ORIGINAL ARTICLE

Affectations Caused to Mechanized Harvest by Weeds of Woody Consistency

Afectaciones causadas a la cosecha mecanizada por malezas de consistencia leñosa

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ABSTRACT: Weeds cause severe damage to crops with large economic losses. In Cuba, in the latter, a group of woody weeds have invaded agro-ecosystems, mainly those linked to sugarcane activity, as a consequence of inadequate crop management. The present work was carried out with the objective of determining the effects caused to the mechanized harvest by the species *A. procera*, of woody consistency, in "Eulalio García" Sugarcane Production Farm, in Mayabeque Province in western Cuba. Blocks and fields were selected in which strips formed by 10 furrows were established, spaced at 1.6 m, which were consecutively numbered for random selection in the sample formation process, which was constituted with 30% of the fringes formed in each field. The time lost due to the obstruction of the weeds was evaluated by measuring the time elapsed from the moment the cutting activity was interrupted by the appearance of the obstacle until its restart once it had been overcome. Statistical processing included the calculation of central tendency and dispersion statistics and analysis of variance. Significant differences were found in the number of obstacles between fields and strips due to the heterogeneous distribution of plants in the area. The average time used to clear the obstacles was 26 seconds and the total time in the entire test was 0.29 hours.

Keywords: Lost Time, Fuel Consumption, KTP-2M Harvester, Sugarcane.

RESUMEN: Las malezas causan severas afectaciones en los cultivos con cuantiosas pérdidas económicas. En Cuba en los últimos años varias especies de malezas de consistencia leñosas han invadido los agro-ecosistemas, principalmente los vinculados a la actividad cañera, como consecuencia del inadecuado manejo del cultivo. Es por ello que se realizó el presente trabajo con el objetivo de determinar las afectaciones causadas a la cosecha mecanizada por la especie *A. procera*, de consistencia leñosa, en la unidad productora de caña Eulalio García, en la provincia Mayabeque en el occidente de Cuba. Se seleccionaron bloques y campos en los que se establecieron franjas formadas por 10 surcos, espaciados a 1,6 m, las que fueron enumeradas consecutivamente para su selección al azar en el proceso de formación de la muestra, la que se constituyó con el 30% de las franjas constituidas en cada campo. Se evaluó el tiempo perdido por obstrucción de las malezas mediante la medición del tiempo transcurrido desde el momento de la interrupción de la actividad de corte por la aparición del obstáculo hasta su reinicio una vez superado este. El procesamiento estadístico contempló el cálculo de los estadígrafos de tendencia central y de dispersión y análisis de varianza. Se encontraron diferencias significativas en el número de obstáculos entre los campos y franjas debido a la heterogénea distribución de las plantas en el área. El tiempo promedio empleado en salvar un obstáculo fue de 26 segundos y el tiempo total en toda la prueba fue de 0,29 horas.

Palabras clave: Tiempo perdido, consumo de combustible, cosechadora KTP-2M, caña de azúcar.

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INTRODUCTION

Sugarcane yields are seriously affected by competition of weeds to a greater extent than by pests and diseases, which is why they are the main scourge of cane fields, where the slightest carelessness in the constancy of their control can cause the elimination of the crop (Barrera *et al.*, 2020). In Cuba, several species of woody weeds associated to sugarcane are distinguished, among which *Albizia procera* (Roxb.) Benth, *Dichrostachys cinérea* L. and *Leucaena leucocephala* (Lam.) are found (Martínez *et al.*, 2018).

These species have invaded the agriculture-ecosystems linked to the sugarcane activity as a consequence of the inadequate management of the crop, in which they cause considerable economic losses. Likewise, they can remodel, modify and change the natural landscape that surrounds them. Population of weeds causes a wide range of losses. The competition for soil nutrients, water and light at early stage of sugarcane developments results in reduced growth and sugar yield (Chauhan & Srivastava, 2002; Ross & Fillols, 2017; Epee, 2018).

A chopper harvester includes a mechanism to chop stalks into uniform-sized pieces to simplify cane handling operation. Sugarcane topping and base cutting are followed by chopping stalks into 30 to 40 cm long cuttings. The harvest system is completed with a transport unit running alongside the harvester loading the cuttings thrown by the harvester (Ma *et al.*, 2014).

In Cuba, a high percent of sugarcane plantations are harvested mechanically with different models of chopper harvesters whose productivity, according to various researches, is affected by several factors, among which the inadequate conditions of the fields highlight (Castillo *et al.*, 2021). The efficiency of sugarcane harvesters depends on the effective working time, which is affected by the time lost in the turns at the end and head of the fields (Suárez *et al.*, 2006; Daquinta *et al.*, 2014; De la Rosa *et al.*, 2014; Ma *et al.*, 2018; Castillo *et al.*, 2021). The time lost during overcoming of obstacles due to obstruction of weed also influences negatively the efficiency of the harvester.

However, they are very few researches carried out with the objective of determining the effects on the throughput capacity of sugarcane harvesters, of the obstruction by woody weeds as a consequence of the depopulation and the execution of inadequate control methods.

This paper was carried out with the objective of determining the affectations in the execution of the mechanized harvesting caused by the presence in the fields of weeds species of woody consistency.

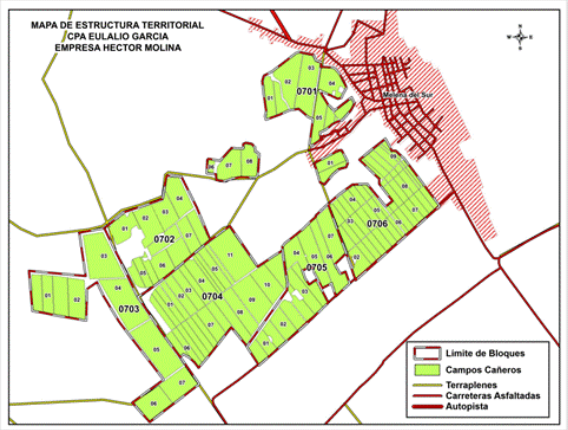

FIGURE 1. Map of territorial structure of "Eulalio García" Sugarcane Production Farm.

MATERIAL AND METHODS

This research was carried out in "Eulalio García" Sugarcane Production Farm (Figure 1), in areas of "Héctor Molina Riaño" Mill, Mayabeque Province, western of Cuba, in calcium Ferralitized soils (Arcia *et al.*, 2014), with plants ready for the first cutting, in non-irrigated soil.

The sample for the execution of the work was formed from the filtering of the database generated by the weeds surveys carried out field by field, by the Service of Weeds Integral Control of the Sugarcane Research National Institute. The condition for filtering was the existence of at least one of the three most frequent woody weeds in Cuba according to Martínez *et al.* (2018).

Next, by means of simple random sampling, the block, fields and strips were selected, taking as criterion 30% of the strips, which were made up of 10 furrows in each field.

Finally, the sample was constituted by the block 703, with 64.9% of infestation of *A. procera*, the field 03 (13.9 ha) with the strips 2, 3 and 6 and field 05 (14.9 ha) with the strips 4, 7 and 10.

Variables Evaluated and Evaluation Method

The effective working time was determined by means of the equation.ç

$$Te = \frac{Lc}{v} \quad (1)$$

where:

Te - effective working time (h);
Lc -length to harvest for the task (km);
v -*advance* speed (km h^{-1}).

$$Lc = Tac\left(\frac{6250}{1000}\right) \quad (2)$$

Tac -total area to be harvested (ha).

The following values and considerations were established:

a. Planting frame: 1,6 m (for which 6 250 m of furrow per hectare correspond).
b. *Tc*: 100 t (the productivity assigned to these harvesters).
c. *Ra*: 30 t/ha (crop yield estimate).
d. *v*: 5 km/h (according to Castillo *et al.* (2021)).

$$Tac = \frac{Tc}{Ra} \quad (3)$$

Tc -cutting task (t).

The time lost in cutting task, due to time lost overcoming obstacles, was determined from the result of the measurements of turning time for overcoming obstacles by means of the stopwatch method.

$$Tp = \frac{Lc * 1000}{L_{fc}} * Tloo \quad (4)$$

where:

Tp -time lost in cutting task (h);
Tloo - time lost overcoming obstacles (h);
L_{fc} - length of the cutting front (m).

The time necessary to carry out the cutting task is the sum of the effective working time and the time lost in the cutting task.

Fuel consumption (*Cc*): it was determined from equation 5.

$$Cc = Te + Tp \cdot \frac{Ch}{Tc} \quad (5)$$

where:

Ch: Hourly fuel consumption (23.65 L/h according to Castillo *et al.* (2021)).

Previously to the execution of the work, it was verified the appropriate qualification and skills of the operative and service personnel, as well as the pertinent regulations were made to the machines to guarantee an optimal operating regime and compliance with the agrotechnical requirements as established by the standard NC 34-37:2003 for the technological evaluation and of operation of agricultural and forest machines.

The processing of the obtained information included the calculation of the statistics of central tendency and dispersion. Simple variance analysis was also performed at 0.05 probability of error.

FIGURE 2. Obstacles of *A. procera.*

RESULTS AND DISCUSSION

The number of obstacles found varied significantly from one field to another and among the fringes of the same field (Table 1), due to the heterogeneous distribution of plants in the area, which coincides with that reported by several researchers. Weeds do not have a homogeneous distribution throughout the surface of the field, they appear irregularly, forming irregular "spots", which originates areas with high density and others with low or zero population levels (Cardina *et al.*, 1995; Fernandez & Barroso, 2001).

The average time used to overcome the obstacles formed by woody weeds was 26 s, with variations between the fields and among the fringes of 24.2 at 28.2 s; even though the most frequent value of all observations was of 29 s. The total time during the test was of 1040 s, just over a quarter of one hour, with differences between the two fields, with 598 s in the field 03 and 442 s in the field 05, corresponding with the number of obstacles encountered (Table 1).

This behavior of the statistic parameters evaluated is explained by the different infestation of *A. procera* in one field and the other and the different magnitude reached by the obstacles formed by the presence of this species in the furrow, which sometimes are formed by a single plant and others by several of them, to which is added the fact that some appear in successively form or at very short distance from one another (Figure 2).

TABLE 1. Number of obstacles and time spent overcoming them

Field	Fringe	Number obstacles	Time spent (s)	Mean	Mode	Variance	Standard Deviation	Variation Coefficient
03	2	12	317	26,4	29	23.3561	4.8328	0.1829
	3	4	106	26.5	28	5.6667	2.3805	0.0898
	6	7	175	25.0	22	15.6667	3.9581	0.1583
05	4	9	218	24.2	21	14.4444	3.8006	0.1569
	7	5	141	28.2	30	12.2000	3.4928	0.1239
	10	3	83	27.7	26	8.3333	2.8868	0.1043
			1040	26.0	29	15.8974	3.9872	0.1534

TABLE 2. Time lost and fuel consumption

Field	Fringe	*TTc* (h)	*Te* (h)	*Tp* (h)	*Cc* (L/h)	*Cclt* (L/h)	%
03	2	7.91	4.17	3.74	1.87	0.89	47.3
	3	5.42	4.17	1.25	1.28	0.30	23.1
	6	6.23	4.17	2.07	1.47	0.49	33.2
Subtotal		19.56	12.50	7.06	4.63	1.67	36.1
05	4	6.27	4.17	2.10	1.59	0.61	38.2
	7	5.53	4.17	1.36	1.38	0.39	28.6
	10	4.97	4.17	0.80	1.22	0.23	19.0
Subtotal		16.76	12.50	4.26	4.19	1.23	29.5
Total		36.33	25.00	11.33	8.82	2.90	32.9
Average		18.16	12.50	5.66	4.41	1.45	32.9

Table 2 shows the results of the time loss and fuel consumption due to *A. procera* infestation in the evaluated fields. The loss of time during the entire test was of 11.33 h; greater in field 03 with 7.06 h and variation of 1.25 to 3.74 h due to greater infestation of woody weeds. Fuel consumption (*Cc*) and fuel consumption in the lost time (*Cclt*) of throughout test were 8.82 and 2.90 L, respectively, much higher in field 03 in correspondence with the previous result. Fuel consumption in the lost time represented 32.9% of the total spent to carry out the cutting task.

These results demonstrate that the presence of woody causes an increase of the traffic intensity within the sugarcane fields and time losses of the harvesters, due to the need to move to the adjacent furrow, together with the means of transport, for overcoming the obstacles of woody weeds, which harms the field, due to the compaction it produces, and it is negative for the harvest efficiency by causing an increase of fuel consumption and non-compliance with the norm for that requirement.

These results also contribute to the knowledge of other factors that affect the harvester's effectiveness. The length of the cutting front and yield, headland turning time and the un-harvest moving and unloading time increases in total time and cause decreasing in the efficiency of the mechanized harvest (Doungpueng *et al.*, 2019; Castillo *et al.*, 2021).

One of the most expenses in each agricultural production systems is machinery cost, decreasing efficiency of farm machinery can affect production costs. Among farm operations, sugarcane harvesting is one of the most important because of its high volume of work (Omrani *et al.*, 2013). This explain why is so important to control the weeds searching for more efficiency in harvesting and sugarcane yield.

The present work constitutes a first approach on the knowledge of economic losses caused by woody-consistency weeds in sugarcane cultivation. According to Martínez *et al.* (2018), in Cuba, there are 144 161.5 ha of sugarcane with woody weeds, of them 80 631.2 ha (15.0%) by *A. procera*, 34 015.6 ha (6.3%) by *D. cinerea* and 29 468.8 ha (5.5%) by *L. leucocephala*. In future works, it will be necessary to make a more exhaustive evaluation that allows determining the economic affectations of these species in other processes related with the production of sugarcane.

CONCLUSIONS

The presence of woody weeds species in sugarcane fields causes losses of time to the harvesters, causing an reduction in their efficiency due to non-compliance of the cutting task and by increment of the fuel consumption.

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