ORIGINAL ARTICLE

Evaluation of Azutecnia Horizontal Probe in Sugarcane Sampling

Evaluación de la sonda horizontal Azutecnia en el muestreo de caña de azúcar

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ABSTRACT: Improving the sugarcane payment to the sugarcane grower, in a differentiated way, according to the quality of the raw material, demanded the design by the national industry of the AZUTECNIA Horizontal Sampling Probe, as part of the kit of equipment for that purposes. The objective of the research was to determine the fulfillment of the quality of work and the technological and exploitation indices of the probe in the sampling of sugarcane to be ground in the mill under the conditions of the Cuban sugar agroindustry. The research was carried out in the laboratory of "Panchito Gómez Toro" Agro-Industrial Sugar Company, in Villa Clara Province. The standards and evaluation procedures for agricultural machines established by the Institute of Agricultural Engineering in Cuba were taken into account. The results showed that the quality of work was satisfactory, as it complied with the sample weight of 15 kg demanded by the laboratory in cane harvested with strange matter less than 12%. The operating system with the working organ active for a short period influenced the marked decrease in the productivity of operating, productive and exploitation time, as well as the exploitation coefficients associated with them; however, there is no difficulty in guaranteeing the established 16 daily samples. It showed adequate reliability, with a technical safety coefficient greater than 70%, and average fuel costs based on the number of samples and their weight of 0.053 L/sample and 0.004 L/kg, respectively.

***Keywords*:** Sugarcane Sampling, Pay for Quality, Probe Sampler.

RESUMEN: Perfeccionar el pago de la caña de azúcar a los productores, de forma diferenciada, según la calidad de la materia prima demandó del diseñó por la industria nacional de la Sonda Horizontal Toma Muestra AZUTECNIA, formando parte del Kit de equipos para esos fines. El objetivo de la investigación consistió en determinar el cumplimiento de la calidad del trabajo, los índices tecnológicos y de explotación de la Sonda en el muestreo de caña de azúcar a moler en el ingenio en la agroindustria azucarera cubana. La investigación se desarrolló en el laboratorio de la Empresa Agroindustrial Azucarera Panchito Gómez Toro de la provincia de Villa Clara. Se tomó en cuenta las normas y procedimientos de evaluación de máquinas agrícolas establecidos por el Instituto de Ingeniería Agrícola en Cuba. Los resultados mostraron que la calidad del trabajo fue satisfactoria, al cumplir con el peso de la muestra de 15 kg demandado por el laboratorio en caña cosechada con materias extrañas inferiores al 12%. El régimen de operación con los órganos de trabajo del equipo activos por un período corto influyó en la disminución marcada de la productividad de tiempo operativo, productivo y de explotación; así como de los coeficientes de explotación asociados a estos; sin embargo, no existen dificultad para garantizar las 16 muestras diarias establecidas. Mostró una adecuada fiabilidad, con un coeficiente de seguridad técnica superior al 70%, y gastos de combustible promedios en función del número de muestras y de su peso de 0,053 L/muestra y 0,004 L/kg respectivamente.

***Palabras clave*:** muestreo de caña, pago por calidad, sonda toma muestra.

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INTRODUCTION

The harvest is one of the most important stages in the production of sugarcane according to Matos et al. (2014) and Lopez et al. (2022), so it is necessary to meet the established efficiency indicators and ensure the stable supply of clean cane to the industry with the highest quality, supported by the use of work systems that encourage and promote the effective development of the process.

The payment system for sugarcane to be ground in the mill has been a topic of analysis with the country's producers for several decades, to increase the quality of the raw material, agro-industrial efficiency and achieve fairness in payment. In this sense, methods, procedures and equipment have been established internationally to carry out a differentiated system of payment for quality, through the taking of samples and their processing in the laboratory (Estrada, 2012; Canales, 2014; Ocampo, 2015; Perdomo, 2015; Diaz, 2019; Santal, 2021; IRBI, 2022).

Taking into consideration the urgent need to begin the implementation of that system in Cuba, a kit of Brazilian origin was purchased by the current Empresa Agroindustrial Azucarera (EAA) "Jesús Rabí", in Matanzas Province, made up of a Stationary Oblique Probe, a cane stalks shredder and a hydraulic press. Later, a similar kit was incorporated in the EAA "Panchito Gómez Toro" of Villa Clara.

According to González (2020), since this payment strategy began to be applied, a better supply of cane to the mills has been achieved, in addition to reducing the gap due to varieties, strain and age, which has made it possible to cut the cane when it has more sugar content.

In general, the implementation of the system caused the favorable satisfaction of the producers, benefited the agro-industrial efficiency and the stimulation to produce with higher quality (Flores et al., 2016). However, the high cost of the equipment in the international market led to the search for alternatives based on the design of prototypes by the national industry, appropriate to the conditions and available material resources.

One of the equipment was the Sampling Probe, designed and manufactured in "Enrique Villegas" Workshops Division, belonging to AZUTECNIA Company. The probe is coupled to the tractor during the sugar harvest, and later, at the end of the harvest, it can be incorporated into other agricultural tasks without difficulty (Azutecnia, 2019). Its introduction began in the previously named "Heriberto Duquezne" Base Business Unit with satisfactory results (Machado, 2019).

The construction or acquisition of new and modern equipment requires validation for Cuban conditions according to established standards (Cruz and Vázquez, 2014; Herrera and González, 2015; Cruz, 2018; Minag-Cuba, 2018; Betancourt et al., 2019). Throughout this process, the coordination of the work and the results are carried out with the Agricultural Engineering Research Institute (IAgric), as it is the leading center of this activity in the country.

The application of the Procedure for the Introduction of Agricultural Mechanization, Irrigation and Drainage Technologies in Cuba, focuses on obtaining the following results: ensuring that the technologies meet the technical and environmental requirements before being introduced into Cuban agricultural production, timely availability of the necessary technical information for decision-making regarding the acquisition of agricultural technologies, anticipating possible effects on the internal of the national economy and anticipating the sustainability of the technologies introduced in the import process (Minag-Cuba, 2018).

The objective of the research was to determine compliance with the quality of the work, the technological and exploitation indices of AZUTECNIA Horizontal Probe in the sampling of sugarcane for the Quality Payment System.

MATERIALS AND METHODS

AZUTECNIA Sample Collection Probe was designed to be coupled to light tractors with an engine power of 56 to 80 hp, especially the Yumz-6 brand (Figure 1a and b). The parts and pieces that make up the probe are presented in Figure 2 (Azutecnia, 2019).

The research was carried out at EAA "Panchito Gómez Toro". The characterization of the research conditions followed the provisions of the Normative Operational Procedure PG-CA-042 (2013) and the following parameters were determined:

- Length and diameter of the cane pieces (mm). A 5 m tape measure with appreciation level of 1 mm and a Vernier caliper of 0.1 mm appreciation, respectively, were used.
- Strange matter (ME) (%). It was determined by separating cane stems from leaves, buds, earth, stones, sticks, among others, in the samples obtained with the probe. The result was expressed as a percentage of weight of the stems with respect to the total weight of the sample.

The determination of the quality of the work considered the following parameters:

1. Mass of the sample released by the dumper (kg): Mass displaced by the dumper and collected in the vessel without the manual action of the auxiliary worker.
2. Mass of the sample left inside the probe (kg): Mass of the material left inside the probe and removed manually by the auxiliary worker.

FIGURE 1. Sampling probe (a) and basket (b) coupled to the Yum-6 tractor.

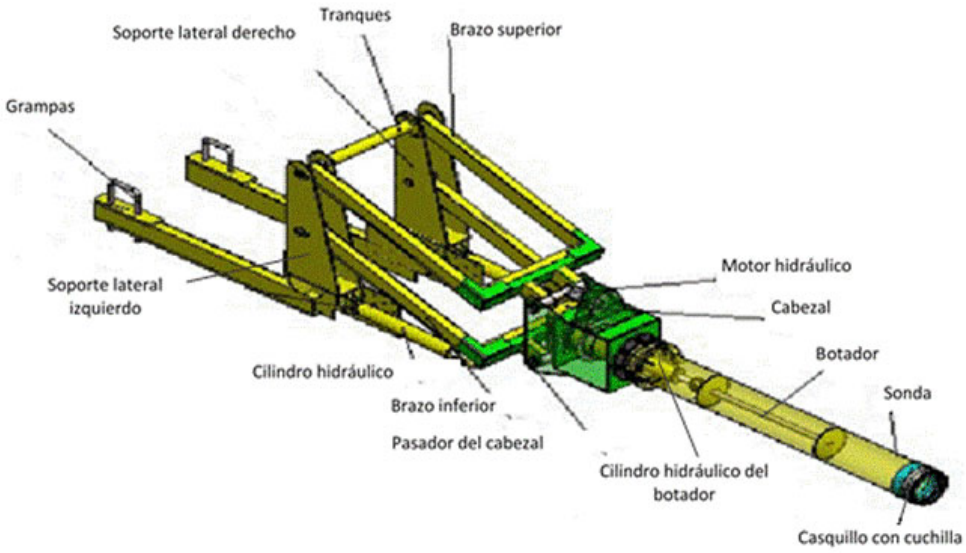

FIGURE 2. Main parts of the sampling probe, not including the basket. Source: Azutecnia (2019).

3. Total mass of the sample (kg): Sum of the masses of the sample released by the plunger and collected manually.
4. Mass of the spilled cane (kg): Mass of the cane fallen from the means of transport through the entrance or exit of the probe, or spilled from inside the probe.

In all cases, a 1g appreciation digital scale was used to determine the mass of the samples.

The influence of the harvest-transport system on the sample mass of cane stems taken by the Horizontal Sampling Probe was determined from the effect of the content of foreign matter on the sample mass taken by the probe. The system composed by the CASE A8800 series combine and the transport with Sinotruck (20t) and 20t trailers was evaluated, compared to that of the combined KTP 2M and the Zil 130 (6 t) with 6 t trailers.

The exploitation indices were evaluated according to what is established in the Normative Operational Procedure PG-CA-043 (2013). For a penetration depth of 1.30 m and a rotation speed of 155.00 rpm in the probe, the following indicators were determined:

1. Time in taking the sample (s). By means of a digital chronometer of 1s appreciation, the time in the operations of the working day was determined.
2. Productivity rates (kg/minutes): Productivity in clean, operational, productive and exploitation times. In addition, the operating coefficients for technical maintenance, technical safety, use of productive time and use of operating time.
3. Determination of fuel consumption. The measurement was made with a Flowmeter of 1mL appreciation. It did not include that required for the transfer of the equipment from the parking lot to the work area or vice versa, however, it did take into account the movement from the parking area to the cane transportation means. Fuel expenditure was determined based on the number of samples (L/sample) and the weight of the sample (L/kg).

The size of the sample of the variables under study and the data obtained in the different investigations was automatically processed using the statistical package STATGRAPHICS plus 5.1. The t-Students test for an independent sample was used as a criterion to estimate the differences between the means of the samples, at a 95% probability, in determining the weight of the sample based on the harvest-transport equipment used.

RESULTS AND DISCUSSION

The characterization of the harvested cane showed that the diameter of the piece corresponds to the values reported by Mesa et al. (2016) for the varieties of Cuba, with an average of 24 mm (Table 1). The average length of 163 mm is related to the dimensions reported by Placeres (2015) in the mechanized harvest for direct shot to the central tipper.

The evaluation of the quality of the work showed an average mass of the sample 1.31 kg lower than that recommended for processing in the laboratory (15 kg) (Table 2), according to Instruction No. 3 of the Sugar Mill "Panchito Gómez Toro" (2019), which was associated with the high percentage of foreign matter (15%) and the harvest medium used.

The mass of the sample remaining in the probe, after the material was discharged, represented 12% of the total value of the sample, due to the fact that the plunger did not reach the end of the probe, remaining 15 cm away from the tip of the blade (Figure 3a). The cane remaining inside the tube was extracted manually (Figure 3b).

The results obtained also show the possibilities offered by the use of the horizontal probe in the determination of the content of strange matter, which is one of the indicators of efficiency in the harvest of sugarcane according to Matos et al. (2014) and the variables to consider in the payment system to the sugarcane producer.

The evaluation of the effect of the harvest-transport equipment on the quality of the work of the probe showed significant differences in 7.23 kg in the variant with CASE 8800 and Sinotruck (20 t) with 20 t Trailer with respect to the KTP 2M and the ZIL130 (6 t) with the 6 t trailer, at the 95% confidence level (Table 3). The strange matter obtained in the

TABLE 1. Characterization of the cane piece

Parameter	Mean*, mm	Standard deviation, mm	Coefficient of variation, %
Diameter	24,07	4,56	18,93
Length	163,46	31,56	19,31
		*n=21	

TABLE 2. Evaluation of the parameters associated with the sampling

Parameter	Mean *	Standard deviation	Coefficient of variation, %
Mass of the sample released by the dumper , kg	12,09	4,61	38,09
Mass of the cane left in the probe , kg	1,60	0,79	49,48
Total sample mass , kg	13,69	4,81	35,08
Mass of cane spilled, kg	5,11	2,41	47,26
Strange matter , %	15,07	5,29	35,09
	*n=21		

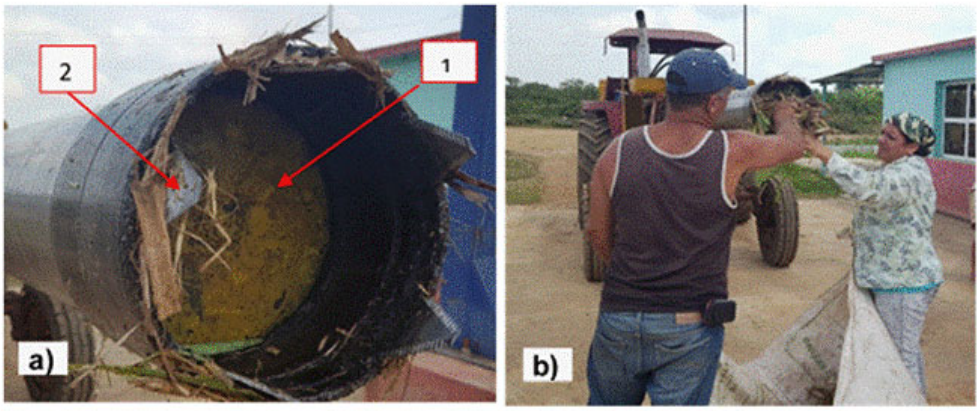

FIGURE 3. Position of the dumper (1) with respect to the end of the blades (2) (a) and conclusion of the manual extraction of the cane (b).

CASE combines was between 10 and 12% and in the KTP between 15 and 20%.

The harvest of cane left and lodged shoots influenced the high percentage of strange matter. However, the particularities of the technological process of the CASE harvesters that cut the cane into smaller pieces, together with the use of extractors, achieved greater efficiency in cleaning the cane compared to the KTP harvesters, coinciding with what Placeres (2015) stated.

For conditions where the harvested cane has a high content of strange matter, greater than 12%, and the established weight is not met, it is recommended to carry out several samples in the transport means until the established mass is completed.

The Probe showed a clean time productivity of 15.15 kg/minute (Table 4). However, the work regime with the organs of the equipment active for a short period, with respect to the total in which the sample is taken, determined that the remaining productivity indices of operative, productive and exploitation times were much lower with respect to the clean time, in 29, 21 and 15%, respectively. However, in practice, 16 daily samples were established by AZCUBA Business Group (2018), for which the Probe easily meets the demand for a working day.

The equipment achieved a technical safety coefficient of over 70%. The fundamental problem was found in the breakage of the blades of the cap, mainly caused by the inadequate dimensioning of the hole to take the sample in the transport means, which is why it is considered strange to the machine. However, it should be noted that there were no spare parts to replace the cap, despite being a fast-wearing component. Another problem of less incidence was the leaks in the hoses of the hydraulic system. In general, it is considered that the Sampling Probe presented adequate reliability. On the other hand, the coefficients of use of productive time and exploitation time are low as a result of the equipment work regime explained above.

Fuel costs based on the number and weight of the sample are low (Table 5), with an average of 0.053 L/sample and 0.004 L/kg, respectively; which was due to the discontinuous regime and the short time of operation with the motor running in the sampling.

In general, the use of the Horizontal Probe in the Sugar Agroindustry of other countries such as Guatemala, Costa Rica and Brazil has also provided satisfactory results in the sampling of sugarcane to evaluate the quality of the raw material that goes to the industry differentiated by producer (Estrada, 2012; Canales, 2014; IRBI, 2022).

CONCLUSIONS

The evaluation of the AZUTECNIA Horizontal Probe in the sampling of sugarcane for the Quality Payment System showed:

- Satisfactory quality of work, by complying with the 15 kg for analysis in laboratories in cane harvested with strange matter less than 12%.

TABLE 3. Mass of the sample depending on the transport harvest system

Variant	Mass*, kg	Standard error	Value P
CASE 8800 and Sinotruck (20t)+Remolque (20t)	18,69a	±1,15	0,0011
KTP 2M and ZIL130(10t)+Remolque 10t	11,46b	±1,27	

*$n=7$

TABLE 4. Probe operation indicators

Parameter	Value
Productivity in clean time, kg/minutes	15,15
Productivity in operating time, kg/minutes	4,33
Productivity in productive time, kg/minutes	3,10
Productivity in exploitation time, kg/minutes	2,21
Technical maintenance coefficient	0,97
Technical safety factor	0,74
Productive time utilization ratio	0,20
Operating time utilization ratio	0,10

TABLE 5. Determination of fuel cost

Parameter	UM	Mean *	Standard deviation	Coefficient of variation, %
Fuel cost per sample	L/sample	0,053	0,019	35,951
Fuel cost per sample weight	L/kg	0,004	0,002	39,717

*$n=9$

- Productivity in clean time of 15 kg/minute, satisfactorily fulfilling the 16 daily samples established for the laboratory.
- Decrease in the productivity of operating, productive and exploitation time with respect to clean time by 29, 21 and 15%, respectively; as well as the exploitation coefficients associated with these due to the operating regime with the active work organs for a short period.
- Technical safety coefficient greater than 70%, which showed adequate reliability, being necessary to make available to the customer spare parts such as the cap with blades.
- Average fuel costs based on the number of samples taken and their weight of 0.053 L/sample and 0.004 L/kg, respectively.

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