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ORIGINAL

Local methods for the control of Monalonion dissimulatun pest in cacao farms in Florencia- Caquetá

Métodos locales para el control de plaga Monalonion dissimulatun en fincas cacaoteras de Florencia - Caquetá

Camila Andrea Gutierrez Soto[1], Verenice Sánchez Castillo[1]

[1]Programa Ingeniería Agroecológica, Universidad de la Amazonia. Florencia, Caquetá. Colombia.

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Corresponding Author
Camila Andrea Gutierrez Soto

ABSTRACT

This study was carried out in the municipality of Florencia, department of Caquetá, in the village of El Venado, subdivision of San Julián. With the objective of knowing what are the local methods that producers implement to control the Monalonion dissimulatum pest in cocoa crops, through which they used different methodological strategies such as the development of interviews, where they relied on participant observation, which which allowed having a checklist through which they evidenced the processes, dates and frequencies that were carried out to mitigate the plague. Finally, they determined that the most used methods are cultural control and biological control, giving more credit to cultural control, since through it they obtained better results, such as a significant reduction of the sources of contamination due to the implementation of the technique of pruning, this being an important factor in the reproduction of the Monalonion, that is, they managed to attack the places of focus of contamination, more specifically, in places with greater shade or that present little solar radiation.

Keywords: Cocoa; Producers; Control; Sources of Contamination; Methods.

RESUMEN

El presente estudio se llevó a cabo en el municipio de florencia departamento del caquetá, en la vereda el Venado, parcelación San Julián. Con el objetivo de conocer cuales son los métodos locales que implementan los productores para el control de la plaga Monalonion dissimulatum en cultivos de cacao, mediante el cual utilizaron diferentes estrategias metodológicas como el desarrollo de entrevistas, donde se apoyaron en la observación participante, que les permitió tener una lista de chequeo mediante el cual mostraron los procesos, las fechas y las frecuencias que se realizaron para mitigar la plaga. finalmente determinaron que los métodos mas utilizados son el control cultural y el control biológico, dándole mas crédito al control cultural, ya que mediante este obtuvieron mejores resultados, como disminución significativa de focos de contaminación por la implementacion de la técnica de poda, siendo esta un factor importante en la reproducción del Monalonion, es decir lograron atacar los lugares de foco de contaminación, mas específicamente, en lugares con mayor sombrío o que presentan poca radiación solar.

Palabras clave: Cacao; Productores; Control; Focos de Contaminación; Métodos.

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INTRODUCTION

Given that cocoa cultivation is underutilized in the municipality of Florencia, another problem arises regarding the control and management of pests that attack this crop. Farmers and rural workers often do not know strategic methods to counteract the presence and damage that phytopathogenic insects can cause to cocoa crops.

The highest cocoa production occurs in the tropical countries of Africa (Ivory Coast and Nigeria) and Latin America (Ecuador, Colombia, and Brazil). There are several types of cocoa worldwide, notably Criollo, Forastero, and Trinitario. Criollo cocoa comprises medium-sized pods, large, generally juicy seeds, and a distinctive sweet aroma. Forastero cacao, on the other hand, has a unique pod color, which is light green or pale pink and eventually turns yellow. In addition, the tip of the pod is round, the shell is slightly smooth and thin, and the seeds are smaller and purple, triangular and flattened. Trinitario cacao is a mixture of Forastero and Criollo cacao, which means that it is a type of cacao with very varied characteristics, as it can have both Criollo and Forastero traits (Romero-Cárdenas et al., 2015).

In Ecuador, cocoa farming is part of the country's socioeconomic development. Romero-Cárdenas et al. (2015) mentioned that cocoa has generated the most economic income despite obstacles such as pests that affect the crop and diseases that damage its production. Regarding the above, Romero-Cárdenas et al. (2015) state that in previous years, Ecuador achieved a 110 % increase in the production and export of the "golden bean." In 2013, exports reached 205 000 tons, a fundamental point for the country's growth. In 2014, exports amounted to 235 000 tons (p.59).

In the study by Romero-Cárdenas et al. (2015), a population survey determined that 55 % of merchants' income in Ecuador depends solely on the sale of cocoa. As a major producer and exporter of cocoa (Theobroma cacao), Ecuador faces production difficulties like any other country and crop, one of which is the low quality of products due to poor local roads. Eighty-two percent agreed with this statement and said that 36 % of cocoa traders report low sales because of this.

According to Riera (2012), Monalonion dissimulatum is considered one of the main pests affecting cocoa crops, with local technicians and producers indicating that this insect's presence in the crop significantly reduces production yields. According to research conducted by Riera (2012), the Monalonion dissimulatum cocoa bug causes damage to 80 % of cocoa plantations, as it found pits in the pods that alter their appearance, making them look petrified and dry. Pods that are 10 to 12 weeks old and have been attacked turn black, harden, and eventually die. Larger pods tend to survive these attacks, but the damage is reflected in deformities and a much smaller size than pods unaffected by this phytopathogenic insect.

As mentioned by Huaycho et al. (2017), adult or nymph-stage stink bugs feed on the sap of the shoots, sucking on the tender stems and ears. In this way, they incorporate toxic saliva that solubilizes starch and pectin, accelerating the death of the cells surrounding the feeding site. This causes noticeable symptoms in plantations, such as black spots 2 mm in diameter. Pods are more severely affected, as they do not ripen and develop a deformed shell.

Riera (2012) determined that there were 9 and 22 monalonion dissimulatum insects per cacao tree. He also found that the higher the altitude, the greater the number of bugs under shade, while at lower altitudes, the number of bugs increased in the sun. He goes on to say that crop damage caused by this insect varies between 6 and 15 %. However, in Costa Rica, the study shows that phytosanitary problems caused by this pest range from 18 to 38 %. Due to these high levels of damage, efficient and effective pest management and control are needed to help mitigate this insect's infestation level. As indicated by Riera (2012), pruning can affect the presence of insects per tree since, as mentioned above, light is an essential factor in the presence of M. dissimulatum. Similarly, controlling host insect weeds contributes to reducing and preventing stink bugs in plantations. At the same time, reviewing the plantation also allows for identifying attack sites, where manual capture of both nymphs and adults is recommended.

The research conducted by Virginio et al. (2014) involves the different control methods used by farmers in Ecuador to manage phytosanitary problems affecting cocoa crops in the Ecuadorian Amazon, such as cultural practices + fungicides; cultural practices + fungicides + biological control (using Trichoderma ovalisporum). This fertilization was carried out according to study quality parameters using annual applications of 600 to 800 g/plant/year of ammonium nitrate plus essential micronutrients 12-40-0, applied every two months. In addition, dolomitic lime was applied to amend soil pH levels. In addition to fertilization, maintenance pruning is carried out, accompanied by phytosanitary pruning twice or thrice a year. Virginio et al. (2014) mention the methods implemented by farmers who incorporate traditional cultural practices, which consist of performing maintenance pruning only once a year, without using fertilizers, and removing bad pods at each harvest.

According to Pabón et al. (2016), in 2011, Colombia's cocoa production was estimated at 44 241 tons, corresponding to 0,95 % of world production, stating that Colombia increased cocoa production by 30,1 % in the last 10 years. By mid-2011, the country had exported 2,304 tons of cocoa beans, 2 475 tons of cocoa butter, and 1 043 tons of cocoa paste. This fruit is grown throughout the country, making it one of the main tropical industrial crops, with 60,1 % of all national production concentrated in Santander, Norte de Santander, Arauca, and Antioquia. According to Agronet (2014), cited by Pabón et al. (2016), Santander's department is considered the country's largest producer, with 28,5 % of national production. It should be noted that Colombia has cocoa production technologies, with an estimated 78.3 % using low-production technology, 22,9 % using medium-production technology, and only 1 % using high-production technology (Pabón et al., 2016).

According to Cruz & Cañas (2018), cited by Jiménez (2015), cocoa is highly valued in Colombia due to its flavor and aroma, which contributes to the country's economic growth, placing it among the countries with the best cocoa. On the other hand, Colombia has a type of cocoa that is less susceptible to pests and diseases, which is considered an advantage for cultivation. However, in the Cauca Valley, cocoa cultivation is greatly affected by the Monalonion dissimulatum bug, causing significant economic losses for farmers who cultivate Theobroma cacao, as this bug attacks fruits of all sizes and tender stems. Feeding on the fruit creates holes and brown or black spots that allow pathogenic and destructive fungi such as Monilis sp or Phytophthora sp to enter (Potes, 1952).

The insect monalonion dissimulatum is a characteristic pest of cocoa, which can cause losses of up to 80 % of production. Riera et al. (2013) argue that this loss is because when the insects are in the nymph and adult stages, they feed on the sap of the pods, which, when they suck this sap from the endocarp, damage the fruit, causing malformations and even causing the abortion of young pods. In addition, when they insert their mouthparts, they introduce toxins that cause yellowing and, subsequently, the death of all the pod tissue.

According to the study conducted by Vilca (2018), there are control techniques for this pest, M. dissimulatum, which he considers cultural control, significantly reducing the bug's appearance. This consists of limiting excess shade to prevent light from entering, as this affects the appearance of myriapods in cocoa. In addition, Vilca (2018) considers that there is a mechanical control technique whereby it is better to manually remove contaminated pods, as this method is easier and faster to control an infestation by Monalonion dissimulatum. This control method is very efficient when carried out during the first stage of crop infestation. However, Vilca (2018), cited by Martínez (2010), mentions that to prevent the spread of pests within cocoa crops, harvesting should be carried out according to a harvest calendar, with this process every fifteen days. This way, the spread of phytopathogenic insects, diseases caused by them, and external factors can be mitigated and prevented.

According to the study conducted by Cuellar (2021), in the case of the Department of Caquetá, the most excellent infestation and damage caused by the cocoa bug Monalonion dissimulatum is concentrated in the fruits, stating that "in 50 pods, the degree of infestation by Monalonium dissimulatum was identified. It was categorized on a scale of [1-5] as follows: 1: free of pecking; 2: 1 to 10 pecking marks; 3: 11 to 25 pecking marks; 4: 26 to 50 pecking marks; and 5: more than 50 pecking marks." (p.26); therefore, the cocoa bug shows a significant difference in affected cocoa trees ($p = 0{,}00045$).

Perlaza (2009) considers that the development of the bug in cocoa is favored by high temperatures, excessive humidity, and shade, which are generally caused by a lack of constant watering and poor control of weeds that can harbor large phytosanitary foci. Therefore, Perlaza (2009) proposes that control of Monalonion dissimulatum should be achieved by promptly determining the sources of infestation, i.e., by understanding its life cycle and the stages at which it can proliferate most rapidly. This method consists of destroying the insects (regardless of their life cycle) and accompanying the process with other measures that help prevent the spread of the pest, such as limiting excess shade by pruning regularly, managing weeds appropriately and promptly, and avoiding planting too close between plants.

In the municipalities of Tarqui and Suaza in the department of Huila, the effects of Monalonion dissimulatum are reflected in the bark of the pods, forming black spots that, when joined together, form the characteristic crust of cocoa affected by this pest. In addition, the pods are brittle, and fruit loss occurs when the attack is severe, or the level of infestation is critical. It should be noted that this bug reproduces in environments with high humidity and places with more shade, which is why Cuellar (2021) asserts that the insects are favored by climatic conditions such as rain and excessive shade, which is, in turn, a consequence of the lack of periodic sunlight.

Cocoa cultivation has several varieties. As Cuellar (2021) indicated, this crop has a higher incidence of the Monalonion dissmulatum pest in certain cocoa varieties TSH-565, ICS-95, and red and yellow hybrids. As determined in his study, the highest percentage of infestation in the pods was found in clones ICS-95 and TSH-565, with 78 % and 84 % of the pods evaluated, respectively. As for the yellow hybrid genotypes, the pest incidence was 17 % with grade 2 damage, 13 % with grade 3 damage, 13 % with grade 4 damage, and 14 % with grade 5 damage, considered the most severe damage. It should be noted that 42 % of the total ears evaluated of this genotype did not show damage caused by the pest. In the case of the red hybrid, 13 % of the damage was grade 2, 13 % was grade 3, 19 % was grade 4, and 17 % was grade 5, indicating that the remaining 38 % of the ears evaluated did not show damage caused by the Monalonion dissimulated pest. This indicates that the clans most affected by this pest are ICS-95 and TSH-565.

Although there are not many studies in the municipality of Florencia on specific control methods for Monalonion dissimulatum, practices for other phytopathogenic insects that affect crops are recognized. When controlling these insects, such as moniliasis in cocoa, the insect Monalonion dissimulatum is controlled, even preventing the appearance of this bug in cocoa, as Bolaños (2017) proposes. Sanitation practices can be carried out through cultural controls such as periodic pruning, which help to reduce the insects that affect production and thus prevent the appearance of the cocoa bug, better known as monalonion dissimulatum. In addition to these practices, physical control is also carried out in the event of damage to the pods by any pest. Biological control is handy for these cocoa-growing communities. When there is a high infestation, they resort to chemical control.

Given that cocoa is one of the crops most sought after by phytopathogenic insects, such as Monalonion dissimulatum, it is essential to know how this pest attacks, what its life cycle is, and the environmental or climatic conditions that favor its reproduction in order to know when to control it and how to do so effectively, thereby eliminating the phytosanitary problem in these plantations. Therefore, this research involves both the imaginary factors related to the pest and its management and control, as this is crucial for good production free of pests and diseases that can lower the production rate in cocoa plantations. Based on the above, this project poses the following research question: What local methods do farmers in the El Venado parcelation of San Julián implement to control Monalonion dissimulatum pests in their cacao trees?

METHOD

This research was carried out in the village of El Venado, parcelation of San Julián in Florencia, Caquetá. It was developed using a mixed approach, presenting qualitative and quantitative data.

Thanks to interviews with producers at the El Canangucal farm, the necessary data was collected to understand the perceptions of producers Amparo Jiménez Cuellar and Heladio Ortegon Vega about their prior knowledge of this pest, the control methods that

mitigate and prevent the appearance of the insect in cocoa crops, and how they identified the symptoms of affected cocoa fruits. It should be noted that the information collected during the interview was previously recorded, transcribed, and processed using the qualitative data processing software Atlas ti version 23.

Initially, the transcribed interview text was transformed into plain text for data processing in the software, and an exploratory analysis was carried out. Once this analysis was completed, a word cloud was obtained, showing the most frequently used words in the interview, which provided an idea of the central theme of the research. In addition, phrases of interest were selected for coding, grouping the codes into families. Following this process, networks were created with each group of code families, thus avoiding repetition in the networks. Finally, a code scheme or diagram was developed to provide an overview of the reasons for the research**.**

RESULTS AND DISCUSSION

Exploratory analysis - word cloud

The control of insects such as malunion in crops such as cocoa is favored by climatic conditions such as low or no solar radiation, which do not allow their reproduction to be controlled, making the situation difficult and creating an urgent need for a solution to combat them. There are different species check-ups, as well as biological and cultural control methods, that allow for a diagnosis of crop behavior. Dissimulatum can cause pockets of contamination where they cause damage and disrupt the harmony of the crops in which these insects coexist since they destroy the fruits or ears, turning them black, which is an indicator that there is a high rate of fruit affected by suckers. Among the various techniques within cultural methods, these include alleys and a review of crops, helping to reduce the challenges and damage found in crops (figure 1). Confirming the above, Ylaquita (2018) also argues in his research about the damage caused by the bug in cocoa, saying, "In Bolivia, damage from the bug is reported to be between 6% and 15%. Meanwhile, comparative studies conducted between lowland and highland areas of Costa Rica found that between 18 % and 38 % of pods were attacked by Monalonion spp., with an average of 27 bites in lowland areas and 20 bites in highland areas. These levels led to a progressive death of 83 % of the eight pods in the lowland community and 47 % in the highland area."



Figure 1. Word cloud on control methods for monalonion dissimulatum

Deductive analysis – family network

Malonion dissimulatum is checked for prevention through three specific controls: biological control, natural control, and cultural control. For biological control, Carmenta is used as a parasitoid, as it lays its eggs inside the eggs of the monalonion, feeding on them and thus controlling the pest. Natural control is achieved through the simple action of nature and its harmony, without any intervention, allowing each species to perform its environmental tasks. Cultural control includes techniques such as ecological alleys, allowing these three controls to achieve optimal results for insect control while also generating harmony, or what is known as ecological harmony, in the environment (figure 2).

Following Contreras (2021), he mentions the importance of having all the information about the crop available in order to carry out the respective checks or monitoring, as he argues as follows: “The first thing we must take into account when carrying out field monitoring is to have a sketch or map of the crop plots to be managed at hand so that we can locate the sites where the monitoring and control work will be carried out” (p.14).

In addition to the above, cultural control is of utmost importance and is even considered the best control method, as Ramírez

& Rodríguez (1999) state that "Regulating the light entering the crop, either by pruning the cacao or providing shade, or placing it where it is deficient. When there is a high incidence of the pest and the height allows it, nymph colonies can be controlled by pressing them against the fruits. " (p.2).

Within these cultural methods, there are techniques such as pruning, which are extremely important for the control of phytopathogenic insects such as Monaloion dissimulated, as indicated by Beningno (2022) "In cocoa plantations, pruning is important for the removal of vegetative parts which are unproductive or have phytosanitary problems with high levels of damage, thus allowing the plantation to have a good structure, balanced aerial canopy, and promote fruit production. The cacao tree should be pruned methodically from its first growth phase to give it good formation and keep it in production throughout its life" (p.25)

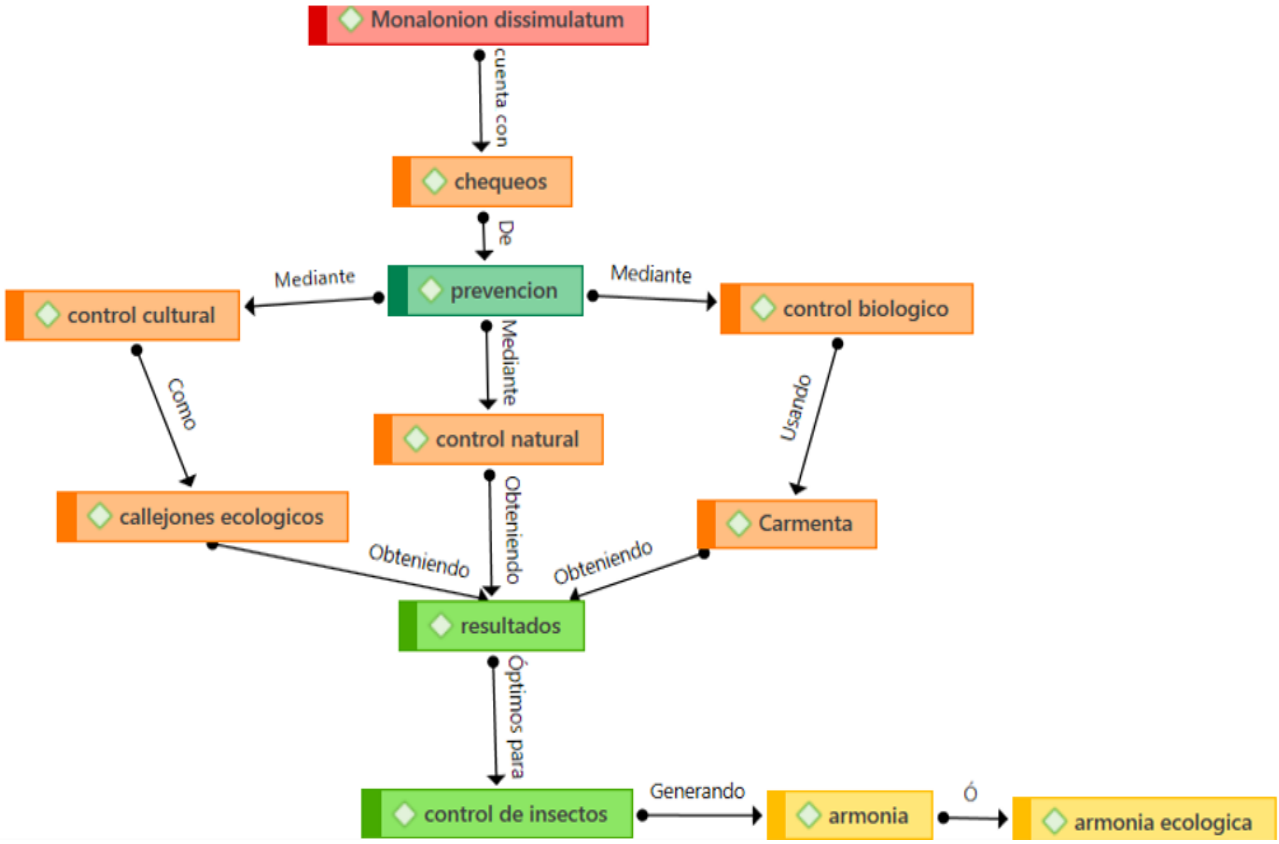


Figure 2. Network of control methods for Monalonion dissimulatum

Cocoa cultivation is affected by two important factors: climatic conditions and poor agricultural practices. These factors generate phytosanitary problems that, in turn, manifest themselves as symptoms, causing damage and anomalies in the pods with serious consequences. In addition, these phytosanitary problems in the habitat generate an increase in contamination sources and significantly increase crops' infestation rate. These limiting factors contribute to economic losses (figure 3).

Considering the above, climatic conditions are an important factor for insects. That is why Moses (1978) mentions that some insects always remain in a crop, but there are periods of the year when they tend to be more abundant due to climatic conditions. According to this, he argues that: "Thanks to certain conditions, their population increases at certain times of the year, which is when they cause losses to corn cobs. In Costa Rica, from August to mid-October, there is a high infestation of fruits and many insects, which then seem to decline, only to rise again in February, possibly until April and May. However, it seems that the greatest infestation is at the end of the year" (p.5).

Riera (2012) presents arguments similar to those of Moses (1978), considering that "the midges feed on all parts of the plant except the leaves and roots, and damage can be caused in their five nymphal stages and their adult stage, as a result of the punctures made in plant parts or fruits when feeding; the saliva injected into the wound causes tissue lysis, probably due to the action of esterases" (p.8), and goes on to say 'in small ears or cherelles, a high number of punctures can cause malformations or prevent fruit development'.(p.9).

In addition to the above mentioned by Moses (1978) and Riera (2012), a new author appears who discusses the consequences, symptoms, and damage caused by phytosanitary problems, as is the case of Vilca (1018), who states, " Under conditions of high infestation, the pits in the ears join together, taking on a petrified and dry appearance, covered with mycelium and fungal spores; during the feeding process, Monalonion injects toxins into the tissues, accelerating their decomposition. Small ears aged 10 to 12 weeks that are attacked soon turn black, harden, and die. Larger ears survive the attack, but some are deformed and have smaller kernels". (p. 9)

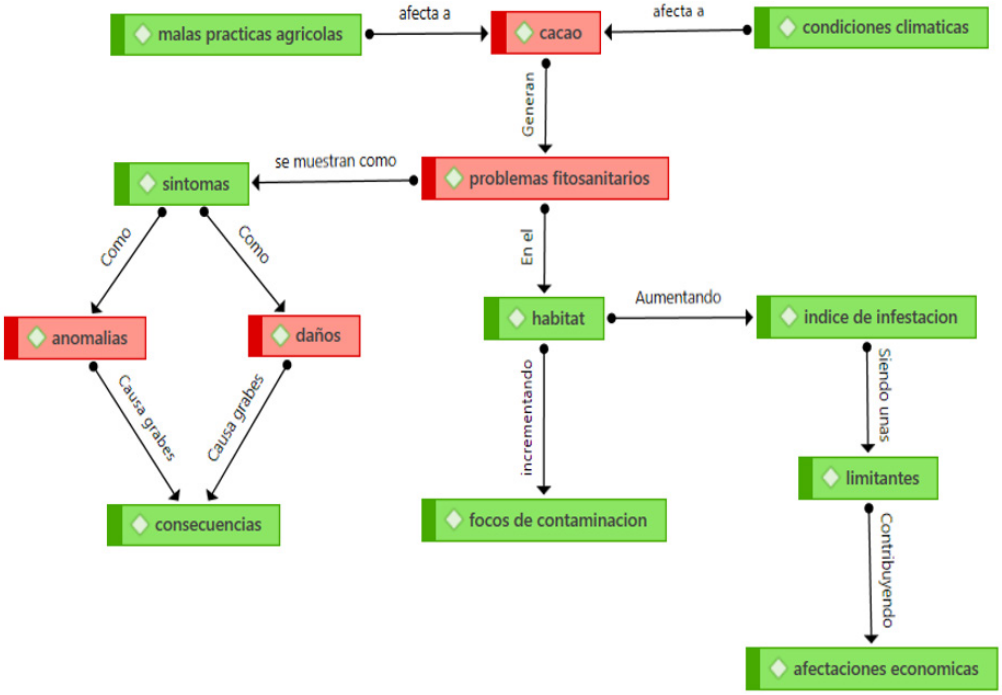


Figure 3. Conditions affecting cocoa cultivation

Insects such as Monalonion dissimulatum are important to observe in terms of their interactions, feeding habits, and reproduction in order to implement agroecological strategies that allow for good pest management and control, implementing both techniques and management checks that allow for good results (figure 4).

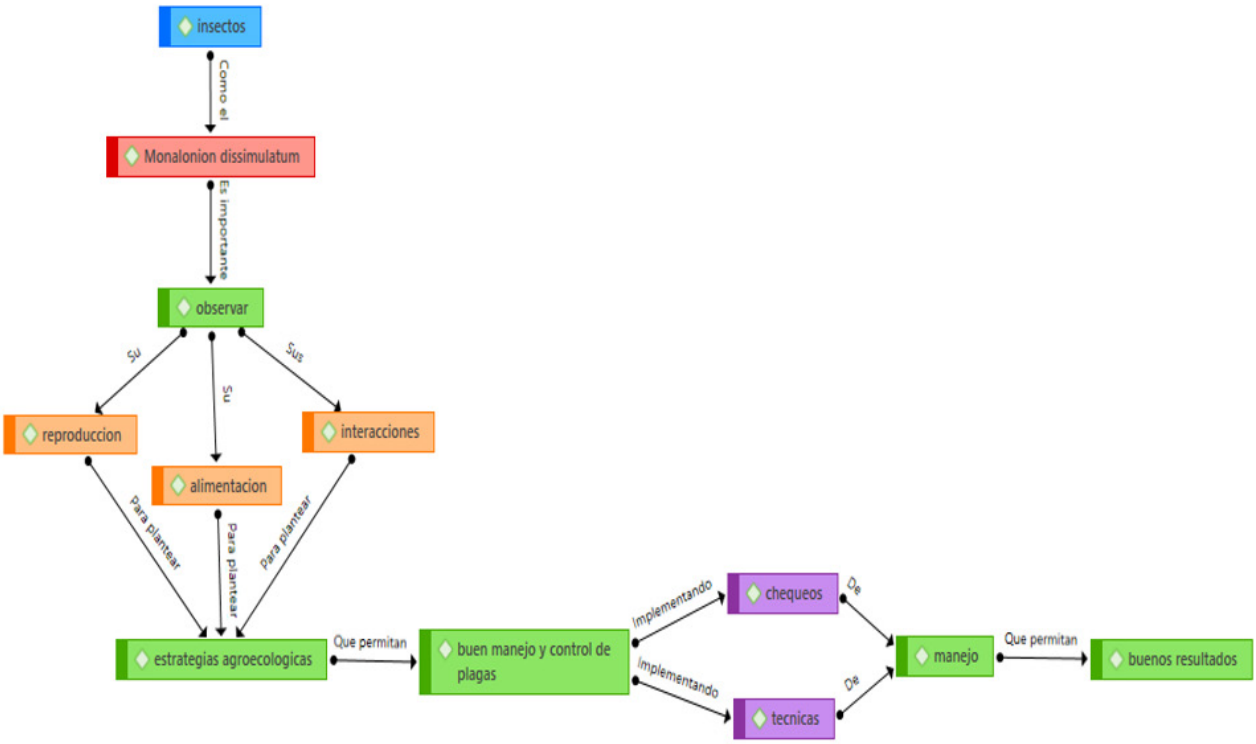


Figure 4. Overview of the Monalonion

The feeding habits of Monalonion dissimulatum play a vital role in determining the stages at which it is most attacked. Huaycho (2017) reports that: "The adult or nymph stage of Monalonion dissimulation Dist. feeds by sucking the sap from shoots, tender stems, and ears, while injecting toxic saliva that solubilizes the starch and pectin in the affected area, accelerating the death of the cells surrounding the feeding site. This produces a violent reaction in the tissues that necrotize around the bite, manifesting as a small spot 2 mm in diameter. When the bite is deep, it sinks in and turns black. The lesions usually heal, except for young ears that do not

reach maturity, which form suberized scabs around which the husk may be deformed (p. 33).

It is essential to mention that the interactions between insects, the plant environment, bacteria, and microorganisms are significant in pest control, as these interactions allow for natural biological control without causing damage to the soil structure or modifying the components that characterize a healthy plant. Therefore, Aragón & Beltrán-Acosta (2018) state that "There is ample evidence of the ability of the entomopathogenic fungi Beauveria bassiana, Metarhizium anisopliae, and Lecanicillium lecanii to colonize plant tissues of some species, which, depending on the plant species and the fungal strain, may determine whether the interaction generates a benefit for both the plant and the fungus, or whether, on the contrary, the interaction is neutral or even antagonistic" (p.858).

Based on the above, interactions are an essential factor in the biological control of phytopathogenic insects such as Monalonion, as mentioned by Aragón & Beltrán-Acosta (2018); explain why this type of control should be used in a crop affected by insects that are not beneficial to the crop, stating that "Endophytes can produce secondary metabolites that confer resistance to the host against biotic factors such as diseases caused by nematodes, bacteria, and pathogenic fungi" (p. 856)

CONCLUSIONS

Considering all the methods observed during this research, it has been determined that the control methods implemented in a crop are essential, as the well-being of the crop and its production depend on them. Considering the methods proposed in this research (cultural, natural, and biological), it was determined that all of them have essential characteristics and components that help prevent, reduce, and/or mitigate a phytopathogenic insect present in a plantation. Many of these characteristics have very positive results, as is the case with the cultural control method since the results of this research developed in this article show that farmers consider this to be the best method for managing pest outbreaks in their crops because it is easy to implement and eliminates the appearance of species and prevents regrowth.

This is one of the most significant studies for future research, as it reveals producers' perceptions about pests that may be affecting their crops. Therefore, producers must be aware of the symptoms, causes, and consequences of the insects that inhabit agroecosystems. This is interesting because if you have a good understanding of what is available in the environment, it will be easier to identify and control health problems that arise in a real crop.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTION

Conceptualization: Camila Andrea Gutierrez Soto, Verenice Sánchez Castillo.
Data curation: Camila Andrea Gutierrez Soto, Verenice Sánchez Castillo.
Formal analysis: Camila Andrea Gutierrez Soto, Verenice Sánchez Castillo.
Research: Camila Andrea Gutierrez Soto, Verenice Sánchez Castillo.
Writing – original draft: Camila Andrea Gutierrez Soto, Verenice Sánchez Castillo.
Writing – review and editing: Camila Andrea Gutierrez Soto, Verenice Sánchez Castillo.

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