Analysis Of The Mechanized Cutting Process Of Sugarcane: A case study

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Abstract: The work aims to analyze the labor day exploitation of the sugar cane harvester CASE IH 7000. For the following three harvesters were evaluated for 26 effective working days. The analysis of the results allowed to determine that the productive potential were not exploited optimally of the harvester, just as the technical and exploitation indicators are below the established parameters of this machine, impacting negatively the utilization of clean time of work, which only reaches 46.63% and downtime for other reasons which rose to 18.40% of the total observation time. Productivity behaved in an average of 55.45 t / h of clean time work during observations, value below the real possibilities of harvesters.

1. Introduction

Today the cultivation of sugarcane (Saccharum spp.) has spread to over 130 countries and territories, among them Brazil stands out, world's leading producer [1] with 30% of production [2], followed by India (21%), China (7%), Thailand (4%), Pakistan (4%), Mexico (3.5%), Colombia (3%), Australia (3%), United States of America (2%) and Indonesia (2%) [3]. The rising rate of annual sugar consumption is currently 2.8% on the planet, positioning it as an important food item for humanity [4]. According to the International Sugar Organization (ISO), for the sugar cycle 2012-2013, world sugar consumption was 173 million ton, and production of 184 million ton [5].

Mexico ranks sixth in the world in the production of sugarcane [6], [7], [8], with 4% of this, and is the seventh in his consumption. According to the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), in 2014, each Mexican consumed on average 47.9 kilograms of sugar a year. In the country's sugar industry is historically one of the most important, because of its economic and social relevance in the field, generates more than two million jobs directly and indirectly. This agricultural activity takes place in 15 states and 227 municipalities, generating a value of primary production of about 30 billion pesos a year [8]. The state with the highest number of cultivated hectares is Veracruz, representing 36.7% of the national total, second is Jalisco with 11.4%, followed by San Luis Potosi with 10.3%, followed by twelve states [5], [9].

In the state of Colima the production of sugar cane covers a total area of 17,250 ha, gathering close to 2,975 producers, we must add to it the production of 5 municipalities in the state of Jalisco, which carry their harvest to the mill Quesería, S.A. de C.V., which is the second sugar production company in the country. This crop is of great importance in the state, because it has a participation in the state’s PIB of 26 % in the primary sector [5], [7]. In his work [8] points out that the sugar industry is one of the most traditional activities and importance in the economic development of the country and the region. However, over time it has slowly been the effect of the economic crisis, disputes between cane growers and mill owners, and technological backwardness.

Despite advances in technology and the importance of this crop, most of the harvest is done by manual cutting and collecting it mechanically, which causes that it arrives to the sugar factory with stones and sprouts [10], also the cutting has to be done 15 cm above the ground, which represents a great waste of sugar sucrose. Performance under this system is approximately 40 tons of cane per hectare, also the plant has to be burnt before cutting it, which causes continuous loss of organic matter in the soil, leading to this continually impoverish, are among others the causes that provoke that the agricultural crop yield decreases considerably over the years [11], [12], [13], [14].

One of the challenges that is facing agribusiness of sugarcane to become more competitive is to increase productivity and reduce production costs [15], so it is necessary to introduce scientific and technological advances in all links of the value chain [9], [16], [17]. Various recent studies [18], [19], [20], [21], [22] analyze the productivity of machines for harvesting of this crop and exploitation of the working day. The analysis of the deficiencies
identified by these authors is aligned with the guidelines established by SAGARPA to raise the development of sugar cane, in which actions of mechanization for the replacement of machinery are promoted, make tasks efficient and reduce production costs. At the same time this instance points out the importance of studies that promote productivity improvements, cost reductions and crop harvest, among others.

Figure 1. States with the largest area of sugar cane grown in Mexico. Source: SAGARPA, 2014.

The measures outlined above are oriented to respond to the problems of the sugar industry in the region, which is given by deficiencies in infrastructure, machinery and equipment in the production and harvesting, as well as the poor organization of the production process and the low level of scientific and technological research in the field. In order to understand the behavior of the machinery that performs the tasks of harvesting, this paper aims to realize a study of the workday exploit of the sugarcane harvest CASE IH 7000 in the area of Jalisco state and northern part of Colima, México.

2. Methods

This work was done in the northern part of the state of Colima and the state of Jalisco. The evaluation 3 harvesters was developed CASE IH 7000, during the days of January 4 to February 2, 2016, a total of 26 effective workdays with a duration of 12 hours approximately, a total of 901 hours of the workday of the machines under study were evaluated. The method of movement was back and forth with a larger turn in 180 degree turns in a closed loop, open with recoil and bent-loop, and other used depending on the particularities of the edges of the field in harvest.

For this purpose the main methodologies for evaluation of machines and/or agricultural equipment were studied, taking as a basis the [24], the methodology for assessing mechanized harvesting , [25], [26], [27], as well as some of the most representative studies [4], [18], [19] made in this area. The methodology used is focused on determining the time in different conditions and operations of the machine, allowing the calculation of technological and exploitation indicators. To determine these indicators data on the behavior of three sugar cane harvesters were compiled.

In the model time keeping prepared for the research it was recorded in chronological order all the operations and the times used these are: clean Working time (T1), auxiliary time (T2), technical maintenance time (T3), Time for elimination of failures (T4), rest time staff (T5), empty time transfers (T6) Time of maintenance of means of transport (T7) and time of stops for external causes of the machine (T8). Data on the organization of harvesting, use and work system of the machine, the characteristics of the cane fields to cultivate, the volume of work done, failures presented and other data related to the exploitation of further specifies the sugar cane harvesters.

The Control, processing, organization, analysis of experimental data, obtaining parameters, graphs and regression equations that characterize the variables and processes investigated were performed with the electronic tabulator Excel. The measuring instruments used were: digital stopwatches, tape measures and machine odometers. After making the observations, we proceeded to determine the average balance of time structure, by which it was determined the actual balance of the working day, for this computational techniques were applied. Finally productivity rates and exploitation coefficients were determined.

3. Results

The overall analysis of the elements of the working day time the results were obtained as shown in Figure 2. Clean working time or principal (T1) represents 46.63% this is a low value, has a result for the losses of time due to external causes of the harvesters. The auxiliary time (T2) with a 11.12%, was generated more by the poor definition of the border turn of the fields, this aspect did not allowed to use rational methods turns. The time of maintenance of the machine under test (T3), accounted for 4.49%, this value is due to the limited availability of technicians for the execution of maintenance media. The time for fault elimination (T4) reached 14.19% of the workday, mostly because of damage that attended before continuing with the activities, this could have diminished consuming normal time to develop the daily technical maintenance.
Figure 2. Percentage representation of time used for sugarcane harvesters CASE-IH 7000.

The behavior of staff rest time (T₁) was low, in relation to the provisions of regulations of agricultural work, with a representing value of 1.37% of the time of the workday. The vacuum transfer time (T₆) represent 3.08%, the same is the product of the distances traveled by moving between harvested fields. Maintenance time or repair of equipment support (T₇) reached a very low value of 0.72%, exerting little influence on the exploiting time of the machine under study. The percentage of downtime outside the machine (T₈) amounted to 18.40% of the workday in it various effects caused by poor organization of productive activiti es, negatively impacting the lack of transport units during harvest were detected.

Figure 3. Behavior of productive time (T₁, T₂, T₃ and T₄), during the 26 days observed.

The behavior of productive times is observed (T₁, T₂, T₃ and T₄) during the 26 work days observed. Statistical analysis of the data, as well as the utilization of the coefficient of productive time K₀₄, gave the results that can be seen in Figure 4, where it is clearly perceived that the greater dispersion was manifested in (T₁) and (T₄).

Figure 4. Statistical Balance of productive times of the workday.

Figure 5 shows the productivity performance of clean time, ranging between 0.43 and 0.65 ha/h, in the same way, it was reported a performance of 43-61 t/h, lower value established by the manufacturer (80 t/h) and that reference other authors (Masute et al., 2014; Daquinta, et al., 2014).

Figure 5. Harvester productivity in clean time (W₁) depending on the crop performance (Ra).

Analyzing these values is inferred that there may be a better use of the productive capacity of the machine, it affects considerably the downtime for reasons beyond the day and due to low agricultural yields of the fields in the fotocronometraje was performed. The curve obtained through the equation
\[ W₁ = 66.854x + 17.59, \]
with a \( R² = 0.9001 \) shows that there is a strong relationship between productivity and performance, and allows to determine for each value of productivity performance in the range determined by the curve.

The behavior of productivity in terms of productive time has a sensible decrease due to the negative impact of expenses of time due to technical problems and technological caused by poor organization of the process to make the repairs in the field, you can see that W₀₄ takes maximum values of 0.25 ha/h. The curve obtained through the equation
\[ 0.0052x + W₀₄ = 0.0699, \]
with an \( R² = 0.9001 \) shows that there is a strong relationship between productivity and performance (Figure 6), and also allows to determine
for each value of productivity performance in the range determined by the curve.

![Figure 6. Harvester productivity into productive time (W04) depending on the crop performance (Ra).](image)

The analysis of technical coefficients and exploitation of the harvester, shown in Figure 7, demonstrate there is a group of inefficiencies that prevent proper development of the process of harvesting potatoes, then the statement is plotted. The coefficient of the exploitative time (K07) and the coefficient of utilization of productive time (K04) are the lowest exploitation arriving reaching values of 0.61 and 0.36 respectively. The coefficient values of technological service (K23), security technology (K41) and technical security (K42) reached values between 0.93 and 0.99, which confirms the high reliability of the machine under study.

![Figure 7. Behavior of technical coefficients and harvester exploitation.](image)

4. Conclusions

The analysis of the results allowed to determine that the harvester CASE IH 7000 productive potentiality aren’t exploited optimally. The technical and exploitation indicators determined for harvesters CASE IH 7000 are below the established parameters of this machine, affecting negatively the use of clean time work, which only reach 46.63 % and downtime by other causes which rose to 18.40% of the total observation time. Productivity behaved in an average of 55.45 t/h of clean time work during observations, value below the real possibilities of harvesters and determined by various authors.

5. References

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