with the present study's findings, the simultaneous application of pruning and oil spraying along with a stage of solution spraying can lead to pest control in the olive-growing regions of Iran. However, the impact of different treatments on the performance of the olive trees indicated that the combined treatment of winter oil spraying + spring solution spraying, as well as the combined treatments of these two factors with spring and winter pruning, ranked next in terms of optimal performance; which led to a reduction in various stages of the pest's life cycle. The effect of spring pruning compared to autumn pruning on increasing the oil content of olives is because autumn pruning seems to stimulate olive trees to increase vegetative growth, causing the plant to expend more of its energy on vegetative growth. Therefore, in autumn pruning, the percentage of oil has even decreased compared to no pruning (Gupta *et al.*, 2024). However, during spring pruning, since the plant has entered the reproductive growth stage and inflorescences have formed, pruning at this time will not halt reproductive growth. Instead, cutting some branches at this stage increases the nutrition of the remaining branches, resulting in improved fruit quality and oil percentage (Moheisni *et al.*, 2013).

The interaction effects of pruning and pest management on the performance of olive trees revealed that pest control combined with spring pruning significantly increased the oil content of the fruit in the experimental treatments. Because, as mentioned, spring pruning and pest control will increase in the oil yield of the fruit. The results of this research, although they do not show a significant impact of pruning and olive psyllid on the plant's alternate bearing, indicate that a longer-term study is necessary to reach a definitive conclusion. The impact of pruning on reducing alternate bearing has also been mentioned. In a ten-year study, the effect of pruning on controlling alternate bearing in olive trees has been proven. In olive trees, the yield in the off-year significantly increases, and the formation of young branches that bear the following year's fruit decreases. This issue is addressed by modified pruning, and pruned trees produce young branches (Camerini *et al.*, 2008). Due to heavy pruning in the first year, the difference in crop yield between the first year (on-year) and the second year (off-year) was not significant. For this reason, the statistical difference between the yield in the third year and the first and second years does not indicate a modification of alternation because this claim can only be made if the product yield in two to three consecutive years falls within the same statistical group. In the present study, although the reduction in alternate bearing has not been statistically confirmed, the continuation of pruning operations every two to three years and proper orchard management, including irrigation, fertilization, prompt harvesting of the crop (Amro, 2017), and control of pests and plant pathogens, will lead to a reduction in the alternate bearing of olive trees. Pruning, while increasing the amount of olive oil, will also reduce the infestation of olive trees by the olive psyllid, support natural enemies due to the reduced use of chemical pesticides, and decrease the risk of frost damage to the trees as a result of autumn pruning. Allahyari *et al.* (2017), emphasized strengthening growers' technical knowledge of IPM through community involvement and extension services among inexperienced small scale olive farmers to reduce unnecessary insecticide sprays. The present study evaluated integrated pest management (IPM) strategies for controlling *E. straminea* (Hemiptera: Aphalaridae) in olive orchards across Zanjan, Guilan, and Golestan, Iran. The results demonstrate that a multifaceted approach combining winter oil applications, spring foliar insecticide treatments, and systematic pruning during both winter and spring seasons constitutes the most effective strategy for reducing psyllid populations. Pruning plays a pivotal role by enhancing canopy aeration and light penetration, environmental factors that are known to suppress pest establishment and development. Importantly, spring pruning coincides with the oviposition and egg stages of *E. straminea*, disrupting its life cycle continuity and contributing to population suppression. Beyond pest control, pruning also fosters improved tree vigor and productivity, highlighting its agronomic significance. Integrating these cultural and chemical tactics within a sustainable IPM framework aligns with contemporary agricultural practices aimed at minimizing environmental

impact while maximizing pest control efficacy. This holistic management approach curtails *E. straminea* infestations and supports the long-term health and yield potential of olive orchards. Consequently, this study substantiates that targeted spring foliar spraying against nymphal stages, in conjunction with well-timed pruning, represents a robust, environmentally sound, and economically viable strategy for managing olive psyllid populations in the region. Adopting these integrated measures is strongly recommended to enhance sustainable olive production and mitigate the adverse effects of this pest.

Author's Contributions

Mohammad Reza Abbasi Mojdehi: Investigation, methodology, draft preparation; **Mahboobeh Sharifi:** Visualization, conceptualization, methodology, supervision, project administration, final review and edit; **Aref Marouf:** conceptualization, methodology, Visualization, methodology, **Bahareh Rafiei:** Visualization, methodology, Formal analysis, final review and edit. **Daryoush Mansouri Razi:** methodology; investigation; draft preparation.

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Data Availability Statement

All data supporting the findings of this study are available within the paper.

Ethics Approval

Insects were used in this study. All applicable international, national, and institutional guide lines for the care and use of animals were followed. This article does not contain any studies with human participants performed by any of the authors.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

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Research Article

تأثیر راهکارهای مدیریت تلفیقی آفات بر روی پسیل زیتون *Euphyllura straminea* Loginova (Hemiptera: Aphalaridae) در باغات زیتون ایران

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چکیده: پسیل زیتون (*Euphyllura straminea*)، یکی از آفات مهم باغ‌های زیتون در سراسر جهان، از جمله استان‌های اصلی تولید زیتون در ایران است. هر دو مرحله پوره و حشره بالغ این آفت با تغذیه از شیره گیاهی، جوانه‌ها و شاخه‌های جوان، باعث آسیب‌های قابل توجهی می‌شوند که شامل تضعیف درختان، ریزش زودرس جوانه‌های گل، کاهش تعداد گل‌ها و کاهش باروری می‌شود. هدف این مطالعه، ارزیابی و تلفیق روش‌های مختلف مدیریت آفت به منظور توسعه یک برنامه کنترل مؤثر بود. روش‌های بررسی شده شامل هرس درختان، سمپاشی با روغن معدنی و کاربرد حشره‌کش‌ها بود که در قالب طرح کاملاً تصادفی با ده تیمار و هر تیمار در چهار تکرار اجرا شد. نتایج نشان داد که در استان گیلان، مؤثرترین تیمارها، روغن زمستانه همراه با سمپاشی بهاره ($0/2 \pm$ ۳۸- پوره) و روغن زمستانه به تنهایی ($2/4 \pm 28/0$ حشره بالغ) بودند. در استان زنجان، هرس زمستانه به همراه سمپاشی بهاره ($2/01 \pm 0/4$ پوره) و هرس زمستانه به همراه سمپاشی با روغن معدنی ($2/16 \pm 0/9$ حشره بالغ)، بهترین نتایج را داشتند. در استان گلستان، روغن معدنی همراه با سمپاشی بهاره بیشترین کاهش تخم‌ها را به همراه داشت ($2/93 \pm 0/91$ تخم)، در حالی که هرس بهاره همراه با سمپاشی بهاره ($0/58 \pm 0/08$ پوره) و سمپاشی با روغن معدنی همراه با سمپاشی بهاره ($1/33 \pm 0/33$ حشره بالغ) برای کنترل پوره‌ها و حشرات بالغ به ترتیب بهینه بودند. بیشترین عملکرد محصول با تیمارهای ترکیبی شامل هرس و سمپاشی بهاره یا روغن زمستانه مشاهده شد. به طور کلی، نتایج نشان می‌دهد که تلفیق هرس با سمپاشی هدفمند بهاره علیه پوره‌ها و سمپاشی با روغن معدنی علیه حشرات بالغ، مؤثرترین راهکار برای کنترل پسیل زیتون و افزایش عملکرد زیتون است.

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کلمات کلیدی: پسیل زیتون، مدیریت تلفیقی آفات، روغن زمستانه، هرس، درخت زیتون