ISSN: 2594-0252

AGRO PRODUCTIVIDAD

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Año 17 • Volumen 17 • Número 1 • enero, 2024

Colegio de Postgraduados

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Determining the economic threshold for the sugarcane stalk borer (*Diatraea* spp.) in the Córdoba-Golfo region, Veracruz, Mexico

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ABSTRACT

Objective: To determine the economic threshold for *Diatraea* spp. in the Córdoba-Golfo sugarcane growing region in Veracruz, Mexico.

Design/Methodology/Approach: During the 2020-2021 production cycle, we established 21 sampling plots to measure damage percentage due to borer larvae in sugarcane stalks. Based on these measurements, we calculated the economic damage level (EDL) and the economic threshold (ET) by regions and subregions.

Results: The most affected subregion was Yanga, with an average annual damage of more than 5 % and a real economic threshold of 1.36. The average ET in the Córdoba-Golfo region was 2.76, which indicates that applying control strategies for *Diatraea* spp. enables the regulation of insect populations.

Study limitations/Implications: Strategies to obtain reality-driven diagnoses are still necessary to design and apply assertive management procedures to control stalk borer populations in the field.

Findings/Conclusions: We posit a suitably calculated ET for each studied subregion, considering updated parameters that include real crop losses per zone (field performance). This can provide the basis for a course of action with an effective management that will, in turn, increase field performance and sugarcane juice quality.

Keywords: Sugarcane stalk borer, Sugarcane, Spatial-temporal data analysis, Economic damage level.

Citation: Cruz-Tobon, M., Hernández-Rosas, F., Silva-Rojas, H. V., Serna-Lagunes, R., Rodríguez-Lagunes, D. A., & Llarena-Hernández, R. C. (2024). Determining the economic threhold for the sugarcane stalk borer (*Diatraea* spp.) in the Córdoba-Golfo region, Veracruz,Mexico. *Agro Productividad*. https://doi.org/10.32854/agrop.v17i17.2675

Academic Editors: Jorge Cadena Iñiguez and Lucero del Mar Ruiz Posadas

Received: September 12, 2023.
Accepted: January 04, 2024.
Published on-line: February 21, 2024.

Agro Productividad, 17(1). January. 2024. pp: 131-136.

INTRODUCTION

Sugarcane (*Saccharum* spp., hybrid, Poales: Poaceae) holds the sixth place in crop relevance in Mexico (CONADESUCA, 2021a). The most damaging insect pests for this crop are the species comprised in the genus *Diatraea* spp., a group known as sugarcane stalk borers. When their population is abundant, they cause significant economic losses in the sugarcane sector (Wilson *et al.*, 2021).

Forty-one species of the *Diatraea* genus have been described that have a natural

distribution in the American continent. Some of these are considered insect pests in sugarcane, corn, sorghum, and rice crops, and affect cultivated fields in various territories from the United States to Argentina (Joyce *et al.*, 2014; Solís *et al.*, 2015; Francischini *et al.*, 2019).

Due to their vagility and natural colonizing capacity, the pest species of the *Diatraea* genus have affected more than 192,662.52 ha of sugarcane fields, which supply raw materials for 18 sugar mills in Mexico. Considering this impact, a decrease of 2 to 10 tons of cane/ha was estimated for the 2020-2021 harvest season (Rodríguez-del-Bosque *et al.*, 2014; Francischini *et al.*, 2019; CONADESUCA, 2021b).

During their larval stage, *Diatraea* spp. pierce the stem and consume the meristematic tissue, causing the "heart" of the sugarcane plant to die. The action of larvae reduces the yield and juice quality and increases susceptibility to pathogens, which makes strategies for their management and control essential (Rodríguez-del-Bosque *et al.*, 2014; Joyce *et al.*, 2014; Wilson, 2021).

However, the intensity of the damage caused by *Diatraea* spp. in sugarcane calls for procedures that require a high economic investment from producers. Calculating the economic damage level (EDL) and the economic threshold (ET) based on regional dispersion will allow the implementation of management strategies in the correct stage and location, thus reducing costs (Serra and Trumper, 2020).

The Córdoba-Golfo region is the site of the largest sugarcane growing area in the country. There, the ET for *Diatraea* spp. shows regional variations and differences. Moreover, its interpretation is unclear because its calculation uses the standard ET value of 10% and does not consider the particularities of each sugarcane growing municipality (Rodríguez-del-Bosque *et al.*, 2012).

Therefore, as a means of social restitution to support the sugarcane sector of the Córdoba-Golfo region, the objective of this work was to determine the EDL by region to calculate an ET based on the percentage of damage caused by larvae of the *Diatraea* spp. group in commercial sugarcane crops during the 2020-2021 production cycle.

MATERIALS AND METHODS

Study area. We studied seven commercial sugarcane crop subregions distributed among three sugar mills in the Córdoba-Golfo region (Table 1). We established a 59.73 linear km transect corresponding to an area of influence of 53,073 ha.

Damage percentage caused by *Diatraea* spp. larvae. We established 21 sampling sites where one hectare is an experimental unit. We counted healthy cane stems and stems perforated by borer larvae (with an entrance hole or feeding tunnels with or without frass) in a 10 linear meters transect that included the four corners and the center of each experimental unit (Flores, 2007).

We quantified the stems that showed perforations by *Diatraea* spp., those with central tunnels starting at the apex between the internodes and with accumulated residues (frass) at the entrance hole (Figure 1) (Rodríguez-del-Bosque *et al.*, 2014).

To determine the percentage of damage per hectare, we analyzed the data obtained in field counts following the equation proposed by Flores (2007).

Table 1. Location and main characteristics of the studied sites

Subregión	Coordenadas		Ingenio	Precipitación (mm^3) promedio anual	Temperatura promedio anual (°C)
	Norte	Oeste			
Potrero Nuevo 1	18.90321	96.78188	Central El Potrero	126.23	22.31
Palmillas 1	18.81905	96.77774	San José de Abajo	128.05	22.48
Paso del Macho 1	18.9467	96.75098	Central Progreso	127.08	23.36
Paso del Macho 2	19.03341	96.63239			
Paso del Macho 3	18.98595	96.70435			
Zentla	19.05551	96.72147			
La Flor	19.05536	96.71426			

CONADESUCA (2021b).

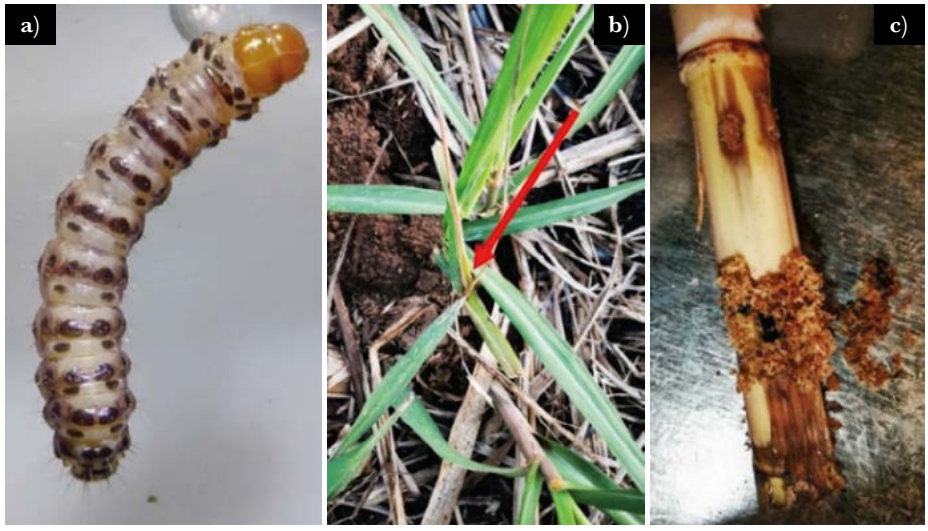

Figure 1. Damage caused by the sugarcane borer. a) *Diatraea* spp. larva; b) "death of the heart" symptom (red arrow); c) stem perforated by *Diatraea* spp., with frass. Laboratorio de Biotecnología Microbiana Aplicada, Colegio de Postgraduados, Córdoba, Veracruz, Mexico.

Economic damage level and threshold. We conducted the theoretical calculation of the economic damage level following Pedigo *et al.* (1986) (Equation 1), considering the application of chemical insecticide (Rynaxypyr®: anthranilic diamide: IRAC Group 28) as well as statistics for production costs and yields (García-Montalvo and Muñoz-Flores, 2017; Serra and Trumper, 2020; CONADESUCA, 2021b).

Equation 1:

$$EDL = C/P*D*K$$

Where: *EDL*=Economic damage level due to *Diatraea* spp., per stem; *C*=Cost of the control procedure (MXN/ha^{-1}), 1,746.75 Mexican pesos; *P*=Price per production unit (MXN/ton^{-1}), 20,537.92 Mexican pesos; *D*=Damage percentage due to *Diatraea* spp. larvae; *K*=Efficiency of the control procedure established at 16.70%.

To compare, establish, and/or modify existing economic damage thresholds, we followed the equation proposed by Trumper (2006).

Equation 2:

$$ET = \frac{EDL}{TD * \frac{(100 - M)}{100}}$$

Where: *ET*=Economic threshold; *EDL*=Economic damage level; *TD*=Number of eggs per individual (Rodríguez-del-Bosque *et al.*, 2012); *M*=Mortality exerted by control established at 16.70% (García-Montalvo and Muñoz-Flores, 2017).

RESULTS AND DISCUSSION

Damage percentage due to *Diatraea* spp. larvae. The most affected subregion was Yanga, with an average annual damage percentage of more than 5% with monthly seasonal peaks.

Damage percentage is indicative of pest incidence. However, it is not sufficient to determine the economic threshold of *Diatraea* spp. Factors such as price per unit of production and investment in control must be considered to determine the ET (Trumper, 2006).

The age of the plant, the intensity of the damage, the damaged part of the plant, the type of damage, and the environmental effects are also factors that can intensify yield losses in the field (Atencio *et al.*, 2017).

Economic damage level and threshold. The annual average ET for the Córdoba-Golfo sugarcane region is 2.76, well below the general ET of 10% (Table 2).

These results could be related to the low efficacy of the current control since management is conducted at the wrong time —when the population of *Diatraea* spp. has exceeded the ET (Solís *et al.*, 2015; Francischini *et al.*, 2019). The Yanga region showed a difference of 4.38% in regard to the estimated ET, followed by Potrero Nuevo-Paso del Macho 2, with 3.35% and 3.75% respectively. Therefore, considering that the ET for applying control strategies equals 5% and is based only on the damage percentage, this parameter is inefficient (Vázquez and Valdez, 2012; Rodríguez-del-Bosque *et al.*, 2014).

Table 2. Estimation of EDL and ET by subregions.

Región	%Daño	NDE	UE	Sobrestimación del daño
Potrero Nuevo	4.39±0.52	6.23	1.04	3.35
Yanga	5.74±0.49	8.16	1.36	4.38
Paso del Macho 1	1.82±0.61	2.58	0.43	1.39
Paso del Macho 2	4.91±0.55	6.98	1.16	3.75
Paso del Macho 3	3.18±0.69	4.51	0.75	2.43
Zentla	2.59±0.42	3.68	0.61	1.98
La Flor	2.70±0.00	3.84	0.64	2.06

The variations in ET lead to untimely management, which in turn leads to an increase in the borer population. This affects the crop yield and/or the quality of sugarcane juice and can even give rise to incidents such as epizootics in the points of origin (Molnár *et al.*, 2016). The impact of borer damage is often incorrectly estimated due to a lack of information about the pest. Consequently, the information generated in this study is an innovative proposal that focuses on the EDL by subregions and allows a precise estimation of ET (Campos *et al.*, 2016).

The damage percentage can be practically expressed in yield losses based on this assumption: "cane stalks can reach an average weight of 1.0 kg in a plot that contains approximately 70,000 stalks/ha, which totals 70 tons/ha". Based on this, if the economic threshold (ET) is 2% due to damage by sugarcane borer larvae, the loss will total 1.4 tons/ha. Considering an EDL of 5%, up to 3.5 tons/ha are lost due to the presence of borers. Therefore, in the 2020-2021 harvest, the economic loss could go from 1,400.00 to 3,500.00 pesos per hectare, bearing in mind that the price per ton of cane was 1,000.00 (one thousand pesos 00/100 M.N.).

CONCLUSIONS

Our study concluded that the EDL has been underestimated. The current ET parameters of 5% for *Diatraea* spp. are inefficient since they do not offer a realistic view of the phenomenon observed in the field, and the economic losses can surpass the range of 1,400.00 to 3,500.00 pesos per ton of sugarcane.

Our calculations allowed us to posit a theoretical ET by subregions and to identify the sites most affected by *Diatraea* spp. larvae feeding on sugarcane. These results will help to establish the bases for a targeted and successful management of *Diatraea* spp. populations.

ACKNOWLEDGEMENTS

The authors thank the Consejo Nacional de Ciencia y Tecnología for the grant awarded with registration 573170. We also thank the Colegio de Postgraduados campus Córdoba-CNPR for the project: "Análisis de los factores de la productividad en campo y en fábrica: estrategias de mejora para la agroindustria azucarera" [Analysis of productivity factors in the field and in the factory: improvement strategies for the sugar agroindustry] (PM20-3021).

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