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Visible Losses in Mechanized Harvesting of Sugarcane Using the Case IH A4000 Harvester

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Abstract

Sugarcane is a major Brazilian agricultural product. The area cultivated in the state of Rio de Janeiro for the 2011-12 crop was of 41.31 thousand hectares. The process of mechanized harvesting of the crop still has many visible losses of raw materials caused by several factors. This study aimed at evaluating the visible losses of sugarcane and ratoon damage using the Case A4000 harvester and was conducted in the municipality of Campos dos Goytacazes, in the state of Rio de Janeiro, Brazil. The materials left on the field by the harvester were collected in six ratoon cane rows, with a length of 350 m, setting the frame sampling to every 50 m. The sampling area consisted of 20 m², with eight repetitions. The losses were calculated in t·ha⁻¹ and in %. The comparison of averages was performed by using the confidence interval, constructed by statistical "t" at 5% probability to compare the types of losses. The estimated productivity of the area was of 54 t·ha⁻¹. The differences between the types of losses were significant. The billets and splinters were found in greater quantity.

Keywords

Saccharum spp., Green Cane, Mechanized Harvesting

1. Introduction

Brazil is the greatest sugarcane producer in the world. In the northern region of the state of Rio de Janeiro, this

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crop is the main agricultural product, and Campos dos Goytacazes is the city with its greatest production.

Sugarcane is a raw material for producing sugar, which is the basis of human feeding and an important agricultural commodity, remaining one of the main cropped cultures in the world, which is why it is widely studied. Besides, one of the major discussions concerns the environmental impacts caused by its cultivation [1].

In the operating cycle generated by sugarcane, cropping can be considered one the most important steps, because the quality of the product delivered to the producing plants depends on it [2]. Even though the mechanized cropping of sugarcane exists since the 1970s, it was only after the 1990s, and more effectively in the new century, that it became a part of the mechanized system of producing plants, mainly due to the need of reducing costs and meeting current social and environmental demands [1].

The mechanized cropping of sugarcane is each time more present in the Brazilian production systems. In the mechanized harvesting system without burnings, the leaves, the sheaths, and the pointers, besides the varying amount of thatches, are cropped, grinded and thrown over the soil surface, forming a permanent vegetal cover (mulch) called straw [1].

In Campos dos Goytacazes, during the 2011-12 harvesting, 25% of the crop was performed by machinery, with no burnings in the cane field. The objective of the producers is to double this figure by 2013 [3]. The areas that use mechanized harvesting are mainly located in places where there is an adequate topography and/or that present problems related to labor shortages.

However, the mechanized harvest of sugarcane still presents many losses, particularly in the process involving the raw cane, in which the field is not burnt to carry out a pre-cleaning session to these vegetables. This is due to the greater vegetal mass, which will be processed by the harvester, increasing the levels of losses and impurities [4].

These losses can be divided in two groups: the visible and the invisible ones. According to [5] the losses are visible when they can be visually detected and when they represent the industrially possible mass, *i.e.*, the content of sugar that remains in the field after the passage of the harvester. It is also mainly constituted by whole canes, billets and stumps resulted from the height of the basal cut.

The losses in the process of mechanized harvesting can be quantified by the demarcation of an area in the field, right after the harvesting, by collecting the thatches, whether they are whole or fractioned, billets and fractions of billets and stumps resulted from the deficient setting of the basal cutting height. After the harvesting, the material must be weighted and related to the demarcated area, so that the losses can be measured by area.

This study aimed to evaluate the visible losses and the damages caused to the ratoons in the mechanized harvesting of raw sugarcane by using the Case A4000 harvester in northern Rio de Janeiro.

2. Materials and Methods

This experiment was carried out in July 2012 in a sugar cane field systematically prepared for mechanized harvesting. The area belongs to a supplier from Coagro ("Agroindustrial Cooperative of the State of Rio de Janeiro, Ltd."), in the municipality of Campos dos Goytacazes, northern Rio de Janeiro. The geographical coordinates were: 21˚47'50"S and 41˚20'02"W. In this area, a sample area of 1800 m^2 was chosen to perform the mechanized harvest and to measure the physical soil variables. The local soil is classified as a typically eutrophic Haplic Cambisol Tb, with a clayey texture [6].

The climate of Campos dos Goytacazes is classified as Aw, according to Köppen, which means warm and wet with a rainy season on summer, presenting and average temperature of 23.2˚C. July is the coolest month (average temperature of 20.1˚C), and February is the warmest (average temperature of 26˚C).

The harvester used in this study was the Case IH A4000 model (**Figure 1**), manufactured in 2009.

The sugarcane, RB7515 variety on its third cutting, was harvested while raw with no previous burning in the daytime. The characterization of the sugar field was done before the harvesting, since this condition influences the operational performance of the used machine. This characterization was made according to the methodology by [7]: medium length and thatch diameter, soil moisture level, soil gradation and soil textural type; age and crop degree of ripeness and estimated productivity.

To evaluate the visible losses, the wastes of sugar cane left on the field after the harvest of six ratoon row were collected (with a length of 350 meters each), while setting the sampling frame for the two central rows to every 50 m, dividing the borders by 40 m, with eight repetitions. Each sample repetition was delimited to 2 m width and 10 m length, accounting for 20 m^2. With this data, the losses were calculated in t·ha^{-1} and in percen-

Figure 1. Harvester Case IH A4000.

tage of losses.

The visible losses of the evaluated sugarcane were divided into billet, whole cane, top cane, fixed piece, loose piece, splinter, shrapnel, stump and total losses. These losses were collected and separated, and their masses were measured according to the classification proposed by [8], according to **Table 1**.

The visible losses were converted in tons per hectare, following Equation (1):

$$P = \frac{m}{a} 10 \qquad (1)$$

P: visible losses, t·ha^{-1}; m: collected mass in the area, kg; a: sample area, m^2.

For the total losses, the value was calculated in percentage, following the Equation (2):

$$P\% = \frac{P}{P + prod} 100 \qquad (2)$$

P% = total losses, %; prod = cane field productivity, t·ha^{-1}.

The results were analyzed by descriptive statistic, which enabled a behavioral view in general, assuming the independence of the data and disregarding the influence of the sample place and the relative positions. The measures of position, arithmetician average and median, measures of variation, amplitude, standard deviation and coefficients of variation were taken into account. Aiming to compare the types of losses, the confidence interval of means was established, built by the statistic "t" at a 5% probability, by using the SAEG software. It is on the confidence interval where the true population average is expected to be, with a probability of 95%. Thus, since there are no overlaps of the CIs, there was a significant difference among the average of losses.

To evaluate the damages caused to the ratoons, the visual methodology used by [9] and adapted by [10] was implemented, as seen in **Figure 2**. Fifty ratoons were randomly chosen for a sample area of 1800 m^2. The percentage of the damages and the mode of the data were calculated, which represents the level of damage found in greater scale.

3. Results and Discussion

The characteristics of the assessed sugar cane field and soil area are in **Table 2** and **Table 3**, respectively.

The estimated productivity of the farming was 54 t·ha^{-1} (**Table 2**), considered low productivity. According [11], in the North Fluminense, most expressive region of the state in the production of sugarcane, especially in the municipality of Campos dos Goytacazes, culture is still the main agricultural activity, but with productivity average below 50 t·ha^{-1}. The average length and diameter of the thatches was 1.5 m and 20.3 mm respectively (**Table 2**).

The moisture content of the soil at the two layers was high, above 40% (**Table 3**). The soil texture class of the soil is clay. May conclude that the harvesting has been realized in a poor condition of soil moisture for this texture class, may cause compaction of this soil.

Table 1. Description of the types of loss.

Billets	Fraction of the thatch with the characteristic cut of the machete in both extremities.
Whole cane	Fraction of cane with size equal to or greater than 2/3 of the total length, attached to the soil by its roots or not.
Top	Fraction of the thatch left in the soil and attached to the pointer.
Fixed piece	Medium cane segment (greater than 0.2 m) that is necessarily attached to the soil.
Loose piece	Medium cane segment (greater than 0.2 m) that is necessarily not attached to the soil.
Splinter	Segmented fraction of the billet.
Shrapnel	Lacerated cane fragments.
Stump	Fraction of the thatch cut above the soil, attached to the roots, with length smaller than or equal to 0.2 m.
Total losses	Sum of every loss.

Source: [8].

Table 2. Characteristics of the assessed sugar cane field.

Characteristics of the culture	
Estimated productivity of the farming (t·ha^{-1})	54
Average length of the thatches (m)	1.5
Average diameter of the thatches (mm)	20.3
Degree of ripeness of the farming (%)	Brix: 19.5; purity: 78.7; fiber: 19.1

Table 3. Characteristics of the assessed soil area.

Characteristics of the soil	
Moisture content of the soil (0 - 10 cm)	41%
Moisture content of the soil (10 - 20 cm)	44%
Soil texture class	Clay

CLASSIFICAÇÃO DOS DANOS	GRAU	LIMITE INFERIOR	LIMITE SUPERIOR
SEM DANOS	1		
DANOS PÉRIFERICOS	2		
RACHADURA	3		
FRAGMENTADO	4		

Figure 2. Methodology used to classify the damages to the ratoons according to [9] and adapted by [10].

3.1. Visible Losses of Raw Material

The differences between the types of losses are in **Table 4**.

The differences between the types of losses were significant at 5% probability; the billets were found in greater numbers, corresponding to 45% of the total losses. The whole cane and fixed piece losses were not found

Table 4. Descriptive statistics of the types of losses.

Losses	Average (t·ha^{-1})	% of types of losses	Median measure (t·ha^{-1})	APT	DP	CV %	IC
Billets	0.84 a	45.14	0.81	1.21	0.37	44.3	0.30
Top cane	0.27 b	14.59	0.15	0.80	0.28	105.5	0.24
Loose piece	0.30 b	16.04	0.21	0.95	0.29	100.7	0.21
Splinters	0.36 b	19.19	0.35	0.45	0.15	42.3	0.13
Shrapnel	0.05 b	2.43	0.045	0.08	0.02	52.9	0.02
Stump	0.05 b	2.79	0.02	0.24	0.08	155.2	0.07
Total losses	1.85	100.00	1.97	1.25	0.45	24.5	0.38

Averages followed by different letters differ from the confidence interval built on "t" statistic at 5% probability. APT = amplitude; DP = standard deviation; CV = variation coefficient; IC = confidence interval.

during this study. In terms of total losses, the percentage splinter loss comes second, corresponding to almost 20% of the total losses (**Table 4**).

Billet losses are likely to occur due to human error [12]. This loss is directly related to the lack of synchronization between the harvester and the cargo truck, since the billet is a fraction of the thatch with a specific cut. This part should be in the transshipment, but it was thrown to the floor and, consequently, lost. This means that the operators of the truck and of the harvester need more training sessions in order to minimize the absence of synchronization and the billet losses.

[13] aimed at quantifying visible losses in the mechanized harvest of sugarcane in Lambari D'Oeste/MT. Using the John Deere 3520 harvester, it was possible to find billets in greater quantity. On the other hand, [12] found billet losses to be in lower quantity, contrary to what appears in this study.

Sugarcane harvesting in chippers that cut fractions smaller than the desired sizes, along with the speed of the exhaust fans, mince the fragments of the thatch [12]. The splinter loss, which is basically a sett suctioned by the airflow and minced due to the shock with the extractor paddles, is directly influenced by the primary extractor rotation. As the extractor rotation rises, the setts are absorbed with the cane straw and the dirt. When the setts pass through the exhaust fans, they turn into splinters [14]. [15] evaluated the level of visible losses in mechanized harvesting of sugarcane using the Cameco CHT 2500 harvester in São Paulo and found splinter losses in greater numbers.

The average of total losses was of 1.85 t/ha, which corresponds to 3.4% of the total losses in the monitored area (**Table 4**).

According to [14], values of losses between 2.5% and 4.5% are classified as the average loss. Some authors found total losses classified as high, such as [12] [16]-[18]. Respectively, they found total losses of 4.7%, 4.96%, 9.3%, and 12.5% in their research projects.

Even though the value of losses in this research is classified as average, the ideal would be a value lower than 2.5%, which is classified as low. However, the mechanized harvesting of sugar cane in Campos dos Goytacazes became more common in the past five years; therefore, the average values are considered good for the region. This value found in the research can be justified by the systematization of the terrain for the mechanized harvesting, by the homogeneous fields in the planting distance, by the non-existence or almost non-existence of gaps insid e the same field, in addition to the appropriate planting distance of the mechanized harvesting (1.5 m). In order to achieve good harvesting results, it is important to suit the systematization of the terrain to the mechanized harvesting. A crop with acceptable level of losses starts in the planting and in the preparation of the ground for a mechanized harvesting.

3.2. Degree of Damage to the Ratoon

By calculating the mode, it is possible to realize that this measure of central tendency is represented by Degree 2 (peripheral damage), since the observed quantity of this degree was the highest among the four degrees, followed by Degrees 3 (cracking), 4 (fragmented), and 1 (no damage), as presented in **Table 5**.

In **Figure 3**, it is seen that Degree 2 is found in greater numbers, corresponding to a total of 49% of the studied ratoons. It is followed by Degrees 3, 4 and 1, respectively corresponding to 27%, 14%, and 10% of the ratoons.

Table 5. Amount of damage found in the ratoons.

Degree of damage	Amount found
1—No damage	4
2—Peripheral damage	20
3—Cracking	11
4—Fragmented	6
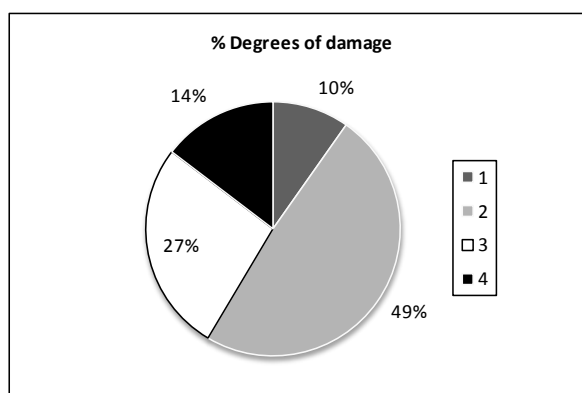
Figure 3. Degrees of damage percentage.

Similarly, [19] found Degree 1 (no damage) in lower quantity and Degree 2 in higher quantity, respectively corresponding to 10% and 42% of the ratoons studied by the author with the Case A8800 harvester in Campos dos Goytacazes/RJ.

That means that the type of damage found in greater quantity was of peripheral damages, while the degree of no damage was found in lower quantity, in only 10% of the ratoons. The damage caused to the ratoon influences the sprouting capacity. The greater the damage is, the bigger is the probability of plague and of disease incidences and the lower is the sprouting capacity. These damages to the ratoon also induce fungi and disease incidences because the fragmentation of ratoons creates a wound that works as a gateway to insects and fungi.

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4. Conclusions

Under the conditions conducted in this research, it was possible to observe a significant difference between the types of losses, in which billets were found in greater numbers, corresponding to 45% of total losses in 1.85 t·ha^{-1}, meaning 3.4% of total losses.

There was a significant difference among the degrees of damage to the ratoon; Degree 2 (peripheral damages) was found in higher quantity, a total of 49%. Degree 1 (no damage) was found in the lower quantity of 10%.

Future studies are necessary to clarify questions related to raw material loss and to damages to the ratoons in sugarcane cultures.

Acknowledgements

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