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Understorey biodiversity management in olive groves for integrated management of olive tree natural enemies

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ABSTRACT

The management of natural enemies of perennial tree crops and especially insects, is usually performed with pesticides, which can negatively impact the quality of products, natural resources, and biodiversity, as well as the health of producers and consumers. An emerging trend focuses alternatively on the use of less or no chemicals and the management of crop pests by natural means. This trend is being promoted by the European Union through the new Common Agricultural Policy. Olive cultivation is one of the most important permanent crops in the Mediterranean area. The most important pest in olive groves is the olive fruit fly [*Bactrocera oleae* (Rossi) (Diptera: Tephritidae)]. In this study, we investigate the relationship between the fly population and plant and insect diversity in the understorey of 15 fields on Lesbos Island during the years 2021 and 2022. The results suggest that maintaining the plant cover undisturbed, significantly improves the biodiversity of the olive groves and by extension the ecosystem services, such as pollination, pest control and soil health.

KEY WORDS: Consumer's attitudes, pesticide residues, factor analysis, logistic regression, European Green Deal, integrated crop management.

Introduction

The increasing world population has led to the intensification and extensification of the agricultural sector to achieve higher yields (Bennet & Balvanera 2007). One of the most common practices of intense farming is the use of insecticides and involves many risks, such as the development of insecticide resistance (Vasconcelos et al. 2022). Plantations and permanent crops have followed these trends with an increasing number of farms choosing small size varieties in order to increase density, industrialize procedures and, at the same

time, treat them with increased use of inputs in order to ensure the, quantitatively, increased production. One of the most important and widespread permanent crops in Europe and the Mediterranean region, culturally and socioeconomically, is olive tree cultivation (Martinez-Nunez et al. 2019). The European Union and the local governments have clearly advocated the reduction of the use of chemical substances that are released into the environment, and their replacement with more environmentally friendly agents and methods, principles that have been expressed in the Common Agricultural

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Policy (CAP) (Pe'er et al. 2019), especially after the enforcement of “Green deal” and the strategy “Farm to Fork”.

The intensification of the olive cultivation affects biodiversity and leads to impoverishment of agroecosystems (Bianchi et al. 2006; Biaggini et al. 2006). It has been established that the agrobiodiversity of the understorey of olive groves, among other factors, contributes to the reduction of plant protection issues in the agricultural production through the support of beneficial insects that are not affected by spraying, by providing habitats or refuges (Porcel et al. 2017; Hole et al. 2005 Fierer et al. 2007; Tilman et al. 2001).

Maintaining an undisturbed understorey benefits the development of larger soil arthropod populations (Blaise et al. 2022; Mantoni et al. 2021; Castro et al. 2021). Arthropods found in the soil of the olive grove understorey have been shown to be able to contribute to the integrated treatment of the olive fruit fly *Bactrocera oleae* (Rossi) (Daane and Johnson 2010). Nevertheless, among insects, bees are a very important group of pollinators. Intensive agriculture (Potts et al. 2010), habitat loss, fragmentation and degradation, affect the availability of key foraging and nesting resources (Tscheulin et al. 2011). According to Martinez-Nunez et al. (2019), bees can benefit from the presence of ground herb cover as they found that colonization rates were higher in olive orchards, in which the understorey was unmanaged.

For all these reasons, it is necessary to investigate how understorey management affects diversity and abundance of arthropods in olive groves. In this study, we monitor land cover, ground arthropod and flying insects and olive fruit fly in the

understorey of extensive olive groves on the Island of Lesvos, Greece for two cultivation periods.

Materials and Methods

For the purposes of this study, we selected fifteen organic olive groves located on the island of Lesvos, Greece, which were treated with equal intensity. The olive groves were grouped into two categories according to the understorey management practices: (a) undisturbed understorey, and (b) understorey cleared with mechanical means.

The diversity of the plant ground cover of the olive groves was assessed during May 2021 and May 2022, with four linear transect walks of 25m length each. Ground arthropods were monitored with pitfall traps (5 per olive grove) from February to November 2021 and February to November 2022, while the flying insects were sampled with pan traps (5 triplets per olive grove) during the same period. Both trap types were active for 7 days. The pan trap triplets consisted of bowls painted with UV-bright yellow, white, and blue color. The specimens captured were initially identified at order level using a binocular microscope and various taxonomic keys (Barrientos 1988; Dindal 1990; Chinery 2005). All Coleoptera and Anthophila Clade (Hymenoptera) were identified to morphospecies level.

Results

The first results show that the type of management of the olive groves' understorey has a significant impact on all the indicators studied in the survey. Specifically, as shown in Table 1, higher values of plant abundance and species richness were found in olive groves with

undisturbed understorey. Moreover, regarding arthropods, it was found that they had the same trend in this type of sub-floor management. The olive fruit fly was negatively affected by the understorey management, as the population was statistically significantly lower in the fields with plant cover.

To further investigate the reasons for the differences between the two types of understorey management, we correlated the studied factors (Table 2). The results showed that all studied arthropod groups have a strong positive relationship with plant species richness. Regarding the relationship with plant species richness of the understorey, it was found that only bee species richness was not statistically significantly correlated, although, here as well, the trend was positive. On the other hand, olive fruit fly had strong negative relationships with all studied arthropod groups and plant richness and abundance (Fig. 1). These relationships were statistically significant.

Discussion

The results show that both arthropod community and plant diversity were increased in olive groves whose understorey is left undisturbed compared to the other type of management, while olive fruit fly has the opposite response.

In general, plant cover in undisturbed understorey was more abundant and this could happen as it was left to grow without obstacles, while the organic practices could also be a factor for the higher plant richness (Kakampoura & Panitsa 2022). Interestingly, the annual plants were more abundant in cleared understoreys, but studies confirm this response (Huqi et al. 2009; Simoes et al. 2014; Solomou & Sfougaris 2011).

As for the arthropod community, the findings can be explained by the fact that an undisturbed understorey provides shelter, nesting sites, and forage, and supports a wide range of ecological processes, such as pollination. Other studies confirm the same findings and suggest that arthropods include species that provide many different ecological services such as pollination, decomposition, insect pest control and this type of understorey can support their population by creating a small ecosystem inside the agroecosystem of the olive grove (Kubiak et al. 2022; Picchi et al. 2016; Knapp et al. 2013).

The arthropod community as mentioned above is more abundant in fields with undisturbed understorey. Among these arthropods are predators and parasitic insects of the olive fruit fly that can control the pest's population when it is adult. At the same time, during the period that the olive fruit fly is pupating in the soil, certain species of predatory coleopterans and ants feed on the fly as it cannot defend itself (Albertini et al. 2018; Albertini et al. 2017; Dinis et al. 2016). These could explain the differences of the olive fruit fly population observed between the two understorey treatments.

In conclusion, this study emphasizes on the significance of olive grove understorey management practices in preserving biodiversity. These practices promote plant diversity, arthropod abundance, and pest control. Olive farmers should prioritize conserving understorey vegetation to support the arthropod community, ecosystem services, and ensure olive production sustainability. Moreover, the maintenance of an undisturbed understorey is in line with the principles of the Common Agricultural Policy (CAP) as it is classified as an environmentally friendly practice.

TABLE 1. Two samples t-test between overall arthropod richness, abundance, and the olive grove's understorey treatment.

	Understorey management			
	undisturbed		cleared	
	Average	Std. Deviation	Average	Std. Deviation
Ground beetle richness	6.21	0.75	2.99	0.59
Ground beetle abundance	14.33	2.15	6.03	2.04
Total ground arthropod abundance	34.18	4.17	12.01	2.00
Bee richness	4.59	0.82	1.44	0.43
Bee abundance	9.83	2.29	2.28	0.70
Flying insect abundance	86.23	20.27	15.21	7.07
Olive fruit fly	6.30	0.69	24.21	3.13
Plant richness	5.4	1.13	2.01	0.83
Plant abundance	58.01	8.37	33.60	18.03
Coleoptera	17.35	21.51	5.75	6.71
Hemiptera	4.68	4.50	1.21	1.01
Hymenoptera	12.76	10.66	2.04	1.49
Orthoptera	2.39	1.33	0.41	0.53
Diptera	8.48	5.42	2.81	1.49
Lepidoptera	1.11	1.35	0.06	0.12
Odonata	0.35	0.42	0.02	0.05
Mantodea	0.10	0.12	0.00	0.00
Dermaptera	0.06	0.12	0.05	0.06
Blattodea	1.78	1.33	0.35	0.56
Thysanoptera	0.98	0.14	0.01	0.01
Embioptera	0.05	0.08	0.04	0.06
Siphonaptera	0.09	0.15	0.00	0.00
Mallophaga	0.12	0.28	0.00	0.00
Arachnida	3.83	1.19	1.02	0.60
Formicidae	15.68	2.79	6.76	0.74
Isopoda	2.39	1.27	0.06	0.11
Chilopoda	1.28	1.14	0.01	0.02
Diplura	0.16	0.24	0.02	0.03

*Statistically significant differences ($p < .001$) are marked with gray shade

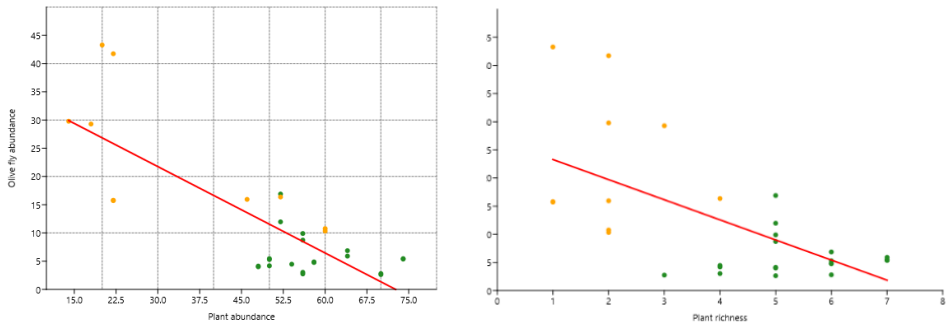
** n=30

TABLE 2. Relationship between overall arthropod data and the olive groves' plant richness abundance (Pearson, r).

	Olive fruit fly abundance	Plant richness	Plant abundance
Ground beetle richness	-.780**	.803**	.737**
Ground beetle abundance	-.806**	.798**	.770**
Total ground arthropod abundance	-.749**	.882**	.752**
Bee richness	-.716**	.758**	.582**
Bee abundance	-.691**	.766**	.590**
Flying insect abundance	-.673**	.658**	.663**
Olive fruit fly abundance		-.633**	-.791**
Plant richness			.726**

* n=30

** Correlation is significant at the 0.01 level (2-tailed).

**FIG. 1:** Scatterplot of (A) average olive fruit fly abundance in the olive grove and the understory plant abundance, and (B) average olive fruit fly abundance in the olive grove and the understory plant richness.

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Διαχείριση της βιοποικιλότητας σε ελαιώνες για την ολοκληρωμένη αντιμετώπιση των φυσικών εχθρών της ελιάς

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ΠΕΡΙΛΗΨΗ

Η διαχείριση των φυσικών εχθρών των δενδρωδών καλλιεργειών και ιδίως των εντόμων, πραγματοποιείται συνήθως με την χρήση φυτοφαρμάκων, τα οποία μπορούν να επηρεάσουν αρνητικά την ποιότητα των προϊόντων, τους φυσικούς πόρους, τη βιοποικιλότητα, καθώς και την υγεία των παραγωγών και των καταναλωτών. Μια ανερχόμενη τάση επικεντρώνεται στη χρήση λιγότερων ή καθόλου χημικών ουσιών και στη διαχείριση των εχθρών των καλλιεργειών με φυσικά μέσα. Η τάση αυτή προωθείται από την Ευρωπαϊκή Ένωση μέσω της νέας Κοινής Αγροτικής Πολιτικής. Η καλλιέργεια της ελιάς είναι μια από τις σημαντικότερες μόνιμες καλλιέργειες στην περιοχή της Μεσογείου. Ο σημαντικότερος εχθρός στους ελαιώνες είναι ο δάκος [*Bactrocera oleae* (Rossi) (Diptera: Tephritidae)]. Στην παρούσα μελέτη διερευνούμε τη σχέση μεταξύ του πληθυσμού του δάκου και της ποικιλότητας φυτών και αρθροπόδων στον υπόροφο 15 ελαιώνων στο νησί της Λέσβου κατά τα έτη 2021 και 2022. Τα αποτελέσματα δείχνουν πως η διατήρηση αδιατάρακτου υποορόφου, ενισχύει σημαντικά τη βιοποικιλότητα των ελαιώνων και συνεπώς τις οικοσυστημικές λειτουργίες, όπως η επικονίαση, η φυσική καταπολέμηση των εχθρών και η υγεία του εδάφους.