ORIGINAL ARTICLE

Service for the Technical Assistance in the Sugar Cane Soil Tillage

Servicio para la asistencia técnica en la labranza de suelos dedicados a caña de azúcar

http://opn.to/a/i3uou

Dr.C. Yoel Betancourt-Rodríguez[I]✉, Ing. Sergio Guillén-Sosa[II], Ing. Justo Félix Rodríguez-Rodríguez[III], Ing. Alejandro Alfonso-Villegas[IV] Ing. Roberto Sánchez-Rodríguez[III], Ing. Luis Oliva-Ágra[II]

[I] Instituto de Investigaciones de la Caña de Azúcar, Estación Territorial de Investigaciones de la Caña de Azúcar Centro Villa Clara (ETICA Centro Villa Clara), Ranchuelo, Villa Clara, Cuba.
[II] Instituto de Investigaciones de la Caña de Azúcar (INICA). Marianao, La Habana, Cuba.
[III] Estación Territorial de Investigaciones de la Caña de Azúcar, Quivican, Mayabeque, Cuba.
[IV] Empresa de Servicios Técnicos Industriales (ZETI). División Datazucar, La Habana, Cuba.

ABSTRACT. The general structure of the service for the technical assistance in the sugar cane soil tillage was based on three offers directed to planning, organization, control and training: Technical attendance in the processes of soil tillage, Technical attendance in machinery management and Evaluation and trial of agricultural machines. This service is projected to reach the total area of sugar cane crop in Cuba and to cover up the whole of the year. The attendance in soil tillage processes was applied to deforestation, land-leveling, fertilization and post-harvest field management, plantation and land preparation technological processes. For the planning of the farm works, the maintenance management and the machinery exploitation control, computer tools were programed. The recommendations given to the producer were technically based according to technological, energetic, economic and environmental approaches; taking in to account the results of more than 40 years of investigations of INICA and other national institutions. It was recommended to strengthen the material and human infrastructure of INICA and to create a methodology for farm processes diagnostic on the service implementation.

Keywords: soil tillage, technical assistance, service, planning.

RESUMEN. La estructura general del servicio para la asistencia técnica en la labranza de suelos dedicados a caña de azúcar se basó en tres ofertas dirigidas a la planificación, la organización, el control y la capacitación: Asistencia Técnica en los Procesos de Labranza de Suelo, Asistencia Técnica para la Administración de la Maquinaria Agrícola y Prueba y Evaluación de Máquinas Agrícolas, con un alcance que abarcó el área cañera y un tiempo que enmarcó todo el año vinculado al productor. La asistencia en los procesos de labranza se aplicó a la deforestación, la nivelación, la preparación de suelo, la plantación y la fertilización y cultivo post-cosecha. Para la planificación de las labores de labranza, la gestión del mantenimiento y el control de la explotación se emplearon soportes computacionales. Las recomendaciones dadas al productor se fundamentaron técnicamente según criterios tecnológicos, energéticos, económicos y ambientales; teniendo en cuenta los resultados de más de 40 años de investigaciones del INICA y de otras instituciones nacionales. Se recomendó fortalecer la infraestructura material y humana del INICA y crear una metodología de diagnóstico de los procesos de labranza para la implementación del servicio.

Palabras clave: labranza, asistencia técnica, servicio, planificación.

✉ Autor para correspondencia: *Yoel Betancourt Rodríguez*. E-mail: yoel.betancourt@nauta.cu, yoelbr15@gmail.com yoel.betancourt@inicavc.azcuba.cu
Received: 21/05/2017
Approved: 14/03/2018

INTRODUCTION

Agricultural mechanization is considered one of the principal causes of soil damage when inadequate agricultural techniques are applied. Compactness and the creation of favorable conditions that reduce organic matter and cause erosion are among the principal causes of soil deterioration (Primavesi, 1998; Cuellar *et al.*, 2003).

Several sugar cane agricultural processes have high incidence on the environment: deforestation, fertilization and post-harvest cultivation, land leveling and soil preparation. The use of sustainable measures includes the preservation of natural resources, environmental improvement and energetic and economic efficiency (Zaénz, 2008; Rodríguez *et al.*, 2010; Valdés, 2010; Chuck *et al.*, 2011).

The energetic and economic efficiency in mechanized operation can be achieved taking into account procedures that go from the selection of the technological alternative in function of the specific characteristic of the area to be cultivated, going through the selection of appropriate operational variants and ending with the selection of the right combination of tractor and implement. The selection of a technological alternative and its operation particularly, requires considering some aspects like soil limiting factors, available resources, field conditions and environmental interests. Because of that it can be said that the correct application of an alternative achieves results that stablish new paradigms and eliminates old dogma of sugar cane farmers.

In Cuban sugar cane sector, some problems related to soil cultivation have been identified (Betancourt *et al.*, 2015): inadequate application of soil preparation technologies, acquisition of means that are not in correspondence with the needs of sugar cane growers, intensive and generalized use of conventional means, not all plowed areas are planted, with great economic wastages; no application of operation or means aimed to find solution to limiting factors such as subsolation, land leveling and contour plantation; high obsolescence aging of machinery, lack of multipurpose machines and the existence of multiple trades and models to carry out the same work; insufficient implements to guarantee a right tractor and implement relationship, lack of a maintenance management system in correspondence with the technological changes and the need of implementing a more effective and sustainable quality control.

The current situation demanded the emergence of a technical attendance service that offers integrative solutions to the problems identified in Cuban sugar cane sector. To show the conception of that service constitutes the objective of this paperwork.

Procedures Description

The conception of the soil tillage service involved procedures like planning, organization, control and training of all operations related to the field, which were supported by offerings to the growers and toward the farm processes that are not included in the current services of INICA.

The objectives and scope of the services introduced by INICA [Service for Recommendation of Fertilizers and Amendments (SERFE), Service for Weed Integral Control (SERCIM), Service for Recommendation of Varieties and Seeds of Sugar Cane (SERVAS), and Service for Plant Protection (Fitosanitarian control) (SEFIT) (Franco *et al.*, 2014) were the bases to establish the working structure of this service.

An informatics system was used in the planning for the recommendation of the technological chart for minimum unit of management, proposed by Betancourt *et al.* (2017). The input and output variables by technological processes are shown in Table 1.

TABLE 1. Input and Output Variables Considered by Technological Process

Process	Input Variable	Output \Variable
Deforestation	Area/Plot number/Type of vegetation/ Date of start the operation/Machinery availability/ Effective days/ operation indexes	• Technological charts. • Deficit or excess of machinery (tractor and implement). • Technical capacity to solve the works planning. • Monthly and annual distribution of agricultural works. • Monthly and annual use of machinery. • Demand of stuck for machinery (fuel, lubricant, grease, among other). • Demand of herbicides for conditioning and preservation of areas.
Land leveling	Area/Plot number/Land conditions/ Date of start the operation/Machinery availability/Effective days/ operation indexes.	
Soil preparation	Area/Plot number/Soil limiting factors/Soil texture/Land conditions/Requirement of surface smooth/Change of furrow direction/Weed presence/Plantation seasons/Date of start the operation/Machinery availability/ Effective days/ operation indexes.	
Plantation	Area/Plot number/Soil limiting factors/Irrigation/ Availability of workers for manual work/ Date of start the operation/Machinery availability/ Effective days/operation indexes.	
Fertilization and post-harvest cultivation	Area/Plot number/Soil limiting factors/Type of harvest/ type of stool/ Percent of stool in the block/Agricultural yield (t/ha)/ Date of start the operation/Machinery availability/ Effective days/operation indexes.	

All aspects related to the norms and dosage of the fertilizer to correspond to the SERFE service and the mechanical weed control to belong to the SERCIM service are excluded in the recommendations.

The results of soil tillage investigations of INICA and other institutions were considered to define the variants conformation in every technological process, which served as base to offer recommendations technically based according to technologic, energetic, economic and environmental approaches (Gómez *et al.*, 1997; Santana *et al.*, 1999; IIMA, 2000; INICA, 2009, 2017; Gutiérrez *et al.*, 2013).

The environmental sustainability principles settled down in the recommendations adhered to the following premises (Betancourt, 2013): eradicate the practice of vegetable residuals burning, conceiving operations like weed mow, application of herbicides and mulch; to minimize the use of the traditional means of land preparation such as discs plows and harrows, to implement alternative that achieve the biggest percentage of covered area by vegetable residuals (superiors to 30%), with the indispensable soil motion; to foment the contour soil preparation and plantation in those areas that require that manage and to recommend practice that facilitate the water management and achieve an adequate ruggedness in the soil surface.

The maintenance management and the operation control of machinery were conceived digitally by means of CPlus[1] software, with a module spatialized in this field. The input and output variables are presented in the Figure 1.

On the other hand, the renovation of the tillage machines is indispensable nowadays and it constitutes a key axis for the economic sustainability of AZCUBA Sugar Group. The acquisition of new and modern equipment requires of the validation under the Cuban conditions, that is why, one of the offers of the service must be specialized in that work line.

Offering appropriate recommendations to the current conditions of the country was the general premise settled down in the service projection, and subsequently, from the based and strategy created, to propose and to implement advanced technologies in Cuban sugar cane industry.

RESULTS AND DISCUSSION

The solution of the current problems in the field of soil tillage with an integrative focus from the agricultural engineering with characteristic, reach and outputs aimed at the different levels of the growing condition, with an appropriate flexibility that is adjusted to the prevailing situation and the immediate and future projection of the machinery, focus to organize the service in three offers (Figures 2) with a general structure of operation like it is shown in Figure 3.

In the soil tillage decisions is of vital importance to stablish an appropriate linking between INICA institution and AZCUBA group to ensure that the recommendations are implemented according to the charts planned, because this service puts to the disposition of the sugary group, systems for planning, organization, control and training; all important constituents to make better decisions and to achieve an opportune and efficient work with quality.

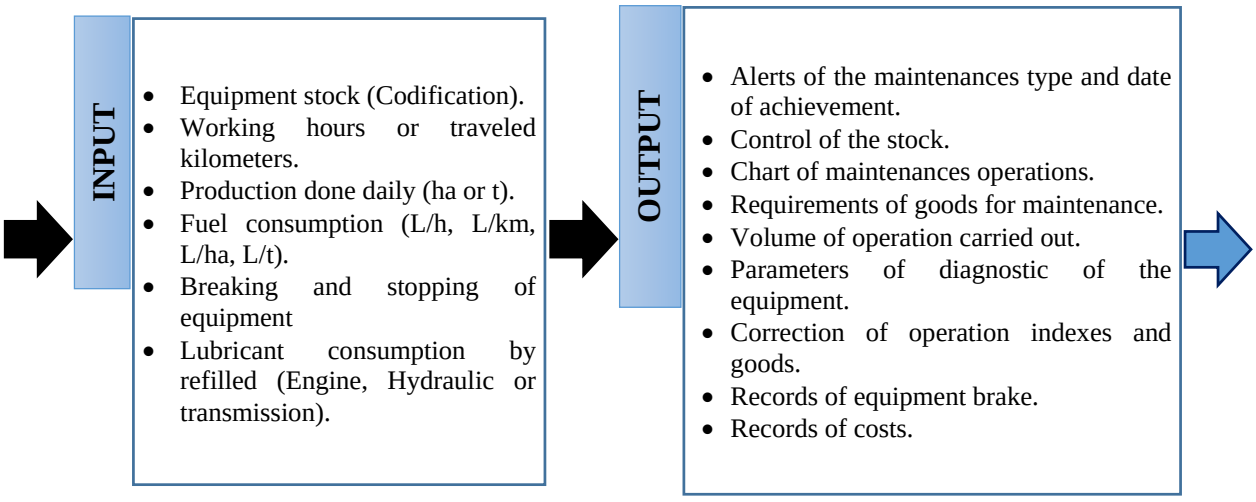

FIGURE 1. Input and output variables considered in the administration of maintenance and the operation control.

[1] Cplus is a web platform mainly design to manage some of the necessary process for the harvest development, allowing the evaluation of all sugar quality parameters, sources balance and other economic indicators of AZCUBA Sugar Group and its dependence.

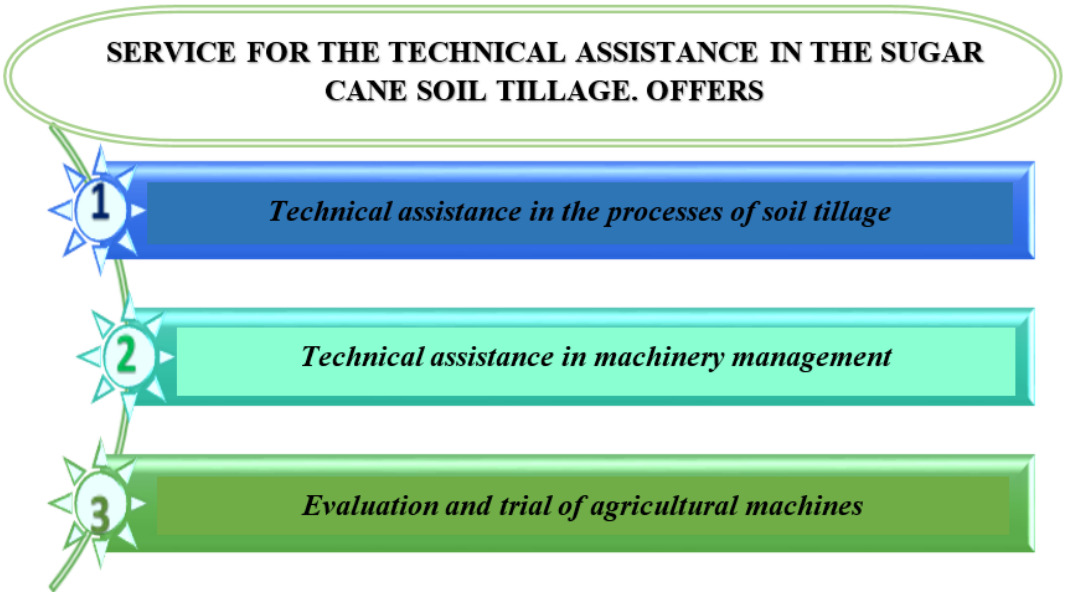

FIGURE 2. Offers of the soil tillage service.

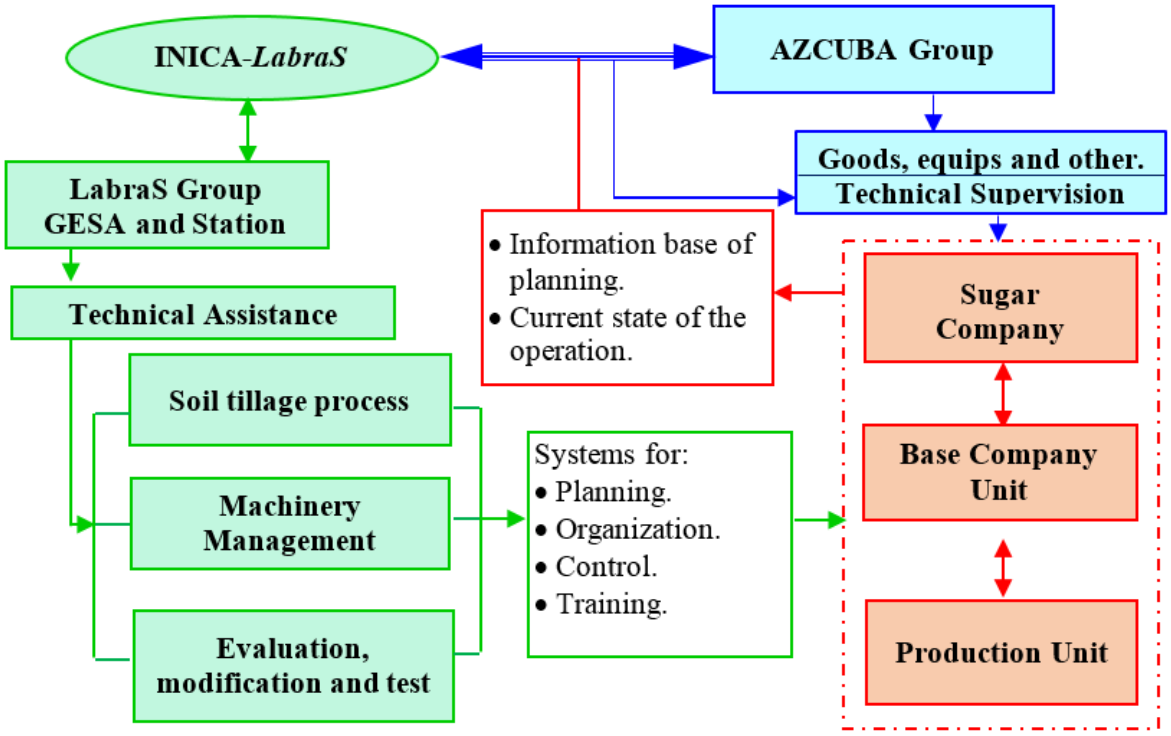

FIGURE 3. Working general structure of the soil tillage service.

INICA by means of LabraS Group present in each province and taking in to account the computer interfaces created, carries out the technical assistance in the three offers of the service in a general way.

It is responsibility of Azcuba to ensure the goods planned appropriately, and by means of the Provincial Companies and the Company Units of Base to guarantee the demanded equipment and with proper technical state; as well as, to carry out technical supervisions at the different levels.

The companies and the Production Units gives the information to archives of planification and the current state on the operation.

The aspects contained in the three offers of the technical assistance are detailed as follow:

Technical Attendance in the Soil Tillage Processes offer contains the aspects linked to the planning of tillage, its operation structure is presented in Figure 4. INICA, by means of LabraS Group in the provincial, and being aided of the planning interface, receives the input information by process. Once the information is processed automatically, the obtained reports are conciliated with the growers. After that, informs are prepared and send to the different levels. Informs delivery goes accompanied by a training program in function of the grower's needs and previous reconciliation with the Cane and Mechanization Office Chief of AZCUBA. The procedures for the demands of inputs, equipment and technical supervisions, stay similar to that described in the general structure. It is important to highlight the preponderant paper of the Grower Cooperatives in the quality control during the achievement of the soil tillage recommendation because the operations will come from specialized brigade where the equipment do not belonged to them.

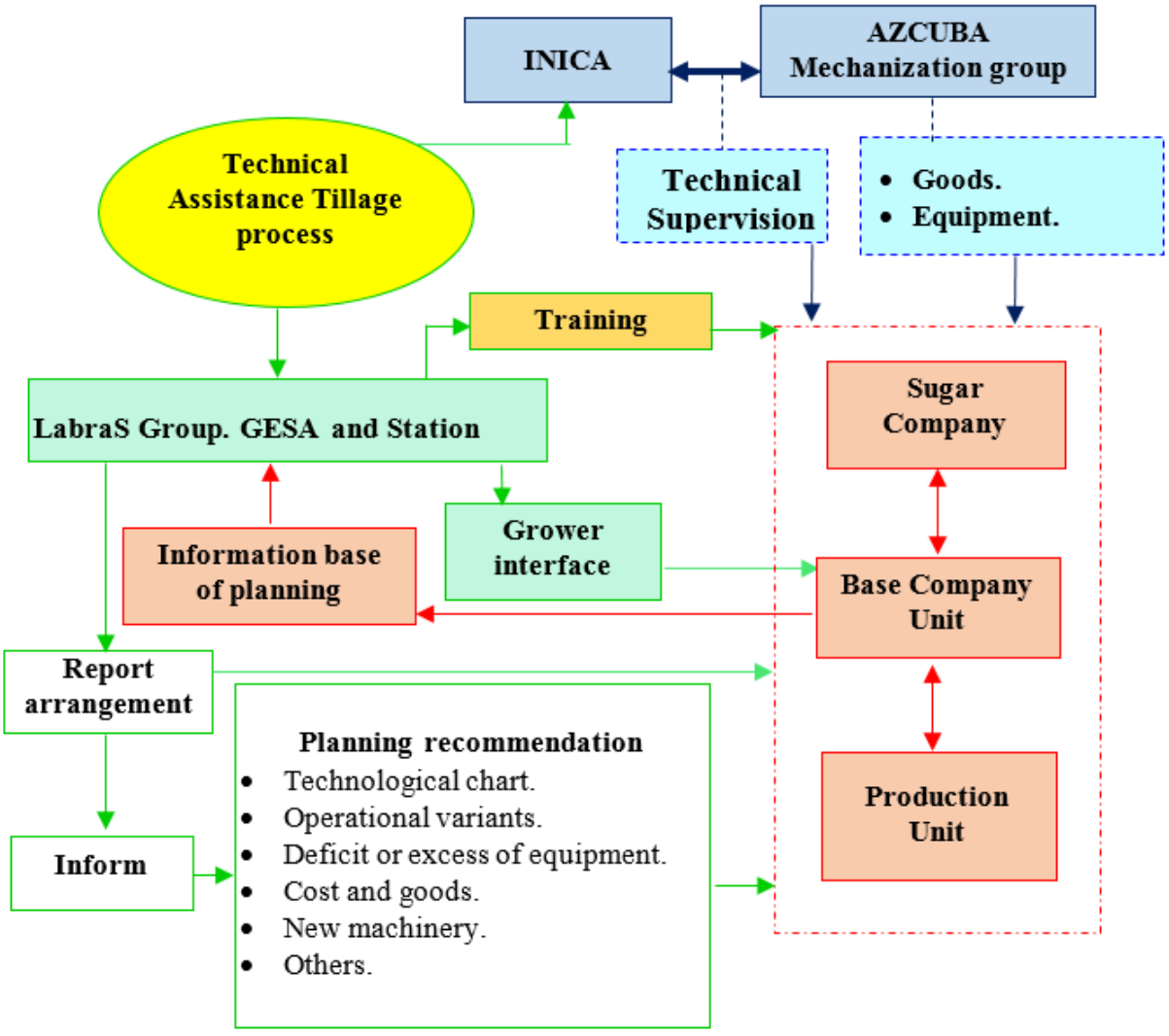

FIGURE 4. Working Chart of the Technical Assistance in the Soil Tillage Processes.

This offer has permanent character, therefore, it assists annually to the grower, with a reach that embraces all the sugar cane companies of the country.

In Figures 5, 6 and 7, examples of recommendations in the technological process of land preparation for UEB Hector Rodriguez, in Villa Clara province, are shown. They are the technological chart, the balance of tractor and the demand of herbicides required for preservation and conditioning of the area, in that order.

Año de trabajo: 2016

INICA

Servicio de Labranza de Suelo

Recomendación Adecuada por Proceso Tecnológico

Empresa Azucarera VILLA CLARA

UEB HÉCTOR RODRÍGUEZ

UBPC 1ro DE MAYO

Proceso Tecnológico: Preparación de Suelos

Bloque	Área (ha)	Alternativa Tecnológica	Variantes	Labores	Fecha de Inicio	Agregados	Productividad (ha/jornada)	Gasto Combustible (L)	Costo (pesos)
00066	31,540	Preparación de Suelos ligero con problemas de compactación, en demolición con cambio de surquería.	Variante 1	Quema (opcional)	20/03/2016	1,4 t (MTZ y YUMZ) con Carreta	100,0	157,7	220,8
				Grada mediana	21/03/2016	YTO Estera con Grada GAPCR (Aradora)	5,0	788,5	774,3
				Subsolación	25/03/2016	YTO con Bayamo 81	12,0	441,6	693,9
				Grada mediana	31/03/2016	YTO Estera con Grada GAPCR (Aradora)	5,0	788,5	774,3
				Subsolación	04/04/2016	YTO con Bayamo 81	12,0	441,6	693,9
				Profundización y mullido (discos)	06/04/2016	YTO Estera con Grada GAPCR (Aradora)	5,0	788,5	774,3

FIGURE 5. Inform with the land preparation chart per plot.

INICA

Servicio de Labranza de Suelos

Balance de las Fuentes Energéticas

Empresa Azucarera VILLA CLARA

UEB HECTOR RODRIGUEZ

Fuente Energética	Proceso	Labores	Area (ha)	Norma (ha/jornada)	Demanda de FE por Labor	Demanda de FE por Proceso	Demanda Total	Existencia	Observaciones
BELARUS 1523	Preparación de Suelos	Cruce (discos)	271,1	14,5	1	2	2	2	Se cuenta con la F.E. BELARUS 1523 necesaria para realizar el trabajo planificado
		Rotura (discos)	271,1	14,0	1				
CASE 150	Preparación de Suelos	Cruce (discos)	73,8	16,0	1	2	2	0	Existe déficit de CASE 150 para realizar el trabajo planificado
		Rotura (discos)	73,8	16,0	1				
T-150K	Preparación de Suelos	Alisado	3691,7	14,0	3	3	3	10	Existe exceso de T-150K para realizar el trabajo planificado

FIGURE 6. Tractor demands per process.

INICA

Servicio de Labranza de Suelos

Demanda de Herbicida para Preparación de Suelos

Empresa Azucarera VILLA CLARA

UEB HECTOR RODRIGUEZ

Bloque	Área (ha)	Fecha de Conclusión de Preparación de Suelos	Fecha de Inicio de Plantación	Área a aplicar (ha)		Herbicida para Acondicionamiento (L)		Herbicida para Preservación (L)	
				Acondicionamiento	Preservación	Glifosato	Esterol	Mayoral	Doblete
00008	13,8	16/05/2016	15/08/2016	0,0	13,8	0,0	0,0	9,7	27,6
00009	96,8	23/02/2016	05/07/2016	0,0	96,8	0,0	0,0	67,7	193,5
00012	12,6	11/05/2016	10/08/2016	0,0	12,6	0,0	0,0	8,8	25,3
00049	14,7	14/03/2016	05/04/2016	14,7	0,0	73,7	29,5	8,8	25,3
00008	79,1	21/02/2016	10/03/2016	79,1	0,0	395,5	158,2	8,8	25,3
00009	45,0	15/02/2016	31/01/2016	45,0	0,0	225,0	90,0	8,8	25,3
00010	93,0	28/02/2016	20/02/2016	93,0	0,0	465,0	186,0	8,8	25,3
00016	64,2	23/03/2016	01/04/2016	64,2	0,0	321,2	128,5	8,8	25,3
00038	38,3	22/03/2016	09/04/2016	38,3	0,0	191,6	76,6	8,8	25,3

FIGURE 7. Demand of herbicide for soil preparation process.

In the recommendation of the technological charts, the information could be obtain independently for technological process if it is desired, and the date to start the operation, the tractor and implements to use according to the machinery stock and their availability, the norm for a day (ha hornada^{-1}), the fuel consumption (L) and the cost (pesos) according to the dimension of the area are presented

The balance of tractor is also carried out general or particular according to the technological process. The data for the analysis come from the recommended chart, the information is also shown general for the trade brand and/or model of equipment.

In the demand of herbicides for soil preparation the type, dose and total quantity of herbicide for plot are defined, either for conditioning the surface or for the preservation of the areas prepared.

The organization and control systems of soil tillage recommendations are found in *Technical Assistance for the Agricultural Machinery Management* offer. This is the support that ensures the achievement of the recommendations planned in the first offer. It defines the administration of the maintenance and repairs, technicians, organizational and economical systems and those of training and required control (Figure 8). It could has a temporary or permanent character in dependence of the applied system, because it assists the grower in actions that define work strategies with a reach that embraces equally to all the production units, workshops, soil tillage platoons and other systems of production. The base instances in this system, by means of the net way of communications, inform the current state of the works carried out.

The main function and objectives of this system are:

The system of maintenance and repairs administration is in charge of implementing strategies and advance technologies to code and to evaluate the technical state of the existent equipment; to elevate the efficiency and quality of the works done in tillage, to perform the work system in the workshop and to implement a program of lubrication that contains the selection, acquisition and managing that product, besides the improvement of the lubrication and maintenances guides.

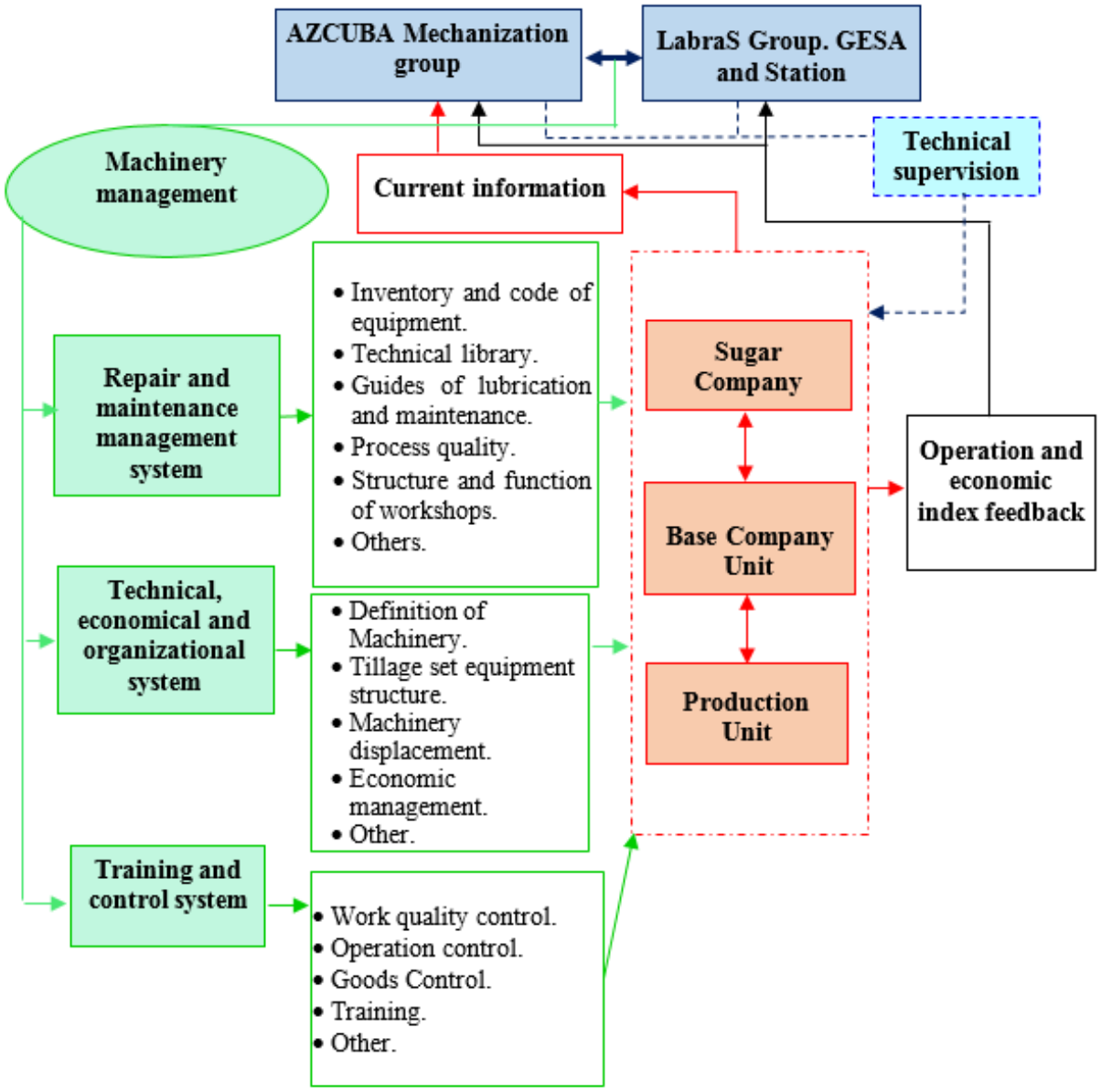

FIGURE 8. Working diagram to the technical assistance of machinery management.

The organizational and economic system defines the soil tillage equipment with immediate and future projection, the structure of the tillage set of equipment, the displacement strategy and of economic administration to assure the sustainability of the system (amortization, planning and analysis of expenses, cost records, renovation of equipment, among other).

The training and control system is in charge of establishing the means and methods for the control of the goods, of the tillage work quality, of the repairs and maintenances and the operation of the equipment. The last one in particular, allows adjusting the operation and economic indexes (work norms, fuel consumption and cost), that will serve to upgrade the indexes used in *LabraS* software of planning (feedback). This system will be accompanied by a training program at all levels that responds to the necessities identified in the control.

In Figures 9 and 10, two reports made through CPlus software are shown, the maintenance control executed (Figure 9) and the equipment breaking control (Figure 10). In the former, the equipment, the executer, the type of maintenance, the waste and the date are shown. All that parameters ensure an adequate control of that process. In the last one, the date when the breaking happened and the period to solve the problem.

AZCUBA CPlus. PANCHITO GOMEZ TORO — Fecha Generación: 30/05/2017 23:09:52

Fecha Trabajo: 15/05/2017

01. Control de Mantenimientos realizados a equipos.

UEB: PANCHITO GOMEZ TORO

Rango de fecha seleccionado: 01-01-2017 hasta 31-12-2017 (365 días)

Tipo Equipo: Tractores pesados S/N

Equipos: Tractores pesados S/N-BELARUS-01V312

Equipo	Completamiento de Tareas	Mecánico	Jefe de Taller o Supervisor	Tipo de Mantenimiento	Gastos (CUC)	Fecha
Tractores pesados S/N-BELARUS-01V312	Realizadas: **43** | Sin Realizar :**0** | % Cump.: **100**	YUNIOR	PABLO PÉREZ	Mtto.1250	809.4	24-02-2017
Tractores pesados S/N-BELARUS-01V312	Realizadas: **47** | Sin Realizar :**0** | % Cump.: **100**	YUNIOR	PABLO PÉREZ	Mtto.1500	809.4	13-03-2017
Tractores pesados S/N-BELARUS-01V312	Realizadas: **43** | Sin Realizar :**0** | % Cump.: **100**	YUNIOR	PABLO PÉREZ	Mtto.1750	809.4	27-03-2017
Tractores pesados S/N-BELARUS-01V312	Realizadas: **63** | Sin Realizar :**0** | % Cump.: **100**	YUNIOR	PABLO PÉREZ	Mtto.2000	809.4	11-04-2017
					Gastos totales: 3237.6	

FIGURE 9. Maintenance control report.

AZCUBA CPlus. PANCHITO GOMEZ TORO — Fecha Generación: 24/05/2017 17:10:20

Fecha Trabajo: 15/05/2017

01. Control de Roturas.

UEB: PANCHITO GOMEZ TORO

Rango de fecha seleccionado: 14-11-2016 hasta 15-05-2017 (183 días)

Tipo de Equipo	Equipo	Fecha	Fecha Salida
Tractores pesados S/N - BELARUS	Tractores pesados S/N-BELARUS-01V332	01/02/2017 00:00:00	01/02/2017 14:00:00
Cosechadoras de Caña - CASE	CASE-043 C PTON 02 PGT	19/02/2017 00:00:00	19/02/2017 00:00:00
Tractores pesados S/N - YTO	Tractores pesados S/N-YTO-01V007	01/02/2017 00:00:00	02/02/2017 14:00:00
Cosechadoras de Caña - CASE	CASE-044 C PTON 02 PGT	19/02/2017 00:00:00	20/02/2017 02:30:00
Tractores Especializados - Tractor Movedor	210 TM PTON 02 PGT	05/02/2017 00:00:00	05/02/2017 00:00:00
Tractores Especializados - Tractor Movedor	216 TM PTON 04 PGT	06/02/2017 00:00:00	07/02/2017 00:00:00
Tractores Especializados - Tractor Movedor	211 TM PTON 02 PGT	07/02/2017 03:05:45	24/05/2017 17:10:21
Tractores pesados S/N - BELARUS	Tractores pesados S/N-BELARUS-01V322	08/02/2017 03:41:24	24/05/2017 17:10:21
Tractores pesados S/N - BELARUS	Tractores pesados S/N-BELARUS-01V357	09/02/2017 00:00:00	09/02/2017 01:00:00
Cosechadoras de Caña - CASE	CASE-047 C PTON 04 PGT	15/03/2017 02:50:57	24/05/2017 17:10:21
Cosechadoras de Caña - CASE	CASE-047 C PTON 04 PGT	10/02/2017 00:00:00	11/02/2017 07:15:00
Cosechadoras de Caña - CASE	CASE-043 C PTON 02 PGT	21/02/2017 00:00:00	21/02/2017 02:00:00
Cosechadoras de Caña - CASE	CASE-044 C PTON 02 PGT	11/02/2017 00:00:00	11/02/2017 17:00:00
Cosechadoras de Caña - CASE	CASE-045 C PTON 02 PGT	11/02/2017 00:00:00	11/02/2017 18:15:00
Cosechadoras de Caña - CASE	CASE-043 C PTON 02 PGT	11/02/2017 01:46:19	11/02/2017 20:00:00
Tractores Especializados - Tractor Movedor	210 TM PTON 02 PGT	11/02/2017 00:00:00	24/05/2017 17:10:21

FIGURE 10. Breaking control report.

All the aspects related to the evaluation, modification and test of machinery is included in the third offer. The structure and operation is less complex than the previous ones (Figure 11). It is carried out according to the client's application, independently of the level in which it is the demanded, either in base (Sugar Companies and Units of Production) or central level (Sugar Group AZCUBA).

The modification of machine is carried out according to the test results and the demand of the grower, and it is developed until the machine reaches suitable results for Cuban conditions. In that process, it is important to agree works and results with the Agricultural Engineering Research Institute (IAgric), because it is the rector center of this activity in the country.

The objectives of this offer are summarized in testing, evaluating and modifying agricultural machines of soil tillage and other destined to the sugar cane cultivation in general.

The appropriate operation of the service requires of the qualified personnel, computer and communications equipment, training, equipment of mensuration and transport. The current situation of INICA demands of a strengthening of the personnel specialized in agricultural engineering and of the material infrastructure, particularly in the transport and computation means that assure a full operation of the service. Also, it is important to create a diagnostic methodology before implementing the service to identify, in the last three to five years, the situation of tillage processes in general (technical, organizational, economic, energetic and environmental); what will allow determining the resulting impact of their implementation with more facility and precision.

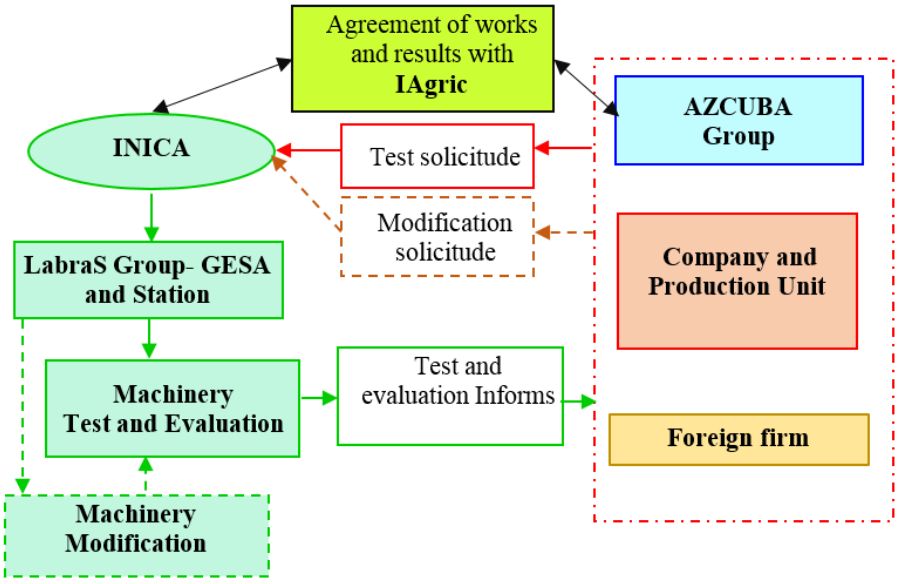

FIGURE 11. Working diagram of machinery test, evaluation and modification offers.

CONCLUSIONS

- The conception of the service is defined in three offers: technical assistance in the soil tillage processes, technical assistance for the agricultural machinery management and test, evaluation and modification of machines. It was aimed to deforestation, land leveling, soil preparation, plantation, fertilization and post-harvest cultivation processes. It comprises all sugar cane area in general and the whole year. It was designed with two computer platforms for planning works, maintenance administration and operation control of machinery.
- To strengthen the material and human infrastructure of INICA and to create a methodology to diagnose the soil tillage processes before the service implementation.

REFERENCES

BETANCOURT, Y.: *Servicios Científicos-Técnicos y extensión agrícola-Servicio de labranza*, Ed. AMA, Instituto de Investigación de la Caña de Azúcar ed., vol. 1, La Habana, Cuba, 277-278 p., 2013, ISBN: 978-959-300-051-2.

BETANCOURT, Y.; ALONSO, D.; BERNARDO, A.; LA ROSA, A.J.: *Software LabraS*, no. 2124-07-2017, Inst. Centro Nacional de Derecho de Autor, La Habana, 2017.

BETANCOURT, Y.; SOCARRAS, D.; GUILLEN, S.; BOU, L.; RIVERA, O.; JEREZ, J.; FERREIRA, R.; GONZÁLEZ, J.C.: "Manual técnico para el jefe de pelotón de preparación de suelo", *Revista Cuba &Caña*, Suplemento especial(1): 61, 2015, ISSN: 1028-6527.

CHUCK, C.; PÉREZ, E.; HEREDIA, E.; SERNA, S.O.: "Sorgo como un cultivo multifacético para la producción de bioetanol en México: tecnologías, avances y áreas de oportunidad", *Revista Mexicana de Ingeniería Química*, 10(3): 529-549, 2011, ISSN: 1665-2738.

CUELLAR, I.; DE LEÓN, M.; GÓMEZ, A.; PIÑÓN, D.; VILLEGAS, R.; SANTANA, I.: *Caña de Azúcar. Paradigma de Sostenibilidad*, Ed. Publinica, Primera edición ed., La Habana, Cuba, 175 p., 2003, ISBN: 959-7023-24-6.

FRANCO, G.I.; GALLEGO, R.; RUBÉN, H.; CHÁVEZ, I.; IZQUIERDO, I.; ZAMBRANO, Y.: *Sistema de asistencia técnica. Transferencia de tecnología e introducción de logros científico-técnicos*, Ed. AMA, 2da edición ed., vol. Instructivo técnico para el manejo de la caña de azúcar, vols. 1, La Habana, Cuba, 79-86 p., 2014, ISBN: 978-959-300-036-9.

GÓMEZ, A.; VELARDE, E.; CÓRDOBA, R.: "Nuevas soluciones para la preparación de suelos en Cuba", 2(3): 31-36, 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, ISSN: 1028-6527.

IIMA: *Instructivo técnico del multiarado M 250 Cañero*, Ed. IIMA, La Habana, Cuba, 12 p., 2000.

INICA: "Taller nacional con los directores de producción de caña de empresas y GEA", *Rev. Cuba & Caña*, Suplemento especial(2): 144, 2009.

INICA: *Instructivo Técnico para la Producción y Cultivo de la Caña de Azúcar*, Ed. Publinica, Primera Edición ed., La Habana, Cuba, 166 p., 2017.

PRIMAVESI, A.: *Manejo Ecológico del Suelo*, Ed. El Ateneo, 499 p., 1998.

RODRÍGUEZ, I.; PÉREZ, H.; CRUZ, O.: "Prácticas agrícolas establecidas para evitar la degradación de los suelos en la UBPC Tuinucú", *Revista Cuba & Caña*, 1: 51-56, 2010, ISSN: 1028-6527.

SANTANA, M.; FUENTES, J.B.; BENÍTEZ, L.; COCA, J.; CÓRDOBA, R.; HERNÁNDEZ, S.; ARCIA, J.; HERNÁNDEZ, 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, 77 p., 1999.

VALDÉS, A.: "Consumo de combustible fósil por efecto de la producción y aplicación de fertilizantes inorgánicos en la obtención de biocombustibles líquidos", *Revista de la Asociación de Técnicos Azucareros de Cuba ATAC*, 3: 13-18, 2010, ISSN: 0138-7553.

ZAÉNZ, T.: "Azúcar, petróleo, biocombustibles y crisis estructural", *Revista de la Asociación de Técnicos Azucareros de Cuba ATAC*, 2: 52-53, 2008, ISSN: 0138-7553.