ORIGINAL ARTICLE

Mobile application to determine means of transportation in the mechanized sugar cane harvest

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Aplicación móvil para determinar medios de transporte, en la cosecha mecanizada de caña de azúcar

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ABSTRACT: The objective of this work is to develop the mobile application that allows determining the number of means of transport, in the process of mechanized harvesting of sugar cane, for different transportation distances, field performance and capacity of the means of transport used (20 and 60 t). It is a mobile application, designed in Android, based on the analytical modeling carried out by the SMCTCA software, developed by a group of authors at the Center for Agricultural Mechanization (CEMA). With the CMT application it is possible to evaluate the mechanized process of harvesting and transporting sugar cane, for different operation conditions, enabling the rational organization of the system with an increase in the time utilization coefficient, productivity and a decrease in expenses of operation.

***Keywords*:** Distance, Android, Analytical Modeling, Software.

RESUMEN: El presente trabajo tiene como objetivo desarrollar la aplicación móvil que permite determinar la cantidad de medios de transporte, en el proceso de cosecha mecanizada de la caña de azúcar, para diferentes distancias de transportación, rendimiento del campo y capacidad de los medios de transporte empleados (20 y 60 t). Es una aplicación móvil, diseñada en Android, basada en la modelación analítica que realiza el software SMCTCA, elaborado por un grupo de autores en el Centro de Mecanización Agropecuaria (CEMA). Con la aplicación CMT es posible la evaluación del proceso mecanizado de cosecha y transporte de caña de azúcar, para diferentes condiciones de explotación, posibilitando la organización racional del sistema con el incremento del coeficiente de utilización del tiempo, la productividad y la disminución de los gastos de explotación.

Palabras clave: distancia, androide, modelación analítica, software.

INTRODUCTION

Cuba is one of the countries with the highest level of mechanization in the sugarcane harvest, in which it uses thousands of complete process machines and varied means of transportation. In recent years, the mechanized cutting system was introduced with bud cutting and cane transfer, for direct unloading to the dumper, with the use of self-tilting semi-trailers pulled by tractor, as intermediate transport, and trucks with trailers for hauling towards the dumper (Martínez *et al.*, 2021).

Harvesting is one of the most important stages in sugarcane production. That is why as a process it requires a high degree of organization and coordination of all the factors involved, from the field to the tilter (López *et al.*, 2022).

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The harvest-transport process does not constitute an element that influences the production process of both cane and sugar itself, but it does determine the economy of the production process, since it is developed with the use of a set of technical means between which include harvesters and means of transportation (tractors and/or trucks with carts or trailers), which, if not rationally organized, negatively influence total production costs (Rodríguez *et al.*, 2019).

The sugarcane harvest is a rigorous process, which requires a high degree of organization and coordination of all the factors involved in the technological process. During it, an average of 40% of the expenses dedicated to the production of cane are incurred, so maximum organization is required in all the actions it includes, from the field to the tilter (Daquinta *et al.*, 2018).

Castillo *et al.* (2021) state that the evaluations of agricultural machines are generally carried out according to the NC 34-37 (2003), standard, according to the phototiming method, making it possible to identify the times used in the production process and define the exploitation indicators of the machines. agricultural sets and self-propelled machines (sugar cane harvesters). Within these investigations, those carried out by the following authors are mentioned: Suárez *et al.* (2006); Matos *et al.* (2010); Daquinta *et al.* (2014); de la Rosa *et al.*, (2014) and others.

In the Base Business Unit (UEB), Attention to Sugar Cane Producers "Héctor Molina Riaño", not only industrial problems have arisen, but at the same time organizational and productive problems have arisen (Rodríguez *et al.*, 2019).

In the case of transportation, the biggest problem is defined by the high rate of transportation interruptions, where it reaches values close to 50% on average, this is due to the wait for the supply of cane, interruptions of the combine and the wait to download into the tilter (Suárez *et al.*, 2006; Matos *et al.*, 2010).

Taking into account the above, the objective of this work is to develop a mobile application to determine the number of means of transport, in the mechanized harvest of sugar cane, for different exploitation conditions.

MATERIALS AND METHODS

Characterization of the technological process, of the mechanized system of harvesting and transporting sugar cane

During the cutting of the sugar cane by the harvester, a moving tractor with a self-tilting trailer moves parallel to it while it is filled. Subsequently, the moving tractor moves full to the head of the field, filling the truck and the attached trailers. to the same, where the trailer trains are formed with the truck. It is then moved to the central dump where the unloading takes place.

Methodology used for the development of the CMT application

The implementation of a methodology for the preparation of the application, which involves the organization of chain processes, such as mechanized sugarcane harvesting, allows the acceleration of analyzes in the decision-making process, as is the case of organizational systems in the Agriculture. It is necessary to take into account all the variables that participate in the technological process such as: transportation distance, field performance, capacity of the means of transportation, among others, allowing possible solutions in advance.

The development of the application for determining the quantity of means of transport (DCMT), the modeling of the mechanized transport and harvest system of sugar cane was carried out, using the SMCTCA software, developed by De las Cuevas *et al.* (2016), for different exploitation conditions.

As an optimization criterion, the maximum values of the time utilization coefficient were chosen during the technological process, guaranteeing that the harvester does not stop during cutting due to lack of means of transport, that is, that the synchronization between them is the same. more rational.

With the software (SMTCA) different runs were carried out, for different operating conditions and capacities of means of transport (20 and 60 t), the behavior curves were defined, for different distances from the field to the plant tilter (5, 10 , 20, 30, 40, 50, 60, 70, 80, 90 and 100 km) and eight field yields (20, 30, 40, 50, 60, 70, 80 and 90 t/ha).

A battery of behavior curves was prepared for all the analyzed variants, defining the equations through a linear fit. These are the methodological basis for calculating the number of means of transport, of the CMT mobile application.

Mobile application for determining the quantity of means of transportation in the mechanized sugarcane harvesting and transportation system

The CMT app was developed on the Android 6.0 platform, based on the synthesized flow diagram shown in Figure 1. According to this scheme, the number of means of transport is determined for eleven distances from the field, to the central tilter (Lx, 5 to 100 km), depending on the performance and load capacity of the selected means of transport. In addition, it provides the behavior graph of the aforementioned variables.

When opening the application by simply touching the screen on it. You directly access the Control Panel (Figure 2), which is interactive, allowing the user to link with the different parts that compose it. It

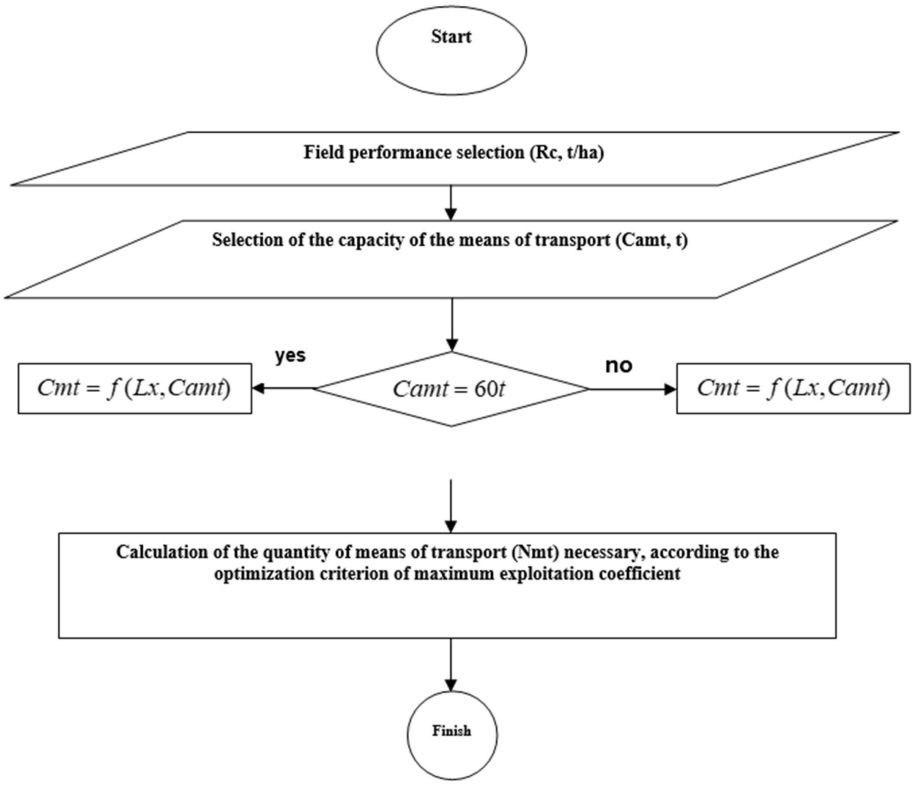

FIGURE 1. Synthesized flowchart of the CMT app.

FIGURE 2. Main Control Panel.

FIGURA 3. Pantalla de resultados.

contains the selection of the field yield in t/ha and the capacity of the means of transportation in the mechanized sugarcane harvesting and transportation system, using the combined CASE. Subsequently, information about the transportation distance is entered.

Click on the calculate button to determine the means of transportation for the conditions established above.

It also has a hyperlink button to transfer it to the results screen, for a specific performance, capacity of the 20 and 60 t means of transport and distances from the field to the center. (Figure 3). Presents a legend specifying the indicators used, with their units of measurement

Using the three dots in the upper right corner, you access the **About screen**: where the names and surnames of the authors are displayed. (Figure 4), as well as, to close the application.

RESULTS AND DISCUSSION

With a view to carrying out an analysis of the variation experienced by the rational number of means of transport, according to the criterion of maximizing the time utilization coefficient of the harvesters, based on the CMT mobile application. We then carry out the evaluation for the CASE combine, with field yields of 50 t per hectare and means of transport of 60 t.

We can see in Figure 5 that, up to a distance of 20 km, the most rational variant, from the point of view of maximum time utilization coefficient, is the one that uses two means of transport with a total capacity of 60 t. Greater than this distance and up to 50 km, the variant that uses three means of transport is the most rational, from 50 to 80 km the variant that uses 4 means of transport and with five for distances greater than 80 and up to 100 km, between field and the collection center of the sugar mill.

This behavior is acceptable, since as the transportation distance increases, a greater number of means of transportation becomes necessary to guarantee a stable behavior of the time utilization coefficient, around 80%. Which allows stable productivity of the harvester and minimal operating expenses of the mechanized sugar cane harvesting and transportation system.

CONCLUSIONS

- The "CMT" mobile application allows defining the number of means of transport, according to the criterion of maximum coefficient of use of the time of the harvesters, in the mechanized system of harvesting and transporting sugar cane, for different exploitation conditions.
- The application of the results of the "CMT" app makes it possible to achieve stable productivity of the combines, with minimal operating costs, with an increase in transportation distance.
- The results of the "CMT" app allow us to define the most rational, productive and economically advantageous means of transportation variants of the mechanized sugar cane harvesting and transportation system.

FIGURE 4. About.

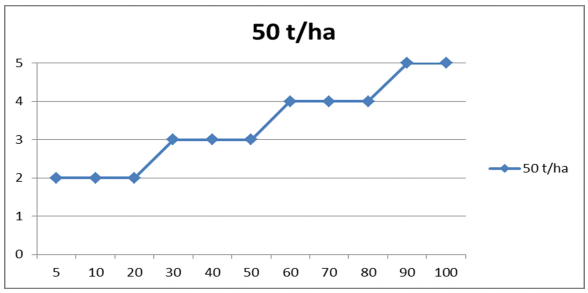

FIGURE 5. Means of transport of 60 t and field yields of 50 t/ha.

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