Impact of the biological control program in sugarcane pest management in Cuba

Mérida Rodríguez Regal, Alberto Fuentes Azcuy, Zoila Loddo Vega, Eida Rodríguez Lema, Jorge Félix Álvarez González and Ana Lidia Jiménez Reyes

Abstract Since man started cultivating the land for food, there has been a proliferation of pest organisms. Factors helping the establishment of pests are many, but the use of chemicals is the most significant one, because it breaks the ecological equilibrium imposed by the action of natural enemies. The other main factor is the continued development of monocultures. Sugarcane is such an extensive and almost perennial crop, giving rise to pest attacks and yield losses. The stem borer Diatraea saccharalis (Fabricius) is the main sugarcane pest in Cuba, and losses have been estimated at 120,000 t sugar/year. Biological control has been the main practice implemented to control this pest. Here, we describe the main results of the research on sugarcane pests in Cuba, and the introduction of biological control by the National Program of Biological Control (NPBC) in normal farming practice. We give a historical review of the discovery of the first natural bio-regulators of pest, Trichogramma sp. and Lixophaga diatraea Townsend, and of the impact of this program on minimizing losses. The role played by Cuban Sugar Industry as a pioneer of using, diversifying and applying biological control is described

Key words Biological control, Diatraea, Trichogramma, Lixophaga

INTRODUCTION

For the Cuban people sugarcane means culture, tradition and identity and since the beginning of the 19th century it has had an important impact on the economy of the country. Not surprisingly, this means that sugarcane research has been important in Cuba.

As with many crops, sugarcane is attacked by many pests. In Cuba the most important are the moth borers or stem borers, particularly Diatraea saccharalis (Fabricius). These pests can cause economic losses in term of biomass and sugar. Since the 18th century, the control of these pests has focused on the use of natural enemies. Across the world, biological control was displaced during the ‘green revolution’ by synthetic insecticides, apparently more economic and efficient (Gómez 2002). However, the tide is turning with more focus on environmental impacts and rising costs.

Here we describe research in the development of the biological control in Cuba that started in 1945 with the foundation of the first laboratory for the production of Lixophaga diatraea, a parasitoid that was discovered in Cuba in 1914 by Wolcotton and used for the biocontrol of the sugarcane borer D. saccharalis. Since its beginning and until 1978 annual releases of parasitoids were made in Matanzas Province and research about basic aspects of the bioecology and breeding methods for mass production were carried out. These results were considered in the establishment of a National Program.

DEVELOPMENT AND RESULTS

The National Program of Biological Control of the sugarcane borer was created in 1980. Figure 1 shows the average number of laboratory units for Lixophaga production in each five-year period – these were termed Centers of Reproduction of Entomophages and Entomopathogens (CREE).

Initially, the production units of parasitoids were implemented with some difficulties and it was not possible to treat all areas. Therefore, the field releases were concentrated in the winter months, close to the harvest season. With improvements in breeding methodology and the overall efficiency, the production of parasitoids increased steadily, allowing the extension of releases to all year round.
Currently, four parasitoids and one entomopathogen are produced on the only alternative host, the great wax moth (*Galleria mellonella*) (Fig. 2).

**Fig. 1.** Average number of laboratory units for *Lixophaga* production in each five-year period.

**Fig. 2.** Biocontrol agents produced in laboratory, and a flow diagram of the production process of the CREE.
The biocontrol agents are used in the sugarcane crop following the requirements of the Sugarcane Plant Health Service (SPHS). The surplus of biocontrol agents and the productive capacity of the laboratory units contribute to the national balance of the biological control strategy in the agricultural sector. In addition, the surplus also serves as food for the production of the scorpion *Rhopalurus juncus* and its active venom (toxins), used in biotherapeutics and homeopathic production.

Figure 3 shows the impact of the release program in the reduction of the overall infestation of stem borers from 1988 to 2012. The strategy has been to increase the number of releases and match application rates with the borer population levels. This is dependent on the availability of the biological control agents. The continuous decrease in the pest infestation below the economic threshold established for the country has been achieved.

Several authors have worked on yield losses due to the borer and the economic impact of the applications of control measures (Barreto 1954; Fuentes and López 1977; Pérez Ochoa 1979; 1980). Until 1978 the program generated CUP 28.5 million profit, with the largest profit in the 1986-90 period with CUP 14.0 million return with 43 working CREEs (Table 1).

**Table 1.** Profits associated with the application of *Lixophaga* for borer control.

<table>
<thead>
<tr>
<th>Five-year period</th>
<th>Number of CREEs</th>
<th>Profit (CUP millions)</th>
<th>Increase in control/year (1980) %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981-1985</td>
<td>16</td>
<td>1.348</td>
<td>-0.102</td>
</tr>
<tr>
<td>1986-1990</td>
<td>43</td>
<td>14.094</td>
<td>-0.166</td>
</tr>
<tr>
<td>1996-2000</td>
<td>50</td>
<td>4.179</td>
<td>3.062</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>28.544</td>
<td></td>
</tr>
</tbody>
</table>

2001-2005
- 50 = 50 %
- 2.438

2005-2010
- 32 sugar loss
- 2.586

2011-2014
- 30 avoided
- 2.490
Currently, the national program generates profits of about CUP 0.6 million, but with an important contribution to the national economy by the reduction of sugarcane losses (10.9%), sugar losses (54.5%) and alcohol losses (43.6%) as a result of a decrease in the borer infestation index (Table 2). This program is guided by the SPHS and has been exported to sugarcane countries such as Mexico, Venezuela, Uruguay, Vietnam and China, among others.

**Table 2.** Cost-benefit through the application of the biological control strategy for *D. saccharalis*.

<table>
<thead>
<tr>
<th>Year</th>
<th>Index of total intensity (II)</th>
<th>Released <em>Lixophaga</em> (thousands)</th>
<th>Area benefited (ha)</th>
<th>Costs of release*</th>
<th>Δ II total with base year</th>
<th>Decrease II total relative to base year</th>
<th>Loss reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>1.42</td>
<td>73100</td>
<td>913.75</td>
<td>3856.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>1.02</td>
<td>44400</td>
<td>555.00</td>
<td>2342.10</td>
<td>0.40</td>
<td>1.39</td>
<td>6.96</td>
</tr>
<tr>
<td>2012</td>
<td>0.61</td>
<td>54600</td>
<td>682.50</td>
<td>2880.15</td>
<td>0.81</td>
<td>2.33</td>
<td>11.64</td>
</tr>
<tr>
<td>2013</td>
<td>0.52</td>
<td>54400</td>
<td>680.00</td>
<td>2869.60</td>
<td>0.90</td>
<td>2.73</td>
<td>13.65</td>
</tr>
<tr>
<td>2014</td>
<td>0.65</td>
<td>37900</td>
<td>473.75</td>
<td>1999.22</td>
<td>0.77</td>
<td>2.18</td>
<td>10.92</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>264400</td>
<td></td>
<td>13947.10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial costs</td>
<td>canoe (T)</td>
<td>104.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial costs</td>
<td>sugar (T)</td>
<td>506.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial costs</td>
<td>alcohol (HI)</td>
<td>105.15</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

* Cost for release CUP 42.20/1,000 *Lixophaga* pupae

**CONCLUSIONS**

The National Program of Biological Control in Cuba has obtained the following results:

- Reduced the infestation index of *D. saccharalis* to 0.7, which is below the economic injury threshold.
- Increased insect and nematode production to allow a permanent control of the sugarcane areas and contribute to the protection of other crops using the surplus.
- Diversified integrated control methods for the main pests.
- Developed an efficient technological process for the production of several key biocontrol agents with profits of more than CUP 28.5 million (USD 147,000).
- The technology of biocontrol ensures avoidance of major sugar losses, guarantees commercialization of the biocontrol agents and enables the export of technology transfer overseas

**REFERENCES**


**Impact du programme contrôle biologique dans la gestion des insectes ravageurs à Cuba**

Résumé. Depuis que les hommes cultivent la terre pour leur nourriture, il y a une prolifération d’insectes ravageurs. Les facteurs aidant l’établissement de ces ravageurs sont nombreux, mais l’utilisation des produits chimiques est le plus significatif car il rompt l’équilibre écologique de l’action des ennemis naturels. L’autre facteur important est le développement continu de monocultures. La canne à sucre est une telle culture extensive, à caractère pérenne, qu’elle stimule l’attaque de ravageurs et des pertes de rendement. Le foreur des tiges *Diatraea saccharalis* (Fabricius) est le ravageur de la canne à sucre le plus important à Cuba, et les pertes de rendement ont été...
estimées à 120,000 t sucre/an. Le contrôle biologique a été la principale pratique mise en place pour contrôler ce foreur. Ici nous décrivons les principaux résultats de la recherche concernant les ravageurs de la canne à sucre à Cuba et l’introduction du contrôle biologique par le National Program of Biological Control (NPBC) comme pratique agricole normale. Nous proposons une revue historique de la découverte des premiers agents de régulation biologique des ravageurs tels que Trichogramma sp. et Lixophaga diatraea Townsend, ainsi que l’impact de ces programmes sur la diminution des pertes. Le rôle joué par l’industrie sucrière cubaine comme pionnière de l’utilisation, de la diversification et l’application du contrôle biologique est décrite.

Mots-clés: Contrôle biologique, Diatraea, Trichogramma, Lixophaga

Impacto del programa de control biológico en el manejo plagas en la caña de azúcar en Cuba

Resumen. Desde que el hombre comenzó a cultivar la tierra para su alimentación, se produjo una proliferación de organismos plaga. Son muchos los factores que ayudan al establecimiento de las plagas, pero el uso de productos químicos es el más importante, ya que rompe el equilibrio ecológico impuesto por la acción de los enemigos naturales. El otro factor principal es el desarrollo continuo de los monocultivos. La caña de azúcar es un cultivo extensivo y casi perenne, dando lugar a ataques de plagas y pérdidas de rendimiento. El barrenador del tallo Diatraea saccharalis (Fabricius) es la principal plaga de caña de azúcar en Cuba, y las pérdidas se han estimado en 120,000 toneladas de azúcar / año. El control biológico fue la principal práctica implementada para controlar esta plaga. A continuación, se describen los principales resultados de la investigación sobre las plagas de caña de azúcar en Cuba, y la introducción del control biológico en la práctica agricola normal por el Programa Nacional de Control Biológico (NPBC). Damos un repaso histórico del descubrimiento de los primeros biorreguladores naturales de las plagas como: Trichogramma sp. y Lixophaga diatraea Townsend, y del impacto de este programa en minimizar las pérdidas. Además se describe el papel desempeñado por la industria azucarera cubana como un pionero de la utilización, la diversificación y la aplicación del control biológico.

Palabras clave: Control biológico, Diatraea, Trichogramma, Lixophaga