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Entomofauna present in plant shelters in a vineyard var. Crimson Seedless in Ica-Peru

Entomofauna presente en refugios vegetales en un campo de vid var. Crimson Seedless en Ica-Perú

Entomofauna em faixas de plantas silvestres em um campo de vinha var. Crimson Seedless em Ica-Peru

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Rev. Fac. Agron. (LUZ). 2024, 41(2): e244119
ISSN 2477-9407
DOI: https://doi.org/10.47280/RevFacAgron(LUZ).v41.n2.09

Crop production
Associate editor: Dra. Lilia Urdaneta
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Received: 01-03-2024
Accepted: 19-05-2024
Published: 11-06-2024

Keywords:
Biodiversity
Natural enemies
Conservation biological control

Abstract

The use of chemical pesticides to control pests also affects beneficial insects, so it is necessary to implement mechanisms that allow them to be protected and promote their development. In the present investigation, three plant shelters were installed to identify their entomofauna and determine the plant species with the potential to host biological controllers of grapevine pests. The study was carried out in the 2020-21 growing season, with seven plant species to make up three plant shelters (A, B, and C) that were installed on the edges of a vineyard of the Crimson Seedless variety in Ica, Peru. In total, 1,209 insects were reported, in six orders, nine families, and fifteen species; the most abundant were pollinators, followed by phytophagous, predators, and some parasitoids. There were no statistical differences between the shelters in terms of the abundance of parasitoids and pollinators, but there were in predators and phytophagous specifically between shelters A and B with C. Shelters A and B, which included the fennel *Foeniculum vulgare* Mill., stood out for having a larger population of predators, including *Chrysoperla externa* (Hagen), the main controller of the "vine mealybug" (*Planococcus* spp.). The importance of plant shelters was demonstrated and their implementation in vineyards is recommended to promote biological control and contribute to integrated pest management in this crop.

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Resumen

El uso de plaguicidas químicos para controlar plagas, afecta también a los insectos benéficos, por lo que es necesario implementar mecanismos que permitan protegerlos y favorecer su desarrollo. En la presente investigación se instalaron tres refugios vegetales con el propósito de identificar su entomofauna y determinar las especies vegetales con potencial para albergar controladores biológicos de plagas de la vid. El estudio se realizó en la campaña agrícola 2020-21, con siete especies vegetales para conformar tres refugios (A, B y C) que fueron instalados en los bordes de un campo de vid de la variedad Crimson Seedless en Ica, Perú. En total se reportaron 1.209 insectos, en seis órdenes, nueve familias y 15 especies; los más abundantes fueron los polinizadores, seguidos de fitófagos, predadores y algunos parasitoides. No hubo diferencias estadísticas entre los refugios en cuanto a la abundancia de parasitoides y polinizadores, pero si en predadores y fitófagos específicamente entre los refugios A y B con el C. Los refugios A y B que incluían al hinojo *Foeniculum vulgare* Mill., destacaron por albergar mayor población de predadores, entre ellos destaca *Chrysoperla externa* (Hagen), principal controlador de la “cochinilla harinosa de la vid” (*Planococcus* spp.). Se demostró la importancia de los refugios vegetales y se recomienda su implementación en los viñedos para fomentar el control biológico y contribuir al manejo integrado de plagas en este cultivo.

Palabras clave: biodiversidad, enemigos naturales, control biológico conservativo.

Resumo

A utilização de pesticidas químicos para controlo de pragas também afeta os insetos benéficos, pelo que é necessário implementar mecanismos que permitam protegê-los e promover o seu desenvolvimento. Na presente investigação foram instalados três faixas de plantas silvestres com o objetivo de identificar a sua entomofauna e determinar as espécies vegetais com potencial para acolher controladores biológicos de pragas da videira. O estudo foi realizado na campanha agrícola 2020-21, com sete espécies de plantas para compor três faixas de plantas silvestres (A, B e C) que foram instalados nas bordas de um campo de vinha da variedade Crimson Seedless em Ica, Peru. No total foram relatados 1.209 insetos, distribuídos em seis ordens, nove famílias e 15 espécies; os mais abundantes foram os polinizadores, seguidos pelos filófagos, predadores e alguns parasitoides. Não houve diferenças estatísticas entre os faixas de plantas silvestres em termos de abundância de parasitoides e polinizadores, mas houve em predadores e filófagos especificamente entre os faixas de plantas silvestres A e B com C. Destacaram-se os faixas de plantas silvestres A e B, que incluíam a erva-doce *Foeniculum vulgare* Mill., por seu hospedeiro uma maior população de predadores, dentre eles destaca-se *Chrysoperla externa* (Hagen), principal controladora da “cochonilha da videira” (*Planococcus* spp.). Foi demonstrada a importância dos abrigos vegetais e recomenda-se a sua implementação nas vinhas para promover o controlo biológico e contribuir para a gestão integrada de pragas nesta cultura.

Palavras-chave: biodiversidade, inimigos naturais, controle biológico por conservação.

Introduction

The grapevine is a very important crop in Peru, which is seriously attacked by several pests such as woodlouse, thrips, and mites, among others (Cáceres & Julca, 2018); to control them, chemical pesticides are generally used, which at the same time affect and reduce the population of biological controllers, affecting the natural and applied biological control of the crop (Vázquez *et al.,*2008). Therefore, promoting actions that favor the presence and growth of beneficial fauna is necessary for the development of the crop. One of these actions is the planting of plants that provide food, shelter, and protection for biological controllers (Landis *et al.,* 2000); and especially in vineyards, the planting of flowering plants is preferable, because it allows maintaining and increasing the richness, diversity, and abundance of predators and pollinators (López *et al*., 2019). The management of agricultural habitat through the planting of varied plants or “plant shelters” then becomes one more strategy of integrated pest management (González-Chang *et al*., 2019).

Plant shelters near vineyards are beneficial (Altieri *et al.,* 2007; López *et al*., 2019), as long as the most suitable plants are selected to ensure the presence of biological controllers (Fiedler & Landis, 2007) and do not promote the development of pests. Asteraki *et al*. (2004) assert that diverse vegetation generates favorable conditions for beneficial entomofauna and López *et al.* (2003) point out that the management of native (wild) plants can improve natural pest control.

In Peru, there are few studies on the use of plant shelters and none on grapevines, so the objective of this work was to study three plant shelters, identify their entomofauna, and determine the plant species with the potential to host biological controllers of grapevine pests.

Materials and methods

The study was carried out in the surroundings of a vineyard of the Crimson Seedless variety, located in Ica-Peru, at 75°42’0.00” south and 14°0’0.00” west at an altitude of 535 m.a.s.l.; between march 2020 and march 2021 (2020-2021 growing season).

Selection of plant species

A bibliographic search of angiosperms with reports of harboring biological controllers and that they met the following criteria was carried out to make their use as a plant shelter more feasible in case of positive results:

1: Available in nurseries or present wild in crop fields.

2: Low water requirement to withstand the grapevine dormancy period.

3: Use as aromatic, medicinal, forage, or ornamental plants.

4: Not considered weeds or main hosts of common grapevine pests.

Based on the established criteria, the following species were chosen, whose distribution in the plant shelters is detailed in the following table.

Installation of plant shelters

The plants were sown in seedbeds from commercial seeds and when they reached a minimum of 10 cm they were distributed in three groups (shelters A, B, and C) based on the fact that each group was made up of botanical species from at least two different families (table 1). The transplanting was carried out at the edge of the vineyard (at each post of the vine plant support line), at a rate of six plants per shelter (two of each plant species arranged in double rows) with eight repetitions for each shelter and a separation of three meters between each repetition.

Table 1. Plants of the three plant shelters.

Shelter	Scientific name	Common name	Family
A	*Calendula officinalis* L.	Calendula	Asteraceae
	Helianthus annuus L.	Sunflower	Asteraceae
	Foeniculum vulgare Mill	Fennel	Apiaceae
B	*Zinnia acerosa* (DC)	Zinnia	Asteraceae
	Crotalaria incana L.	Crotalaria	Fabaceae
	Foeniculum vulgare Mill	Fennel	Apiaceae
C	*Crotalaria incana* L.	Crotalaria	Fabaceae
	Salvia splendens L.	Salvia	Lamiaceae
	Ocimum basilicum L.	Basil	Lamiaceae

The evaluations were carried out on a biweekly basis, at the same time (10:00 a.m.) and with an approximate duration of one minute/plant; the technique of direct observation was used, reviewing the structure of each plant to detect, identify and record the entomofauna present; unidentified specimens were manually collected in the field in 70 % alcohol jars and were taken to the Klaus Raven Büller Entomology Museum Laboratory of the National Agrarian University La Molina, for subsequent identification.

To determine species richness (Margalef Index (DMg)), dominance (Simpson's Index (D)), and Pielou's evenness (J'), the PAST: statistical software for paleontology and biodiversity was used. Statistical analysis by functional group between shelters was done using the InfoStat program.

Results and discussion

Abundance of general entomofauna and main species found

A total of 1,209 insects belonging to 15 species, nine families, six orders, and four functional groups were detected in the three plant shelters (table 2). Hymenoptera (35.7 %) was the most abundant order and had the highest number of families and species, mainly *Apis mellifera* L., the dominant species (32.5 %), presumably due to the available supply of flowers and pollen offered by the three shelters; Zumbado & Azofeifa (2018) highlight the role of Hymenoptera as the most important group of angiosperm pollinators, but also for being made up of many biological controllers of agricultural pests. The other braconid Hymenoptera and Ichneumonidae were scarce; according to García-Gutierrez*, et al*. (2013), these Hymenoptera are common parasitoids of Lepidoptera and Coleoptera, which would explain their low presence in the surroundings of the vineyard, a crop whose main pests do not belong to any of these orders.

Diptera (24.07 %) was the second most abundant order, and like the Hymenoptera, it was composed of insects of importance as pollinators and biological controllers, highlighting the blowflies of the family Calliphoridae: *Chrysomya* sp. (21.09 %) as the second dominant species, which in the present study was found in flowers as well as bees; in Colombia *C. putoria* (Wiedemann) is common in avocado flowers (*Persea americana* Mill) (Carabalí-Banguero *et al.,* 2018) and in Turkey, much of the mango production (*Mangifera indica* L.) is due to *C. megacephala* Fabricius (Nurul *et al*., 2015). The two hoverfly species, *Allograpta exotica* and *Pseudodorus clavatus*, are reported as predators of true bug pests (Hemiptera), mainly aphids (Soca-Flores *et al*., 2022; Arcaya *et al*., 2013) and are also associated with the importance of the presence of flowering plants in the environment of agricultural fields (Bertolaccini *et al*., 2008; Morales & Köhler, 2008).

Thysanoptera, third in abundance (16.87 %) fully represented by *Thrips tabaci* is usually found in the grapevine in the phenological stage of flowering and initiation of fruit set (Viglianco *et al*., 2021); their presence in plant shelters should not be considered harmful, taking into account that phytophagous act as alternative prey for natural controllers to continue their biological cycle when they do not find their prey in the fields, this usually happens during agrochemical applications (Peredo *et al*., 2020). Neuroptera with the green lacewing *Chrysoperla externa,* occupied the fourth place in abundance (9.93 %), the presence of this predator was an important result considering that,

Table 2. Abundance of entomofauna in three plant shelters adjacent to a vineyard in Ica-Peru.

Order	Family	Species/Morphospecies	FG	Shelter		
				A	B	C
Coleoptera	Coccinellidae	*Harmonia axyridis* (Pallas)	P	12	9	3
		Hipodamia convergens Guerin-Meneville	P	21	9	0
		Cicloneda sanguinea L.	P	12	3	0
Diptera	Syrphidae	*Allograpta exotica* (Wiedemann)	P	18	0	6
		Pseudodorus clavatus (Fabricius)	P	6	3	3
	Calliphoridae	*Chrysomya* sp.	Po	129	114	12
Hemiptera	Aphididae	*Aphis cracivora* Koch	F	6	9	0
		Aphis spiraecola Match	F	51	27	0
Hymenoptera	Braconidae	*Braconidae* sp. 1	Pa	3	3	3
		Braconidae sp. 2	Pa	0	3	3
	Ichneumonidae	*Ichneumonidae* sp.	Pa	6	6	0
	Apidae	*Apis mellifera* L.	Po	138	84	171
		Bombus sp.	Po	0	3	9
Neuroptera	Chrysopidae	*Chrysoperla externa*	P	48	51	21
Thysanoptera	Thripidae	*Thrips tabaci* Lind.	F	114	72	18

FG = Functional group; P = Predator; Po=Pollinator; F=Phytophagous; Pa=Parasitoid.

in the vineyards of Peru, its release is common to control a wide range of soft-bodied insects, mainly due to its effectiveness as a controller, its adaptation to various agricultural environments and its resistance to several pesticides (Núñez, 1989).

Finally, Hemiptera and Coleoptera, both represented by only families, Aphididae and Coccinellidae respectively, together constituted less than 14 % of the insects recorded in the evaluated shelters. According to Greco & Roca (2020), Coleoptera is one of the most used orders in biological control programs and Coccinellidae is one of its main families, so despite the low population reported, it is relevant if we take into account that they feed on insects considered by Evans (2009) as pests of the grapevine: aphids (Aphididae), mealybugs (Pseudococcidae), whiteflies (Aleyrodidae) and thrips (Thysanoptera).

The four functional groups found were: pollinators, phytophagous, predators, and parasitoids, coinciding with similar studies carried out in vineyards (Miles *et al*., 2012; López *et al.,* 2019), where the presence of these four functional groups confirms that when the structure of the agricultural environment is diversified, insects appear, including many beneficial ones available to potentiate the biological control of many pests. In the present study, the proportion of the functional groups of shelters A and B was similar to that of the total, except for shelter C, where there were more pollinators and fewer phytophagous plants (figure 1).

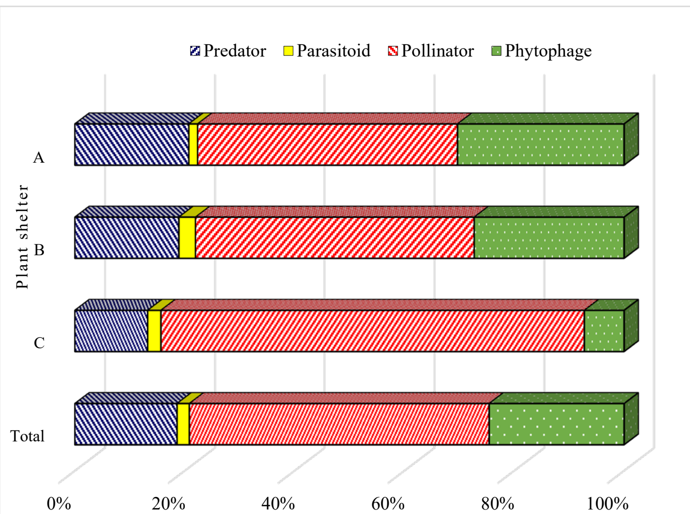

Figure 1. Abundance of entomofauna by functional group.

Statistical analysis and biodiversity indices

As reported in table 3, there are no significant differences between shelters A, B, and C in terms of the abundance of pollinators and parasitoids, but there are significant differences between shelters A and C in terms of predators and between shelters A and B with C in terms of phytophagous; in general, and statistical terms, shelters A and B were more similar to each other, with respect to the composition of the functional groups.

The highest values of richness and diversity were found in shelters A and B, being consistent with the greater number of individuals and species that both shelters hosted. The lowest evenness index was found in shelter C, which is explained by the majority presence of *Apis mellifera,* which with 68.67 % was the dominant species in this shelter unlike shelters A and B, where the same species represented 24.47 % and 21.21 % respectively.

Table 3. Indices of richness (Margalef), diversity (Simpson), and venness for entomofauna by the functional group present in three plant shelters adjacent to a vineyard.

Functional group	Shelter	Abundance	Margalef (DMg)	Simpson (1-D)	Evenness (J)
	A	564	2.29	0.83	0.78
Total	B	396	2.68	0.81	0.74
	C	249	2.04	0.51	0.53
	A (a)	117	1.05	0.75	0.88
Predators	B (ab)	75	0.93	0.51	0.64
	C (b)	33	0.86	0.55	0.75
	A (a)	9	0.46	0.44	0.92
Parasitoids	B (a)	12	0.80	0.63	0.95
	C (a)	6	0.56	0.50	1.00
	A (a)	267	0.18	0.50	1.00
Pollinators	B (a)	201	0.38	0.50	0.68
	C (a)	192	0.38	0.20	0.38
	A (a)	171	0.39	0.47	0.68
Phytophagous	B (a)	108	0.43	0.49	0.75
	C (b)	18	0.00	0.00	-

Lowercase letters in different parentheses indicate significant differences ($p \leq 0.05$).

In terms of functional groups, predators were more abundant, diverse, and with greater evenness in shelter A, while parasitoids were more diverse in shelter B, but with very similar evenness in all three shelters; pollinators had low richness and diversity in all three shelters, with high dominance in shelter C. As for phytophagous, they were more abundant and diverse in shelters A and B, but very scarce in shelter C.

Composition of plant shelters and functional groups present

The distribution of functional groups according to the species comprising the plant shelters is shown in figure 2.

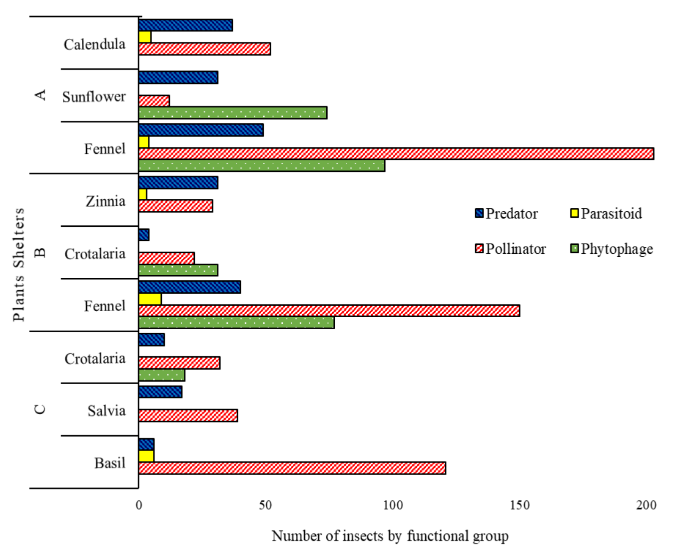

Figure 2. Abundance of entomofauna in each component of the different plant shelters.

It is observed that in shelter A, fennel (Apiacea), calendula and sunflowers (Asteraceae), in that order, stood out for hosting the largest population of predators in the study, mainly *C. externa*, coinciding with similar studies that highlight fennel as an excellent reservoir of green lacewings (Chrysopidae), hoverflies (Manfrino *et al.,* 2011) and ladybugs (Coccinellidae) (Rebolledo *et al*., 2007). As for the pollinator, it was observed that this plant hosted the largest populations of *Chrysomya* sp. Calendula did not harbor any phytophagous and, like the reports by Andorno *et al.* (2014), was a shelter for ladybugs and parasitoid wasps. Coinciding with the results of Ramírez-Reyes *et al*. (2019), the sunflower did not harbor parasitoids, but if there was a high population of *Thrips tabaci*, this attraction could be due to the size of the sunflower flowers, which, being very large, show much more their yellow color, a color that, according to Joyo &Narrea (2015), exerts an attractive effect on thrips to the point that it is common to use yellow sticky traps in vineyards to attract and trap individuals of this pest.

Predators of shelter B were found mainly in zinnia (Asteraceae) and fennel (Apiaeae); zinnia hosted the largest population of predator *C. externa* of the entire study; fennel, as in shelter A, hosted the four functional groups, of which predators were the most abundant, although in smaller numbers than zinnia. In contrast, crotalaria harbored few predators, more phytophagous species, and no parasitoids. According to Van Rijn & Wäckers (2016), not all of the plant species that make up the varied plants (plant shelters) produce adequate resources, nor is it known for sure which species will be most effective in hosting beneficial organisms.

In shelter C, characterized by being the least abundant, least diverse, and with the lowest population of biological controllers, basil (Lamiacea) stood out for being the only plant in the entire study in which no green lacewings were found; according to Adam *et al*. (2019) and Hassan *et al*. (2015), this plant has a repellent effect against several insects, which is one reason why this shelter had the lowest insect population in general (20.6 % of the insects present throughout the study); however, this repellent effect would not apply to bees, which preferred basil over other plants, probably since, unlike other plants, basil flowers are small and open, conditions that, according to Altieri & Nicholls (2012), make its pollen and nectar more accessible to bees and other pollinators; crotalaria and salvia had the lowest population records in the study, with bees being the most important population.

Conclusions

In the three shelters evaluated, entomofauna composed of predators, parasitoids, pollinators, and phytophagous was found; pollinators are the most abundant and parasitoids are the least abundant. Shelters A and B were similar in terms of the composition of these functional groups.

Shelter A was the most abundant and, together with shelter B, stood out for hosting the largest number of biological controllers of the grapevine; in both shelters, fennel (*Foeniculum vulgare*) was the outstanding plant species in richness and abundance of predators, followed by calendula (*Calendula officinalis*) (shelter A) and zinnia (*Zinnia acerosa*) (shelter B), which also contributed a significant share of predators and parasitoids. Of lesser abundance, shelter C was widely inhabited by pollinators, especially *Apis mellifera* L., which was found mostly in basil (*Ocimum basilicum*).

Among all the predators found, *Chrysoperla externa* (Hagen) stands out, the main controller of the "vine mealybug" (*Planococcus* spp.), which means that the installation of plant shelters in vineyard fields could represent an additional alternative to enhance the biological control of pests in this crop.

Recommendations

Considering that the behavior of insects can vary throughout the day and with it the composition, dominance, and evenness of the population in plant shelters, it is recommended to carry out similar studies with sampling at different times than the one in this study.

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