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RESEARCH ARTICLE

Chemical Control versus Biological Control Agent in the Fight against the Main Harmful Agent of Sugar Cane

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Abstract

The aim of this study was to analyze comparatively the cost of biological control and chemical control of main noxious agent of sugarcane, the drill (Diatraea saccharalis). This research was exploratory and descriptive in nature, through a case study in business Companhia Melhoramentos Norte do Estado do Paraná-Brasil (Company Improvements North of Paraná State, Brazil). There was the economic viability of the use of biological control in the cultivation of sugar cane. This is an economical viability of approximately 24% compared to chemical control. Moreover, under the sustainable approach, it is clear that the adoption of organic control practices , such as biological pest control with Cotesia flavipes, is environmentally friendly and has higher efficiency, medium and long-term productivity the sugarcane industry.

Keywords: *Biological control, Chemical control, Sustainability.*

Introduction

The search for effective sustainability initiatives and new perspectives adopted in relation to the environment brought agriculture to adapt to sustainable development. These actions have been supported by the Ministry of Environment through policies and projects financial incentives, technical assistance and standardization of sustainable rural practices in order to maintain Brazil as global supplier of raw materials and sustainable food Ministério Da Agricultura[1].

According to the Ministério da Agricultra [1] Brazil is the fourth largest producer in ranking in organic agriculture, with production growth of 20% per annum. These products are from organic farming which includes the use of sustainable agricultural technologies for low chemical inputs Campanhola and Valarini [2].

One of the technologies employed in agriculture is the biological control of pests, according to the Organic Agriculture Association Associação Da Agricultura Orgânica, [3] includes the use of living organisms to maintain the population of a specific pest organisms in balance in agroecosystem. This is the case of Cotesia Floripes which is considered an agent of biological control of pests in sugar cane, as the "drill" (Diatraea saccharalis). The insect is released in the sugarcane fields and naturally attack the parasite cane sugar, combating pests without using chemical inputs.

Sugarcane suffers major damage in relation to their productivity and quality when it is hit by this plague. Hence the concern with fighting is common in sugarcane cultivation and for this purpose there are various products of biological and chemical origin.

From the foregoing established the following research question: Besides the environmental benefits, the use of biological control in the cultivation of sugar cane can reduce production costs compared to chemical control?

To answer the question proposed the goal of the article is: to analyze comparatively the cost of biological control and chemical control of main noxious agent of sugarcane, the drill (Diatraea saccharalis).

This paper is organized into 4 sections besides this introduction. The second section discusses the literature review to substantiate the case analyzed. The third section presents the methodology of the work, in order to make clear how the research was conducted. The fourth section presents the results of research and analyzes. Finally, presents conclusions of the

study, in order to respond to the issues and the proposed objective.

Theoretical

Environmental Management

Since the 1970s concern for the environment has become a topic of discussion on the agenda of organizations, whether private or public, worldwide. Given this concern, in 1972 was held the first world movement for the environment: the Stockholm Conference, organized by the United Nations. This conference was representatives from various countries gathered to set policy on the use of natural resources and public awareness about the balance between man and the environment.

Another milestone on discussions with leaders of countries and representatives of society was the ECO - 92, in Brazil. The ECO -92 resulted in important agreements between the participating countries, such as Agenda 21, which is a document with strategies for nations to achieve sustainable development. According to the Brazilian Agenda 21, sustainable development means meeting the needs of the present without compromising the ability of future generations to meet theirs Agenda 21 Brasileira [4]. Implicit in this definition is the idea of a model of planning and environmental management. However, both the planning and the environmental management model are comprehensively since its establishment and execution of an overall concept for the site, arriving at the citizen level.

Consistent to the purpose of Agenda 21 Brasileira [4], the Management Environmental has become a strategic factor for enterprises implement sustainable development practices at the local level. According to Ribeiro [5]:

Environmental management is therefore a set of routines and procedures that enable an organization to properly manage the relationship between their activities and the environment in which they develop. Your goal is, among other things, meet the legal requirements applicable to various stages of the process, from production to final disposal , through marketing , so that preventive and proactive procedures that consider environmental aspects and achievements of activities, products and services, and only interests and expectations of stakeholders.

Therefore believes that environmental management is the management of environmental resources, or at least of resources that impact or relationship with the environment. Thus, environmental management seeks organizations to use natural resources in its economic activity so that it does not harm the environment or reduce as much as possible the impact on the ecosystem.

From the need to better manage environmental resources and the effects on the environment of corporate activity that arises is the biological control of pests in sugar cane as an alternative to chemical control. Thus, the purpose of the next subsection is to contribute to better understand the effects, advantages and disadvantages of biological and chemical control in agriculture.

Biological Pest Control in Agriculture

To elucidate the underlying reasons to use biological control, Table 1 shows, in summary, the advantages and disadvantages of biological control compared with chemical control in agriculture.

In the specific case of the culture of sugar cane is another advantage in the use of biological control. In crops where not performed detrash (burning of sugarcane straw), increases the possibility of Cotesia Flaripes reproduce in culture, reducing the need to reapply it to the new crop. With the natural reproduction of the biological agent of culture reduce costs.

It is noteworthy that in several Brazilian states a burned sugarcane is already prohibited by law and there are laws of projects aimed at banning the burning across the country. This legal measure favors the use and efficiency of biological control.

In addition, studies show that sugar and alcohol mills that have adopted biological control in 1980, three years reduced from 9% to 3,71 % the rate of infestation of pests in sugar cane with the application of Cotesia Flaripes Copersucar [6]. As for the economic benefits of the use of biological control compared to chemical control various studies, as shown in Table 2.

Based on these studies, it is observed that in all cases the cost of biological control was lower by increasing the result of the producer. But the rates of profits and costs have wide variation between studies, achieving a 40% difference in cost reduction.

Table 1: Advantages and disadvantages: biological control versus chemical control advantages

Advantages	
Biological Control Chemical Control	**Biological Control Chemical Control**
Non-toxic natural agent therefore does not cause environmental imbalance, does not harm the environment, leaves no residues in soil, water, food.	Chemical agent, toxic main cause of contamination of groundwater, rivers, food, animals and people. For this reason it is harmful to the health of humans and other animals.
Efficient to use the natural predator of the pest, there is no risk that the pest becomes resistant to control, respecting the food chain.	Due to the use of chemical agents to protect plague, mutates becoming resistant input. It is therefore necessary to increase the dose or even create new pesticides to combat it.
Reduces the risk of environmental and legal sanctions.	Great risk of legal intervention or prohibition of use.
In most cultures the biological agent reproduces itself naturally, reducing the cost of reapplication.	Every season the application is required, and often the reapplication, especially in case of rains in the applied area.
Specific to combat the plague which was intended, not causing harm to other animals or plants.	Combat, most of the time, everything other than the cultivated crop, insects and other plants that could be ecologically important and potentially useful for culture and ecosystem.
Disadvantages	
Biological Control.	Chemical Control.
Slow effect, it depends on the life cyclic of the biological agent, thus not effective in urgent struggles.	Effective because the combat is almost instantaneous.
Few studies, specialized and difficult to access businesses.	Large trade and types / varieties
Requires more knowledge and training of those responsible.	Easy Application.
Fighting a specific pest.	Combating various pests simultaneously.

Source: prepared by the authors.

It is noteworthy that all these studies were conducted using biological control was already implemented, and the higher costs attributed to this type of control is in their implementation and research.

Table 2: Studies on the benefits of the use of biological control and chemical control

Author (Year)	Purpose of Study	Results
Globo Rural [7]	Examine whether it is possible to maintain good productivity without using poison.	In addition to efficient biological control is safer and cheaper than pesticides. The cost of controlling the scolding in cane sugar made with cotesia is 30% cheaper than chemical control.
Monteiro; Souza; Pastori [1]	Economic Comparison of biological and chemical control for managing red mite on apple tree.	The biological control of mites on apple - red were 15.8 % lower than the costs expended in orchards that used only insecticides and miticides to control.
Balsalobre and Santos [8]	Analysis of chemical control and biological control in pest control "Cigarrinha Pastures".	Any chemical control as the biological efficiency are low. The organic products found in the market feature , generally poor quality , which still required a lot of care during application of the fungus to obtain some success.
Medeiros; Vilela; França [9]	Analysis of technical and economic efficiency of the biological control of the leafminer in greenhouse tomato.	When the two systems are compared, it appears that the costs of biological control were significantly lower in insecticides (-526.40 %) ; services (-36.84 %) , other (3.4%) . Despite the productivity of biological control was lower (-10.93) system , the unit cost was lower , due to the cost reduction with insecticides and hand labor and others.
Revista Attalea Agronegócios [10]	Biological Control in culture cane sugar.	Every 1 % infestation with the drill decreases the production of 0.77 %. With the use of parasitoid reduced the infestation level of 3 % to 2.6 % in the 2005/ 2006 harvest, yielding an economic benefit of U.S. $ 2.5 million.

Source: prepared by the authors.

Therefore, based on these results, we note that biological control both protects the environment and economic benefits back to the company that adopts this practice. After discussion of these aspects, where relevant aspects were presented environmental management for sustainable development and the advantages and disadvantages of using d biological and chemical control, the next section aims to present the methodological procedures followed by research with a view to make clear how the study was implemented.

Methods

Every science has the characteristic of verifiability. For this, it is necessary to identify the methods and techniques used to meet the goal of scientific research Gil [11]. These ratings are presented below, in accordance with the framework that this research presents.

As to the objectives this research is exploratory and descriptive. According Beuren *et al* [12] exploratory research "we seek to know the subject in greater depth in order to make it lighter or build important for the conduct of research issues." To the same author, descriptive research comprises to observe, record, analyze and establish relationships between variables in the object of study.

Thus a case study was conducted at the Company Improvements North of the Paraná (CMNP) in order to compare the cost of fighting the plague that attacks the production of sugarcane in the

modalities biological control and chemical control. As stated by Silva [13], "The case study when it involves the profound and exhaustive study of one or a few objects in a way that allows their broad and detailed knowledge."

To better exploit the theme of scientific work also embasou in bibliographical material. According to Gil [11] "The literature is prepared based on previously published material. Traditionally, this type of research includes printed material, books, journals, theses, dissertations and scientific events". So they gathered knowledge on the subject studied.

As it was necessary to measure the costs of biological control and chemical control, document analysis (management reports) the company was a procedure of data collection used. Another procedure for data collection was the use of questions in the form of semi - structure interview. This procedure was important to supplement / confirm information obtained in documentary research.

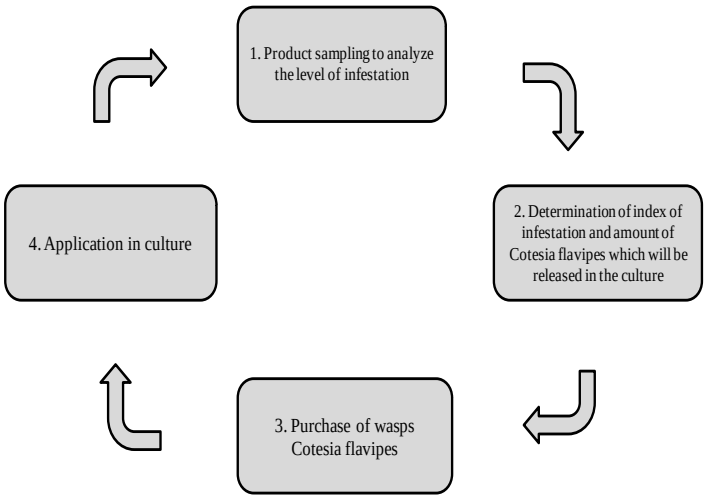
Thus, the study was ex post facto, and without control variables in their real environment so that the results were presented in a descriptive manner, and relations between the variables of deductive mode. Furthermore, this research is characterized in relation to the approach method, such as deductive on the nature of the problem is quite compared to the research environment and field.

The study was conducted at company engaged in the business of sugar cane, called Cia Improvements North of the Paraná located in a rural area of the municipality of Jussara, Parana State, Brazil. The data relating to the 2013/2014 harvest. The next section presents the results and analysis of the study.

Presentation and Analysis Results

Cost of Culture of Sugar Cane with Biological Control

The biological control used in combatting earful from sugar cane is the introduction of the parasite Cotesia flavipes on sugarcane cultivation. The introduction is by releasing wasps in areas where it was evidenced a given population index sugarcane borer. The wasps lay eggs released in the field, which in turn release larvae, which feed on the caterpillar parasite of sugarcane. The process of identification of sugarcane borer infestation is shown in Fig. 1.



Fig, 1: Operational Steps of applying input *Contésia flavipes*
Source: prepared by the authors.

To assess the need for reapplication of biological control and start this process, it is necessary to drill new population sample, after 21 days after the first application.

Besides all this procedure is still performed to study the estimate of crop losses due to the attack drill in the culture of cane cutting period. This study defined as sample about 20 rods per hectare, to obtain the percentage of infestation rate (% II). The calculation of % Î.I. is made as follows:

$$\%\ \hat{I}.I. = \frac{\text{No. brocades internodes}}{\text{No. total internodes}} \times 100$$

Table 3: Steps of biological control

Stage	
Product sampling to analyze the level of infestation (pre- release)	Through operating procedure is done the pest population survey in culture, in order to prioritize local release. This procedure considers the history of the area, the varieties of sugarcane with more chances of infestation and age of sugarcane (2 to 3 internodes formed approximately between 2 and 3 months).
Determination of the infestation and the amount of Cotesia flavipes to be released	By the sample medium agronomist calculates the rate of infestation and determines that the need for application of biological control. Are usually introduced 6,000 wasps Cotesia flavipes per hectare, 6 cups containing 1,000 wasps each cup. In reapplying high infestation is recommended.
Request Shopping control	The flavipes Contésia even being considered an agricultural input can not be stored because it is a living organism which needs conducive environment for survival. Thus the process of buying and inventory period is very fast : the insect is purchased from a laboratory , it still sends the form of larvae, which are "born " in the company shortly before its application in the field , in the form wasps.
Application in culture	The application is made by the same developers who made sampling. Wasps are released in accordance with the operating procedures define the company . In liberation is considered that the Cotesia flavipes dispersion has a radius of 34 meters.

Source: survey data (2013).

The purpose of this index is to calculate the economic return to the control of the drill, the reduction of one percentage point in % II corresponds to recovery: a) 0.77% in sugarcane production; b) 0.25% in sugar production and; c) 0.20% in ethanol production. According to data from the Center for Sugarcane Technology, it is estimated that every 80 tons of sugar cane per hectare losses for each 1 % of borer infestation are 616 pounds of sugar, 20 pounds of sugar and 16 liters of alcohol.

The company has studied crop in 2013/2014 26,000 hectares of cane sugar. In its budget for this crop estimated a cost of R $ 35.71 per hectare of cane sugar for biological control (Table 4).

Table 4: Budgeted cost of biological control

Discrimination	Per hectare	Total Projection Projection
Feedstock (Cotesia flavipes)	R$ 16.00	R$ 416,000.00
Hand labor Direct - Manual application of Cotesia flavipes	R$ 15.98	R$ 415,487.21
Rent bus	R$ 2.79	R$ 72,600.00
Fuel	R$ 0.94	R$ 24,360.00
Total costs	R$ 35.71	R$ 928,447.20

Source: survey data (2013).

In calculating feedstock was considered that the implementation of Cotesia flavipes wasps 6,000 per hectare, ie four units (cup with 1,500 wasps) the unit cost of R$ 4.00 is required. To obtain the value of the hand labor needed for manual application of Cotesia flavipes, considered the minimum wage category R$ 840.00, plus an hour of work (hours journey or displacement) and social contributions (FGTS Social Security 8% and 20%). It is worth mentioning that this hand labor both sampling for analysis performs the infestation index as does the application of input in culture.

Other indirect costs are related to the transport of the hand labor, in which the company uses a third-party bus with monthly cost of R$ 6,050.00 and spent fuel by the vehicle, calculated based on the average consumption of diesel per kilometer traveled. It was not considered the cost of hand labor administrative agronomist responsible for the coordination of services for the fact of having to apportion the value of this cost among the other departments and activities that he is responsible.

Cost of Culture of Sugar Cane with Chemical Control

Chemical control is accomplished by pesticides. Its application is aerial, requiring little manual labor, which in this study is outsourced company. There is a peculiarity in the application of chemical control: for the application to be efficient it is necessary that the larva of the drill is being fought at the beginning of its life cycle, with about 1 inch.

After this stage the larvae migrate into the cane and are not affected by the insecticide, unlike biological control which he moves to capture the bit following its natural cyclic. Costs of three brands of insecticides were quoted. The values are shown in Table 5.

Table 5: Cost of chemical control

	Certeiro, Bayer brand	Match, Syngenta brand	Altacor, Du Pont brand
INPUT			
Dose (liters / ha)	0.08	0.03	0.08
Value liter	R$ 100.00	R$ 31.78	R$ 300.00
Value per hectare	**R$ 8.00**	**R$ 0.95**	**R$ 24.00**
Labour (Outsourced)			
Value of the application of air product per hectare	R$ 23.00*	R$ 23.00*	R$ 23.00
Total value per hectare	**R$ 31.00**	**R$ 23.95**	**R$ 47.00**

* Required 2 to 3 applications, according to the level of infestation.
Source: survey data (2013) [14].

The Altacor is the only insecticide that is effective in controlling the pest with only one application, without the need for future reinvestment. Considering this factor and the other insecticides require 2 to 3 applications Pesticide Action Altacor is more efficient. Therefore, even considering that only 2 applications Surestrike or Match necessary costs would be R$ 62.00 and R$ 47.90, respectively. Still, Altacor remain at the lowest economic cost.

It is noteworthy that the pesticides are mostly imported, carrying a price change can not be very stable character since they are purchased in U.S. dollars and converted into Brazilian currency.

Chemical controls also require the sampling rate of infestation services in order to determine the amount and the need for pest control and also need the hand of administrative work of an agricultural technician responsible. Opposing this, chemical control may be considered a cost of prevention, ie, apply the crop before it is shown the plague.

Cost of Biological Control versus Chemical Control

A comparison of the economic feasibility of the method of biological control and chemical control is important to verify the contribution in the cost of culture. Table 6 shows the cost per hectare according to the number of applications required.

Table 6: Cost per hectare number of applications

Input	Cost per hectare		
	1 Application	2 Application	3 Application
Cotésia flavipes	R$ 35,71	R$ 71,42	Not Applicable
Certeiro	R$ 31,00	R$ 62,00	R$ 93,00
Match	R$ 23,95	R$ 47,90	R$ 71,85
Altacor	R$ 47,00	Not Applicable	Not Applicable

Source: survey data (2013) [14].

Based on the results from Table 6, when considering the need of only one application, the agricultural input match would be the most viable, followed by Surestrike. The Cotesia flavipes has the third highest cost. However, both the Mach as Surestrike in rare situation has satisfactory efficacy on pest control with just one application. In turn, the Cotesia flavipes, biological, gets great effect on pest control with just one application. Altacor is now limited to only one application because its efficiency is great precisely because of its high concentration of poison. Thus, it appears that biological control becomes more economically feasible with only one application.

If two applications are necessary, the Match is the one with the lowest cost per hectare, followed by Surestrike and Cotesia flavipes. In rare situations, when there are three applications the Cotesia flavipes is not applicable because the time between the first and third application is large, so that the sugar cane has reached the point of cut. So with three applications, the lowest cost per hectare is the Match.

Given the situation that only one application of the biological input is most common in the culture of sugar cane, to control the drill, we note that the Cotesia flavipes has a cost about 24% less than the Altacor. Applying this difference to the 26,000 acres of cane sugar, the cost savings realized at R $ 293,540.00 in just one season.

Final Considerations

This study began with the questioning that besides the benefits to the environment, the use of biological control in the cultivation of sugar cane can reduce production costs compared to chemical control. To answer the question proposed the goal of the article is: to analyze comparatively the cost of biological control and chemical control of main noxious agent of sugarcane, the drill (Diatraea saccharalis).

Based on the presented results we found the economic viability of the use of biological control in the cultivation of sugar cane. This is an economical viability of approximately 24% compared with the insecticide Altacor.

Another positive for the company to use biological control is the cost of storage, which occurs in different ways. Because of Cotesia flavipes be a live input your storage time is virtually nil, since it is immediately applied to the culture so it arrives in the company. Unlike this, the chemical inputs are bought in large batches and stored for use, which in the high environmental and harmful power to humans and the environment issues, has strict criteria warehousing and inventory that must be controlled by the company. Another storage cost that should be considered for chemical inputs refers to the disposal of packaging after application. Added to these costs of stocking the risk of exchange rate changes because they are imported and have the need to convert dollar to real time of purchase and payment.

These differences in costs and outcomes achieved by the adoption of biological control generate not only economic benefits but also environmental benefits. Thus, the Cotesia flavipes can be shown to be an environmental asset, because it is an input that its use results in production of sugar

cane sustainable. Furthermore, it generates economic benefits that can be shown to be environmental outcome because actually participates in determining the price of sugar cane, and tied to it, can be characterized as an environmental cost for the replacement of the responsible chemical control.

However, if the company used the chemical control to control the sugarcane borer, it should recognize a liability (provision) potential damage that can cause chemical control, such as: risk the health of people in the workplace the handling, contamination of rivers and groundwater contamination or areas adjacent to sugarcane fields. Thus, while running at higher costs the company would have an obligation, environmental nature.

Regarding the environment, aimed at sustainable approach, it becomes apparent that the adoption of organic control practices, such as biological pest control with Cotesia flavipes, is safer and responsible.

Among these advantages and drawbacks highlights the harmful effects of chemical control may cause to the environment. In contrast, environmental responsibility actions in agricultural production, by directly involving natural resources like soil and water, has gained prestige among the various stakeholders.

Therefore, it is concluded that biological control using the input Cotesia flavipes proved to be the best option to control the sugarcane borer. This control is economically viable, environmentally sound and has higher efficiency, medium and long-term productivity of the sugarcane industry. Finally, with an economy focused on sustainable development, even though the chemical control was considered the most economical, environmental gain provided by the biological control put in debate the economic return would be afforded by chemical control is warranted.

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