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A Comparison of IPM and Organic Farming Systems Based on the Efficiency of Oophagous Predation on the Olive Moth (*Prays oleae* Bernard) in Olive Groves of Southern Iberia

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Abstract: The olive moth, *Prays oleae* (Bernard, 1788) (Lep., Praydidae), is one of the most common insect pests affecting the olives groves of the Mediterranean basin. Current farming practices are largely oriented to optimize the effectiveness of beneficial insects, among which the common green lacewings (Neur., Chrysopidae) stand out. Two different types of management models, organic and IPM, were compared in this study, which was conducted in olive groves in the regions of Andalucía (Spain) and Alentejo (Portugal). During 2020 and 2021, fruit samples were periodically collected, analyzing the population parameters (POP) and potential attack on the fruit (%PA), as well as the predatory impact (%PRED), which has allowed the estimation of the final attack (%FA), and derived fruit recovery rates (%REC). The results show that in organic olive groves of both countries, the infestation parameters (POP, %PA) were significantly higher than in IPM ones. However, predation rates were also higher in organic olive groves, which resulted in REC rates of between 75% and 80%, reducing FA rates to values of approximately 10% and 20% in Portugal and Spain, respectively. In contrast, in the IPM olive groves, significantly lower predation values were recorded, with lower REC rates than in the organic olive groves; the rates were very similar in both countries (ca. 54%), which led to a higher percentage of fruit loss (%FA) equivalent to 22% (Portugal) and to 34% (Spain). This paper discusses potential drivers influencing differences in the population values and percentages of infestation by *P. oleae* observed, as well as the differences in the final attack rates between olive groves of both countries, subject to the same type of agricultural management.

Keywords: olive farming; Chrysopidae; *Chrysoperla carnea* complex; olive losses; oophagous predation

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1. Introduction

The olive moth, *Prays oleae* (Bernard, 1788) (Lep., Praydidae), is one of the most common insects that damages olives in the producing countries of the Mediterranean basin [1–3] in the south of the Iberian Peninsula, where approximately 50% of the world's olive oil is produced [4]. Economic losses caused by this pest can exceed 40% of the harvest [2,5,6]. These are mainly caused by the carpophagous generation of the olive moth [7] whose larvae feed on the tissue inside the olive stone during the summer. Once developed, the larva emerges at the end of summer from the fruit through a hole in the apical zone, causing the fall of the affected fruits [2,5,6].

Regarding the interaction between *P. oleae* and its natural enemies, Chrysopids (Neuroptera) are among its most voracious predators [8–14]. These predators have long attracted the attention of applied entomologists, for they are good candidates for use in integrated pest management (IPM) programs [8]. This is due to their wide geographic distribution, their wide spectrum of host plants and prey [15], their relatively easy mass production [16], the possibility of protecting lacewing numbers by overwintering chambers [17], and their ability to develop pesticide-tolerant populations [18]. Given these advantages, members of the Association of Applied Insect Ecologists (AAIE) placed *Chrysoperla* ssp. as the most important lacewings, unrivaled among all other commercially obtainable predatory species [19].

The taxonomic status of the common green lacewing, which was formerly named as *Chrysoperla carnea* (Stephens, 1836) (Neur., Chrysopidae), has undergone major changes, and instead of a polymorphic single species, it is accepted as a complex of sibling cryptic species, the *Chrysoperla carnea* complex, or *carnea* group [20,21]. The existence of the following cryptic species has been assumed: (1) *Chrysoperla affinis* (Stephens, 1836) former *Ch. kolthoffi* (Navás, 1927) [20], (2) *Chrysoperla lucasina* (Lacroix, 1912) [21], (3) *Chrysoperla carnea* sensu stricto [20] and *Chrysoperla pallida* Henry et al., 2002 [22], and (4) *Chrysoperla agilis* Henry et al., 2003 [23]. In southern Spain, the presence of these cryptic species has been reported in Andalusian olive groves, of which the later species, *Ch. agilis,* was dominant (>90%) [24]. In olive groves, *carnea* complexes are polyphagous and effective predators in the natural control of *P. oleae* [1,24].

Several methods are used to control moth populations, although most of them are based on the application of synthetic insecticides, of which the use is not as difficult as it could be, especially because these chemicals are highly harmful to natural enemies [6]. The adverse effects are especially notable in crops under conventional farming practices, in which the frequency of use of synthetic insecticides is much higher than any other type of agricultural management. This farming system is followed by the largest proportion of Spanish olive groves (70%) [25], as is also the case in Portugal. In addition, in these crops, plant biodiversity is extraordinarily low, as the herbaceous plant cover is often eradicated by the regular application of herbicides.

In view of the adverse effects and environmental risks of conventional management, integrated pest management (IPM) allows notable environmental improvements [26]. This farming system is followed in approximately 25% of Spanish olive groves [25] where the objective is to reconcile chemical and natural control elements through a reduction in insecticide application and an attempt to adapt the crop in an agroecosystem more favorable for beneficial insects. Among the innovative elements incorporated in the IPM olive groves is the promotion of a herbaceous vegetable cover that protects the soil from erosion and contributes to maintaining the populations of beneficial insects. In addition, IPM drives the establishment of population thresholds, which allows farmers to discern the need to apply synthetic pesticides, which leads to considerable savings in the use of synthetic pesticides. However, in practice, important aspects of IPM practices remain largely unresolved, such as the integration of the population levels of natural enemies/antagonists in decision-making, as well as improving pest management programs through the implementation of less disruptive tactics. The integration of these aspects must consider both the damages caused in the control of the target pest (called vertical or first level), as well as the indirect effects on the remaining pests (considered as a second or horizontal level) [27]. However, regarding IPM crops, environmentally safer farming systems have arisen, such as organic olive growing (syn. ecological) and biodynamic olive growing, which can be considered the greatest exponents and best approaches towards sustainability [28]. These two types of farming systems, although with different origins, are largely similar, representing a holistic view of nature based on a cyclic understanding of crop production, along with a return to traditional agricultural principles [29]; the foundations are based on a mixture of ancient agronomic philosophies, empirical observations and scientific approaches [28]. Among the main differences between them, biodynamic crops incorporate specific fermented herb preparations as compost additives. In both systems, current standards for certified production have a legally regulated procedure, outlining the use of soil building activities and natural pest management [30] through a plan that allows the application of pesticides of natural origin. The complete suppression of synthetic pesticides is reflected in organic crops through a greater diversity and abundance of natural enemies [31,32], and frequently results in an acceptable level of pest control [33]. However, as demonstrated by Scherber et al. [34], increased biodiversity in organic farms does not always suffice to adequately control pests, as it enforces the farmer to use organically accepted pesticides, which negatively affect biodiversity. Among the drawbacks, it has been highlighted that the methods used in organic farming can be more expensive than conventional chemical-based farming practices, although these estimates often do not take into account the high environmental costs associated with the use of conventional pesticides [35]. As a result, the organic industry is not yet at a level that allows it to compete with synthetic pesticides, so the proportion of organic olive farming represents only a minority (4% organic sensu stricto and 1% organic–biodynamic in the Iberian Peninsula) [25].

Organic farming systems thus represents an approach more aligned with natural conditions than IPM, which a priori should lead to a higher level of biodiversity and sustainability standards. As mentioned before, although increased biodiversity does not always suffice in adequately controlling pests, an increase in predation rates of endemic pests such as the olive moth would be expected. The objective of this study is to make an accurate estimate of the predatory impact of the common green lacewings on the carpophagous generation of *P. oleae*. This may allow for an accurate comparison of the impact of the pest on the harvest of the two farming systems in olive groves of Spain and Portugal, and provide practical elements for their better characterization in terms of sustainability.

2. Materials and Methods

2.1. Description of the Study Area

The study was carried out in 10 olive groves in southern Portugal (Alentejo region, Évora and Beja districts) and in 12 olive groves in southern Spain (Andalusia region, Jaén and Granada provinces) during the oviposition period of the anthophagous generation of *P. oleae* (June/July 2021). The start of the oviposition period took place about 7 days after the start of the fruiting process (phenological stage G) [36] that occurred in both countries in the last week of May. The selected olive groves (Figure 1) were subject to the two different types of management practices analyzed: IPM and organic management (ORG). The main characteristics of the crop and the control measures applied are summarized in Tables 1 and 2. It should be noted that, from Portugal, two olive groves with biodynamic olive growing were included in the study. These are the ones indicated (*) in Table 2. Since this type of olive management practice is very similar to organic management, these 2 olive groves were included within the cluster of organic olive groves.

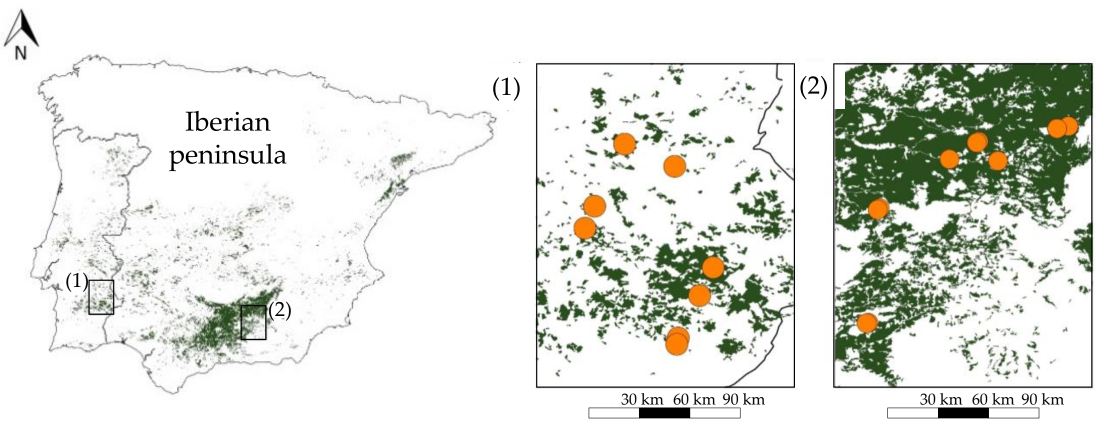

Figure 1. Location of the olive groves selected in this study. The green spots on the map correspond to the areas of land in Portugal (1) and Spain (2) used for olive cultivation. Orange circles indicate the location of the olive groves selected for the study.

Table 1. Geographical location of the olive groves (IPM and organic management) considered in the south of Spain. The main characteristics of each of them (variety, area, age of the trees, plantation density) and the chemical control measures applied to control herbaceous plant cover, as well as against the carpophagous generation of *P. oleae,* are indicated.

								Herbicide	Insecticide (Olive Moth)
				Variety	Area (ha)	Age (Years)	Density (Trees × ha)	Active Principle (Dose); Date	Anth. Generation
SPAIN	IPM	Baeza	37°55′29.9″ N 3°24′10.9″ W	"Picual"	47.9	150	100	Glyphosate 36% (1.5 L/ha) + Flazasulfuron 25% (0.06 kg/ha); March & October	Deltametrin 10% (0.125 L/ha); April
		Deifontes	37°23′11.8″ N 3°38′09.9″ W	"Picual"	15.8	30	150		
		Pegalajar	37°45′03.2″ N 3°37′31.2″ W	"Picual"	24.3	80	80		
		Úbeda	37°58′57.7″ N 3°19′04.1″ W	"Picual"	9.4	40	100		
		Villacarrillo I	38°03′05.1″ N 3°01′28.3″ W	"Picual"	7.1	200	90		
		Villacarrillo II	38°02′31.0″ N 3°03′46.0″ W	"Picual"	4.8	100	100		
	ORGANIC	Baeza	37°55′40.0″ N 3°14′47.9″ W	"Picual"	23.6	100	100	–	–
		Deifontes	37°23′04.8″ N 3°38′30.2″ W	"Picual"	72.2	25	150		
		Pegalajar	37°45′21.8″ N 3°37′08.2″ W	"Picual"	15.6	40	120		
		Úbeda	37°59′12.2″ N 3°18′43.9″ W	"Picual"	58.8	40	100		
		Villacarrillo I	38°03′03.3″ N 3°01′33.0″ W	"Picual"	5.3	200	90		
		Villacarrillo II	38°02′29.5″ N 3°03′43.6″ W	"Picual"	1.8	100	100		

Table 2. Geographical location of the olive groves (IPM and organic management) considered in the south of Portugal. The main characteristics of each of them (variety, area, age of the trees, plantation density), and the chemical control measures applied to control the herbaceous plant cover, as well as against the anthophagous/carpophagous generations of *P. oleae,* are indicated. An asterisk (*) indicates organic–biodynamic crops.

								Herbicide	Insecticide (Olive Moth)	
				Variety	Area (ha)	Age (Years)	Density (Trees × ha)	Active Principle (Dose); Date	Anth. Generation	Carp. Generation
PORTUGAL	IPM	Évora	38°26′56.0″ N 7°41′22.2″ W	"Arbequina"	250	10	1667	Glyphosate 36% (3 L/ha); March and October	Lambda cihalotrin 15% (1.3 L/ha); April	Lambda cihalotrin 15% (1.3 L/ha); May–June
		Pias	38°01′30.8″ N 7°29′43.9″ W	"Cobrançosa"	140.5	20	205			
		Vidigueira I	38°10′01.5″ N 7°44′23.5″ W	"Cobrançosa"	130	16	285			
		Vidigueira II	38°11′19.8″ N 7°49′13.7″ W	"Cobrançosa"	163	29	200			
		Vidigueira III	38°11′01.1″ N 7°47′45.2″ W	"Arbequina"	163	9	600			
	ORGANIC	Portel I	38°16′26.9″ N 7°46′24.6″ W	"Galega"	35	100	139	–	–	Kaolin (35 kg/ha); May–June
		Portel II	38°18′26.9″ N 7°43′39.7″ W	"Galega" + "Blanqueta"	35	100	139			
		Reguengos de Monsaraz	38°23′10.7″ N 7°32′58.5″ W	"Cobrançosa"	100	13	285			
		Serpa I *	37°54′08.4″ N 7°32′24.2″ W	"Arbequina"	200	3	1770			
		Serpa II *	37°53′04.7″ N 7°32′38.9″ W	"Cobrançosa" + "Arbequina"	100	5	300			

2.2. Experimental Design

In Spain, 6 pairs of olive plots were chosen and within each pair one plot corresponds to organic management and the second to IPM. In this way, we intended to establish paired comparisons in each study area. In contrast, the distribution of management types in Alentejo (Portugal) did not allow for the establishment of paired plots. To cope with this, 5 olive groves were selected with organic farming and 5 with IPM farming, but these plots were not directly adjacent (Table 2). Consequently, in Portugal, the comparisons of the different parameters between the two types of agricultural management models were made considering the data corresponding to the set of crops of each type of farming.

2.2.1. Sampling of Fruit and Determination of the Attack Parameters of *P. oleae*

The study was carried out during the oviposition period of the anthophagous generation of *P. oleae*. The egg population was monitored by periodic fruit sampling. The first fruit sampling in the olive groves of both countries was carried out at the beginning of June, 7 days after the beginning of the oviposition period and about 15 days after the start of the fruit formation process (phenological stage G). From the first sampling date onwards, fruit samples were collected at 15-day intervals so that by the end of the oviposition period, a total of 4 samples had been collected in each olive grove. In Spain, on each sampling date, 6 olive trees were randomly selected from each olive grove, while in Portugal, from each olive grove, 3 olive trees were randomly selected. From each selected olive tree, 100 fruits were collected (25 fruits of each cardinal orientation). The fruits were and placed in opaque plastic vials, protecting them from solar radiation, and were taken to the laboratory where they were temporarily stored in a cold room (T < 4 °C).

The olives were observed using a stereomicroscope (LEICA, M205C, WETZLAR, GERMANY), taking note of the number of *P. oleae* eggs for each of them and differentiating between live eggs, predated eggs and hatched eggs according to the indications by Arambourg [8] and Ramos and Ramos [37]. Once all the fruits had been examined, the following parameters were calculated for each olive grove on each sampling date:

- Population Index (POP): Total number of eggs/100 fruits. This density value reflects the relative density of ovideponent females in the cultivated area.
- Potential Attack (%PA): Number of fruits with any type of eggs (live, predated or hatched) × 100/total number of fruits observed. It represents a value equivalent to the fruit drop that P. oleae would cause in case of the total absence of oophagous predation activity.
- Hatching rate: Number of hatched eggs × 100/(sum of live and hatched eggs).
- Predation rate (%PRED): Number of predated eggs/(sum of live eggs + predated + hatched). This allows for the assessment of predatory activity, an index of the activity of predatory eggs.
- Final Attack (%FA): Number of fruits that contain at least one hatched egg × 100/(number of fruits observed). Given that the loss of fruit caused by P. oleae is exclusively due to the emergence of the larvae inside the attacked fruits once their development is complete, only hatched eggs are considered for its calculation. Therefore, it may be considered that the latter have survived the predatory action of natural enemies. For the calculation of the %FA value, therefore, live eggs were not taken into account, since these are likely to hatch or be predated. The entomophagous action allows discarding a proportion of the population of P. oleae eggs; however, in the opposite case, its hatching involves the establishment of the larva in the endocarp of the fruit and his subsequent fall. %FA describes the magnitude of this drop, providing a realistic estimation of the impact of P. oleae on the harvest.
- Fruit Recovery (%REC): Number of fruits in which all the eggs have been predated × 100/(number of fruits that have contained eggs). This parameter indicates the real effectiveness of predation, since it corresponds to the percentage of fruits in which all the eggs have been predated. Once all P. oleae eggs have been eliminated, fruits are considered as recovered, so for practical purposes, the recovery percentage is a parameter that indicates the real effectiveness of oophagous predation by lacewings. It is important to note that this value does not always correspond to the %PRED, except in those cases in which the number of fruits attacked present infestation densities equal to 1 egg/fruit.

2.2.2. Sampling of Lacewings

During the summer of 2021, lacewings adults were sampled in the olive groves of southern Spain. In each pair of plots, 6 traps were placed (3 for IPM and 3 for organic) which were installed in central olive trees within each plot, at a height of 1.5 m, in the southern side of the olive trees. This was performed at a rate of one trap per tree and separated by a minimum distance of 50 m, using McPhail traps baited with a solution of diammonium phosphate (4% w/v). The traps were installed once the oviposition process of *P. oleae* had begun, renewing them at 10-day intervals. A sieve was used to collect the insects captured in the traps, which were later placed in glass vials containing an aqueous dilution of 70% ethanol. In the laboratory, a proportion of the captured individuals, as permitted by their conservation status, were determined taxonomically, recording the capture numbers for each species. According to previous studies, this type of trap is attractive for lacewings, although the largest proportion of captured individuals corresponds to female individuals (>90%) [12].

2.3. Statistical Analysis

For statistical analysis, the Statgraphics Centurion XVIII statistical package was used. The normality of the distributions was verified using the Shapiro–Wilk normality test in the case of a sample size of more than 50 data, while for sample sizes of less than 50 data, the Kolmogorov–Smirnov test (K–S, with the Liliefors correction) was applied since the power of the Shapiro–Wilk test is lower for a small sample size [38]. Levene's test was then applied to evaluate the homogeneity of variance. To determine the existence of significant differences between the parameters calculated in the IPM and organic olive groves (POP, %PA, %PRED, %FA and %REC), an analysis of variance (ANOVA) was performed. To determinate the level of statistical significance, Tukey's HSD (honestly significant difference) test was applied.

3. Results

3.1. Analysis of the Attack Parameters of P. oleae

3.1.1. Population Index (POP)

In the olive groves of southern Spain, the POP values showed statistically significant differences between the IPM and organic farming systems ($p < 0.01$ in five of the six pairs of plots), with greater records in the organic plots (Figure 2A,A'); at the end of the oviposition period values ranged between 106.7 and 248.0 egg/100 fruits (X = 176.1; SD = 46.8), while in the IPM plots, these values ranged between 84.3 and 181.7 egg/100 fruits (X = 142.9; SD = 35.1).

In the olive groves of southern Portugal, POP was generally lower than those described for southern Spain (Figure 3A,A'), ranging, at the end of the oviposition period, between 48.0 and 230.0 egg/100 fruits in organic olive groves (average of 121.2 egg/100 fruit; SD: 66.8 egg/100 fruit) and from 49.3 to 94.0 (average of 76.8; SD:19.9) in IPM olive groves. As was also the case in the Spanish olive groves, statistically significant differences were recorded between POP values for different olive farming systems, with greater values recorded in organic olives ($p < 0.001$; Table 3).

Table 3. Mean values and standard deviation rates of the Population Index (POP), Potential Attack (%PA), oophagous predation (%PRED), Final Attack (%FA) and Fruit Recovery (%REC) in the organic and IPM olive groves selected in Spain and Portugal (last sampling date). The level of statistical significance (ANOVA) is also indicated.

	SPAIN						PORTUGAL					
	IPM		ORG		ANOVA		IPM		ORG		ANOVA	
	Mean	(SD)	Mean	(SD)	F	*p*-Value	Mean	(SD)	Mean	(SD)	F	*p*-Value
POP	142.9	(35.1)	176.1	(46.8)	12.8	$p < 0.001$	76.8	(19.9)	121.2	(66.8)	19.6	$p < 0.05$
%PA	80.2	(12.3)	88.8	(7.3)	10.1	$p < 0.01$	58.3	(11.2)	71.0	(19.9)	12.1	$p < 0.05$
%PRED	68.1	(3.7)	85.8	(3.1)	80.6	$p < 0.001$	56.8	(4.9)	86.5	(4.1)	107.8	$p < 0.001$
%FA	34.0	(5.5)	19.7	(2.7)	32.5	$p < 0.001$	22.0	(8.0)	9.3	(4.2)	9.9	$p < 0.05$
%REC	53.8	(3.2)	76.2	(2.2)	192.6	$p < 0.001$	53.8	(5.5)	80.2	(7.2)	42.8	$p < 0.001$

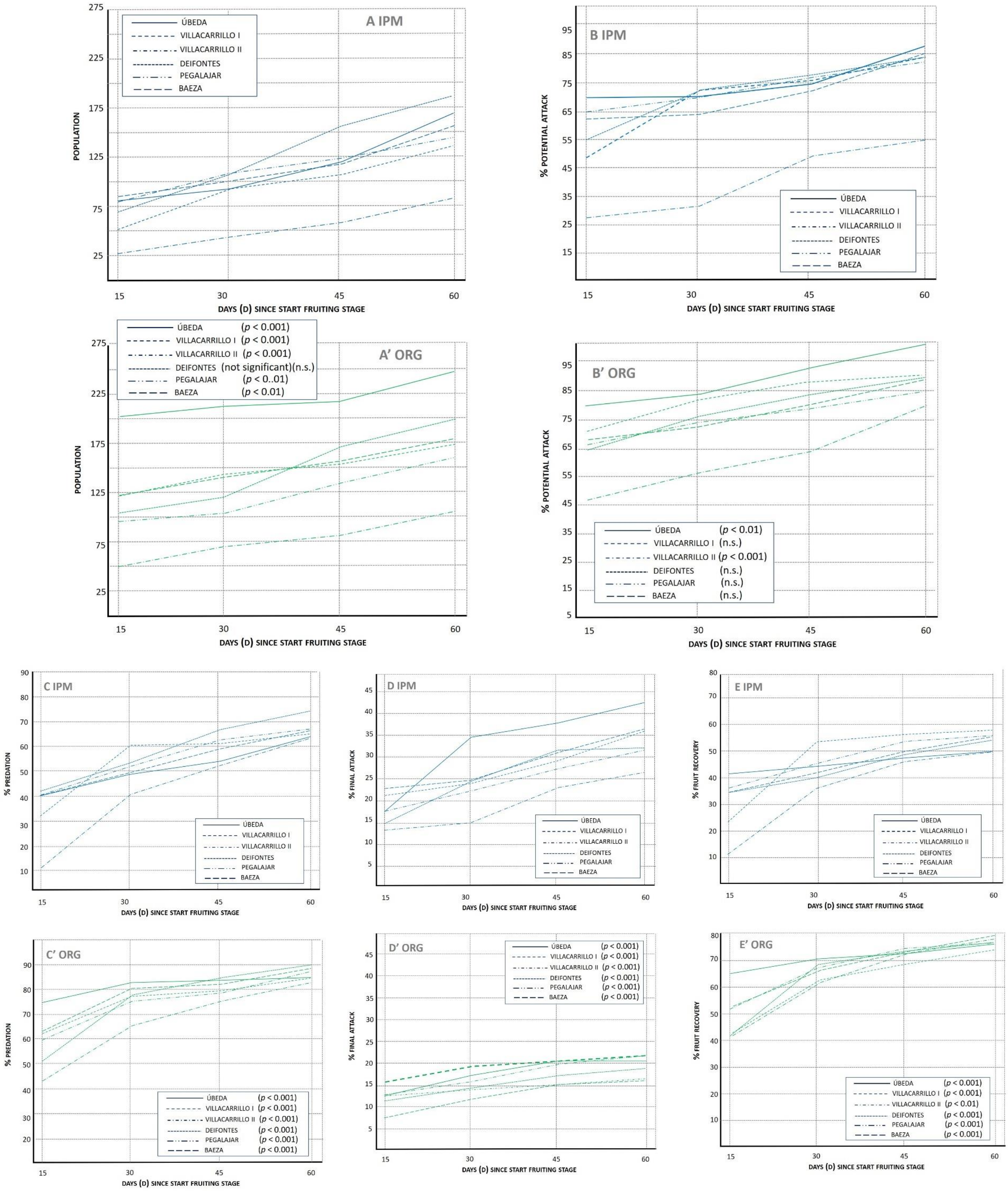

Figure 2. *P. oleae* attack parameters in the paired plots in southern Spain, corresponding to the two agronomic managements models: IPM (**A**–**E**) and organic (**A′**–**E′**). Population index (POP, Graphs **A**,**A′**). Potential Attack (%PA, Graphs **B**,**B′**); Predation (%PRED, Graphs **C**,**C′**); Final Attack (%FA, Graphs **D**,**D′**); % Recovery (%REC, Graphs **E**,**E′**). The graphs corresponding to the organic olive groves show the results of the analysis of variance (ANOVA) conducted to determine the levels of statistical significance between olive farming systems at the last sampling date.

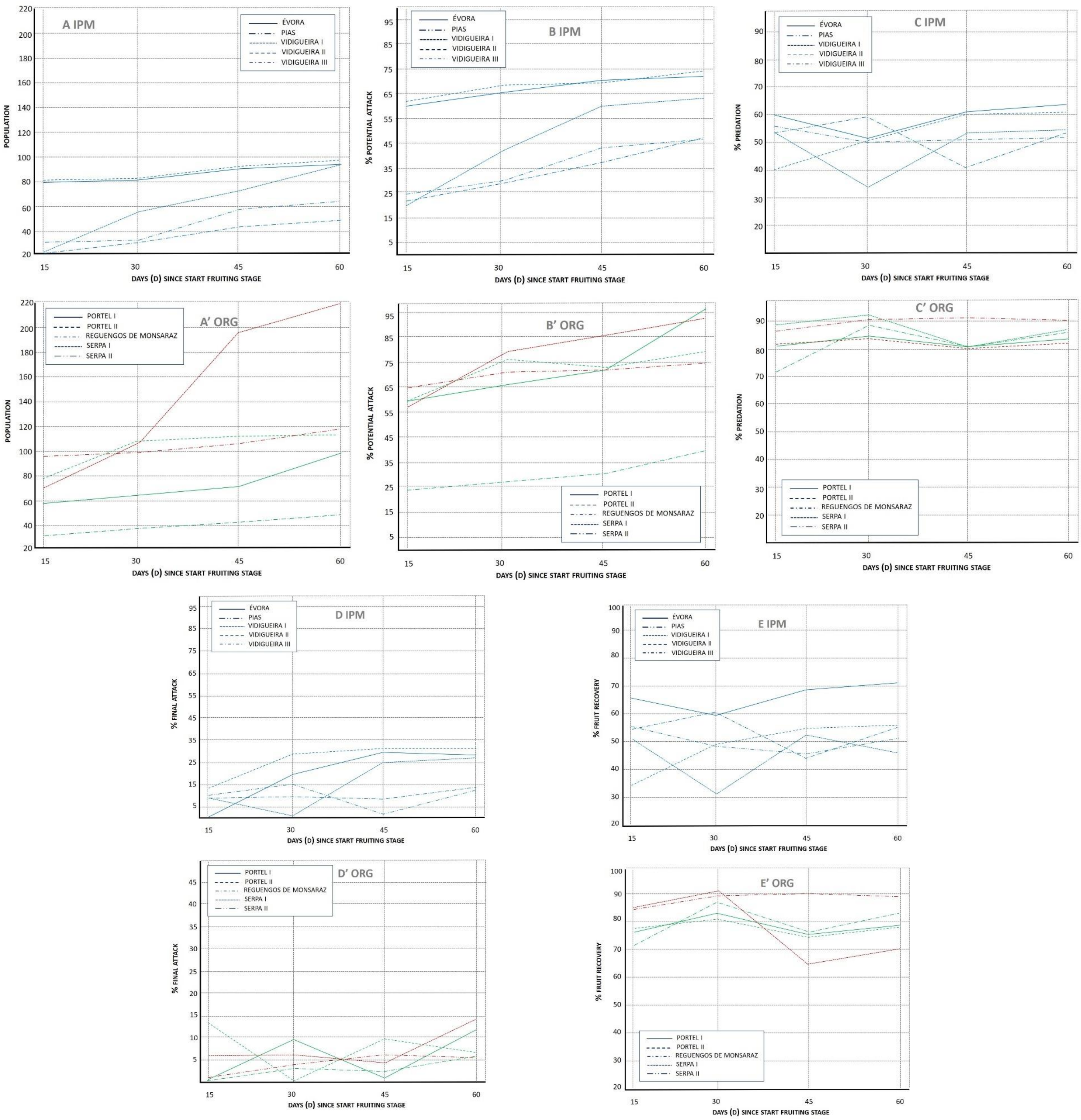

Figure 3. Parameters of *P. oleae* attack in olive groves under different agronomic management models: IPM (Graphs **A**–**D**) and organic (Graphs **A'**–**D'**) selected in southern Portugal. Population index (POP, Graphs **A**,**A'**). Potential Attack (%PA, Graphs **B**,**B'**); Predation (%PRED, Graphs **C**,**C'**); Final Attack (%FA, Graphs **D**,**D'**); % Recovery (%REC, Graphs **E**,**E'**). Among the organic olive groves, the olive groves corresponding to organic–biodynamic management are marked with red lines.

The sequential analysis of fruit sampling indicates that POP values increased gradually throughout the oviposition period of anthophagous generation, following a linear regression model (Figure 4A).

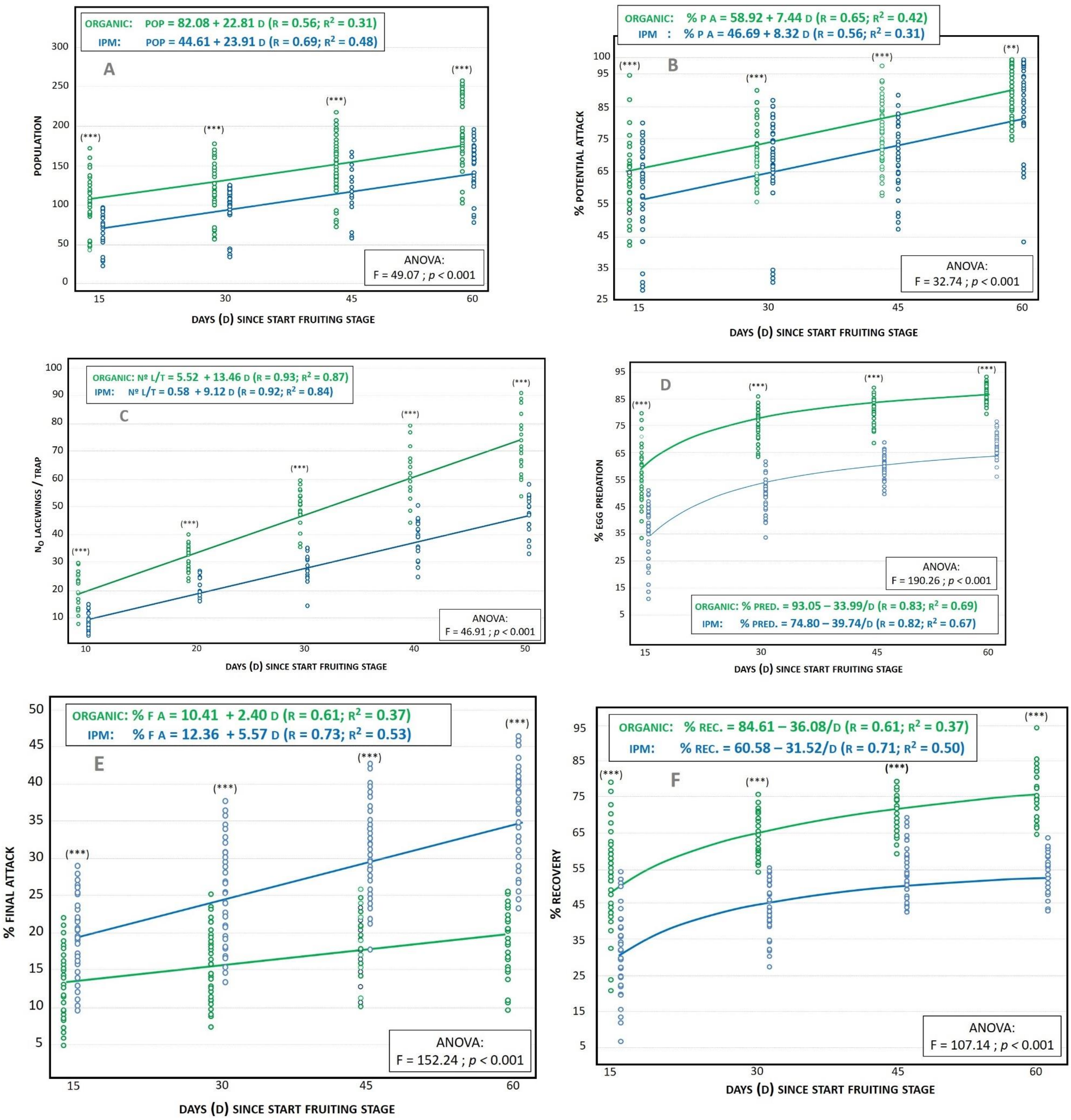

Figure 4. Regression curves of *P. oleae* attack parameters in pairs of plots with organic (green) and IPM (blue) management selected in southern Spain during the oviposition period. Each circle represents the value obtained in one of the olive trees selected from each plot on each sampling date. Population index (POP, (**A**)); Potential Attack (%PA, (**B**)). Number of captures of green lacewings in Mcphail traps (**C**). Egg predation (%PRED, (**D**)). Final Attack (%FA, (**E**)) and Fruit Recovery (%REC, (**F**)). With asterisks, the levels of statistical significance (ANOVA; ** $p < 0.01$; *** $p < 0.001$) between sampling series corresponding to organic and IPM plots, for each sampling date, are indicated.

Similar to what was obtained in the south of Spain, the %FA values of the olive groves of the south of Portugal presented statistically significant differences between IPM and organic systems (Figure 3D,D′) (Table 3; $p < 0.001$), with the final %FA in the IPM ranging between 12.0% and 29.0% (X = 22.0%; SD = 8.0). In the Portuguese organic olive groves, %FA values ranged between 5.3% and 14.7%, with an average value of 9.3% (SD = 4.2).

3.1.2. Potential Attack (%PA)

Among the paired plots of Spain, %PA in the IPM plots ranged at the end of the oviposition period between 55.3% and 88.7% of the fruits (average of 80.2%; SD = 12.3%). These values were even longer in the organic plots—between 78.7% and 99.6% of the fruits—with a mean value of 88.8%, (SD = 7.3%). The analysis of the sequential fruit sampling showed that the %PA increased steadily and gradually throughout the oviposition period, which through regression analysis could be adjusted to a linear function (Figure 4B). In the organic plots, the %PA values were significantly higher in two out of the six pairs of plots (Figure 2B,B′). Equally, statistically significant differences also became evident when considering the final data (at the end of the oviposition period) from the six pairs of plots, considered as a whole (Table 3; $p < 0.01$).

%PA in olive groves in southern Portugal were approximately 20% lower than those recorded in southern Spain. In the IPM groves, the potential fall of the fruit caused by *P. oleae*—in the absence of oophagous predation—could have reached values between 46.3% and 70.3% (X = 58.3%; SD = 11.2%) at the last sampling date. Similar to what was reported for Spain, %PA in the Portuguese organic groves were significantly higher than in IPM orchards, ranging between 39.0% and 93.0% (X = 71.0%; SD = 19.9%) (Table 3; $p < 0.05$) at the last sampling date. As shown in Figure 3B,B′, in the Portuguese olive groves with organic–biodynamic management, both the %PA values and their development during the oviposition period do not differ from the rest of the organic olive groves.

3.1.3. Lacewing Diversity and Egg Predation (%PRED)

Among the individuals captured in the McPhail traps, a sample of 25% of the captured lacewings were taxonomically determined, resulting in the identification of six species. Most (86%) corresponded to *Ch. agilis*, 4% to *Pseudomallada prasinus* (Burmeister, 1839), 3% to *Pseudomallada flavifrons* (Brauer, 1851), 3% to *Ch. affinis*, 2% to *Ch. lucasina* and 2% to *Chrysopa viridana* Schneider, 1845. Since *Ch. agilis* is the dominant species, its impact on olive moth eggs is the greatest amongst all lacewing species considered [24,39].

As shown in Figure 2C,C′, the percentage of oophagous predation in Spanish olive groves increases rapidly throughout the oviposition period, reaching maximum values close to 90%, adjusting this variation to an inverse X function (Figure 4D). Predation values were significantly higher in plots under organic management (Figure 2C,C′), ranging at the end of the oviposition period between 82.1% and 89.6%, with a final average of 85.8% (SD: 3.1%). Statistically lower values were recorded in the IPM olive groves (Table 3; $p < 0.001$), which ranged between 64.7% and 75.1%, with an average of 68.1%, (SD = 3.7%).

Similarly to the olive groves of southern Spain, in southern Portugal there are also differences in the predation rates under both management models (Figure 3C,C′). These were significantly higher in organic farming (Table 3; $p < 0.001$), ranging between 82.3% and 92.9% (X = 86.5%; SD = 4.1%). As observed in %PA, %PRED in the groves with organic–biodynamic management in southern Portugal showed very similar trends to the rest of the organic ones (Figure 3C,C′). In contrast to the organic ones, %PRED in IPM Portuguese olive groves was, on average, 30% lower, ranging between 52.0% and 63.1%, resulting at the end of the oviposition period in a final average value of 56.8% (SD = 4.9) (Table 3).

3.1.4. Final Attack (%FA)

As indicated above, the attacked fruits will be lost at the end of the summer as a consequence of the emergence of the larva once its development is complete. In the IPM groves of southern Spain, %FA at the end of the oviposition period ranged between 26.0% and 42.3% of the fruits (X = 34.0%; SD = 5.5). In organic plots, %FA was significantly lower in every one of the pairs of plots (Figure 2D,D′) ranging at the end of the oviposition period between 16.3% and 22.7% (X = 19.7%; SD = 2.7), which represents a decrease of 15% with respect to the IPM plots (Table 3; $p < 0.001$).

3.1.5. Fruit Recovery (%REC)

In the olive groves of southern Spain, the percentages of fruit in which eggs were present (with respect to the total number of infested fruits) had been entirely eliminated by the predatory action of the lacewings (%REC), ranging, at the end of the oviposition period, between 49.7% and 56.9% in the IPM plots, with an average value of 53.8% (SD = 3.2). Compared with the IPM plots, the %REC in the organic plots was significantly higher in each of the pairs of plots (Figure 2E,E′), ranging between 73.1% and 79.2%, with an average value of 76.2% (SD: 2.2) (Table 3). This represents an increase of approximately 22% with respect to the IPM groves.

As with the predation parameter, the percentage of fruit recovered in Spanish olive orchards increases rapidly throughout the oviposition period, with this variation fitting an inverse X function (Figure 4F).

Regarding the olive groves of southern Portugal with IPM management, %REC (Figure 2B,B′) ranged, at the end of the oviposition period, between 46.1% and 61.1%, with an average value of 53.8% (SD = 5.5). In the plots under organic management, significantly higher data were recorded (Table 3; $p < 0.001$), ranging between 70.2% and 89.4%, with an average value of 80.2% (SD: 7.2%) (Table 3).

4. Discussion

From the results of the comparative study of the impact of organic/IPM farming systems on the entomophagous activity of lacewings (oophagous predators of *P. oleae*) during their carpophagous generation, a series of aspects ought to be considered. Among the parameters analyzed, it is significant to note that in olive groves of both countries there are differences between both types of management. With regard to POP and %PA, these represent a measure of the relative density of *P. oleae* populations, thus acting as indicators of the degree of infestation in the fruit, which is independent of environmental and ecological variability, since in both countries the highest values were recorded in olive groves cultivated with organic farming. Most likely, this difference is a consequence of the fact that the control procedures applied in organic olive groves against the carpophagous generation of *P. oleae* have either been completely suppressed (as is the case with organic olive groves in southern Spain in this study), or are based on environmentally friendly non-chemical control measures, such as the application of a thin layer of kaolin, which is increasingly being applied for the control of important olive grove pests [40,41]. This measure represents a physical barrier of kaolin that would limit the oviposition of females, as was detected in the organic olive groves in southern Portugal, where lower rates of POP and %PA have been recorded in relation to Spanish organic olive groves. In agreement with these observations, Pascual et al. [40] indicate a significant reduction in the infestation of important olive grove pests, such as the olive black scale *Saissetia oleae* (Olivier) (Hem., Coccidae), and the olive fruit fly *Bactrocera oleae* (Rossi, 1790) (Dip., Tephritidae), through the application of kaolin particle films.

Regarding the percentages of oophagous predation (%PRED) in both countries, they were detected as being much higher in organic olive groves (reaching rates of 85–87%) in relation to IPM olive groves, where they were on average 30% lower. This difference is attributable to the lighter ecological pressure of the control measures applied in organic olive groves. In this sense, since no control measures had been applied to the olive moth in organic olive groves in southern Spain, it follows that kaolin, in addition to significantly reducing the rate of *P. oleae* infestation in the fruits, appears to be harmless to lacewing predators, as indicated by the results obtained in organic olive groves in Portugal. In agreement with these observations, in laboratory studies, Medina et al. [42] showed that the oviposition of *Ch. carnea* was not affected, and even increased on olive twigs treated with kaolinite (Surround WP) and, in line with the results of Pascual et al. [43], its application does not seem to be a problem for these oophagous predators. Likewise, Bengochea et al. [41] reported that kaolin appeared to be harmless or only slightly harmful to the green lacewings, indicating that its use might be considered as an alternative chemical product for controlling olive pests in the contexts of both organic farming and integrated olive pest management programs. However, studies on pests of other fruit crops indicate that its effectiveness seems to be highly variable depending on the target pest, even being counterproductive for certain pests [44].

Organic farming methods mitigate the ecological damage caused by aggressive agronomic management practices, which have negatively affected evenness [45]. Since these practices are often at the origin of ecological imbalances that result in an uncontrolled increase in pests, organic management practices have been considered to compensate for these alterations, promoting evenness in the complex of natural enemies [45]. These statements are corroborated by verifying the notable increase in predation rates in olive groves under organic management, exemplified in the impact on the increase in fruit recovery that was approximately 25% higher in organic olive groves compared to IPM olive groves. This corresponds to a recovery rate of between 70% and 90% of the initially infested fruit in organic olive groves. Regarding IPM crops, organic management allows for correcting the imbalances generated by environmentally aggressive practices derived from the use of synthetic pesticides and reestablishing the natural balance. Apart from the benefits due to the absence of pesticide residues in the oil, organic management allows for higher agricultural yields, reducing losses by approximately 40% and 60% in organic olive groves in southern Spain and Portugal, respectively. In comparative studies on organic and conventional management in Greece, authors such as Berg et al. [46] indicate the greater sustainability of organic management from an environmental and financial point of view, compared with conventional cultivation, resulting in healthier and better-quality olive oils.

5. Conclusions

The comparative study of the effect of entomophagous predation on *Prays oleae* in olive groves in southern Spain and Portugal has revealed great differences depending on the farming system (organic or IPM). Among the parameters considered, these differences include the population density of the pest, which in both countries has turned out to be significantly higher in organic olive groves.

Significant differences among both farming systems were also found in the rates of oophagous predation, being equally high in organic olive groves, which allowed the suppression of approximately 86% of the original egg population, ultimately resulting in the recovery of 76–80% of the fruits initially infested. In contrast, in IPM olive groves, recovery rates were detected as only 54%, approximately.

The differences in the predatory potential of lacewings imply estimated mean fruit drop rates of 28% in olive groves with IPM management and approximately half (14.5%) of that in olive groves with organic management.

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