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Brief Communication

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Operational performance of a sugarcane harvester as a function of the tillage system

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Abstract

The objective of this work was evaluate the performance of a sugarcane harvester in the harvesting process in different soil tillage systems. The experiment was carried out in the municipality of Tietê-SP, in a sugarcane field with a flat bed and without prior burning, spaced 1.5 meters between rows of the crop. For mechanized harvesting, a single row harvester was used. The treatments consisted of 4 types of soil tillage systems, with treatment 1 (T1) only subsoiling the soil; treatment 2 (T2) subsoiling plus light grid; treatment 3 (T3) heavy grid and light grid; treatment 4 (T4) direct planting of sugarcane on soy straw. The harvester's displacement speed, effective field capacity, hourly and operational fuel consumption were measured. The soil tillage systems influenced the results of the operational performance of the sugarcane harvester, however the hourly fuel consumption was not affected due to the soil tillage systems.

Key-words: Mechanization, Soil Management, *Sacharum spp*

Sugarcane is considered one of the great alternatives for biofuels producers, due to the great potential in the production of ethanol and its respective by-products. In addition to the production of ethanol and sugar, the production units have sought to increase their efficiency in generation of electricity, helping to increase supply and reduce costs and contributing to increasing the sector's sustainability (CONAB, 2019).

The preparation of the soil in the cultivation of sugarcane is essential for the development of the culture, since an inadequate soil preparation, that is, carried out outside the established agronomic recommendations, can compromise the subsequent agricultural operations, hindering the satisfactory development of culture and the longevity of brass knuckles (Barros and Milan, 2010).

The harvest is the last operation of the crop cycle and some aspects inherent to the operation must be taken into account. Harvesters are capable of harvesting all types of sugarcane, both upright and extremely flat, despite decreasing their operational yield (CONAB, 2019).

The performance of the harvesters is influenced by agricultural productivity, the size of the field and the spacing between planting rows, along with other characteristics of the area to be harvested (Belardo and RIpoli, 2015).

The fuel consumption of the harvesters is one of the important factors of the mechanized harvesting system and can be measured in several stages of the process through equipment specialized in flow measurements (Ripoli and Ripoli, 2009).

Given the above, the present study aimed to evaluate the performance of a sugarcane harvester in the harvesting process in different soil tillage systems.

The experiment was carried out in the municipality of Tietê-SP, in a sugarcane field with a

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flat bed and without prior burning, spaced of 1.5 meters between rows of the crop. For mechanized harvesting, a CASEIH line harvester, model A8800, with 330 hp engine power (243 kw), was used during the harvest.

The treatments consisted of 4 types of soil tillage systems, with treatment 1 (T1) only subsoiling the soil; treatment 2 (T2) subsoiling plus light grid; treatment 3 (T3) heavy grid and light grid; treatment 4 (T4) direct planting of sugarcane on soy straw. The mechanized planting and crop management system carried out was the same in all soil tillage systems.

The experimental plots consisted of 100 meters in length, which were determined using a Garmin 60CSx Global Navigation Satellite System (GNSS) receiver, with six replicates for each treatment.

The determination of the displacement speed was measured as a function of the time spent to travel each parcel, according to equation 1:

$$Vel = \frac{L}{\Delta t}\,3{,}6 \qquad (1)$$

On what:

Vel = speed of travel of the harvester (km h^{-1});
L = length of the experimental plot (m);
Δt = time spent traveling through the experimental plot (s);
3.6 = conversion factor.

For the determination of the effective field capacity, it was the relation between the useful area of the worked plot and the effective time spent in the experimental plot route, through equation 2:

$$CE = \frac{Atr}{\Delta_t} \cdot 0{,}36 \qquad (2)$$

On what:

CE = effective field capacity (ha h^{-1});
Atr = useful area of the worked portion (m^2);
□t = time spent traveling the parcel (s);
0.36 = conversion factor.

The harvester's fuel consumption was determined by using two Oval flow meter fuel meters, model LSF45 with a maximum reading capacity of 500 L h^{-1}, installed in the fuel supply system between the tank and the engine and another installed on the return to the tank. To acquire the data, a programmable logic controller (PLC) was used, which records a pulse unit for every 10 mL of fuel that passed through the flow meters, allowing to calculate through the difference in fuel that enters the engine and what returns to the tank, the hourly fuel consumption, being calculated by equation 3:

$$Ch = \left(\frac{\sum (pe - ps)\ .\ 3{,}6}{\Delta t}\right).10 \qquad (3)$$

On what:

Ch = hourly fuel consumption (L h-1);
Σ (pe - ps) = difference between the sum of the pulses of the input and return flowmeters of the engine, equivalent to the volume of fuel spent;
Δt = time spent traveling the parcel (s);
3.6 = conversion factor;
10 = ratio between pulses generated by the flow meter and the measured fuel volume.

Operational fuel consumption, which represents fuel consumption by area worked, was obtained from equation 4.

$$COC = \frac{Cch}{Cce} \qquad (4)$$

Where:

COC = Operating fuel consumption (L ha^{-1})
Cch = Fuel consumption per hour (L h^{-1})
Cce = Effective field capacity (ha h^{-1})

The results were subjected to analysis of variance and the means were compared using the Tukey test at 5% significance level. For data analysis, Minitab 16 software was used.

Table 1 shows the results of the harvester travel speed and the effective field capacity, in the respective treatments.

It is observed that when preparing the soil with subsoiler (T1) and subsoiler followed by light harrow (T2), the lowest values were obtained in the travel speed of the harvester of 2.61 and 2.52 km h^{-1} respectively, not differing statistically (Table 1). However, for the other soil tillage systems, there was a greater displacement speed during the harvest.

The speed of travel for mechanized sugarcane harvesting can be influenced by several factors, such as the size of the crop, where in this work with a bedridden characteristic, it generated lower speeds for harvesting, and according to Ripoli (2009), the speed of travel of sugarcane harvesters is directly influenced by the conditions of the crop and the terrain.

Table 1. Operation performance of mechanized harvesting.

Treatments	Travel speed (km h^{-1})	Effective field capacity (ha h^{-1})
T1	2,61 b	0,39 b
T2	2,52 b	0,37 b
T3	3,20 a	0,48 a
T4	3,18 a	0,47 a
CV (%)	12,03	12,05

Means followed by the same letters in the column do not differ by Tukey's test (= 0.05).

Table 2. Operation performance of mechanized harvesting.

Treatments	Hourly fuel consumption (L h^{-1})	Operation fuel consumption (L ha^{-1})
T1	54,53 a	139,30 b
T2	52,10 a	138,00 b
T3	53,44 a	111,30 a
T4	52,82 a	110,90 a
CV (%)	3,08	12,76

Means followed by the same letters in the column do not differ by Tukey's test (= 0.05).

According to Silva et al. (2015), for mechanized sugarcane harvesting, the most indicated travel speed is 3.2 km h^{-1}, values similar to this study.

With the increase in the harvest speed, higher values of effective field capacity resulted, as can be seen in Table 1. The effective field capacity and the increase in the machine's travel speed, are directly related according to Testa et al. (2016).

Table 2 shows the results of hourly (L h^{-1}) and operational (L ha^{-1}) fuel consumption during harvest.

The hourly fuel consumption (L ha^{-1}) showed no statistical difference between the treatments evaluated, which can be justified by the low variation of the machine's travel speed at the time of harvest.

According to Drudi et al. (2019) fuel consumption can be influenced by the productivity of the area and the speed of travel of the harvester. According to Banchi et al (2012), calculating the hourly fuel consumption can generate a false advantage when the consumption value decreases over time.

Regarding the operational fuel consumption (L ha^{-1}), it is observed that for treatments T3 and T4 the lowest values of 111.30 and 110.90 L ha^{-1} were obtained, respectively, differing statistically from the treatments T1 and T2 which resulted in 139.30 and 138.00 L ha^{-1} (Table 2). This fact occurs due to the relationship between hourly fuel consumption and effective field capacity, since for the parameters of operational performance the highest values were observed in treatments T1 and T2.

The soil tillage systems influenced the results of the operational performance of the sugarcane harvester, however the hourly fuel consumption was not affected due to the soil tillage systems.

Conflict of interest: All authors declare no conflict of interest.

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