ORIGINAL ARTICLE

Agricultural Planning in the Soil Preparation for Sugar Cane in a Sugar Agroindustrial Company

Planeamiento agrícola en la preparación de suelo para caña de azúcar en una Empresa Agroindustrial

https://cu-id.com/2177/v33n4e04

Yoel Betancourt-Rodríguez[I*], Roberto Bravo-Agriel[II], Juan Carlos González-Damas[III], Rigoberto Martínez-Ramírez[IV], Omar González-Cueto[III]

[I]Instituto de Investigaciones de la Caña de Azúcar Villa Clara (INICA-Villa Clara), Ranchuelo, Villa Clara, Cuba.

[II]Instituto de Investigaciones de la Caña de Azúcar (INICA), INICA-Cienfuegos, Cuba.

[III]Universidad Central “Marta Abreu” de las Villas, Facultad de Ciencias Agrícolas, Departamento de Ingeniería Agrícola, Santa Clara, Villa Clara, Cuba.

[IV]Instituto de Investigaciones de la Caña de Azúcar (INICA), Boyeros, La Habana, Cuba.

ABSTRACT: The proper management of sugarcane plantations in the country demands the consideration of sustainability principles in the planning and execution of work to achieve the prompt recovery of the crop. This research aims to carry out agricultural planning in the soil preparation for sugar cane under the management conditions of the Antonio Sánchez Agroindustrial Sugar Company (EAA). The soil preparation campaign was considered for an area of 2349,05 ha. The single database, the information from the 1:25 000 Soil Map and the technical-economic plan were used to identify the structure of the company, select the most limiting factors for tillage and identify the preparation blocks and their characteristics, respectively. The results in the characterization of the management conditions indicated a predominance of compaction as the main limiting factor for tillage (66%), light-textured soils (77%) and soil conditions under demolition (49%). The technological alternatives, their variants, operations and labors by management condition were appropriately selected, which corresponded to the agronomic requirements for sustainable soil preparation. The time between labors, the demand and type of equipment to be used, the workload and the need for fuel were satisfactorily identified as part of the agricultural planning; the latter two established on a monthly and annual basis.

Keywords: Planning, Sustainable Farming, Technological Chart.

RESUMEN: El manejo adecuado de las plantaciones de caña de azúcar en el país demanda de la consideración de principios de sostenibilidad en la planificación y ejecución de los trabajos para lograr la pronta recuperación del cultivo. Esta investigación tiene como objetivo realizar el planeamiento agrícola en la preparación de suelo para caña de azúcar en las condiciones de manejo de la Empresa Agroindustrial Azucarera (EAA) Antonio Sánchez. Se consideró la campaña de preparación de suelo para un área de 2349,05 ha. Se utilizó la Base de Datos Única, la información del Mapa de Suelo 1:25 000 y el plan técnico económico para identificar la estructura de la empresa, seleccionar los factores más limitantes para la labranza e identificar los bloques de preparación y sus características, respectivamente. Los resultados en la caracterización de las condiciones de manejo indicaron un predominio de la compactación como principal factor limitante para la labranza (66%), de los suelos de textura ligera (77%) y de las condiciones del terreno sobre demolición (49%). Se seleccionaron adecuadamente las alternativas tecnológicas, sus variantes operacionales y labores por condición de manejo, las cuales se correspondieron con los requerimientos agronómicos para la preparación sostenible de suelo. Se identificó satisfactoriamente como parte del planeamiento agrícola el plazo entre labores, la demanda y tipo de equipamiento a emplear, la carga de trabajo y la necesidad de combustible; estos dos últimos establecidos de forma mensual y anual.

Palabras clave: planificación, labranza sostenible, carta tecnológica.

*Author for correspondence: Yoel Betancourt-Rodríguez, e-mail: yoel.betancourt@nauta.cu; yoelbr15@gmail.com

Received: 19/01/2024
Accepted: 05/09/2024

The authors of this work declare no conflict of interests

AUTHOR CONTRIBUTIONS: **Conceptualization:** Yoel Betancourt Rodríguez. **Data curation:** Y. Betancourt. **Formal analysis:** Y. Betancourt. **Investigation:** Yoel Betancourt Rodríguez, Roberto Bravo Agriel, Juan Carlos González Damas, Rigoberto Martínez Ramírez, Omar González Cueto. **Methodology:** Yoel Betancourt. **Validation:** Yoel Betancourt Rodríguez y Roberto Bravo Agriel. **Roles/Writing, original draft:** Yoel Betancourt Rodríguez, Roberto Bravo Agriel, Juan Carlos González Damas, Rigoberto Martínez Ramírez Omar González Cueto. **Writing, review & editing:** Yoel Betancourt Rodríguez, Roberto Bravo Agriel, Juan Carlos González Damas.

INTRODUCTION

The agricultural sector dedicated to the cultivation of sugarcane in Cuba is going through a complex situation given the low level of production, with figures lower than those reported in the last 100 years (Tamayo, 2022). The country's highest leadership has called for the recovery of the sector given the historical, cultural and identity value it represents. In this sense, one of the aspects that allows the expected transformation is the quality compliance with the planned planting plans, for which it is an essential requirement to carry out good soil preparation, since this technological process fulfills its main objective, to create optimal conditions for the seeds sprouting and the subsequent growth and development of plants (Santana *et al.*, 1999; Cuéllar *et al.*, 2003; INICA-Cuba, 2009).

From a technological process approach, in Cuba three technologies have been defined for soil preparation in sugarcane: Total Tillage with Prism Inversion, Total Tillage without Prism Inversion and Localized Tillage (Crespo *et al.*, 2013; Oliva *et al.*, 2014). However, inadequate selection from planning combined with technological indiscipline in production conditions has kept this process as one of the problems that affects sugarcane production in the country.

The planning of soil preparation tasks implies a high technical level, as well as an adequate organization of activities to satisfy agronomic requirements with timeliness, quality and environmental sustainability (Pérez, 2018). The plan in its broad conception will help understand who, when, where, what and how the work is done (Kurihara, 2022). If the environment to be faced is heterogeneous in terms of the machinery park and the edaphoclimatic conditions, as happens in the Antonio Sánchez EAA, planning is complex, so it is necessary to take into account the wide range of factors that influence technological changes.

According to Finnegans (2022), agricultural planning contains advice on the establishment of crops and includes its technical and economic analysis. If the planning process is carried out in a digitalized way, the work is facilitated, while it is possible to integrate multiple factors in decision-making. In this sense, for agricultural planning in sugar cane, the LabraS software (SW) was developed, which integrates knowledge of the soil, machinery, cultivation and work environment (ISMACE Criteria) into the algorithms for recommendations (Betancourt *et al.*, 2019b).

It is important to highlight that the computer application is part of a technical scientific service, the Tillage Service of the Sugarcane Research Institute (INICA), which facilitates obtaining integrative results from the point of view of the administration of the sugarcane. agricultural machinery, which cover not only planning, but also the organizing, executing and controlling of tillage work (Betancourt *et al.*, 2018).

The use of SW LabraS has shown satisfactory results in the recommendation of technological chart in soil tillage, in different processes and soil-climatic conditions where sugarcane is grown in Cuba Pérez (2018); Álvarez (2018); Betancourt *et al.* (2019a); Sánchez (2021); Villavicencio (2021); Valerón (2022);Therefore, through the appropriate application of said platform under the conditions of the Antonio Sánchez EAA, it is possible to carry out sustainable planning of soil preparation, so that the technology, the sequence of work, the equipment, among other technical-agronomic aspects of interest to the producer are identified.

Based on the above, the objective of the work is to carry out agricultural planning in the preparation of soil for sugar cane in the EAA Antonio Sánchez.

MATERIALS AND METHODS

The research was carried out in areas dedicated to sugarcane of the Antonio Sánchez EAA, in the province of Cienfuegos. The information corresponding to the EAA structure and limiting factors were taken from the Territorial Planning (OT) database (INICA Cienfuegos, 2023).The soil preparation campaign of 2349.05 ha was considered, concentrated in 71 sugarcane blocks.

The Ferralitic (82%) and the Brown Sialitic (15%), according to the 2015 genetic classification (Hernández *et al.*, 2015). are the predominant soils genetic groupings in the EAA.

Soil texture followed the classification given by Betancourt *et al.* (2019a);The procedure applied for sustainable agricultural planning of soil preparation was based on the use of the LabraS software, proposed by INICA (Betancourt & Alonso, 2023). The application of sustainable principles was based on the ISMACE criteria stablish in the algorithms of the SW. It is important to highlight that the blocks defined for the plantation were recommended by the Variety and Seed Service (SERVAS) of INICA, and are not the subject of this investigation.

The parameters considered for the recommendations in the LabraS platform were the following:

1. In the SW, 169 possible technological alternatives to recommend were established, with three variants as an average per alternative.
2. The third quartile method was used to define the areas with stony and/or rocky problems. The presence of that factors in a percentage greater than or equal to 25% of the area was used as a criterion.
3. Cost (pesos ha^{-1}) was selected as an exploitation criterion for the selection of the soil tillage variants and aggregates (tractor plus implement) in the recommended labors.

The information regarding the input data in the soil preparation process was requested at the production unit level and was provided by the production manager. The final information from the EAA company was agreed with the directors of the cane department.

The aggregates available in the EAA and used in the configuration of the SW LabraS brigade, to respond to the needs of the lbors are presented in table 1.

RESULTS AND DISCUSSION

The characterization of the research conditions, in terms of the evaluation of the most limiting factor for tillage mechanization (FML) per minimum management unit (the cane block), for the preparation of 2349.05 showed a predominance of compaction problems (67%) and effective depth (15%); however, areas without limitations for tillage were found in 9% (Figure 1). In this sense, for adequate agricultural planning, the agronomic management recommendation is aimed at mitigating the edaphic limitations that affect the development of the crop and creating favorable conditions in the seedbed formation for planting (Crespo *et al.*, 2013; Oliva *et al.*, 2014; Betancourt *et al.*, 2018).

From the point of view of soil texture (ST), light ST predominated with 77% (Figure 2) and no representation of heavy ST was found. From the tillage point of view, a predominance of soils with light ST shows favorable conditions for tillage, since power demand and fuel consumption is reduced and the period between labors and the total time for soil preparation are shortened.

The land surface conditions (Figure 3) indicated the predominance of the demolition areas, which represented 49% (1157, 06 ha). Fallow or low yield cane areas unharvested (FoLY) were found in 21% and woody plants occupied the remainder (29%). No areas from rotation with other crops were found.

The existing situation in 51% of the area (the sum of woody and FoLY) complicates the planning of soil preparation since it demands a longer period between operations and total soil preparation time, which implies an increase of the costs for hiring since there is no heavy equipment for work in areas with woody plant vegetation. In all cases, its identification and inclusion within the LabraS software algorithms creates the conditions for more precise planning, where the most varied and complex conditions find a solution for agronomic management.

TABLE 1. Tractor and implement by labors in soil preparation

Aggregates (tractor plus implement)	Agricultural labors
MTZ-80 + ADI-3 Discs plow	Break (Discs)[1]
BELARUS 1523 + AT-90 Discs plow	Break (Discs)[1] and Crossing (Discs)[1]
YTO 1604 + Bayamo (Modified)	Medium subsolation[3]
YTO 1604 + Triple furrower	Deepening and furrowing (Arrows)
YTO 1604+ Chisel plow	Break (Arrows)[2] and Crossing (Arrows)[2]
Komatsu D80 + SP280 Subsoiler	Heavy subsoiling
Komatsu D80 + Discs harrow of 6363 kg	heavy harrow
YTO 1604 + GAPCR Discs harrow (Medium)	De-crown and medium harrow
YTO 1604 + Genovesa Discs harrow (Fine)	Medium and light harrow
YTO 1604 + AF Leveler	Land leveling

Legend:
1- Using implements with disc work organs.
2- With implements that do not invert the soil prism without including subsolation.
3- Refers to subsoilers for medium-power tractors, that is, those that are not designed to work in areas with the presence of roots, trunks, stones and rocks.

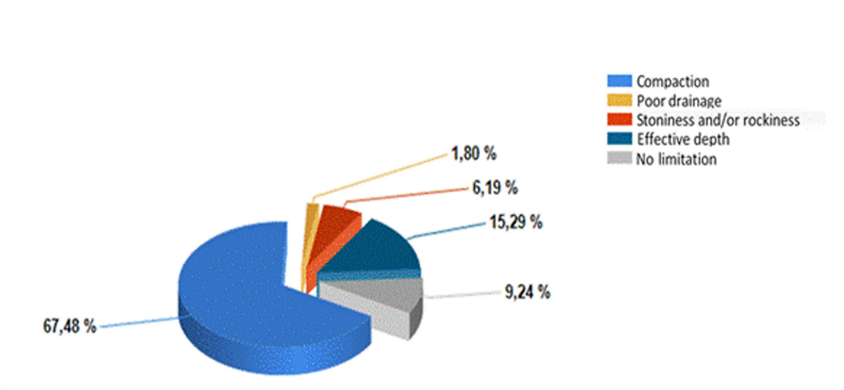

FIGURE 1. Percentage of most limiting factors for tillage

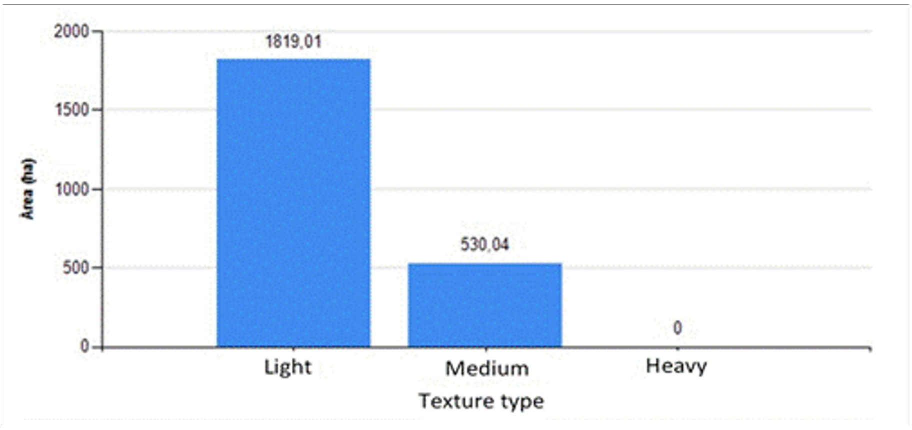

FIGURE 2. Soil texture.

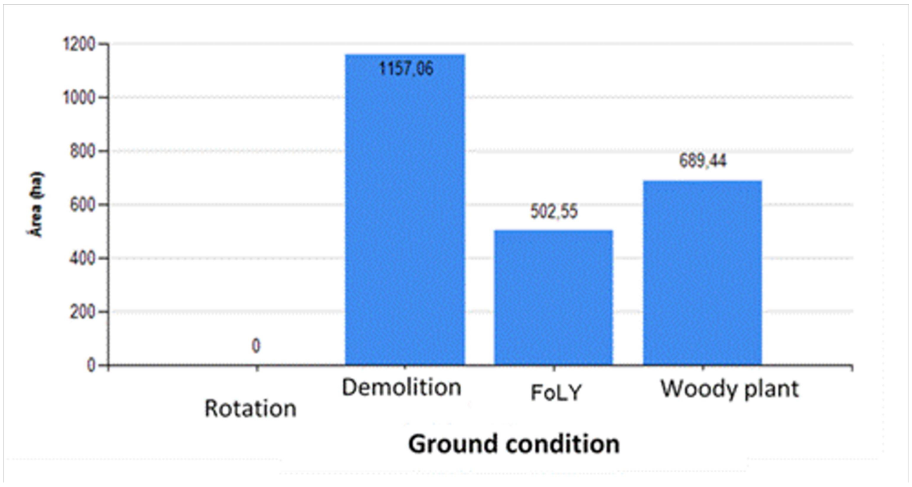

FIGURE 3. Soil surface conditions (Legend: FoLY-Fallow or low yield cane areas unharvested).

Table 2 shows an example of a recommendation by the LabraS software for the 00425 block, belonging to the Basic Cooperative Production Unit (UBPC) Vietnam. The recommendations contain the identification of the block, the area, the technological alternative and its variant, the execution date that includes the period between labors, the sequence of operations, the aggregates according to the inventory of active equipment, the formation of the brigades and the main operating indicators (performance, fuel consumption and cost).

14 technological alternatives (TA) were recommended in soil preparation (Table 3). The ATs with the greatest application were 68 and 6 with a frequency of 25 and 12, respectively. In addition, 1215.67 ha correspond to the largest area, which represented close to 60%. The AT recommendations made correspond to the management conditions, associated with the limiting factors for tillage, the texture and the conditions of the soil surface.

The recommended labors with the SW LabraS demonstrate sustainable planning of soil preparation for sugarcane in the EAA (Figure 4). The agronomic management included 10 labors, both for primary and secondary tillage of the soil.

Scarifiers for total primary tillage were recommended in two labors, Breaking (Arrows) and Crossing (Arrows), and directed to soils without limitations, with poor surface drainage, with a problem of effective depth and without the presence of woody plants. This operation incorporates not only environmental benefits, but also technological, energy and economic benefits (Gómez *et al.*, 1997; Crespo *et al.*, 2013; Gutiérrez *et al.*, 2013; Oliva *et al.*, 2014). Likewise, its application was avoided in areas that have limitations due to rocks and stones (AT 100 and 118), which reduces the occurrence of breakages that could technically invalidate the implement.

Subsolation was recommended in 75% of the area, which included areas with woody presence (heavy subsolation) and soils with compaction problems (medium subsolation), which coincided with the premises established in the SW LabraS related to the management conditions.

Heavy harrows complement the work with heavy subsoiling in complex soil conditions due to the existence of woody plants such as Dichrostachys cinerea (Marabú), Albizia procera (Algarrobillo) and Leucaena leucocephala (Leucaena). Besides, the medium and light harrow, which belong to secondary

TABLE 2. Example of recommendation for soil preparation by minimum management unit (block)

Block	Area (ha)	Technological Alternative	Labors	Start date	Finish date	Aggregate	Norm (ha/day)	Fuel Expense (L)	Cost (peso)
00425	15,8	68- Preparation of light soil with compaction problems in demolition with change of the furrows direction	Medium subsolation	01/28/2022	01/28/2022	YTO 1604 with Bayamo (Modified)	12.0	443.2	15830.0
			Medium subsolation	01/29/2022	01/29/2022	YTO 1604 with Bayamo (Modified)	12.0	443.2	15830.0
			Medium harrow	02/03/2022	02/04/2022	YTO 1604 with GAPCR Discs harrow (Medium)	15.5	235.2	12567.6
			Light harrow	02/09/2022	02/10/2022	YTO 1604 with Genovesa Discs harrow (Fine)	15.5	158.3	12502.9
		Total	4	14 (Days)		4	-	1279.9	56730.5

tillage, are the ones that predominate in terms of the level of work with more than 1700 hectares.

The proper management of preparation work, such as scarification and subsoiling, recommended in the conditions of the EAA Antonio Sánchez, which do not invert the prism of the arable layer, are among the soil conservation measures with a high positive impact on the environment, an aspect that favorably affects the implementation of sustainability principles in agriculture (Bihari *et al.*, 2021; Hussain *et al.*, 2021).

The results obtained in the recommendations made validate the ISMACE criteria used in the SW LabraS algorithms for the adequate selection of labors in the sugarcane sustainable soil preparation established by the FAO (FAO & ITPS, 2021). Likewise, it satisfies the agronomic requirements for sugar cane as established in the instructive and other manuals defined in Cuba (Crespo *et al.*, 2013; Gutiérrez *et al.*, 2013; Oliva *et al.*, 2014).

The satisfactory result obtained with the use of SW LabraS in planning coincides with other reports carried out in Cuba for different edaphoclimatic conditions and technological processes (Pérez, 2018; Álvarez, 2018; Betancourt *et al.*, 2019a; Sánchez, 2021; Villavicencio, 2021; Valerón, 2022). Furthermore, it is important to highlight the value of having digitalized information, which ensures the adjustment of the process when required by the grower as soon as possible.

In the planning process, it is important to determine for each month the area to be carried out per labor (table 4), among other objectives to carry out the corresponding machinery exploitation analyzes and ensure its compliance with quality and timeliness. The first four months of the year concentrate the demand for work, of which March is the critical month with 4 510,7 hectares.

The demand for fuel for the planned labor (Table 5) is another important element to consider in planning, and which properly established favors energy sustainability and contracting with the supply company in a timely manner. In this sense, a total of 209, 71 thousand liters of diesel fuel are demanded, where the months of February and March are with the highest demand with 76 305,7 L and 90 923,1 L, respectively.

CONCLUSIONS

- The research conditions for soil preparation planning were characterized by the predominance of soil compaction as the main limiting factor for tillage (66%), light-textured soils (77%) and soil conditions over demolition (49%).
- The technological alternatives, their operational variants and tasks were appropriately selected by management condition, which corresponded to the agronomic requirements for the sugarcane sustainable soil preparation.

TABLE 3. Area carried out by technological alternatives

Alternative Number	Alternative Name	Frequency	Area (ha)	%
100	Preparation of light soil with stoniness and/or rockiness in demolition and with change of the furrow direction	2	49.43	2.42
118	Preparation of medium or heavy soil with stoniness and/or rockiness in fallow or low yield	1	96.00	4.70
123	Preparation of light soil with problem of effective depth in fallow or low yield and with change of the furrow direction	3	76.91	3.76
128	Preparation of medium or heavy soil with problem of effective depth in fallow or low yield and with change of the furrow direction	1	34.99	1.71
14	Preparation of shallow light soil on demolition with change of the furrow direction	2	66.06	3.23
22	Preparation of medium and heavy soil with problem of effective depth in fallow or very low yield areas	3	57.79	2.83
27	Preparation of medium and heavy soil with problem of effective depth on demolition with change of the furrow direction	4	103.23	5.05
33	Preparation of medium and heavy soil without limitations on demolition with furrow changes	4	195.81	9.58
57	Preparation of light soil without limitations in fallow or low yield with change of furrowing	1	21.20	1.04
68	Preparation of light soil with compaction problems in demolition with change of the furrow direction	23	700.31	34.27
6	Preparation of light compacted soil in fallow or very low yield areas	12	515.36	25.22
70	Preparation of light soil with compaction problems in fallow or low yield with change of furrowing	4	64.20	3.14
89	Preparation of medium or heavy soil with poor drainage in demolition that requires smoothing and changing of the furrow direction	2	42.22	2.07
8	Preparation of light soil with ieffective depth problem in fallow or very low yield areas	1	20.29	0.99

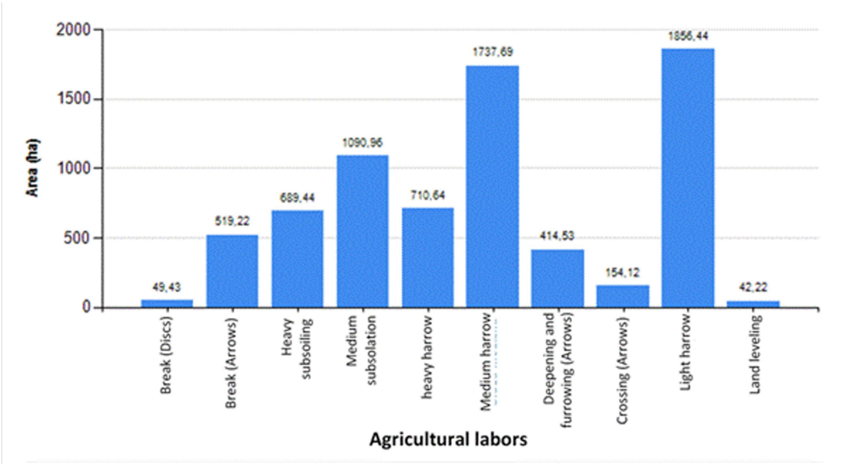

FIGURE 4. Recommended labors for preparation.

TABLE 4. Monthly distribution of the area (ha) by labor

Agricultural labors	Monthly area, ha			
	January	February	March	Abril
Light harrow	291,4	407,9	1088,7	68,4
Medium harrow	433,5	769,5	1042,1	0,0
heavy harrow	192,8	432,6	690,1	84,6
Deepening and furrowing (Arrows)	44,1	42,5	328,0	0,0
Break (Arrows)	71,8	355,8	91,7	0,0
Medium subsolation	553,0	1137,9	367,6	0,0
Heavy subsoiling	192,8	482,7	664,0	39,4
Break (Discs)	0,0	49,4	0,0	0,0
Land leveling	0,0	0,0	84,4	0,0
Crossing (Arrows)	0,0	0,0	154,1	0,0
Total	1779,4	3678,3	4510,7	192,4

TABLE 5. Monthly distribution of fuel demand by soil preparation tasks

Agricultural labors	Monthly fuel demand, L				Total, L
	January	February	March	April	
Light harrow	6411.5	7221.8	23444.8	1505.2	38583.3
Medium harrow	6251.3	11216.5	15072.1	0.0	32539.9
heavy harrow	4665.0	10469.6	16699.7	2047.6	33881.9
Deepening and furrowing (Arrows)	220.6	488.2	2304.1	0.0	3012.9
Break (Arrows)	1361.0	6641.2	1910.5	0.0	9912.7
Medium subsolation	13477.0	25585.2	9190.5	0.0	48252.7
Heavy subsoiling	5436.1	13613.0	18725.3	1109.9	38884.3
Break (Discs)	0.0	1070.2	0.0	0.0	1070.2
Land leveling	0.0	0.0	844.4	0.0	844.4
Crossing (Arrows)	0.0	0.0	2731.7	0.0	2731.7
Total	37822.5	76305.7	90923.1	4662.7	209714

- The workload and fuel demand for soil preparation labor were satisfactorily determined from the technological charts recommended with the SW LabraS, differentiated for a specific and total period in the year.

REFERENCES

ÁLVAREZ, L.: *Implementación del Sistema Automatizado LabraS en la toma de decisiones para la preparación de suelo en caña de azúcar*, Universidad Central "Marta Abreu" de la Villas, Trabajo de diploma, Santa Clara, Villa Clara, Cuba, 60 p., 2018.

BETANCOURT, Y.; ALONSO, D.: *SW LabraS versión 3.0.1.0. Manual de usuario*, Ed. Instituto de Investigaciones de la Caña de Azúcar (INICA), La Habana, Cuba, 74 p., 2023.

BETANCOURT, Y.; ALONSO, D.; GONZÁLEZ, A.B.; LA ROSA, A.J.: "Sistema automatizado LabraS para la toma de decisiones en la planificación de la labranza de suelo en caña de azúcar", *Revista Ciencias Técnicas Agropecuarias*, 28(4): 89-100, 2019a, ISSN: 1010-2760, e-ISSN: 2071-0054.

BETANCOURT, Y.; GUILLÉN, S.; RODRÍGUEZ, J.F.; ALFONSO, A.; SÁNCHEZ, R.: "Servicio para la asistencia técnica en la labranza de suelos dedicados a caña de azúcar", *Revista Ciencias Técnicas Agropecuarias*, 27(2): 1-13, 2018, ISSN: 1010-2760, e-ISSN: 2071-0054.

BETANCOURT, Y.; PÉREZ, D.; ÁLVAREZ, A.: "Asistencia técnica de la labranza de suelos en el control de arvenses en la reposición de caña de azúcar", *Ingeniería Agrícola*, 6(3): 10-15, 2019b, ISSN: 2306-1545, e-ISSN: 2227-8761.

BIHARI, B.; KUMARI, R.; PADBHUSHAN, R.; KUMAR, R.; KUMAR, G.; KUMARI, S.; KUMARI, M.: "Management of crop residue for enhancement of crop productivity and nutrient cycling", *The Pharma Innovation Journal*, SP-10(9): 495-502, 2021.

CRESPO, F.R.; PÉREZ, H.I.; RODRÍGUEZ, I.; GARCÍA, I. (2013). *Manejo sostenible de tierra en la producción de caña de azúcar*, Ed. Ediciones AMA, I. Pérez, I. Santana, I. Rodríguez ed., La Habana, Cuba, 119-146 p.

CUÉLLAR, I.A.; DE LEÓN, M.E.; GÓMEZ, A.; PIÑÓN, D.; VILLEGAS, R.; SANTANA, I.: *Caña de Azúcar. Paradigma de sostenibilidad*, Ed. Editorial Publinica, La Habana, Cuba, 15-170 p., 2003.

FAO & ITPS: "Recarbonizing global soils: A technical manual of recommended management practices", En: Ed. FAO, vol. 3, Rome, Italy, 2021, DOI: https://doi.org/10.4060/cb6595en.

FINNEGANS: *Planificación agrícola: la clave para tener una visión a futuro*, *[en línea]*, Finnegans, 2022, *Disponible en: https://finneg.com/insights/2019/04/03/planificación-agrícola-la-clave-para-tener-una-visión-a-futuro/* .

GÓMEZ, A.; VELARDE, E.; CÓRDOBA, R.: "Nuevas soluciones para la preparación de suelos en Cuba", *Revista Cuba & Caña*, 2(3): 31-3, 1997, ISSN: 1028-6527.

GUTIÉRREZ, A.; DÍAZ, F.R.; VIDAL, L.; RODRÍGUEZ, I.; PINEDA, E.; BETANCOURT, Y.; GÓMEZ, J.R.: "Manual de buenas prácticas agrícolas para el cultivo de la caña de azúcar en los suelos arcillosos pesados con regadío superficial", *Revista Cuba & Caña*, Suplemento Especial(1): 15, 2013.

HERNÁNDEZ, J.; PÉREZ, J.; BOSCH, I.; CASTRO, S.: *Clasificación de los suelos de Cuba 2015*, Ed. Ediciones INCA, San José de las Lajas, Mayabeque, Cuba, 93 p., 2015, ISBN: 978-959-7023-77-7.

HUSSAIN, S.; HUSSAIN, S.; GUO, R.; SARWAR, M.; REN, X.; KRSTIC, D.; ASLAM, Z.; ZULIFQAR, U.; RAUF, A.; HANO, C.: "Carbon Sequestration to Avoid Soil Degradation: A Review on the Role of Conservation Tillage", *Plants*, 10(10), 2021, DOI: https://doi.org/10.3390/plants10102001.

INICA CIENFUEGOS: *Base de Datos de Ordenamiento Territorial (OT) de la Empresa Agroindustrial Azucarera (EAA) Antonio Sánchez*, Inst. Instituto de Investigaciones de la Caña de Azúcar de Cienfuegos, Cuba, Cienfuegos, Cuba, 4 p., 2023.

INICA-CUBA: "Taller nacional con los directores de producción de caña de empresas y GEA,", En: *Revista Cuba & Caña*, La Habana, Cuba, 2009.

KURIHARA, T.: *Guía Técnica sobre Mejoramiento de Administración Agrícola para Pequeños Agricultores*, *[en línea]*, Inst. JICA, No.6: Planificación de la Producción, 2022, *Disponible en:* https://www.jica.go.jg/proyect/elsalvador/0603028/pdf/producion/farm_06.pdf .

OLIVA, L.M.; GALLEGO, R.; FERNÁNDEZ, G.; RUBÉN, H.: *Fomento y reposición, de la Caña de Azúcar en Cuba*, Ed. AMA, S. Ignacio, G. Maribel, G. S. Sergio, C. Ramón, Instructivo técnico para el manejo de la caña de azúcar ed., La Habana, Cuba, 79-106 p., 2014.

PÉREZ, D.: *Planificación de la labranza de suelo en caña de azúcar mediante el sistema automatizado LabraS*, Universidad Central "Marta Abreu" de las Villas, Tesis de Maestría, Santa Clara, Villa Clara, Cuba, 2018.

SÁNCHEZ, R.: *Perfeccionamiento del sistema utilizado para la determinación de la demanda de lubricantes en las fuentes energéticas de preparación de suelo*, Universidad Central "Marta Abreu" de las Villas, Tesis de Pregrado, Santa Clara, Villa Clara, Cuba, 2021.

SANTANA, M.; FUENTES, J.; BENÍTEZ, L.; COCA, J.; CÓRDOBA, R.; HERNÁNDEZ, S.; ARCIA, J.; HERNÁNDEZ, I.; SOCARRÁS, D.: *Principios Básicos para la aplicación de tecnologías de preparación de suelos en el marco de una agricultura conservacionista y sostenible*, Ed. Publinica, La Habana, Cuba, 1999.

TAMAYO, R.: "Analizan desempeño de la zafra 2021-2022, la producción más baja en más de cien años", *Cubadebate*, La Habana, Cuba, 2022, *Disponible en:* https://www.cubadebate.cu/noticias/2022/06/26/analizan-desempeno-de-la-zafra-2021-2022-la-produccion-mas-baja-en-mas-de-cien-anos/ .

VALERÓN, M.: *Planificación sostenible de la atención postcosecha de la caña de azúcar en la Empresa Agroindustrial Azucarera George Washington*, Universidad Central "Marta Abreu" de las Villas, Tesis de Pregrado, Santa Clara, Villa Clara, Cuba, 2022.

VILLAVICENCIO, L.: *Adecuación Funcional del Software LabraS en la Planificación de Labores para la Preparación Sostenible de Suelo en Caña de Azúcar*, Universidad Central "Marta Abreu" de las Villas, Tesis de Pregrado, Santa Clara, Villa Clara, Cuba, 2021.

Yoel Betancourt-Rodríguez, Dr. C., Investigador titular, Instituto de Investigaciones de la Caña de Azúcar Villa Clara (INICA-Villa Clara). Autopista nacional Km 246, Ranchuelo, Villa Clara. Profesor Titular adjunto de la Universidad Central "Marta Abreu" de las Villas (UCLV), Cuba.
Roberto Bravo-Agriel, Ingeniero Agrícola, Instituto de Investigaciones de la Caña de Azúcar (INICA), INICA-Cienfuegos, Cuba. e-mail : roberto.bravo@gesacf.azcuba.cu.
Juan Carlos González-Damas, Estudiante de Ingeniería Agrícola, Universidad Central "Marta Abreu" de las Villas (UCLV). e-mail: juancarlosgonzalezdamas@gmail.com.
Rigoberto Martínez-Ramírez, MSc., Investigador Agregado, Instituto de Investigaciones de la Caña de Azúcar (INICA). Carretera a CUJAE, km. 1½, Boyeros, La Habana, Cuba, C.P. 19390, e-mail: rigoberto.martinez@inica.azcuba.cu.
Omar González-Cueto, Dr. C., Profesor Titular, Universidad Central "Marta Abreu" de las Villas, Facultad de Ciencias Agrícolas, Departamento de Ingeniería Agrícola, Santa Clara, Villa Clara, Cuba, e-mail: omar@uclv.edu.cu.
The mention of trademarks of specific equipment, instruments or materials is for identification purposes, there being no promotional commitment in relation to them, neither by the authors nor by the publisher