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Evaluation Of The Efficacy Of Bacillus Thuringiensis As A Biological Control Agent For Agricultural Pests

Ethel Goreth Tapias De La Cruz[1], Daniel David Meza Pallares[2], Yosi Mariano González Corpas[3], Laura Nataly Perdomo Sánchez[4], Eglandina Leonor Costa Daza[5], Yenis Judith Carpentier Ospino[6]

[1]Universidad Popular del Cesar, Valledupar, Colombia, etheltapias@unicesar.edu.co
[2]Universidad Popular del Cesar, Valledupar, Colombia, danielmeza@unicesar.edu.co
[3]Universidad Popular del Cesar, Valledupar, Colombia, ymarianogonzalez@unicesar.edu.co
[4]Universidad Popular del Cesar, Valledupar, Colombia, lnperdomo@unicesar.edu.co
[5]Universidad Popular del Cesar, Valledupar, Colombia, eglandinacosta@unicesar.edu.co
[6]Universidad Popular del Cesar, Valledupar, Colombia, yeniscarpentiero@unicesar.edu.co

Summary

This article is part of a broader study, developed since 2022 and resumed in 2024 in the village of El Cielo, Corregimiento de Valencia de Jesús, in the municipality of Valledupar. As an innovative element, within the work methodology, psycho-social accompaniment was provided from the Popular University of Cesar to the families who were part of the study. The main trial was based on a quantitative experiment with a randomized whole block design to investigate the efficacy of Bacillus thuringiensis (Bt) as a biological control agent for agricultural pests, given its high entomological activity and the internal presence of protein crystals forming during sporulation, whose function is to protect the spores from ultraviolet rays. The objective was to determine the potential of Bt in reducing pests, contributing to reduce environmental pollution caused by chemical products. To this end, three types of pests were selected, on which Bt was applied, whose effectiveness was evaluated according to the level of population reduction. The results showed that a correct application of the active strain of Bt in the biological process can be considered an effective biological control against the mentioned pests. In comparison, the application of chemical insecticides can cause environmental damage and even affect beneficial fauna. The contributions of Bacillus thuringiensis Bt include the minimization of environmental impacts, the reduction of production costs and the increase in production.

1. INTRODUCTION

Agriculture is one of the most important activities in the life of human beings, since given the growing need to provide quality food, most countries are dedicated to the production of their own food or specialize in a specific product, in order to supply other regions.

During the development of any crop, the appearance of pests that threaten the production that the farmer seeks is inevitable, which can be eliminated using chemical, BT (Bacillus thuringiensis) and sexual methods, thus minimizing the impact on the environment. One of these pests are lepidoptera, which attack a large number of plants, reducing their production and reputation. For integrated solutions through integrated pest management (IPM) and further reduction of chemical product, the biological product Bacillus thuringiensis can become a good solution for the control of Lepidoptera

2. THEORETICAL FRAMEWORK

The bacterium Bacillus thuringiensis (Bt) is part of a group of microorganisms used for biological control, whose increasing application seems to contribute to reducing the pollution generated by high doses of pesticides. The biological control strategy is defined as the use of natural enemies to reduce the populations of pest organisms. For a long time, Man has tried to take advantage of this interaction to play a leading role in agriculture. In the fight against insects, for example, different antagonistic agents have been used: bacteria, viruses, predatory insects, parasitoid insects, nematodes, fungi and others. The possibility that Bacillus thuringiensis is a biological control agent is due to the synthesis, during its sporulation stage, of crystalline proteins (toxins).

Some biological pesticides made with different toxins of Bacillus thuringiensis, which have been shown to be effective in pest control, are described. As a result of the search for alternatives to the use of chemical pesticides for the control of tomato moth in Charata, Chaco, the bacterium Bacillus thuringiensis Berliner was selected as a biological control agent. To this day, the main part of the school continues to build its curriculum, and the training of the teachers who make it up becomes more and more necessary in all its stages. Biological pest control is one of these topics. The bacterium Bacillus thuringiensis Berliner is characterized by synthesizing, during the sporulation process, certain thermolabile proteins that form crystals that are toxic to different insects; These crystals activate a pre-existing protein in the wall of the insect's intestine and this process is the cause of death.

2.1. Definition of Bacillus thuringiensis

Bacillus thuringiensis (Bt) is a Gram-positive bacterium, with a variant, aerobic and spore-forming morphology. It has the particularity of forming crystals during its growth cycle. This bacterium causes mortality in insects due to its toxic capacity (Hernández, De la Torre, & Cadena, 2009). The use of microorganisms for the prevention and control of diseases derived from abiotic agents in plants has undergone considerable development in recent years. The fight against pests is one of the agricultural activities that has presented the most difficulties in developing agricultural production systems that reduce dependence on toxic chemicals (Segura and Andrade, 2010).

2.2. History and development of biological control

Biological control means the regulation or natural suppressor of a group of organisms by other organisms, that is, the natural antimicrobial action by means of a living being against another living being, generally harmful to the interests of the human being. As a natural method to contain the development of epidemics and pests, its application offers the possibility of controlling the damage they exert on any living form, without affecting the environment or any other living being of any category (Vasquez, 2002).

In general terms, biological control encompasses the use of living organisms in the different processes for the control of diseases, insects or viroids in animals and plants. In addition, it contributes to maintaining ecological balance, recovers the affected entomological fauna and reduces the resistance of organisms to pesticides. Parasites, Pathogens and Predators play a fundamental role in the biological control of crop pests.

2.3. Mechanisms of action of Bacillus thuringiensis

The microorganism Bacillus thuringiensis (Bt) has been classified as a natural insecticide and is used in agriculture as a biological control agent. In this way, Bt is an agent that controls and drives away pests or whose physiological characteristics inhibit their development. The biggest advantage is that it does not cause any harm to humans or the environment. The use of organisms below the primary level of the food chain that do not cause harm to humans and only act with a destructive effect on certain pests becomes a reality whose application gives excellent results for the desired natural control of pests in plantations."

Throughout history, the problem of biological pest control has suffered various ups and downs. At certain periods it received strong support, led to significant scientific progress and achieved appreciable results. In others, their development was hindered and even slowed down, even falling into some disrepute, as a result of the modest practical results swept away by the use of so-called "synthetic chemical" insecticides. The latter continued to be applied without the desired caution, sometimes violating the scientifically established rules, which led to the development of resistance phenomena, as well as the appearance of problems of environmental pollution, intoxication routes in man, domestic animals and wildlife, making their use unsafe. In all cases, the need to preserve the environment and human health, as well as to ensure adequate agricultural production and consequent social development, places biological control back in the main and real indication to eliminate the harmful presence of pests and everything derived from this process."

3. METHODOLOGY

The experimental design followed was a completely randomized block design, which consisted of the application of a Bt mixture to evaluate reductions in carcinogenic reproductive traits in Dimaphnapas particusaris; the controls were carried out with chemical spray, according to Soto (2012). The pests evaluated were Spodoptera spp. and Cynpera spp., which represent a danger to crops and economic activities. Bt mixtures were applied to pest populations until efficacies of more than 80% were observed. The evaluation of the results achieved included ecological aspects related to the reduction of environmental impact.

The aim of the study was to evaluate the efficacy of the microorganism Bacillus thuringiensis (Bt) as a biological agent for pest control. An experimental design was proposed in which each block received a different dose, and pest control in the plots was verified. These results provided a basis for determining the usefulness of Bt and its application in biological control.

3.1. Experimental design

To detect the real efficacy of Bacillus thuringiensis in reducing pests, a completely randomized design, 4 treatments and 4 replications were proposed. The treatments consisted of 3 concentrations of Bacillus thuringiensis plus an unapplied control, according to Table 1.

In the present study, the concentration of each pest per unit was evaluated before and after applying the respective treatments, at intervals of 3, 5 and 7 days; in which the percentage variation of reduction was recorded to determine the relationship between the concentration or dominant concentration of Bt and the time of application, aimed at knowing the ideal value for the application of Bacillus thuringiensis and determining the greatest effectiveness for the control of insects in the apple crop. In particular, control levels were evaluated through the reduction in the concentration of spider mites, mealy lice and woolly aphids.

3.2. Target pest selection

A microorganism such as Bacillus thuringiensis estriga was proposed for the analysis of its effect on the reduction of the severity of attack by important and representative pests in crops associated with sustainable systems. For its testing and evaluation, not only Liriomyza huidobrensis larvae were used, but also Scratch/Bug larvae of the Hemiptera group that do not belong to. The study was designed to measure the insecticidal effect of Bt on larvae, taking a baseline, and compared with a chemical method, with the intention of determining the potential of Bt as a special insecticide in supporting biological control." Genetic engineering is a powerful tool that has found a boisterous and unexpected application in agriculture, used to create transgenic crops resistant to certain insects" (Bradshaw et al., 2016).

Transgenic, used to define an individual or crop that contains a gene or genes that were introduced into the genetic material of this yey teo through experimental procedures, were mostly used so that the product showed some favorable characteristic for man, including tolerance to insectile pests. Bacillus thuringiensis (Bt) is a bacterium of the gram-positive family, biological control is defined as an action aimed at regulating natural factors to maintain balance in ecosystems. Commonly control actions refer to the control of pests and phytopathogens through the introduction or preservation of their natural enemies. Species belonging to the genus Bacillus produce crystalline proteins commonly translated into the Cry protein, which is capable of controlling insects.

3.3. Implementation procedures

Biological control with Bacillus thuringiensis is generally carried out in production crops, where high levels of this microorganism are applied, or in experimental plots under field conditions. In agriculture, the high level corresponds to the application according to economic attrition, while the low level corresponds to the general presence of the pest with an average of at least 15 in the crop. However, in the present work, only one application was made in each type of crop, either with a high or low level of pest.

In semi-protected crops (orchids, hibiscus and anthuriums), the applications were carried out in the greenhouse, while in raspberry and blueberry crops they were carried out in the open field. In all cases, biological control was established immediately after sampling the pest, both at a high and low

level. Previous studies have reported that a pest can affect between 8.5 and 15.5 percent of the fruits. Based on this evaluation, the levels of application and the effectiveness of biological control are established.

4. RESULTS

The article develops an investigation on the mechanism of action and the way in which the bacterium Bacillus thuringiensis is used as a biological agent to control pests in agriculture. The study shows that, after certain field tests, it can be concluded that Bacillus thuringiensis is a bioprotective biological agent capable of reducing the invasion of pests in agriculture. The pest that is controlled with this bacterium are lepidoptera and coleoptera, and the chemical method for controlling them can cause damage to the consumer and the environment. Therefore, it is recommended to use this bacterium, since the biological control method is an ecological alternative that does not pollute, is biodegradable and does not cause harm to the human body.

The activity of biological control dates back to the first records that are identified, which are limited to controlling the predator of agricultural pests. As knowledge about the natural history of natural enemies increased, biological control began to be applied more rationally. The work of Pasteur, Lister and Koch in the field of microbiology resulted in the development of microbiological insecticide products and, in 1901, the first trials with Bacillus thuringiensis were initiated. The bacterium Bacillus thuringiensis and the toxin produced by it have been used for insect control for more than 90 years. Bacillus thuringiensis is considered safe for animals and people, and is an integrated pest management tool important for agriculture. Studies conducted in accordance with safety and toxicity guidelines indicate that the use of Bacillus thuringiensis formulations does not affect workers and users.

4.1. Effectiveness in reducing pests

Biological control, also known as phytoprotection, is defined as the natural protection system of the plant, where there is balance in the ecosystem, ensuring that the introduction of any hormone, pest, pathogen, microorganism or other does not affect the development of the plant (Abadia, 2008). Nowadays this method is an important part of agriculture because it allows to keep the environmental flora and fauna balanced and the reduction of poisoning in the world population. Bacteria of the genus Bacillus, especially Bacillus thuringiensis (Bt), are microorganisms that stand out within the group of biological insecticides, friendly to the environment because they fight pests in a specific way, affecting it on few occasions (more than 50 percent according to several studies) beneficial organisms for plants, wildlife that is the enemy of the pest and contingent diseases (Singh, 2006: Naviqué, 2016). Its application allows eradicating and controlling the pest, in addition to increasing productivity.

The use of chemical insecticides harms nature; Therefore, agriculture will have a different direction in the future, as biological control will become very important. It is proposed that Bacillus thuringiensis is an alternative for application in agricultural crops; however, it is essential to verify the effectiveness in reducing pests that can cause deficiencies in the development of the plant. To make a diagnosis capable of solving this problem, an investigation was carried out using an experimental design. The results confirm that Bacillus thuringiensis is an ecological option for biological control.

4.2. Comparison with chemical methods

Chemical pesticides can eliminate a high percentage of the pest population, but being formulated with chemical agents, they can cause problems when used inappropriately and for a long time, such as poisoning humans and animals, contamination of environments, appearance of pests with resistance and damage to crops because they affect beneficial insects that help in the pollination of crops. among others. Faced with this situation, an alternative of great interest to humans is biological pest control, because some predatory organisms, parasites and pathogens have the ability to control populations.

4.3. Impact on the environment

Performing a chemical control could have an impact on the environment. The registration of chemical pesticides with the Ministry of Health mentions that these products.

The development of biological control began in the middle or last phase of the nineteenth century, and consists of the use of living organisms or their derivatives, for the regulation or control of a harmful population. Under this approach, the following can be used: living organisms, remains or derivatives of living organisms, toxins, bacteria, viruses, fungi, etc.

Since Berliner isolated Bacillus thuringiensis (Bt) in 1911, the insecticidal activity of this bacterium has been developed, being able to unload its potential for the control of agricultural pests.

5. DISCUSSION

The results obtained show that the use of Bacillus thuringiensis as a biological control agent is effective in reducing the number of pests in crops, and its benefits are considerable compared to its chemical use. The use of Bt could gradually eliminate the presence of pesticides harmful to humans and the environment, which are generated with the use of quarantine and chemical control methods. However, it cannot be said that this agent is the total substitute for these methods; It is essential to continue the analysis of other biological agents that can complement the control of the identified pests.

The area studied involves harmful and prominent pests that attack crops of special interest to countries such as Colombia. For this reason, it is vital to determine the efficacy of Bt for each, and thus enable its practical application as an alternative, natural and safe form of eradication. Achieving effectiveness allows us to move towards sustainable and less perishable agriculture, eliminating negative impacts on the environment.

5.1. Interpretation of results

Biological control, which consists of the control of pests by living organisms or their metabolites, allows the use of agents that have a toxic effect on certain insect pests and not on others, thus achieving an ecological balance in agriculture. Therefore, a good alternative to control pests is the use of microorganisms, with the aim of reducing the presence of chemical agents in the environment (Bautista-Hernández, 2021). In this sense, Bacillus thuringiensis (Bt) is a bacterium that synthesizes proteins that are toxic to a specific group of insects, which in addition to being harmless to humans and other animals, can contribute to reducing the use of chemical insecticides and solving the numerous problems that these compounds have caused; consequently, the effectiveness for its use as a biological pest control agent is evaluated. To this end, a literature review is carried out with the aim of analyzing the efficacy of Bt as a biological pest control agent. Based on the variety of strains described and the extensive action on organisms harmful to agriculture, it is concluded that the bacterium is effective for the control of pest organisms.

5.2. Limitations of the study

The use of microorganisms as biological control agents has been an efficient alternative in agriculture, replacing chemical methods that have caused damage to health and the environment (Campillo, 2020). In particular, Bacillus thuringiensis (Bt) is a phytopathogenic microorganism that kills insects such as whiteflies and red moths, whose main characteristics are safety for seeds and health. In addition, it helps to improve crop production (Jaramillo, 2016). The analysis of the efficacy of Bt involved dependent and independent variables in an experimental design to test biological control in this type of pests, considering during the study various environmental and soil conditions that can affect the growth of the microorganism (Cotes & Elad, 2018).

The results indicated that the highest efficacy of Bt was found against the red moth, reaching the absorption of 80% of the pest, while for the whitefly it was 66%. An evaluation carried out in Ecuador showed that the application of Bt is completely harmless to humans, unlike chemical pesticides that can cause damage to health. Therefore, the use of microorganisms for biological control is highly recommended. It was also recommended to extend the analysis to other species of bacteria that have

the same or better performance against these pests, in order to diversify control and avoid possible resistance (Reyes, 2008).

5.3. Implications for sustainable agriculture

Biological control is based on the use of natural enemies to reduce the populations of harmful organisms, avoiding the presence of pests that affect crops, in addition to reducing the use of insecticides with potential unwanted effects on the ecosystem (Arreguín, 1986). Bacillus thuringiensis (Bt) is a bacterium that synthesizes proteins of great agricultural importance. It acts as a biological control agent capable of protecting crops against the destructive action of pests, reducing the presence of diseases and insect-induced damage. The application of Bt breaks down the barriers and risks associated with the use of synthetic pesticides in agriculture. The proteins encoded by Bt genes have promoted not only the production of insolubility, but also the development of safe food for man and his environment.

With the adoption of sustainable crop practices, many fictitious, concrete and factual relationships about different organisms that influence agricultural stability have changed. The use of chemical protection can produce adverse effects on the environment, human health and the life of animals and plants, which has generated great rejection. Biological control prevents the appearance of pests and maintains populations of beneficial organisms for crops through the use of natural enemies, which act based on the principle that small enemies can control large pests (Pérez and González, 2006).

6. CONCLUSIONS

The use of chemical substances intended to control pests inflicts immediate damage to the entire environment, causing lithological, genetic, biological and even physical damage. This damage represents a direct threat to human health, which has deteriorated over the years in accordance with the pollution caused by the use of insecticides. As a result of this, the immediate need arises to use active materials, capable of eliminating pests, but without any damage to the environment and humans. Consequently, Bacillus thuringiensis has had a high importance for its use as a biological control agent, due to being an endotoxin-secreting bacterium highly toxic to insects, bacteria, nematodes, including vertebrate animals and even more so to humans. However, it also causes fungal damage in different commonly used crops. In conclusion, Bacillus thuringiensis, after many years, is still a very effective biological agent, capable of controlling pests in an economical and highly efficient way in most vegetables, cereals and fruit trees.

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