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TOWARDS A MORE SUSTAINABLE REGION

ANNUAL REPORT 2020

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Colombian Sugarcane Research Center.
CENICAÑA

I 119 p.; 27 cm

ISSN 2805-9638

Annual Report 2020 / Colombian Sugarcane Research Center. CENICAÑA. – Cali: Cenicaña, 2021.

INCLUDES

Annex, references and addendumx

1. Research center. 2. Cenicaña. 3. Cauca river valley. 4. Climate. 5. Sugarcane. 6. Production. 7. Productivity. 8. Varieties. 9. Cultural practices. 10. Factory processes. 11. Innovation. 12. Biosecurity.

I. Title
633.61 CDD 23 ed.
C395

Editorial production

Office of Strategic Communications

Postal address

Calle 38 norte No. 3CN-75
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CORPORATE PROFILE

The Colombian Sugarcane Research Center (Cenicaña, its Spanish acronym) is a not-for-profit private institution, financed with direct contributions of 13 sugarcane mills of the Cauca river valley and its sugarcane suppliers.

The Center, founded in 1977 by initiative of the Colombian Association of Sugarcane Growers (Asocaña, its Spanish acronym), supports knowledge management and technological innovation in the Colombian agroindustrial sector through research and the rendering of specialized services.

MISSION

To contribute to the development, competitiveness, and sustainability of the sugarcane agroindustrial sector in Colombia by generating knowledge and technological innovation through research, technology transfer, and the rendering of specialized services, based on an integrated crop management system so the sector is recognized for its socioeconomic improvement and environmental conservation of sugarcane-producing areas.

VISION

To be a center of excellence in research and innovation worldwide, generating technologies that improve the competitiveness of the sugarcane agroindustrial sector in Colombia, recognized by donors as a profitable investment, by its staff as an ideal place to work, by the scientific community as a center of creativity and quality, and by society as a respected institution.

CORPORATE VALUES

Coherence

Integrity

Loyalty

Respect

Responsibility

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Luis Eduardo Gonzáles Buriticá
Head, Experiment Station Superindendency

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TOWARDS A MORE SUSTAINABLE REGION

Annual Report 2020

This annual report summarizes the main advances and achievements of the Colombian Sugarcane Research Center (Cenicaña, its Spanish acronym) in 2020 that aim to increase the competitiveness and sustainability of the sugarcane agroindustry in Colombia.

The report details the different activities carried out in a year in which the World Health Organization (WHO) declared COVID-19 a pandemic on March 11, a situation that was decisive in determining many of the activities carried out during 2020.

To help us better understand the situation that the agroindustry faced during this period, different leaders of the sugarcane agroindustry share their thoughts on the conditions in which sugarcane growers and sugar mills continued to operate and the post-pandemic challenges they will face, especially in terms of science, technology, and innovation.

In these conditions and despite the physical distancing that marked many of the year's activities, the collaborative work between Cenicaña, sugar mills, and sugarcane growers prevailed throughout 2020. The photos shared in this report are a recognition of that relationship, which grows stronger, year after year, through research, services, and information.

Organized in seven sections, the report addresses the highlights of Cenicaña's three research programs and four specialized services that form part of the Center's institutional structure. Through its different research projects, the center seeks to better understand the sugarcane crop, develop crop management technologies and tools from a site-specific agriculture (SSA) approach, improve factory processes, and expand the diversification of the industry.

All activities carried out during 2020 aim to consolidate Cenicaña as a renowned research center of excellence that complies with biosecurity regulations.

Each research advance, result, and activity serves to consolidate a more sustainable region.

01

CLIMATE IN THE CAUCA RIVER VALLEY 2020:
Cenicaña's new agroclimatic service presents an analysis of the records obtained by the Automated Meteorological Network to date for the main meteorological variables of the Cauca river valley as well as the data provided by international meteorological agencies.

Photo: Diana Catalina Delgado, Head of Precision Agriculture and GIS, Mayagüez sugar mill, and Jorge Celades, Communications Technologist, Cenicaña's Information Technology Service.

02

PRODUCTION AND PRODUCTIVITY OF THE SUGARCANE AGROINDUSTRY 2020:
Analyzes the main productivity indicators of the sugarcane agroindustry.

Photo: Angelo Andrés Hurtado, Supervisor, Riopaila Castilla sugar mill, and Natalia González, Agricultural Engineer, Cenicaña's Technical Cooperation and Technology Transfer Service.

03

SUGARCANE: THE BASIS OF OUR AGROINDUSTRY:
Presents the research results and advances of the Variety Program and each of its work areas: biotechnology, plant breeding, entomology, and plant pathology. The management given to the varieties by the Technical Cooperation and Technology Transfer Service as well as the Economic and Statistical Analysis Service is also presented.

Photo: Luis Orlando López, Plant Breeder, Cenicaña's Variety Program; Jaime Andrés Marín, Agronomy Engineer, Incauca; and Oscar Andrés López, professional, Providencia sugar mill.

04

CROP MANAGEMENT TECHNOLOGIES AND KNOWLEDGE:
Covers the developments and results of activities carried out by the Agronomy Program in the areas of water management, nutrition and fertilization, physiology, maturation, geomatics, and the CATE project that addresses aspects related to the uploading, transportation and delivery of cane. This section also includes the main outputs relevant to crop management of both the Information Technology Service and the Technical Cooperation and Technology Transfer Service during 2020.

Photo: Fanny Hoyos, Agricultural Engineer, Cenicaña's Agronomy Program, and Dulima Mosquera, Director, Corpopalo.

05

TOOLS AND DEVELOPMENTS FOR FACTORY PROCESSES:
Presents results and advances of the Factory Processes Program.

Photo: Julio Calpa, Electrical Engineer, Cencaña's Factory Processes Program, and Jairo Rubio, Head of Factory Processes, Maria Luisa sugar mill.

06

STRATEGIES TO PROMOTE INNOVATION IN THE AGROINDUSTRY:
Comprehends the activities carried out by the Technical Cooperation and Technology Transfer Service related to different technologies involving sugarcane varieties, irrigation management, and precision agriculture.

Photo: Adriana Guzmán Maldonado, sugarcane grower, and Alejandro García, Transfer Agronomist, Cenicaña's Technical Cooperation and Technology Transfer Service.

07

ACTIONS TO BECOME A RENOWNED CENTER OF EXCELLENCE THAT COMPLIES WITH BIOSECURITY REGULATIONS:
Presents the activities carried out by Cenicaña's Information Technology and Knowledge Management Services for Institutional Strengthening. It also covers the main activities carried out by the Experiment Station Superintendency, the Workplace Safety Management System, and the Strategic Communications Office.

Photo: Onésimo Rubio, Cenicaña's field collaborator.

PHOTO GALLERY 1:

Magda Ortiz, Director, Asoamaime; Dulima Mosquera, Director, Corpopalo; Alejandro García, Transfer Agronomist, Cenicaña; Miguel Angel Cagüeñas, Agronomy Engineer, Cenicaña; John Jaime Riascos, Variety Progam Director, Cenicaña; Hernando Ulloa, professional staff member, Occidente sugar mill; and Freddy Garcés, Director General, Cenicaña; Laura Ramírez, Head of Area, Risaralda sugar mill; Héctor Chica, Biometrician, Luz Ángela Mosquera, Statistician, and Claudia Posada, Economist, Cenicaña; Jairo Valencia, professional staff member, La Cabaña sugar mill; Michael Arredondo, Topographical Engineer, Cenicaña; Isaías Mendoza, Agricultural Technician, Cenicaña; and Óscar López, Agronomy Supervisor, Providencia sugar mill.

PHOTO GALLERY 2:

Photos: José David Velásquez, harvester operator, Mayagüez sugar mill; Tomás Valencia, tractor operator, Mayagüez sugar mill; Jhon Fernando Echeverry, Carmelita sugar mill; Julián Montes, Mechanical Engineer, Cenicaña; and José Luis Naranjo, Carmelita sugar mill; Nicolás Gil, Factory Processes Program Director, Cenicaña; Luisa Barona, Factory and Distillery Director, Riopaila Castilla sugar mill; Bernardo Bolaños, field collaborator, Cenicaña; Tomás Valencia, tractor operator, Mayagüez sugar mill; and Alejandro Estrada, Logistics Engineer, Cenicaña.

PHOTO GALLERY 3:

Photos: Claudia Echeverry, Biologist, Cenicaña; Angie Valencia, undergraduate student working at the Providencia sugar mill; professionals of Cenicaña and the Manuelita sugar mill; Liliana Echeverry, Chemical Technologist, Cenicaña; Diana Campo, Head of Laboratory, Pichichí sugar mill; Germán Prado and José Ricardo Burgos, field collaborators, Cenicaña.

ICONS ACCOMPANYING THE REPORT

QR code: To access audiovisual material complementary to each theme presented.

Scan with smartphone camera

Webinars

Videos

Tools

Documents

Services

Note to take into account.

Messages of the Director and other invitees.

Photo galleries.

2020: SCIENCE, TECHNOLOGY, AND SOLIDARITY

Freddy Fernando Garcés Obando
Director General de Cenicaña

In 2020 a viral particle posed a threat to mankind that led to an economic and health crisis from which it has not yet recovered. Nonetheless, the sugarcane agroindustry in Colombia continued forward, showing the resilience that has always characterized it when faced with threats and adversities.

Many factors influenced this situation, but it is well worth highlighting those that allowed us to stay afloat, without losing hope. In fact, in 2020 it became clear that the future is only possible through science and technology, two pillars on which the Colombian Sugarcane Research Center is based, as well as the collaborative spirit that as always characterized our sector.

Message of the Director General of Cenicaña

To cope with the pandemic, sugar mills and sugarcane growers showed significant gestures of solidarity and this should be highlighted because these gestures directly impacted the entire sugarcane belt. These sectoral actions are valuable because they reaffirm before others our commitment to the region and the country

Technology also played a key role in Cenicaña's activities throughout 2020 as it allowed us to move forward with our lives and projects. Technology is the backbone of a large part of our technology transfer activities. Different platforms keep us connected and allow us to interact with our donors, despite the distances, even at times when social isolation was at its highest.

This allowed us to continue to promote innovation at the field and production plant levels by providing new technologies, methodologies, and knowledge; by delivering new technological solutions, such as the IoT Network, which will be crucial to monitor field, harvest, and factory processes for increased efficiency and sustainability; and by presenting proposals that mitigate impacts on the processes of sugar production, energy cogeneration, and ethanol production.

2020 was also a year in which advances such as genome assembly and molecular fingerprinting of variety CC 01-1940 gained relevance. These advances will serve as support to the conventional improvement and development of sugarcane varieties, as well as the search for alternatives that support diversification projections and broaden agroindustrial opportunities. Based on these advances and achievements, we can assert that our future holds hope and the sugarcane agroindustry should be granted priority in the current world scenario.

Precisely, to respond to that future with the capabilities that are required, in 2020 Cenicaña continued to strengthen its infrastructure with new equipment and adaptations considered important to increase the level of precision in experiments, accelerate the processes of technology validation and delivery, and implement actions that support knowledge management at the sector level, such as the pilot centers.

Of course, to be able to move forward with planned activities in a particularly atypical year, we embraced and applied the measures decreed by the National Government to reduce the risk of contagion of our collaborators and their families, our contributors, and the surrounding community. Thanks to the conscientious enforcement of preventive measures by our collaborators, at the end of 2020 only 8% of our work team had been infected with the virus, its transmission being attributed in all cases to non-work activities.

This report summarizes our main advances and achievements during 2020. We also share the thoughts and viewpoints of sugar mill representatives and sugarcane growers on the past year's opportunities and challenges, which reiterated our vulnerability as society and gave us the opportunity to change the way we see the world and our region and act accordingly with greater solidarity.

2020 was also the year we said goodbye to Clímaco Cassalett Dávila and Juan José Lülle Suárez, two leaders whom we will always remember for their commitment and contributions not only to Cenicaña but also to the sugarcane industry in Colombia. Their contributions form part of the history we've all built together over these past 43 years.

WE MOVE FORWARD TO A MORE SUSTAINABLE REGION WHEN WE WORK TOGETHER WITH THE COMMUNITY AND OUR DONORS, SHARING THE SAME GOALS.

1

CENICAÑA, A PARTNER THAT MAKES ANYTHING POSSIBLE

Luis Felipe Gaviria,
General Manager, Risaralda sugar mill

Although the sugarcane sector has been able to continue its operation despite the preventive isolation decreed by the National Government, the reality is that we all had to transform the way we operate and in a very short time.

We put to test our creativity, flexibility, and above all our ability to work as a team, including affected communities and coping with uncertainty and the impact that it generates.

People are the heart of the Risaralda sugar mill and the entire agroindustrial sector. The social aspects of our work, implicit in the community work we carry out with not only with our collaborators but also with our different interest groups, were the filters we used to prioritize our actions and investments.

This inclusive and all-embracing approach lead us at the Risaralda sugar mill to discover that not only were we undeniably vulnerable before basic needs, but also capable of generating good results, even in the context of a pandemic. It was through structured and disciplined work to improve the efficiency of field, harvest, and factory production processes that we were able to improve our business performance indicators.

But these results are not achieved unilaterally. It's extremely important to have partners that provide support and teach us what we don't know, allowing us to evolve continuously. Every day is a win-win situation. For a company like the Risaralda sugar mill, where 95% of the cultivated land belongs to sugarcane suppliers, to be able to offer our growers a portfolio of tools and technical, research, technological, and training developments, together with Cenicaña, gives us peace of mind. The research center's specialized professionals work hard to make sure we are doing the things the right way and that we continually improve.

Field processes benefit remarkably from the range of Cenicaña Colombia (CC) varieties available for the multiplication of materials as well as from the strategy designed for the adoption of new varieties for different environments. We also have in place tools for production forecasting (TCH and sucrose) and for studying and predicting climate behavior. The area of plant health provides support in pest and disease management, in addition to guidelines to achieve healthy crop maturation and accompaniment in issues related to the compliance of regulations, mainly in the application of agricultural inputs.

The benefit of having a partner like Cenicaña is not only evident in the field. In 2020, we significantly improved factory efficiency in terms of sucrose extraction and recovery, steam consumption, and increased power generation.

The results were highly positive in terms of sucrose losses. The total losses of sucrose (% cane) decreased 7.13% with respect to the losses presented in 2019 (1.767% vs 1.627% in 2020). This achievement is the result of a corporate effort to increase the recovery of sucrose as packed quintals and total sucrose. The Risaralda sugar mill presented a sugar recovery of 2,207 t sucrose, equivalent to 44,190 quintals as compared with the results of 2019.

In addition, the detailed monitoring of the water use matrix and the improvements implemented in the entire production process helped reduce energy consumption in kW/TCM as well as the capture of water for the sugar mill processes. The year ended with 40% less water intake at the factory level, evidencing a 35% increase in the efficiency of our water cooling circuit.

Our heartfelt gratitude to the entire Cenicaña team for their support. Our goals for 2021 are even more ambitious, which we're sure we will achieve working together.

2020: AN OPPORTUNITY TO ACCELERATE TECHNOLOGY ADOPTION

Ana María Payeras,
Sugarcane grower

Beginning 2020 we never imagined that a virus would change our lives, starting with the way we relate to each other.

Even though the pandemic physically distanced many of us, it also brought us closer to others with the new ways to communicate that are now available.

Because of digital and online alternatives, many sugarcane growers now feel closer to Cenicaña as research center and are aware of other opportunities that could lead to a greater adoption of technology and, definitely, greater innovation.

The webinars, virtual trainings, and digital content on social networks developed and offered by Cenicaña were central to expanding the scope of technology transfer strategies and activities. In good time, the Colombian Association of Sugarcane Producers and Suppliers (Procaña, its Spanish acronym) and the Colombian Association of Sugarcane Technicians (Tecnicaña, its Spanish acronym) made alliances to support the sector with timely and quality information, holding virtual events such as the International Sugarcane Connection 2020.

Despite the difficult conditions that arose with the arrival of COVID-19, alternatives like these that I mention not only made the opportunities that technology offers us more visible, but helped us lose our fear of using these different technologies and assume the risks until we were able to apply them correctly.

This happened to Vicente Espinosa Casañas, a 71-year-old farm administrator. It was only in 2020 that he ventured, after having a pilot tensiometer station for more than 1 year on the property he manages for us, to learn how to use this technology. Nowadays he checks the data and schedules irrigation accordingly.

Like Vicente, we all had to overcome fears during 2020 and quickly rediscover the immense possibilities that technology offers us.

2020 was a year that we probably want to forget in many ways, but it should also serve to reflect on what science and knowledge offer us today and thus push the technological leap that our agroindustry and the region need.

THE RESILIENCE OF THE SUGARCANE CLUSTER

Santiago Fernández,
Sugarcane grower

We will certainly not miss 2020, but we will always remember this year because it left a path of death and misery as the days went by. However, it also left reflections and learnings.

In March, with the declaration of the sanitary emergency, many of our sugarcane farms became the temporary shelter where many passed their days of preventive isolation, opening the opportunity to strengthen family ties and appreciate what we always took for granted, for example a hug.

By April, while life in cities and towns was difficult and slow-paced, economic activities were limited, and the situation of migrants on roadside berms getting more precarious, we began to use biosafety protocols to perform our agricultural tasks in sugarcane fields. Never before had taking care of ourselves been so important because the lives of others depended on the measures we took on.

In addition, the peace of mind of many depended on our ability to continue operating. Mechanics, farm managers, technical assistants, and many others were ready to cope with the new normality. Sources of employment were preserved.

Despite the enormous impact of the pandemic on Colombia's social and economic situation, sugar mills and sugarcane growers ended the year in better conditions than many other productive sectors. The sugarcane cluster passed this pressure test with robustness and resilience (as we say in the northern Valle del Cauca, with "perrenque", in other words with great drive and determination).

Solidarity and unity characterized 2020 and this is something we must preserve the following years because of our immense commitment to the region and the country in post-pandemic times.

It is our duty as sector to prepare ourselves for these challenges by developing new technologies, improving our capabilities and other approaches, as those Cenicaña continually proposes to us.

This year Cenicaña presented new varieties for our use, strengthening our plans for renewal to improve productivity while guaranteeing good phytosanitary conditions. The research center also proposes alternatives to improve connectivity in the fields such as the sugarcane agroindustry's IoT Network as well as tools to make agronomic work more efficient and sustainable.

The pandemic has shown us that science and knowledge are the best way to prepare for the future and that rural areas will always play a key role in Colombia's development. This is something we have to come to terms with.

POST-PANDEMIA CHALLENGES

Óscar Flórez,
Sugarcane grower

The crisis caused by the coronavirus has made us face numerous challenges on a day-to-day basis. The pandemic hit hard and will continue to batter the comfortable practicalities we were used to.

We were doing poorly on many fronts and the crisis triggered by the pandemic now makes it possible for us to better redirect our activities. We should not let our vision of the future be clouded because this "new normality" allows us to better tap new technologies and digital skills. In such an uncertain scenario, the only thing that we have clear is that change is necessary.

The "new normality", as we now call it, enabled us to become more resilient, while also showing us how fragile we are. These months of preventive social isolation have brought about important changes and the unification of personal and work-related routines. In the midst of the pandemic, we discovered that we need other skills to achieve our objectives, that we do not always have to commute to carry out our activities, and that it would have been difficult to move forward without the internet.

During the first months that the world almost came to a standstill, nature showed us how unhealthy our relationship with the environment was. Although the coronavirus is currently the main crisis we face, just around the corner is the climatic crisis that we are already experiencing.

Are we going to continue to endorse the same prevailing resource-intensive production technologies that are based on high-risk products? Or, are we going to encourage and support other alternatives? The future of humanity depends on the actions of each one of us. We must all work to change the course. Our task, as human beings, is to protect every drop of water and every molecule of oxygen with more sustainable and non-threatening industries.

Before us we have science and research as fundamental key pillars for the present and future of the sugarcane agroindustry in Colombia. Our research center, Cenicaña, must continue to search for alternatives of diversification, beyond sugar and alcohol. We must do so taking into account the decrease in non-renewable resources and the need for clean energy. Another priority axis should be the promotion of the adoption of sustainable agricultural practices that protect our environment, without compromising the future.

Cenicaña, sugarcane growers, and sugar mills all face the enormous challenge of continuing to bring stability and progress to the region and country by developing practices that are more environment friendly and more sustainable on all fronts.

01

CLIMATE IN THE CAUCA RIVER VALLEY 2020

Climate behavior during 2020 presented two dynamics, one warm and one cold, associated with El Niño Southern Oscillation (ENSO) climate variability. In the first semester of the year, climate was modulated by the warming of Pacific Ocean waters, causing below-normal levels of rain as well as temperatures above the climatological averages in the Cauca river valley. During the second semester, the cold phase of ENSO, referred to as La Niña phenomenon, was consolidated in the tropical Pacific Ocean. Precipitation usually increases with La Niña; however, 2020 presented an anomalous condition with the months of September, October, and November recording below-normal rainfall values.

Conditions in central tropical Pacific Ocean

According to different international centers, sea surface temperature in the Pacific Ocean basin presented slightly warm values during the first semester of 2020, recording a normal behavior at those sites where neutral ENSO conditions prevailed. In the second semester, beginning in August and especially in El Niño zone 3.4 (Figure 1A), the sea surface became was cooler than average, presenting below-normal values.

Sea surface temperatures in El Niño zone 3.4 **(Figure 1C)** fluctuated, presenting anomaly values between +0.1 °C and +1.2 °C between January and May 2020. Since June, a gradual cooling of sea surface temperature began, with values between -0.4 and -0.6 °C.

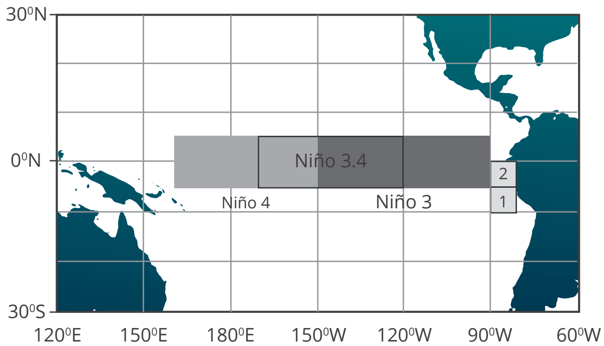
From July to December, negative anomalies predominated towards the central and eastern Pacific Ocean, with values oscillating between -0.1 and -1.7 °C **(Figure 1B).**

On the other hand, sea subsurface temperature began to record negative anomaly values starting in August, consolidating a large area of cold waters over the central and eastern Pacific Ocean basin, favoring the development of La Niña phenomenon.

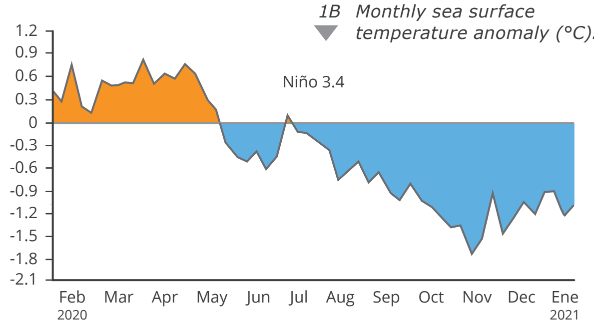
The aforementioned behavior of cooler-than-normal surface and subsurface sea temperatures in the central Pacific Ocean, along with the strong trade winds pattern towards the east of the ocean basin and the Walker cell in the west prompted the development of the La Niña phenomenon, moderated by its coupling in the ocean-atmospheric conditions present during the second semester of 2020.

Fig. 1 Evolution of sea surface temperature anomaly (°C) in the tropical Pacific Ocean during 2020.

1A El Niño regions

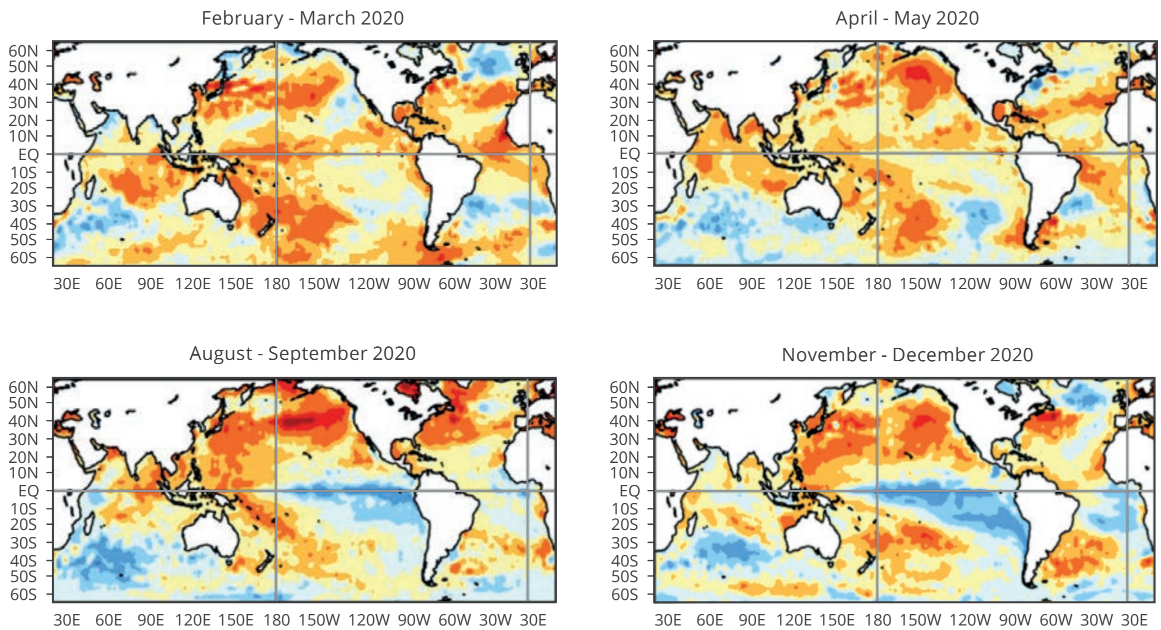


1B Monthly sea surface temperature anomaly (°C).



As of 2020, Cenicaña's area of meteorology became the Agroclimatic Service of the Colombian sugarcane agroindustry, integrating and expanding the scope of products and services already being offered to sugar mills and sugarcane growers. New services, such as daily and weekly forecasts, were included, allowing the Colombian sugarcane agroindustry in the Cauca river valley to have timely access to weather forecasts, climate predictions, and analysis of climatological and meteorological data, among others.

1C Average of sea surface temperature anomalies for March, May, September, and November 2020.



Behavior of meteorological variables in the Cauca river valley in 2020

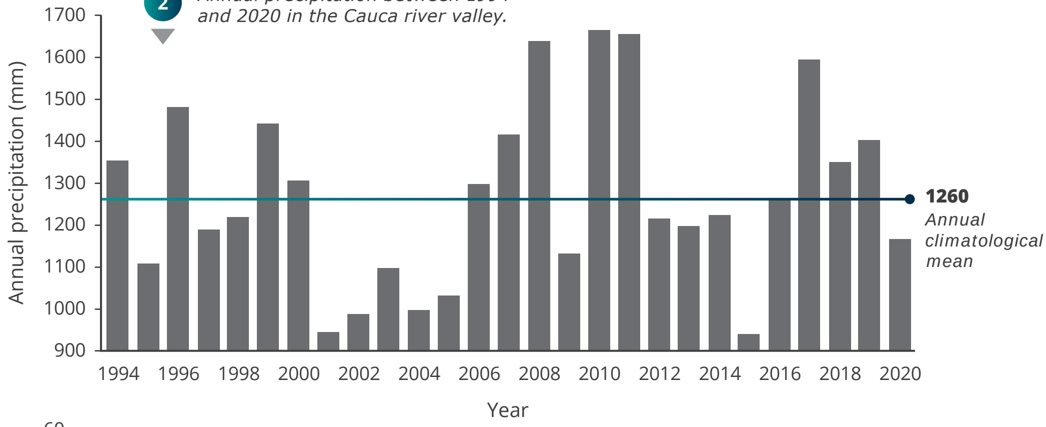
Precipitation

Precipitation behavior in the Cauca river valley presented anomalous conditions associated with intra-seasonal scale disturbances and intra-annual variability oscillations, especially in the second semester of 2020. Annual average rainfall accordingly reached 1157 mm, being the lowest recorded if compared with values of immediately preceding years **(Figure 2).**

The decrease in the monthly mean values of rain in the first semester of 2020 in the Cauca river valley is associated with the presence of slightly warm waters in the equatorial Pacific Ocean and other smaller-scale oscillations.

In the second semester of 2020, despite the presence of cold waters in the Pacific Ocean, precipitation presented an anomalous behavior during the second peak of rains, with below-normal values being recorded, while the highest volumes of precipitation occurred in July and August, considered transition months. Figure 3 indicates the negative anomalies during the second semester of 2020 that determined the onset of the La Niña phenomenon.

Fig. 2 Annual precipitation between 1994 and 2020 in the Cauca river valley.



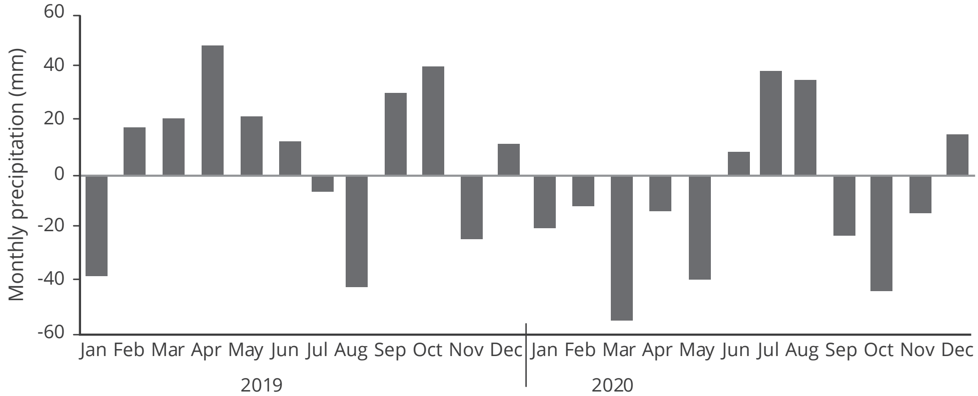


Fig. 3 Precipitation anomaly during 2019 and 2020.

Quarterly precipitation anomaly in the Cauca river valley

In **Figure 4,** the precipitation anomaly distribution maps clearly show conditions of low-to-extremely low precipitation in the first quarter of 2020 in northern Cauca river valley (homologous climate zone 1), the Risaralda river valley (homologous climate zone 5), and in central-western Cauca river valley (homologous climate zone 3), associated with the warming of Pacific Ocean waters during the first less rainy season of the year. The increase in volumes of rainfall during the third quarter of 2020 (July, August, and September), as a response to the cooling of sea waters in the Pacific Ocean basin and the indirect incidence of cyclonic activity in the Caribbean Sea, should be highlighted.

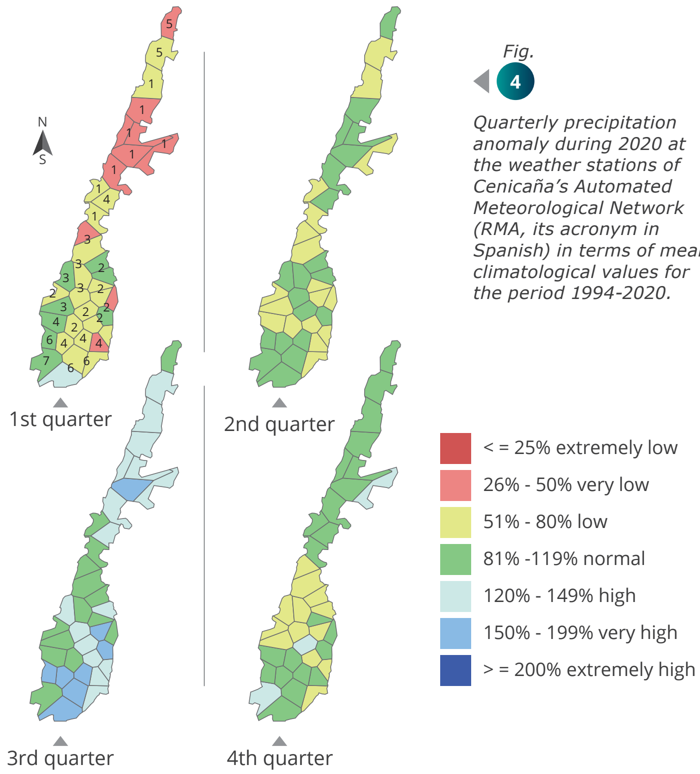


Fig. 4 Quarterly precipitation anomaly during 2020 at the weather stations of Cenicaña's Automated Meteorological Network (RMA, its acronym in Spanish) in terms of mean climatological values for the period 1994-2020.

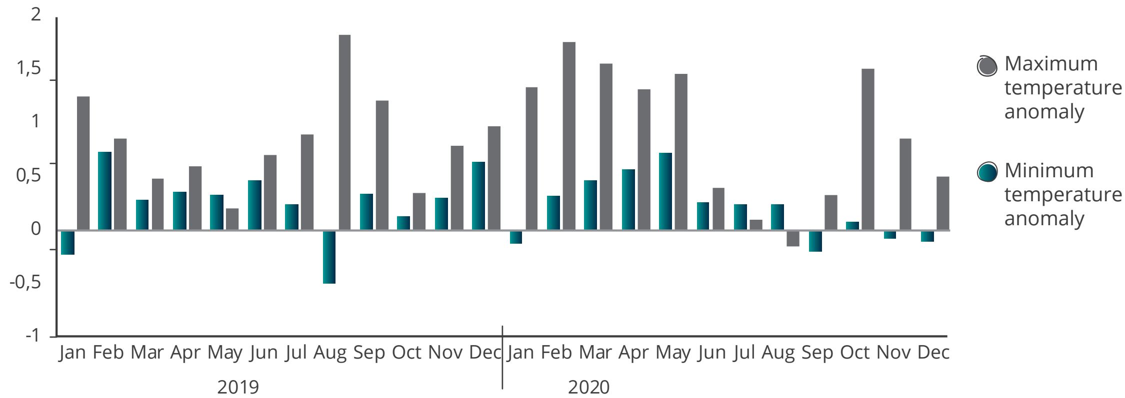
01 *Climate in the Cauca River Valley 2020*

Temperature anomaly

The maximum and minimum air temperatures showed above-normal records during the years 2019 and 2020.

Despite the occurrence of the La Niña phenomenon in the second semester of 2020, maximum temperature values recorded were above the climatological average in October, November, and December **(Figure 5).**

Fig. 5 *Minimum and maximum temperature anomaly during 2020 in the Cauca river valley (average temperature of RMA stations).*



Solar radiation

During the first quarter of 2020, global radiation recorded values above respective climatological averages in all homologous climate zones, with zone 1 (northern Cauca river valley) and zone 5 (Risaralda river valley) recording the highest solar radiation values. Figure 6 indicates that during 2020 the daily incident solar radiation (453.9 cal/cm^{2}xday) was approximately 10% higher than the corresponding multi-annual daily average (413.9 cal/cm^{2}xday). Since 1993, 2020 was the year presenting the highest annual mean daily radiation (413.9 cal/cm^2 x day).

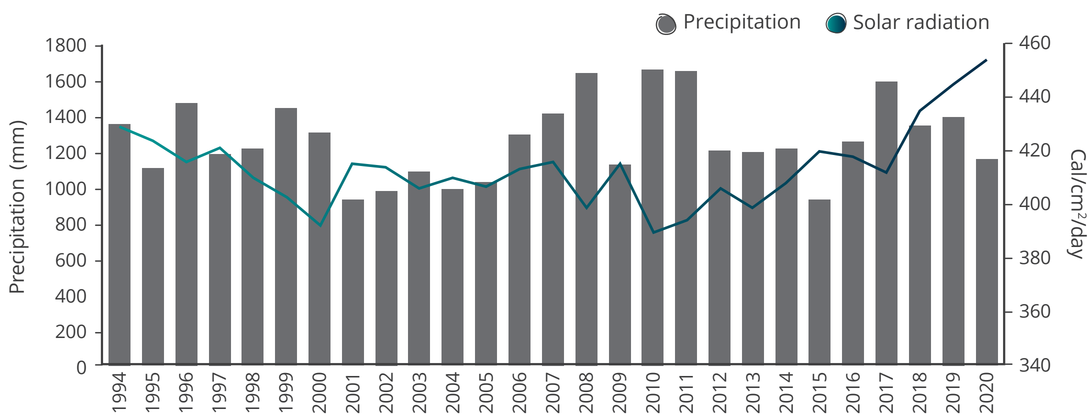
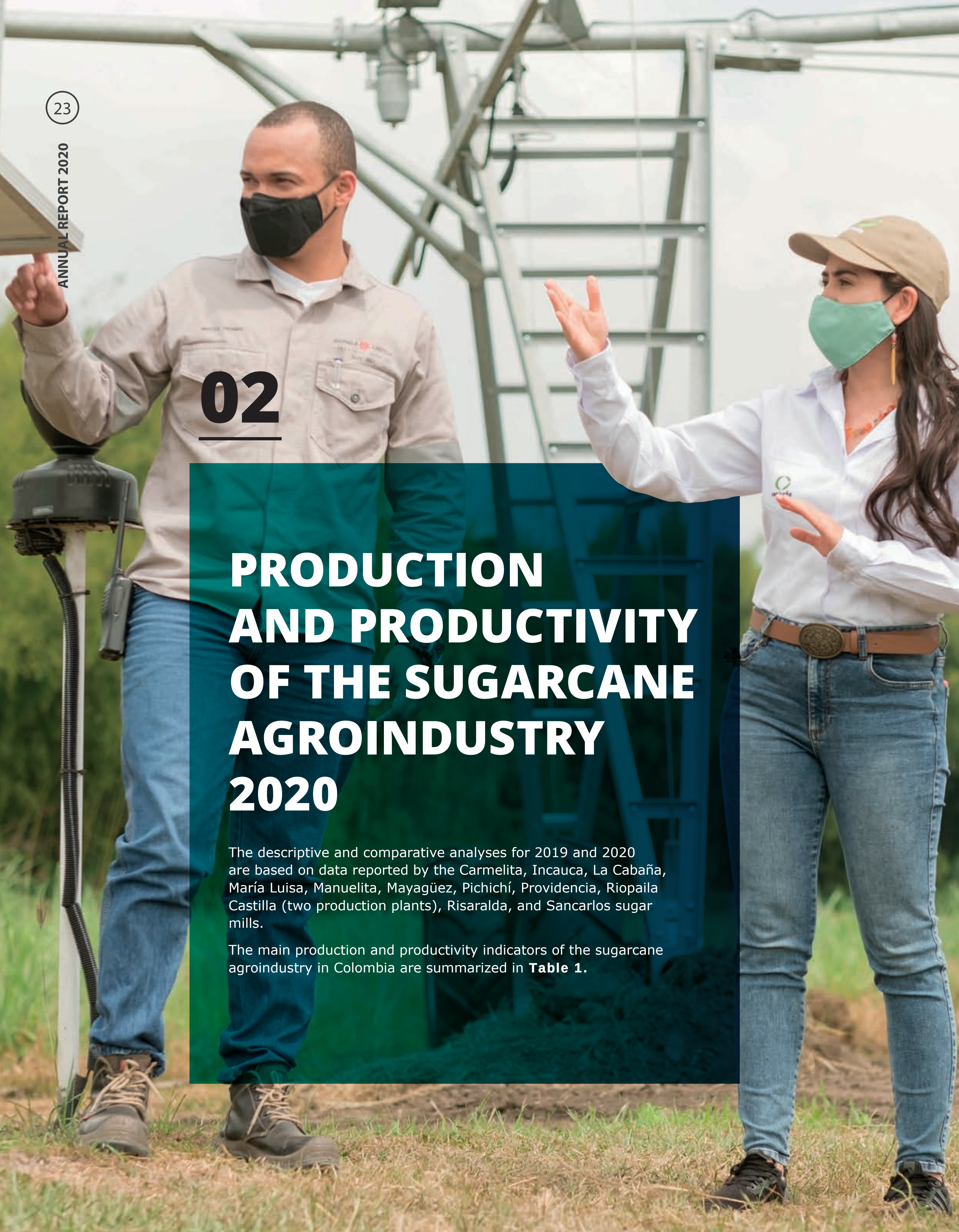


Fig. 6 *Comparison of monthly precipitation and solar radiation in the Cauca river valley over the period 1994–2020.*



02

PRODUCTION AND PRODUCTIVITY OF THE SUGARCANE AGROINDUSTRY 2020

The descriptive and comparative analyses for 2019 and 2020 are based on data reported by the Carmelita, Incauca, La Cabaña, María Luisa, Manuelita, Mayagüez, Pichichí, Providencia, Riopaila Castilla (two production plants), Risaralda, and Sancarlos sugar mills.

The main production and productivity indicators of the sugarcane agroindustry in Colombia are summarized in **Table 1.**

Table 1 *Productivity indicators of the sugarcane agroindustry in Colombia during 2019–2020.*

INDICATOR	QUARTERS 2020				JANUARY-DECEMBER		DIFFERENCE 2019-2020 (%)
Field (12 sugar mills)	First	Second	Third	Fourth	2019	2020	
Lots harvested	7561	5437	8103	7336	29,652	28,437	-4.10
Harvested area (ha)	53,038	35,186	57,030	51,652	201,500	196,907	-2.28
Tons of cane per hectare (TCH)	106.2	111.3	117.0	114.8	111.7	112.5	0.72
Tons of sugar per hectare (TSH)	11.8	11.8	12.8	12.9	12.5	12.4	-0.98
Tons of cane per hectare per month (TCHM)	8.5	9.2	9.6	9.2	8.8	9.1	3.19
Tons of sugar per hectare per month (TSHM)	0.94	0.97	1.05	1.04	0.99	1.00	1.43
Commercial yield	11.1	10.6	11.0	11.3	11.2	11.0	-1.69
Harvest age (months)	12.6	12.2	12.3	12.6	12.8	12.4	-2.78
Number of cuttings	5.3	5.6	5.2	5.3	5.2	5.3	1.37
Factory (12 sugar mills)							
Total tons cane milled[1]	6,171,611	4,539,931	6,920,459	5,926,733	23,319,660	23,558,734	1.03
Total tons sugar produced[2]	688,024	490,505	770,153	688,911	2,658,718	2,637,594	-0.79
Real yield based on 99.7% Pol[3]	11.24	10.78	11.15	11.49	11.34	11.18	-1.38
Cane fiber (%)	14.76	14.88	14.55	15.23	15.03	14.83	-1.28
Apparent sucrose in cane (%)	12.79	12.37	12.64	13.04	12.90	12.73	-1.30
Losses in sucrose in final molasses % sucrose cane	6.80	6.82	6.58	6.17	6.48	6.39	-1.36
Losses in muds % sucrose cane	0.57	0.58	0.59	0.64	0.59	0.59	0.73
Losses in indeterminate % sucrose cane	1.59	2.10	1.48	1.73	1.63	1.69	3.52
Losses in bagasse % sucrose cane	3.52	3.61	3.35	3.63	3.66	3.51	-4.12
Liters of ethanol (thousands)[4]	125,825	57,431	101,839	97,217	444,433	382,311	-13.98
Electrical energy generated (MWh) (reported by XM.A. ESP)					1,571,406	1,644,708	4.66
Electrical energy sold (MWh) (reported by XM.A. ESP)					649,540	680,128	4.71
Climate							
Precipitation (mm per month)	207	342	241	348	1353	1138	-15.95
Daily mean oscillation in temperature	12.7	11.1	12.1	11.7	11.7	11.9	1.56
Mean minimum temperature (°C)	19.3	19.7	18.6	18.8	19.1	19.1	-0.29
Daily mean solar radiation (cal/cm^2 x day)	484	430	448	445	445	452	1.59

1. Total tons of cane milled: Includes the cane inventory in yards plus the cane that enters during the period minus the cane balance in yards at the end of the period (inventory + cane that entered - balance in yards).
2. Total tons of sugar produced: Sum of the total tons of the different kinds of sugar produced, including what is diverted to ethanol production.
3. Real yield: Percentage (%) of net sugar (by weight) obtained per ton of cane milled, where net sugar corresponds to processed and packed sugar plus the difference between the previous and current sugar inventories of materials being processed in the period under consideration (molasses, mashes, magmas, syrups, and juices). This index converts all types of sugar to the same base content of Pol 99.7º, which corresponds to white sugar, the type of sugar most produced by the sector.
4. Includes bioenergy.

Multi-annual values 1994–2020	Precipitation (mm)	Daily mean solar radiation [cal/(cm^{2}xdía)]	Daily mean oscillation in temperature (°C)	Minimum mean temperature (°C)
Quarter 1	293	425	11.3	19.0
Quarter 2	386	399	10.5	19.1
Quarter 3	188	424	12.0	18.5
Quarter 4	388	404	10.6	18.8

Field observations

The value of tons of cane per hectare (TCH) corresponding to the first months of 2020 was consistent with the trend of late 2019, attributed to the high precipitation associated with the previous harvest.

An unusual positive anomaly of precipitation in the second season of low rains of the year translated into greater availability of water for the crop during its time of maximum growth. This favored TCH values after July, presenting values above 115 t **(Figure 7).**

Harvest age was around 12 months during the first 8 months of the year. As of September 2020, harvest age was prolonged 15 days **(Figure 8)**. Sucrose (% cane) had its usual seasonal behavior of two peaks in the first and second semesters of the year. However, the first peak (13%) occurred in March and was maintained in April (12.7%). During the second semester, the usual September peak was recorded in October (13.3%). Compared with 2019, this indicator was lower, given that not all the conditions for maximum sucrose expression (highest minimum temperature) are met this month **(Figures 9 and 10)**

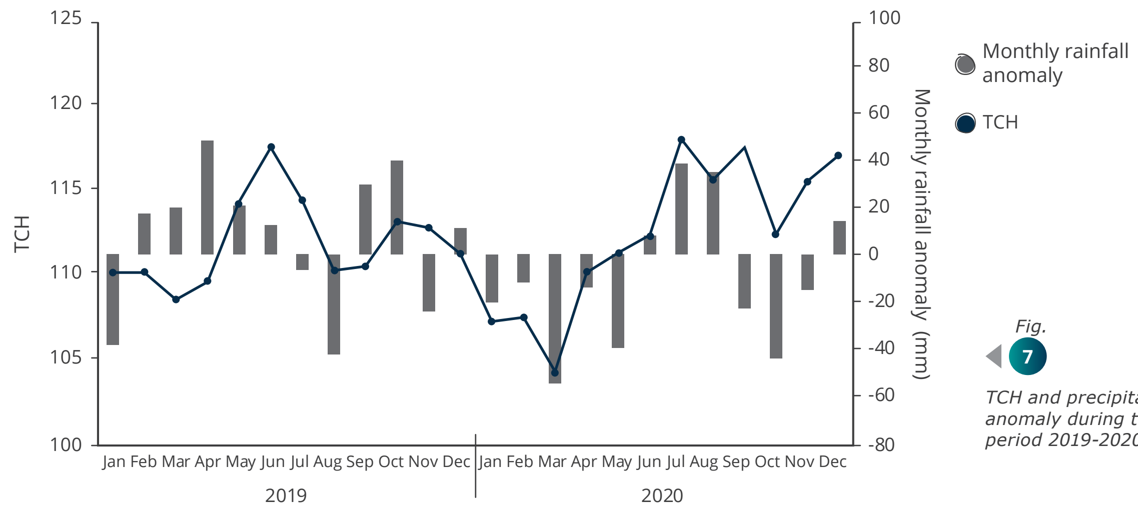


Fig. **7**

TCH and precipitation anomaly during the period 2019-2020.

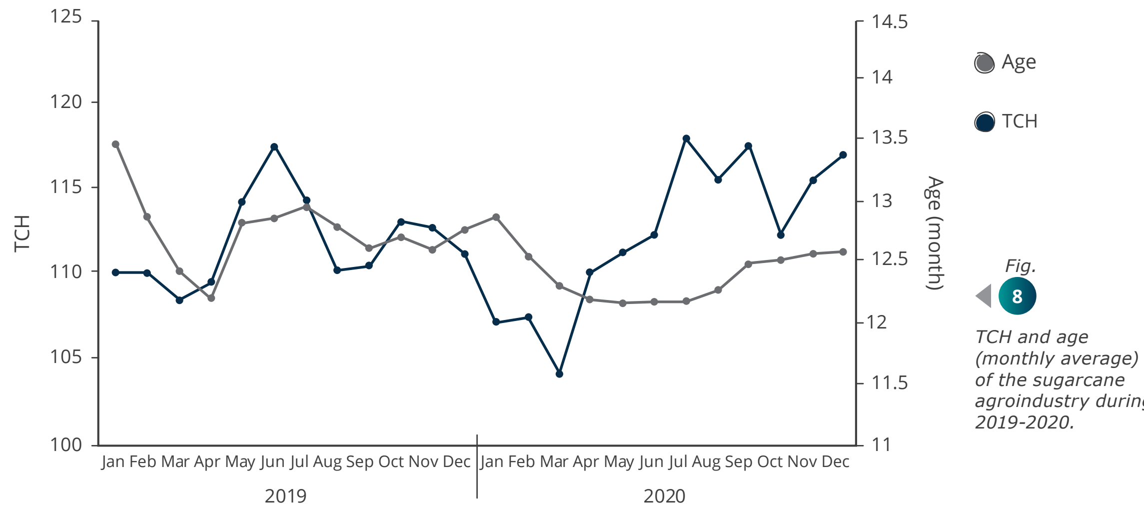


Fig. **8**

TCH and age (monthly average) of the sugarcane agroindustry during 2019-2020.

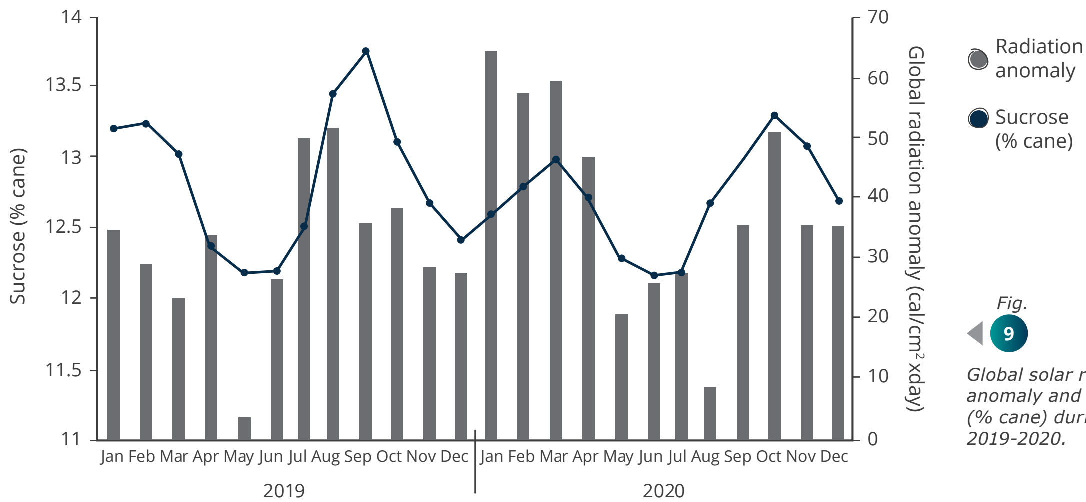


Fig. **9**

Global solar radiation anomaly and sucrose (% cane) during 2019-2020.

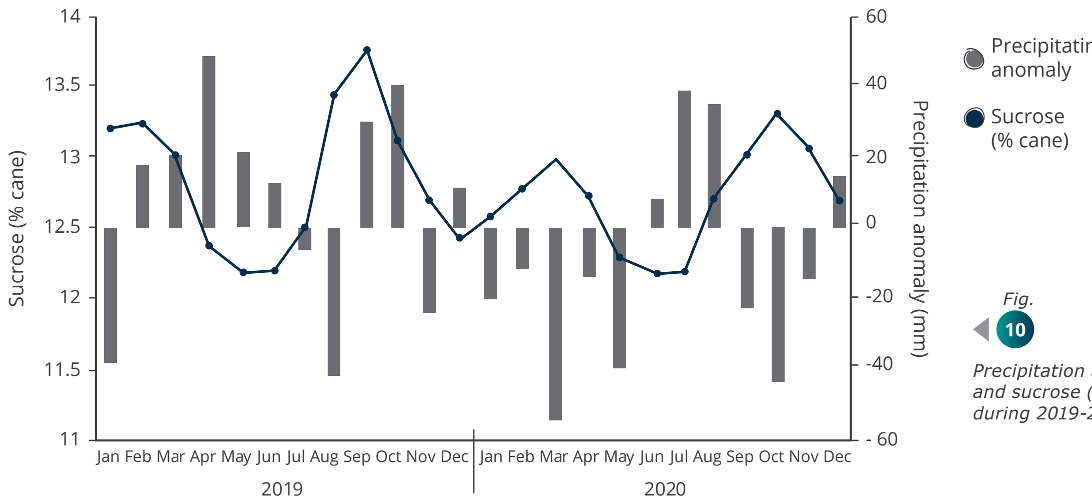


Fig. **10**

Precipitation anomaly and sucrose (% cane) during 2019-2020.

The commercial yield followed the trend of sucrose (% cane), presenting percentage values 1.73% lower, on average **(Figure 11).** Tons of sugar per hectare (TSH) increased from June 2020 onwards and surpassed values reported in the second semester of 2019 **(Figure 12).**

An analysis of the indicator tons of cane per hectare per month (TCHM) by climate zone showed that the highest values were recorded in climate zones 2 and 3 (the latter corresponding to central Cauca river valley) as has been usual in the agroindustry, but, unlike other years, the TCHM in zones 4 (south-central) and 5 (north) reached values similar to those of zones 2 and 3 **(Figure 12).**

The increase in TCH in 2020, with a harvest age similar to that of 2019, translated into high TCH for all climate zones in 2020 **(Figures 13 and 14).**

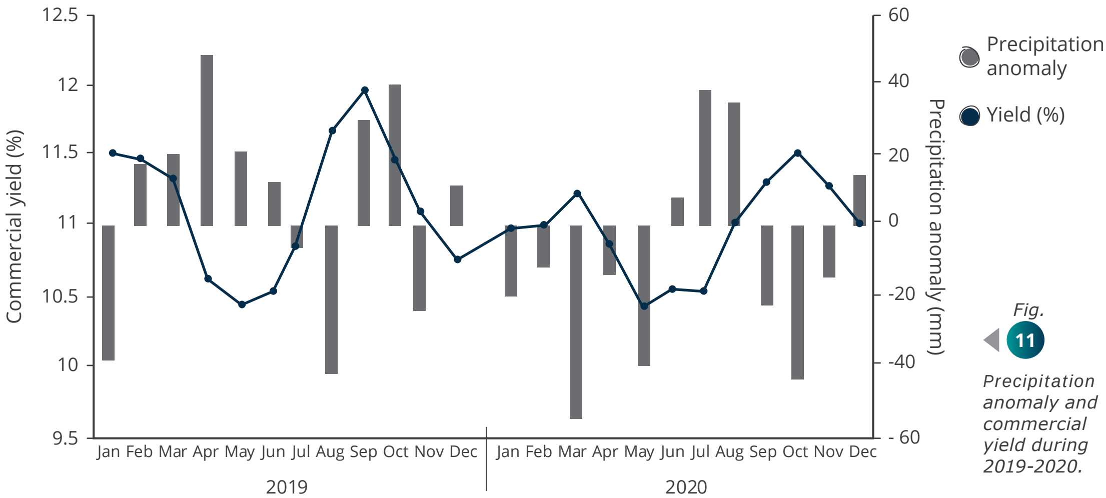
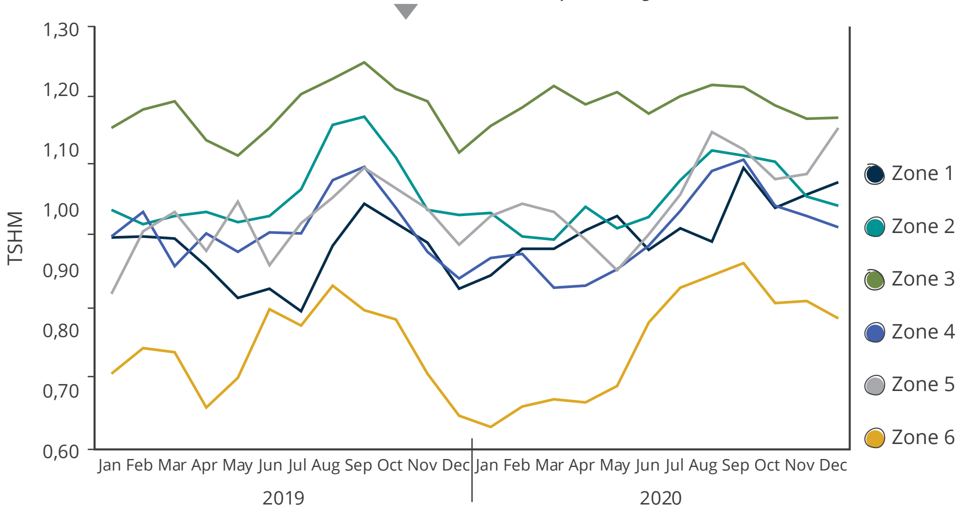
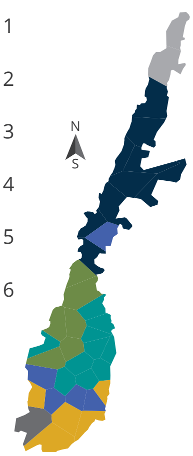


Fig. **11**
Precipitation anomaly and commercial yield during 2019-2020.

Fig. **12** *TSHM of the sugarcane industry during 2019 – 2020 by homologous climate zone.*





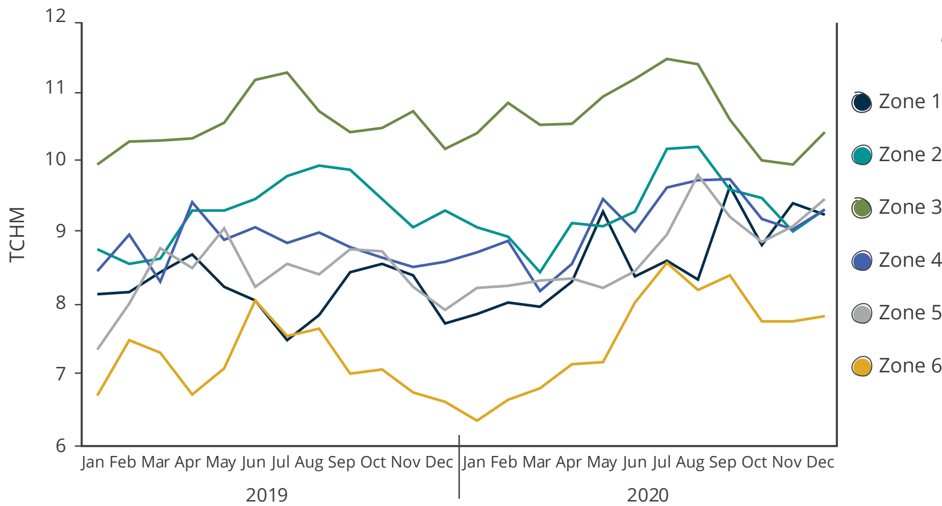


Fig. **13**
TCHM of the sugarcane industry during 2019-2020 by homologous climate zone.

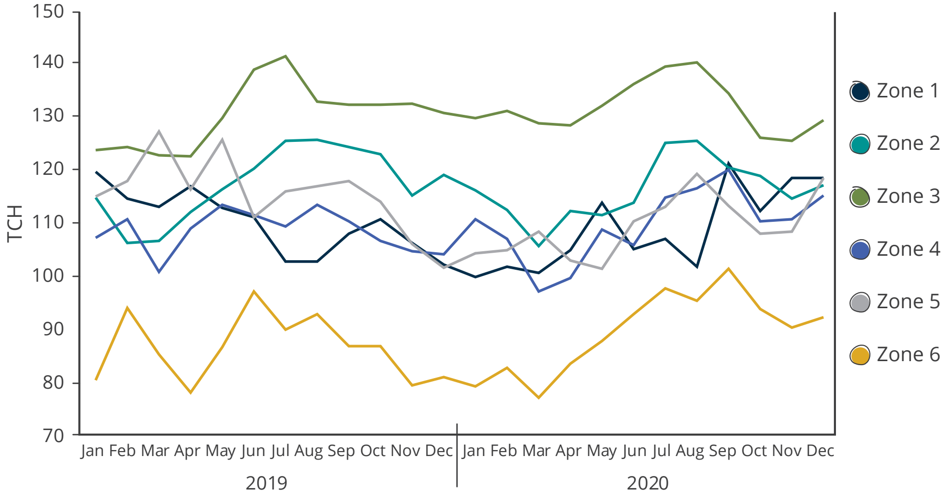


Fig. **14**

TCH of the sugarcane agroindustry during 2019-2020 by homologous climate zone.

The commercial yield of each climate zone is correlated with the precipitation behavior in each zone **(Figures 15 and 16):**

- **Zone 5 (Risaralda river valley):** The negative rainfall anomaly (very dry) throughout the year favored a higher yield.
- **Zone 6 (south):** Because this is a rainy zone, the higher negative rainfall anomaly (very dry) in the second semester of the year had a positive influence on TCH and commercial yield.
- **Zone 2 y 3 (center):** The positive anomalies in months that were expected to have less rain had an impact on the commercial yield during the second semester (delay of its peak and reduced percentage).

Rainfall behavior during the second semester of 2019 (excess rainfall), the first semester of 2020 (rainfall deficit), and the second semester of 2020 (excess rainfall) created ideal conditions for the recovery of TCH in all the homologous climate zones.

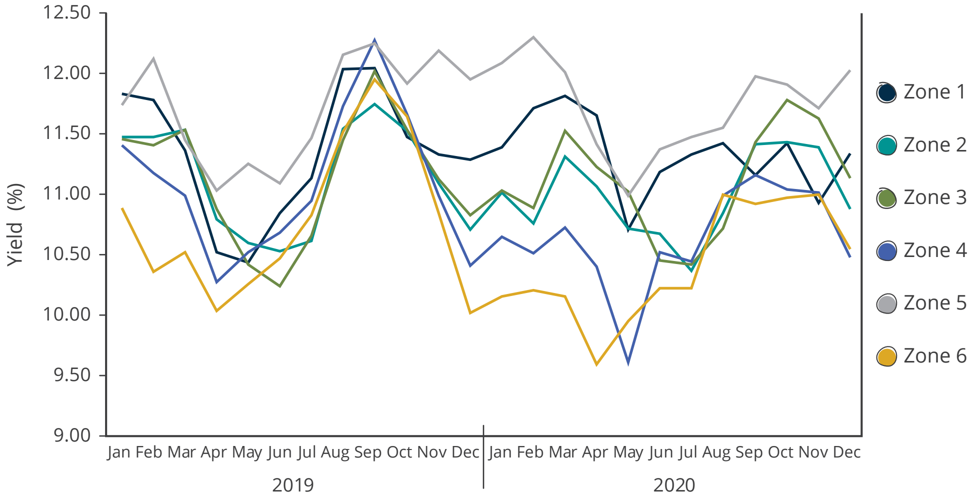


Fig. **15**

Commercial yield of the sugarcane agroindustry during 2019-2020 by homologous climate zone.

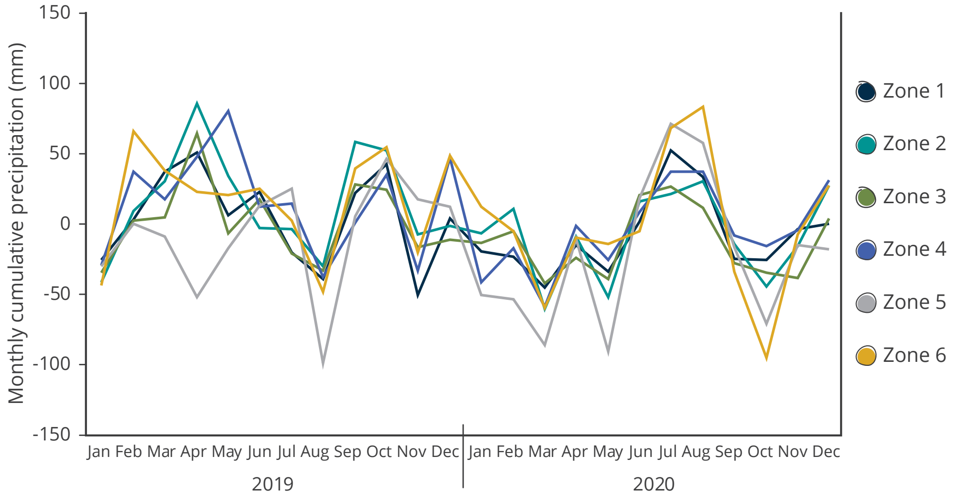


Fig. **16** *Monthly accumulated precipitation anomaly by homologous climate zone during 2019-2020.*

Area planted to sugarcane in 2020 was calculated at 241,994 ha, with CC 01-1940 being the variety most planted accounting for 102,162 ha (42% of the area) **(Table 2).**

Table **2** *Participation of sugarcane varieties in area planted during 2020.*

VARIETY	AREA (HA)	AREA (%)
CC 01-1940	102,162.90	42.22
CC 85-92	51,675.08	21.35
CC 05-430	18,118.32	7.49
CC 93-4418	13,011.26	5.38
CC 11-600	9,071.74	3.75
CC 11-595	6,403.26	2.65
SP 71-6949	3,031.85	1.25
CC 01-678	2,640.60	1.09
CC 00-3257	2,141.67	0.89
CC 97-7170	1,849.60	0.76
CC 01-746	1,763.20	0.73
CC 01-1228	1,723.89	0.71
CC 10-450	1,611.44	0.67
CC 09-066	1,545.43	0.64
CC 84-75	1,541.81	0.64
CC 98-72	1,053.57	0.44
RB 73-2223	962.73	0.40
V 71-51	670.30	0.28
CC 93-4181	669.12	0.28
CC 09-535	634.61	0.26
PR 61-632	629.93	0.26
CC 92-2198	598.96	0.25

VARIETY	AREA (HA)	AREA (%)
CC 91-1606	593.67	0.25
CC 04-195	508.96	0.21
CC 93-3826	480.46	0.20
CC 00-3771	378.51	0.16
CC 05-230	333.87	0.14
CC 99-2282	299.17	0.12
CC 12-2120	293.48	0.12
CC 93-3895	248.75	0.10
CC 06-783	234.05	0.10
CC 03-154	223.05	0.09
CC 14-3296	190.30	0.08
CC 09-874	176.60	0.07
CC 05-948	159.17	0.07
CC 11-605	146.06	0.06
CC 03-469	140.73	0.06
CC 09-235	119.58	0.05
CC 09-702	104.26	0.04
SEVERAL	6,072.13	2.51
RENEWAL	5,201.54	2.15
OTHERS	2,244.69	0.93
STAPLE CROPS	334.09	0.14
ÁREA TOTAL	**241,994.39**	

Monitoring of field indicators

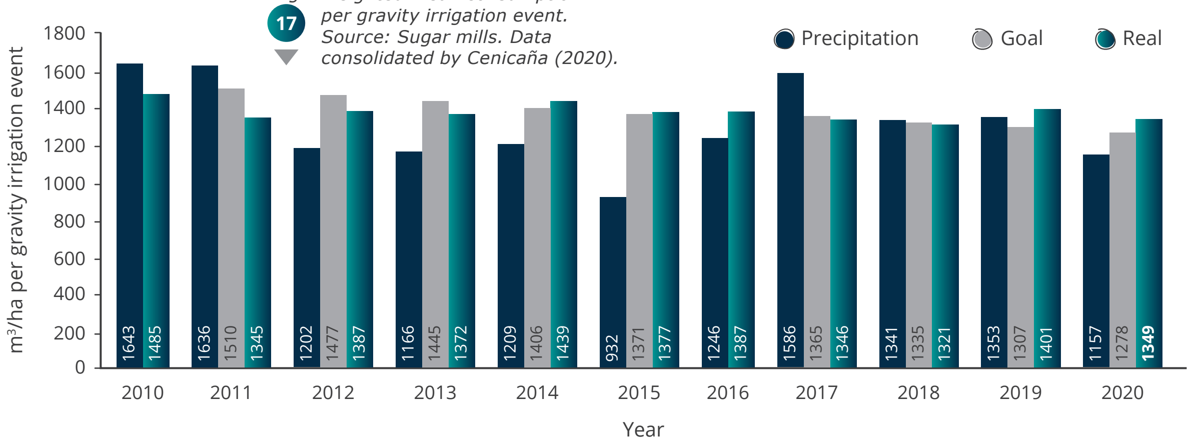
01 Irrigation

The water requirement of sugarcane crops in the Cauca river valley ranges between 1200 and 1500 mm (12,000 and 15,000 m³/ha per crop cycle), depending on the environmental conditions prevailing during the crop production cycle. The sugarcane agroindustry monitors water consumption indicators for irrigation at the source through the Water Table initiative of the Colombian sugarcane agroindustrial sector ("Mesa del Agua" in Spanish).

According to consolidated data for the year 2020, the annual accumulated precipitation was 1,157 mm, which means that rains contributed 11,570 m³/ha per crop cycle of the water required by the sugarcane crop. For lands under direct management, the weighted average water consumption per crop cycle was 528.3 mm. Therefore irrigation provided 5,283 m³ water/ha per crop cycle. Considering 80% effective precipitation, total water use attributed to precipitation (925.6 mm) plus irrigation (528.3 mm) was approximately 1,454 mm (14,540 m³/ha per crop cycle), which falls within sugarcane's water requirement range for the sugarcane growing area of the geographical Cauca river valley.

- **Annual accumulated precipitation 2020 (Cauca river valley):** 1157 mm (11,570 m³/ha per year).
- **Weighted average water consumption per gravity irrigation event:** 1,349 m³/ha, which represents a decrease of 9.2% with respect to the baseline (2010), that is, 136 m³/ha per event, and a decrease of 3.7% with respect to 2019. However, this value exceeded the goal established for 2020 by 71 m³/ha per event (5.5 %) **(Figure 17).**
- **Weighted average water consumption per sprinkler irrigation event:** 759 m³/ha per crop cycle, which represents a decrease of 1.3% with respect to the goal (10 m³/ha per event) and an increase of 15.5% in relation to 2019.
- **Number of waterings (mean value):** 4.5, which is an increase as compared with 2019. This value depends on the precipitation.
- **Weighted average water consumption per crop cycle:** 5,283 m³/ha, 2.8% (151 m³/ha per cycle), which is below the goal for 2020 (5,434 m³/ha per cycle). However, this indicator increased 19% compared with values of 2019 (precipitation-dependent indicator).

Fig. 17 Weighted mean consumption per gravity irrigation event. Source: Sugar mills. Data consolidated by Cenicaña (2020).



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- **Efficiency in the use of irrigation water per ton of cane (weighted average):** 47 m³ irrigation water/t sugarcane, which is 4% below the goal established for 2020 (precipitation-dependent indicator) **(Figure 18).**
- **Efficiency in total water use (precipitation + irrigation) per ton of sugarcane (weighted average):** 128 m³ total water/t sugarcane, which 9% below the value of the previous year (2020), despite precipitation having contributed a lower amount (precipitation-dependent indicator) **(Figure 18).**

The increase in weighted average consumption per gravity irrigation event with respect to the goal set for 2020 can be attributed to the higher volumes of water required in areas under renovation, which increased 26% in 2018 and 22% in 2019 as compared with 36% in 2020 (30,784 ha), as well as to changes in the investment made in irrigation infrastructure that do not coincide with those projected when calculating the goals for 2019 and 2020.

02 Maturation

Maturation is an agronomic management practice used to increase sucrose (% cane) and sugarcane yield. During 2020, 76% of the harvested lots were treated with some type of maturing agent. **Figure 19** presents the monthly comparison of yield between matured and non-matured lots. February was the month that presented the greatest yield increase efficiency, with 1.19 percentage units with respect to non-maturation, followed by August, with 1.04 percentage units. In contrast, November showed the lowest maturation efficacy, with a difference of 0.43 percentage units as compared with non-maturation. On average, the practice increased the commercial yield of sugarcane by 0.74 percentage units (7.4 kg sugar/t cane). When maturation was performed, the unweighted average of TCH was 112.1, while the same average without maturation was 112.8.

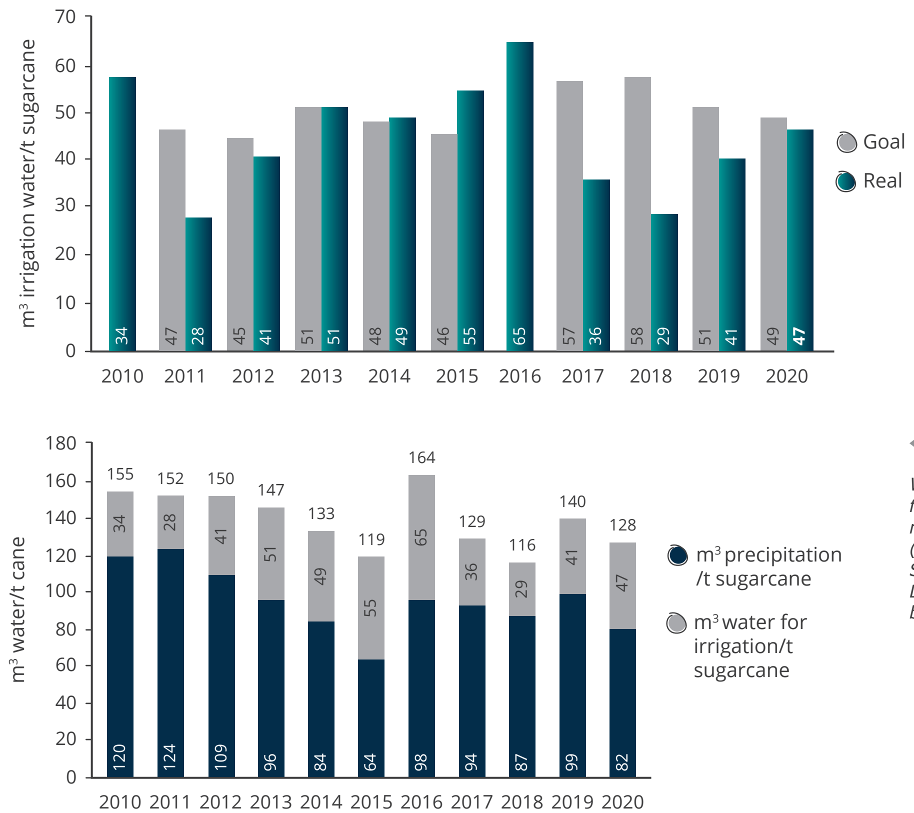


Fig. 18

Water use efficiency from the source managed directly (weighted average). Source: Sugar mills. Data consolidated by Cenicaña (2020).

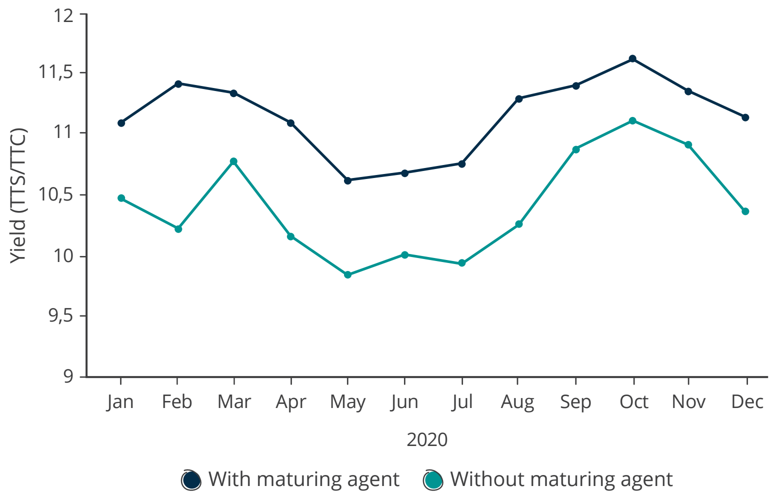


Fig. 19

Comparative of sucrose between matured and non-matured sugarcane by month during 2020.

03 Harvest

- **Green cane:**
  133,333 ha (70%), a value higher than that reported in 2019 (125,462 ha; 66%).
- **Harvests in unscheduled burnings:**
  19,821 ha (10%), a value similar to that reported in 2019 (18,837 ha).
- **Length of permanence:**
  Reduction of 8% (20.1 hours) as compared with the same period in 2019 (21.8 hours).
- **Mechanical harvest:**
  Over the last 8 years, the sugarcane agroindustry has evolved towards more technified harvesting systems. While 76,512 ha were mechanically harvested in 2013, reports indicate that this figure increased to 133,083 ha in 2020, representing 74% of the absolute value for this period. In the same sense, the absolute value of mechanically harvested green cane areas increased by 86%, increasing from 64,741 ha in 2013 to 120,488 ha in 2020. During the last year, the sugarcane agroindustry mechanically harvested 70% of its area, of which 92% corresponded to the mechanical harvest of green cane (no burning).

In 2020, Cenicaña provided technical support to the agroindustrial sector in actions carried out before the Regional Autonomous Corporation of Valle del Cauca (CVC, its Spanish acronym) for the regulation of controlled burnings in sugarcane crops and the modification of pumping equipment in groundwater wells.

Regarding the regulation of burnings, an agreement was reached to reduce to less than half the area where burning of sugarcane was allowed in the department of Valle del Cauca: from 78 (~ 135 thousand ha) to 32% (~ 55 thousand ha) of the cultivated area. Regarding the modification of pumping equipment, a 3-year extension until 2023 was granted, according to CVC Agreement 029 of 2020. Likewise, it was agreed to institute a Technical Table between CVC and the Sugarcane Agroindustry Sector to monitor reconversion actions and commitments and evaluate technical alternatives for well lubrication as well as special cases, such as the reconversion impact on wells.

Factory observations

The amount of cane milled increased by 239,074 t in 2020 as compared with 2019, given the increase in TCH. This increase could be greater, but the harvested area decreased by 4,594 ha. Sugar production (including raw sugar equivalent and molasses destined for ethanol production) decreased by 21,124 t as a result of lower sucrose content (% cane) entering the factory, which decreased from 12.90% in 2019 to 12.73% in 2020 (Table 1). Ethanol production decreased by 14%, which is equivalent to 62.12 million liters, probably associated with the lower fuel consumption nationwide due to the COVID-19 pandemic and an increase in imports of fuel ethanol.

Electrical energy generation and its sale increased by 4.7% in 2020 as compared with 2019 **(Table 1).** The percentage of generated energy that was distributed to the National Interconnected System (SIN, its Spanish acronym) remained constant at 41.4%.

An analysis by quarters shows a decrease in cane milled during the second quarter, associated with scheduled factory shutdowns and an increase in time lost due to unscheduled events per harvest, the highest of the entire year. On the other hand, the second quarter was also characterized by the lowest sucrose content (% cane) entering the factory, associated with higher precipitation, lower solar radiation, and fluctuating temperature.
As is traditional, the highest amount of cane milled was reached in the third quarter; however, both sucrose amount of cane milled was reached in the third quarter; however, both sucrose content (% cane) and yield presented better values in the fourth quarter.

Industrial fiber (% cane) decreased by 0.19 units in 2020 as compared with 2019, while insoluble solids, which are part of industrial fiber, did not vary, accounting for the effective decrease in vegetable fiber reached in two consecutive years. Sucrose recovery efficiency at the factory level decreased slightly from 87.64% to 87.56%, mainly due to the increase in indeterminate losses.

Carbon footprint of ethanol production

In 2019, the carbon footprint associated with the production chain of anhydrous denatured fuel ethanol (DFE) was calculated as a weighted average of 580.9 kg CO^2eq/m^3 anhydrous DFE, with a maximum of 768.1 and a minimum of 398.0 kg CO^2eq/m^3 anhydrous DFE **(Figure 20).**

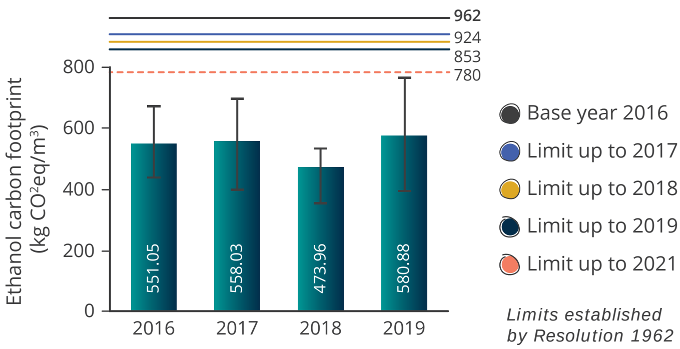
These values are below the emission limit established by Colombian legislation for 2019 (853 kg CO^2eq/m^3 anhydrous DFE).

This calculation implies compliance with Resolution 1962 of 2017, which establishes the annual limit of emissions associated with the production of national and imported ethanol.

Cenicaña is currently working to update its tool to calculate greenhouse gas inventory and carbon footprint to classify emissions and their sources, facilitate the generation of reports, and estimate the uncertainty associated with the calculation procedure. This aims to translate into greater transparency in the implementation and reliability of the results presented as well as make future verification processes more agile.

Projection of productivity 2021 (first quarter)

Fig. 20 *Historic carbon footprint values of anhydrous DFE (2016-2019).*



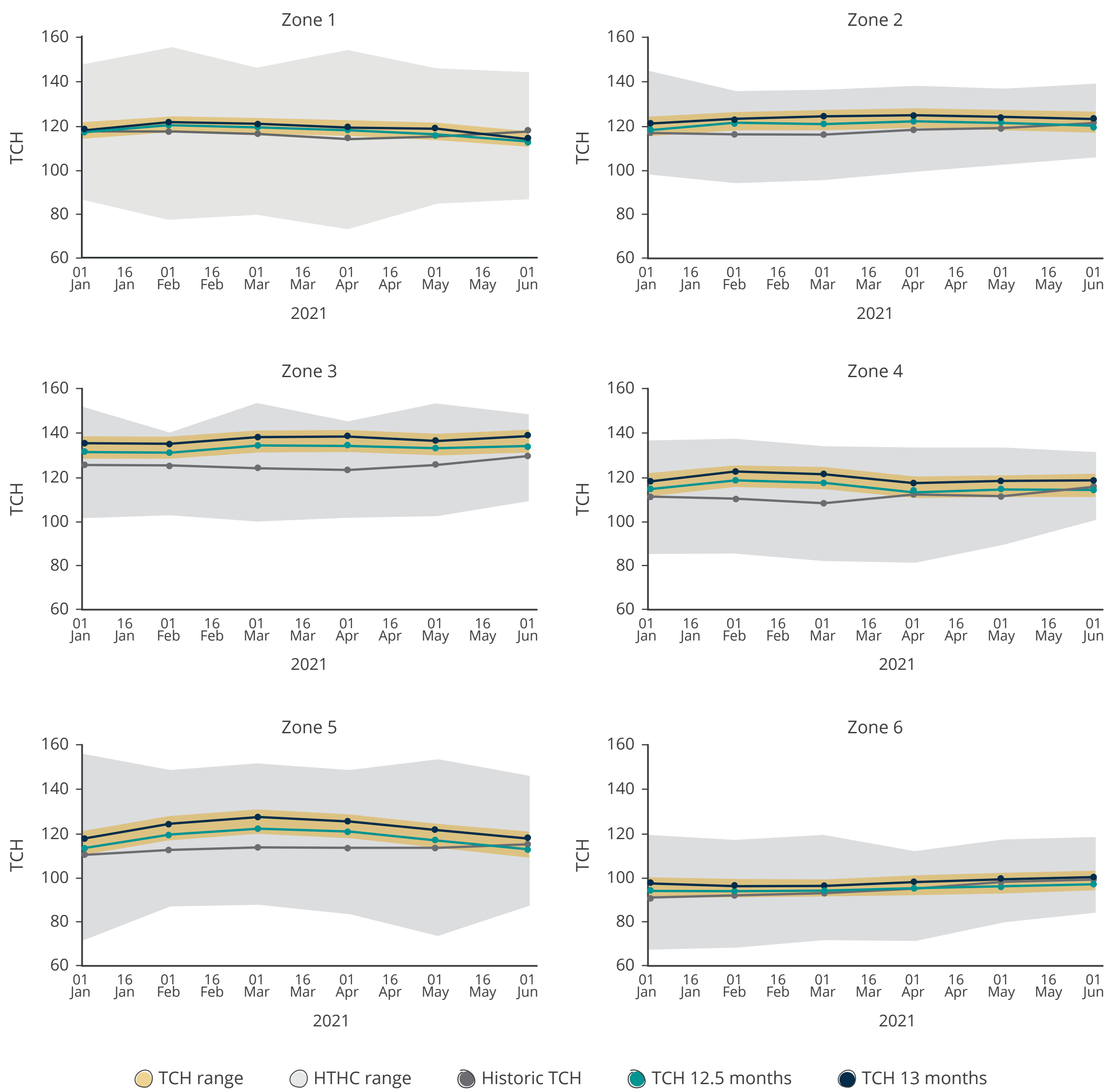
Limits established by Resolution 1962 of 2017

At least until May, above-historic TCH values are expected in the six homologous climate zones (Figure 21).

TCH

01

Fig. **21** *Projection of TCH by homologous climate zone.*



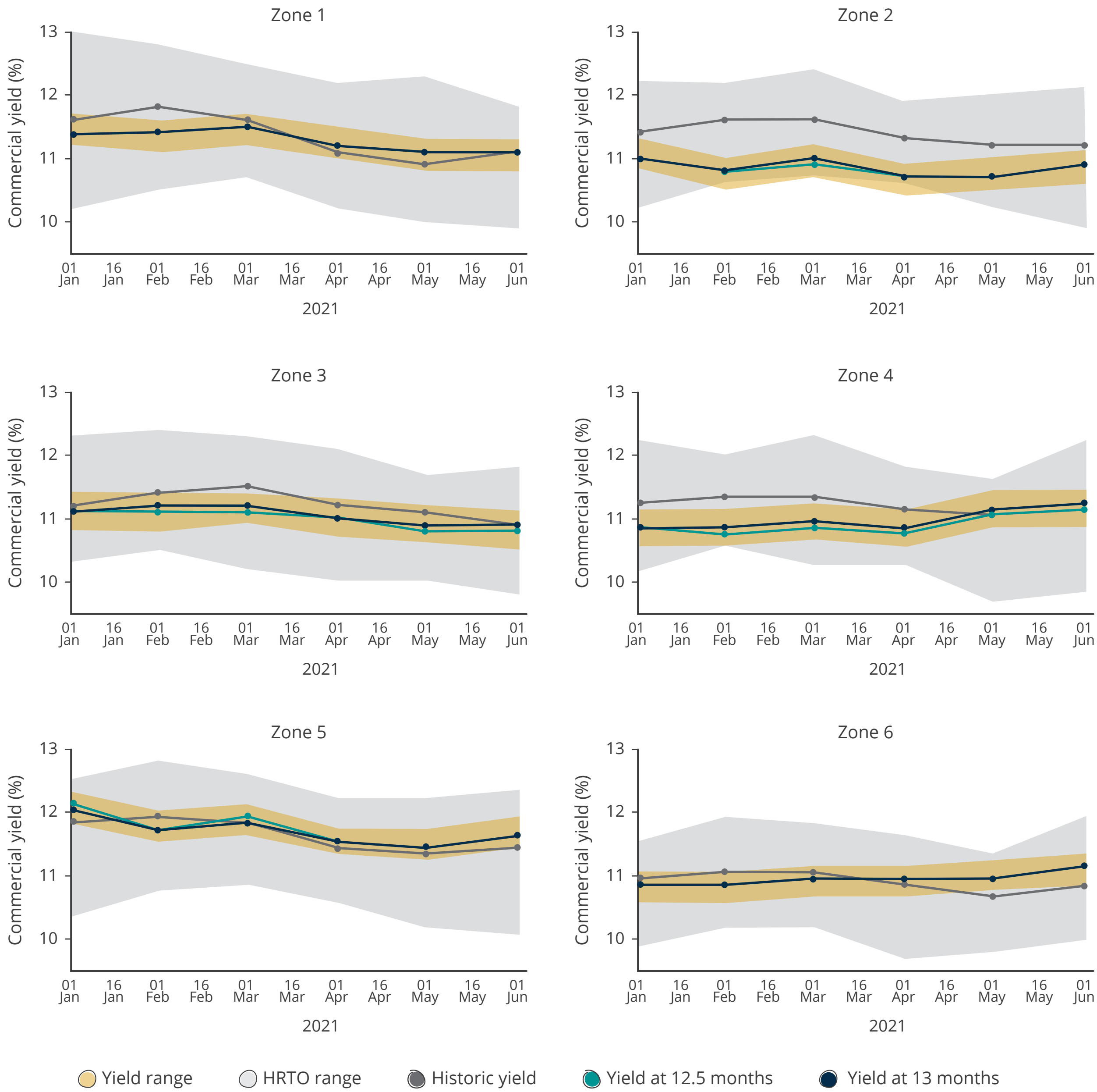
Continues

Projection of productivity for 2021 (first semester)

02 Commercial yield

Yield values below the monthly historical value are expected in homologous climate zones 1, 2, and 3. Above-historical yields are projected for the second quarter of 2021 for areas located at the far ends of the Cauca river valley: zone 1 (north) and zones 4 and 6 (south-central and south) ***(Figure 22).***

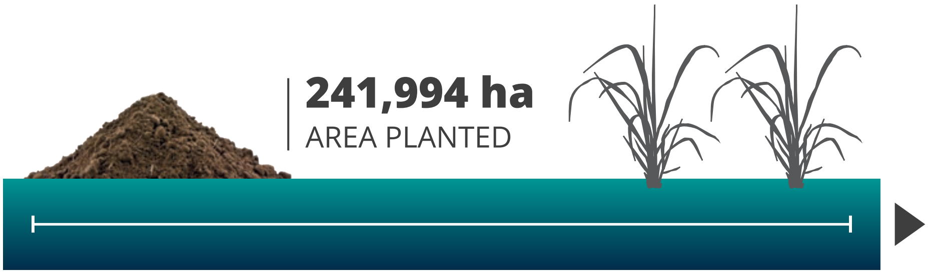
Fig. 22 *Projection of yield by homologous climate zone.*



The projection is made based on climate behavior expected for 2021 and for harvest ages between 12.5 and 13 months. This trend could be influenced by any difference in this value or decrease in TCH due to lack of irrigation or presence of a disease or pest.

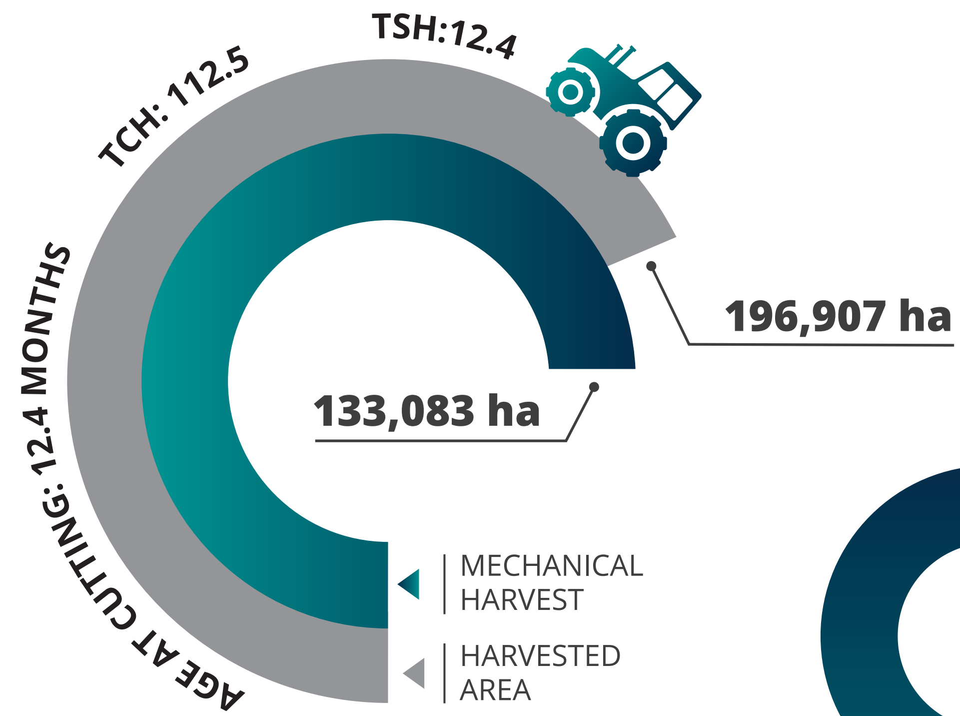
SECTORAL STATISTICS AND DATA 2020

Summary of the main productivity indicators and general data of the sugarcane agroindustry in Colombia and Cenicaña.



MOST PLANTED VARIETIES

- A CC 01-1940
- B CC 85-92
- C CC 05-430
- D CC 93-4418
- E Others

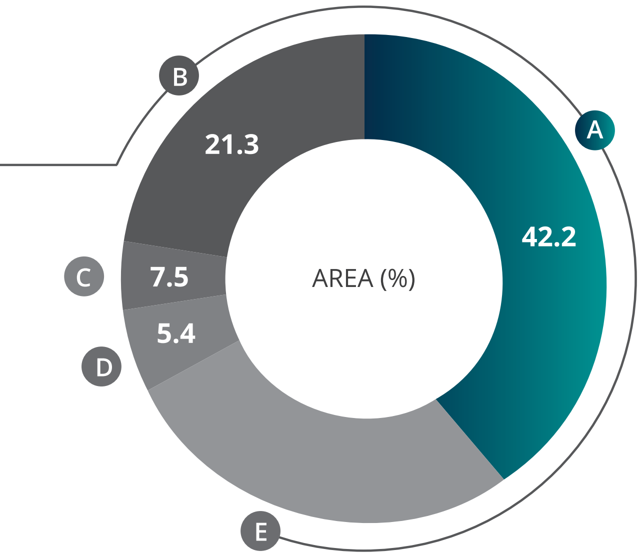


New contributor Starting 2020
INGENIO DE OCCIDENTE
1932 HA
of its own land

76 *Ongoing*
RESEARCH PROJECTS

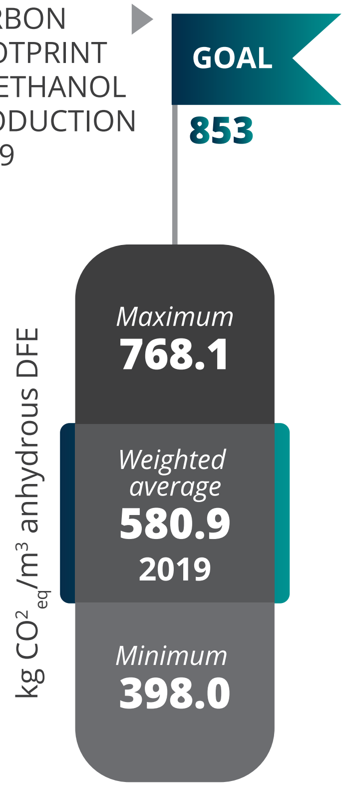
Online Library Catalogue
36,920
SPECIALIZED DOCUMENTS
on sugarcane

La estación experimental de Cenicaña, ubicada en el corregimiento de San Antonio de los Caballeros, Florida, cuenta con 24 lotes experimentales



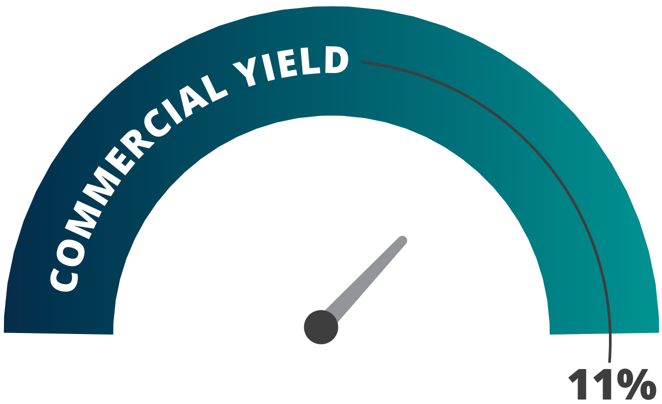
AREA (ha)
102,162.90
51,675.08
18,118.32
13,011.26

CARBON FOOTPRINT OF ETHANOL PRODUCTION 2019



2,637,594
TOTAL TONS SUGAR PRODUCED

680,128 MWh
ELECTRICAL ENERGY SOLD



LITERS OF ETHANOL
382,311,000

1,644,708 MWh
ELECTRICAL ENERGY GENERATED

03

SUGARCANE: THE BASIS OF OUR AGROINDUSTRY

In 2020, Cenicaña made important advances in the use of biotechnological and molecular tools to support conventional breeding scheme with a site-specific agriculture (SSA) approach. Important achievements included the genome assembly of sugarcane variety CC 01-1940 and the development of a molecular fingerprint to differentiate the varieties of the Center's germplasm bank. There was also evidence of an increase in the area planted with new varieties, which broadens the array of varieties available to sugar mills and sugarcane growers in the future. The collaborative work carried out with the Colombian Corporation of Agricultural Research Agrosavia and the UNODC was strengthened to support the jaggery industry by supplying healthy and more productive varieties.

Similarly, during 2020, studies on the *Telchin* insect *(Lepidoptera: Castniidae)* continued as a preventive measure against the attack of the giant sugarcane borer on cane crops in the high plains region. Plans included the economic evaluation of sugarcane varieties using accumulated profit as indicator. Other research results and advances are highlighted below.

Genome assembly of variety CC 01-1940 and development of a molecular fingerprint for Cenicaña sugarcane varieties

With the performance of genome completeness (correlation of assembled genetic information) and contamination analyses, in 2020 Cenicaña completed the construction of the first monoploid genome of Colombian sugarcane hybrid CC 01-1940.

Results indicated that, of the 1,440 expected genes, the assembly contained 91.8% of the genetic information, which to date is the largest amount of information found in a public sugarcane reference genome. The BUSCO tool (Simão *et al.* 2015) and the *Viridiplantae_odb10* database, which consists of 425 gene groups distributed in 57 plant species, were used to evaluate genome completeness.

Blob Tools (Laetsch & Blaxter 2017 were used to evaluate the presence of contamination in the genome, and results indicated out of the 1254 Mbp assembled, 1251.53 Mbp (99.8%) belong to sugarcane, confirming that there is no significant contamination in the assembly.

The identification and organization of the genetic information of sugarcane variety CC 01-1940 grants greater precision to future research aiming to develop new sugarcane varieties by serving as basis to identify molecular markers and, as a result, increase the probability of identifying varieties with desirable and undesirable characteristics in an early stage of development.

Scan the QR code
To access the webinar "The genome of variety CC 01-1940 and its importance" (in Spanish).

Validation of SNP molecular markers

SNP markers associated with agronomic characteristics of interest identified in 2019 were validated by Cenicaña in 2020 to determine whether they can serve as a molecular fingerprint to instead of and differentiate the rest of the germplasm bank of the sugarcane agroindustry.

Targeted resequencing (TR) technology we used to reproduce the markers in 360 individuals, from which 64 belonged to the 220 genotypes originally selected.

These results have made it possible to define a unique allele dosage pattern for all the individuals evaluated, using different sequencing technologies such as GBS, RADSeq, and TR. The next step in this process, now ongoing, is the routine implementation of this new tool.

The validation of a molecular marker consists of determining, in a reliable way, if the results observed in the discovery stage are maintained in different populations, in such a way that they can be of practical use. Although there are no guidelines on how to validate molecular markers, there are several pertinent recommendations. Cenicaña carries out both a technological and biological validation.

Marker Assisted Selection (MAS) Project

Validation of markers for sucrose content

In the framework of the MAS project, technological and biological validations were carried out on 53 molecular markers for sucrose for subsequent use in the selection of sugarcane varieties.

Of all the validated markers, four were able to identify a group of individuals with higher sucrose content. Markers were mapped to the reference genome CC 01-1940 reference genome as part of this validation process. Six genes related to carbohydrate production were found:

- ***Glycosyltransferase*** *(BC10_ORYSJ)*
- ***Transaldolase*** *(TAL_THIDA)*
- ***Ligase ATL31*** *(ATL31_ARE3 ubiquitin-protein ATH)*
- ***Alpha-galactosidase*** *(AGAL_COFAR)*
- ***Alpha-galactosidase 2*** *(AGAL2_ARATH)*
- ***MAIN-LIKE 2 protein*** *(MAIL2_ARATH).*

GWAS analysis for sucrose and resistance to brown rust and smut

A genome-wide association study (GWAS) was performed with 30,448 markers aligned to the reference genome *saccharum spontaneum* and using phenotypic data from a subset of 220 varieties from the germoplams bank of the sugarcane agroindustry.

One marker was significantly associated with sucrose content (% cane), while 39 and 37 were associated with smut and brown rust resistance, respectively. The next phase is the biological validation of these markers.

Cenicaña also continued evaluations aiming to confirm whether previously selected sugarcane genes have the potential to contribute to tolerance to water deficit. One gene was characterized, which codes for an enzyme related to carbohydrate metabolism and can contribute not only to water deficit tolerance, but also to increased biomass production.

Advances in transformation processes and genome editing

different in vitro regenerartion and rooting methodologies were compared using three commercial sugarcane varieties to improve embryogenic callus production in genome editing transformation and editing projects.

Different tests carried out identified that an induction culture medium called RP-IND was the best in producing embryogenic callus of sugarcane varieties and therefore will be routinely implemented to produce this type of material.

The resistance to insect pests, such as *Diatraea* spp., was evaluated based on plant transformation of variety CC 01-1940 using the Cry1Ab gene. The production of mRNA was considered as proof of gene expression in 10 out of the 74 plants undergoing the tissue culture process **(Table 3).**

Table 3 *Plants of variety CC 01-1940 transformed with the Cry1Ab gene and presenting resistance to* Diatraea *spp.*

<table>
<tr><th>EVENTS</th><th>NUMBER OF PLANTS</th><th>PCR-POSITIVE PLANTS (DNA)</th><th>RT / PCR-POSITIVE PLANTS (CDNA)</th><th>ELISA-POSITIVE PLANTS</th></tr>
<tr><td>Cry210319</td><td>35</td><td>25</td><td>2</td><td rowspan="4">4</td></tr>
<tr><td>Cry290319</td><td>35</td><td>27</td><td>7</td></tr>
<tr><td>Cry090419</td><td>4</td><td>4</td><td>1</td></tr>
<tr><td>TOTAL</td><td>74</td><td>56</td><td>10*</td></tr>
</table>

* Partial results of 13/56 plants evaluated.

Selection of sugarcane varieties for the Cauca river valley

SEMI-DRY ENVIRONMENT
Regional trials
2004 - 2009 series

Outstanding varieties were CC 05-430, CC 04-195, CC 05-230, CC 09-066, CC 08-22, CC 09-246, CC 05-231, CC 09-535, and CC 09-235, presenting between 2%–22% higher TCH and between 7%-29.3% higher TSH per hectar as compared to the control variety CC 85-92 **(Figure 23).**

HUMID ENVIRONMENT
Regional trials
2009 - 2010 - 2011 series

In the regional trial carried out for the 2009-2010 series, the sugarcane variety CC 10-450 obtained 2% higher sucrose (% cane) and 2% higher TCH as compared to the control variety CC 01-1940. Sugarcane varieties CC 10-450, CC 10-476, and CC 10-503 were also higlighted for presenting a productivity similar to that of the control variety in the agroecological zones 5H3, 5H4, and 8H3. These varieties also showed resistance to the main diseases affecting the crop **(Figure 24).**

In the regional trials of the 2011 series, sugarcane varieties CC 11-600, CC 11-595, CC 11-606, and CC 11-470 were outstanding in terms of tons of cane per hectare, varieties CC 11-493 and CC 11-465 in terms of sucrose content (% cane), and CC 11-600 in terms of tons of sucrose per hectare (TSH). Variety CC 11-468 showed specific adaptation to agroecological zones with a semi-dry environment, CC 11-605 to high-humidity zones, and CC 11-600 to transition zones of humidity groups H3 to H4.

FOOTHILLS ENVIRONMENT
Regional trials
2003 - 2011 series

Best-performing sugarcane varieties in semi-dry and humid environments were evaluated in the foothill environment to select those presenting the best adaptation. Results indicated that in the foothill environment the productivity of varieties CC 05-430, CC 09-535, CC 04-195, CC 06-489, and CC 11- 600 was equal to or higher than that of the control variety (i.e., CC 01-1940), and higher than that of CC 85-92 **(Figure 25).**

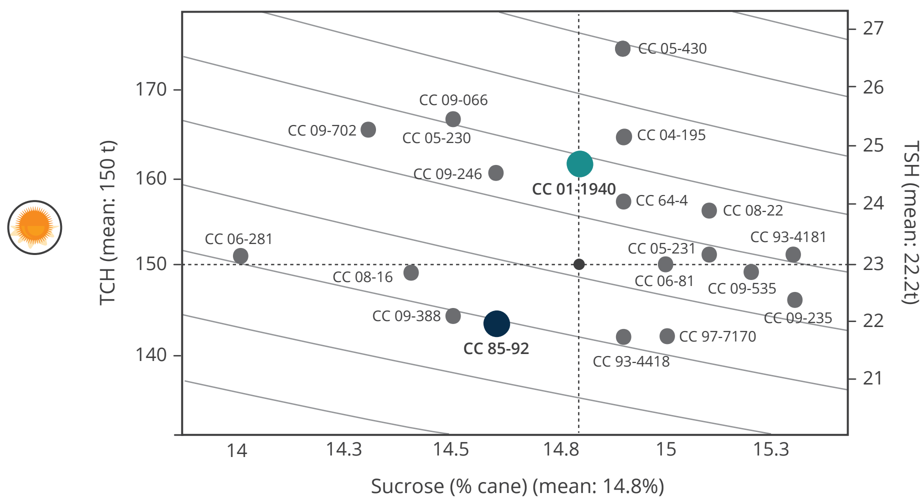


Fig. **23**

Combined analysis of results of regional trials conducted from 2015 to 2020 at 23 fields (plant cane and three ratoons) in dry/semi-dry environments using sugarcane varieties of the 2004–2009 series.

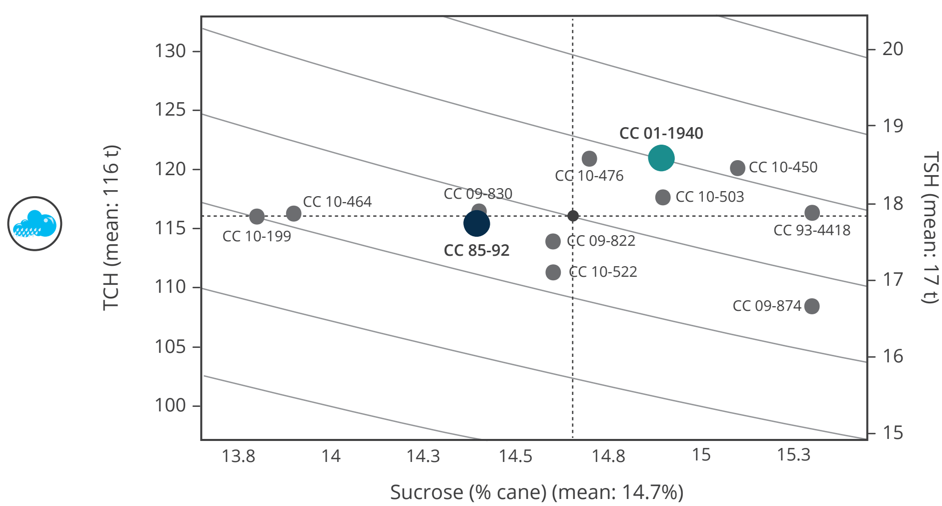


Fig. **24**

Combined analysis of results of regional trials conducted from 2017 to 2019 at eight fields (plant cane and first ratoon) in humid environments using sugarcane varieties of the 2009–2010 series.

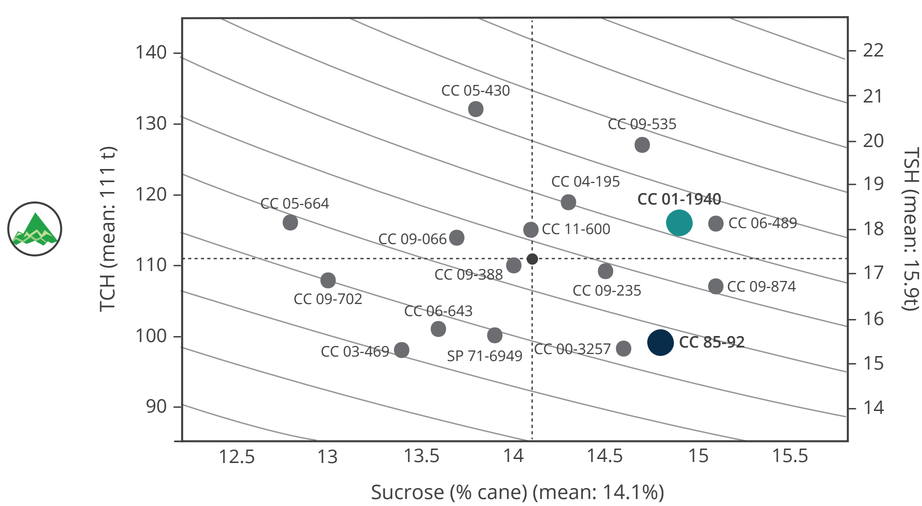


Fig. **25**

Combined analysis of results of regional trials conducted at three fields (plant cane) in foothill environments using sugarcane varieties of the 2003–2011 series.

Guaranteeing genetic variabilitya

Varietal crosses produce new combinations of genes, thus increasing the possibilities of developing more productive varieties. A total of 2,350 crosses were produced at the San Antonio de los Caballeros Experiment Station (EESA, its Spanish acronym) during the 2019-2020 season. Of these crosses, 476 were self pollinations, 1562 biparental crosses, and 312 multiple crosses. In addition, 100 biparental crosses were imported from the hybridization station of Mexico's Sugarcane Research and Development Center (CIDCA).

The following varieties were also imported to broaden the genetic diversity of future crosses:

- Brazil: Foundation for the Institutional Support of Scientific and Technological Development (FAI, its Spanish acronym) /Federal University of San Carlos (UFSCar, its Spanish acronym): sugarcane varieties RB 985476, RB 975201, RB 965917, RB 935744, and RB 975952 (closed quarantine facilities).
- Australia: Sugarcane varieties MQ 239, Q 188, Q 182, Q 246, Q 217, Q 243, KQ 236, Q 223, Q 237, and Q 224 which presented resistant to brown rust, smut, and sugarcane mosaic virus (SCMV). Only varieties Q 182 and Q 224 showed susceptibility to orange rust.

Phytosanitary evaluation

Clones were evaluated in each stage of the selection process to identify disease-resistant materials.

A total of 178,687 seedlings or potential varieties were evaluated in 2020, of which 56% were resistant to brown rust, orange rust, SCMV, and smut. Of these materials, 59.5% are adapted for semi-dry environments, 51.3% for humid environments, and 38.1% for the foothill region.

The 220 sugarcane accessions belonging to the MAS (Marker Assisted Selection project were also evaluated under semi-controlled conditions. this trials or condition allowed the development of symptoms of the different evaluated diseases as well as the identification of resistant and susceptible varieties **(Table 4).**

DISEASE	EVALUATION AGE (MONTHS)	VARIETY SOURCE OF INOCULUM	ACCESSIONS EVALUATED (2020)	TOTAL NUMBER OF ACCESSIONS EVALUATED	RESISTENT (%)	INTERMEDIATE RESISTANCE (%)	SUSCEPTIBLE (%)
Brown rust (*Puccinia melanocephala* H. and *P. Sydow*	2	CC 85-92	0	220	35.4	43.6	21
		CP 57-603	123	220	40.5	42.7	16.8
		Mixture (CC 85-92, B 43-62 and CP 57-603)	75	75	30.7	60	9.3
Orange rust (*Puccinia kuehnii Krüger*)	2	CC 01-1884	110	213	21.1	31.9	46.9
Smut (*Sporisorium itamineum* M.)	Plant crop 5 and 9	CP 57-603	0	220	85	N/A	15
	Ratoon I 5 y 9		220	220	87	N/A	13
	Ratoon II 5		220	220	95	N/A	5
Mosaic virus (SCMV)	1	CP 31-294 y CC 85-92	87	210	70.5	N/A	29.5
Leaf scald disease (LSD)	2	CC 85-92	59	165	56	30	14
Yellow leaf virus (SCYLV)	2	CC 84-75	34	125	47	33	20

Table 4

Results of the phytopathological evaluation of a group of 220 sugarcane variety or genotypes under controlled conditions.

Variety Adoption and Multiplication Strategy

Cenicaña's Variety Adoption and Multiplication Strategy evaluates sugarcane varieties presenting outstanding performance in regional trials by stages. As part of this strategy, an increase in semi-dry areas planted with CC 05-430 and CC 09-066 (both stage 1) and CC 04-195 (stage 2) was observed during 2020.

In humid environments, an increase of planted areas was observed for varieties CC 11-600, CC 11-595, and CC 10-450 (all stage 2), while in the foothill region, the area planted with varieties CC 00-3771, CC 91-1606, and CC 00- 3257 (stages 2 and 3) remained stable **(Table 5).**

A total of 30,784 ha were renewed in 2020, of which 15,705 correspond to areas directly managed by the sugar mills and 15,078 to areas managed by cane growers. The main varieties planted for semi-dry environments were CC 01-1940, CC 05-430, and CC 09-066, and for humid environments, CC 01-1940, CC 11-600, and CC 11-595.

The area renewed in 2020 was 11% greater than that renewed in 2019 (27,730 ha) **(Figure 26).**

Estimates are that 32,938 ha will be renewed in 2021, of which 49% will correspond to areas managed by cane growers. This information serves as basis to identify potential users by variety/ environment and to define marketing strategies aimed to identify the best locations for the cultivation of each of the new variety.

Table 5 *Adoption of new sugarcane varieties in stages 1 and 2 for the three selection environments during the period 2018 - 2020.*

AMBIENTE DE SELECCIÓN	STAGE	VARIETY	YEAR (HA)		
			2018	2019	2020*
Semi-dry	1	CC 05-230	51.26	174.92	277.30
		CC 05-231	7.48	44.08	76.15
		CC 05-430	878.88	5,682.47	1,609.7
		CC 09-066	113.67	617.41	1,391.28
		CC 09-235	86.98	129.37	122.95
		CC 09-702	156.84	16.55	112.62
	2	CC 01-385	69.92	67.71	25.30
		CC 04-195	151	443.65	472.85
		CC 04-667	57.29	45.27	30.13
Humid	1	CC 11-606	106.05	101.37	86.00
	2	CC 09-874	148.47	189.22	185.25
		CC 10-450	246.43	883.43	1,504.16
		CC 11-595	729.42	3,560.83	6,345.94
		CC 11-600	1,286.45	5,064.53	8,504.44
		CC 11-605	173.59	195.71	166.80
foothill	2	CC 00-3771	199.31	380.46	383.19
		CC 91-1606	581.81	623.79	604.64
	3	CC 00-3257	1,990.76	2,243.25	2,375.42

*Data up to October 2020.

This adoption behavior of new varieties can be attributed to Cenicaña's promotional strategies, together with the support of sugar mills and sugarcane growers:

Accompaniment

This accompaniment of the renewal process by Cenicaña increased from 557 ha in 2019 to 1,182 ha in 2020.

Field Days and Technology Transfer Groups (TTGs)

Prior to the declaration of health emergency issued by Colombia's National Government, field days were held with the sugarcane suppliers of the Pichichí sugar mill to promote varieties CC 05-430, CC 09-066, CC 09-535, and CC 03-154 as options for semi-dry environments, and variety CC 11-600 for humid environments.

Subsequently, Technology Transfer Groups (TTGs) held four virtual meetings with the Cauca, Risaralda, Castilla, and Manuelita sugar mills.

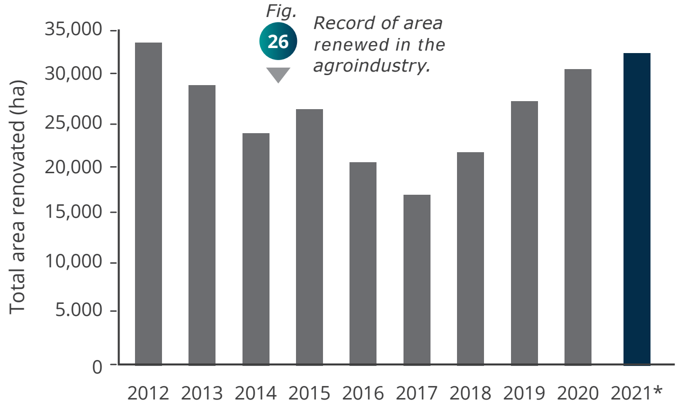
Market research

A interview was conducted with the research directors of 12 sugar mills located in the Cauca river valley to learn about variety adoption processes in directly-managed production units and also identify research needs and aspects that need to be improved.

Demonstration lots

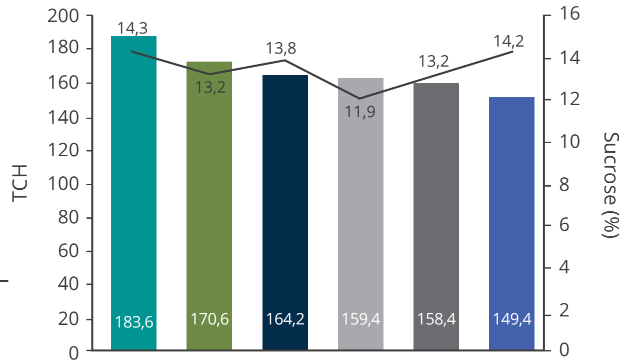
The first cutting showed that sugarcane varieties CC 09-066, CC 97-7170, CC 05-430, CC 98-72, and CC 01-678, in addition to CC 01-1940, are excellent options for semi-dry environments, with plant crop productivity ranging from 149 to 184 TCH, from 11.9% to 14.3% sucrose, and from 11.3 to 13.9 TCHM. Varieties CC 01-1940 and CC 01-678 presented an outstanding performance in terms of sucrose content **(Figure 27).** The following five ratoon will be monitored. Average agroindustrial productivity indicators for plant crops harvested in agroecological zone 6H1 in October and November 2019 were 135 TCH, 11.55% sucrose, and 9.99 TCHM.

Fig. **26** *Record of area renewed in the agroindustry.*



*Renewal forecast for 2021.

Fig. **27** *Harvest results (plant crop) of the demonstration lot located at the International Center for Tropical Agriculture (CIAT, its Spanish acronym).*



Harvest: Mechanical harvest of green cane at 13.2 months and without induced maturation.	**Age:** 13.2 months.	**Irrigation:** With matrix potential sensors.	**Agroecological zone:** 6H1 (Cantarina consociation).	**Demonstration lot:** 7.3 hectares.

CC 01-1940 CC 09-066 CC 97-7170 CC 05-430 CC 98-72 CC 01-678

Analyses to facilitate agronomy-related decisions

Cenicaña developed tools based on simulation and sensitivity methods to analyze costs, investment, and impact of different economic decisions made by the sugarcane agroindustry. These economic, financial, and econometric models allow us to evaluate the relationships between variables of interest, as well as estimate the economic and financial results of a given decision over time.

Economic evaluation for renewal

Cenicaña evaluated the economic aspects of a renewal project using a model that presents the additional net profit at today's value. Therefore, as an investment, not only is the cost of adaptation, preparation, and planting (APP) taken into account, but also the loss in income incurred if the crop is discontinued in the current crop cycle.

This economic model estimates the net present value (NPV) of the accumulated additional profit per cutting and the marginal value of profit per cutting. If the NPV is positive, then the profitability of the renewal project will be higher than the investor's opportunity interest rate.

Table 6 presents the economic evaluation of a renewal project using hypothetical prices and costs.

Table 6 *Model assumptions for renewal and non-renewal alternatives.*

HYPOTHETICAL CONSIDERATIONS
Yield for premium: 11.6%
Payment in kg: 58
Price per kg (COP$/kg sugar): $1400
Cost of adaptation, preparation, and planting (APP) in COP$/ha: $5,3 million (Procaña)
Weighted establishment cost (plant crop and ratoon) in COP$/ha: $4 million (Procaña)
Lease (kg/net "plaza" or 0.64 ha per month): 100
Discount rate (interest): 11.5%
Agroecological zone: 6H1
Next cutting: 1
Months until renewal: 2
Next cutting without renewal: 3

ALTERNATIVE A: RENEWAL (CC 10-1940)				ALTERNATIVE B: NON-RENEWAL (CC 85-92)			
Cutting	Age	TCH	Yield	Cutting	Age	TCH	Yield
1	13.7	161	11	3	13.3	118	11.3
2	13.3	149	11	4	13.3	123	11.4
3	13.1	142	11.2	5	13.2	116	11.6
4	12.7	133	11.3	6	13.1	119	11.3
5	12.3	119	11.5	7	13.6	123	11.4
6	12.9	146	11.1	8	13	116	11.5

Table 7 presents the economic results, income, loss of profit, establishment costs, and opportunity cost of land of each cutting, as well as the profit for each cutting according to renewal and non-renewal options.

The marginal delta is negative in the case of cuttings 1 and 2; in other words, this variety will not yield profits for the first two cuttings. It is only after the third cutting that a profit is generated (COP$627,000/ha) and renewal can be considered as an economically viable option **(Table 8)**.

Continues

New economic indicator

Based on this analysis, Cenicaña proposes a complementary indicator of accumulated profit to economically evaluate sugarcane varieties to identify those materials presenting the best economic results. This indicator results from accumulating the profit per hectare during the renewal cycle. **Table 9** presents the accumulated profit calculated for a hypothetical scenario.

It is fundamental to conduct this analysis at the end of the renewal cycle as the total profit will define whether one variety is better than another during its useful life. **Figure 28** shows the results of the profit obtained cutting by cutting for varieties planted in different soils in a semi-dry environment in northern Cauca river valley. According to the calculation, variety CC 01-1940 presented the highest accumulated profit, followed by CC 93-4418.

Table 7 *Estimation of income, costs, and profit for the renewal and non-renewal alternatives.*

CUTTING	INVESTMENT IN RENEWAL AND APP	INCOME	LOSS IN PROFIT	ESTABLISHMENT COSTS	OPPORTUNITY COST OF LAND	TOTAL COST	PROFIT PER CUTTING	ACCUMULATED PROFIT	NPV ACCUMULATED PROFIT
RENEWAL: CC 01-1940									
1	-$ 5	$ 13	$ 2	$ 3	$ 3	-$ 14	-$ 1	-$ 1	-$ 1
2		$ 12		$ 4	$ 3	-$ 7	$ 5	$ 4	$ 4
3		$ 12		$ 4	$ 3	-$ 7	$ 4	$ 8	$ 7
4		$ 11		$ 4	$ 3	-$ 7	$ 4	$ 12	$ 9
5		$ 10		$ 4	$ 3	-$ 7	$ 3	$ 15	$ 11
6		$ 12		$ 4	$ 3	-$ 7	$ 5	$ 19	$ 14
TOTAL	**-$ 5**	**$ 69**	**$ 2**	**$ 24**	**$ 19**	**-$ 50**	**$ 19**		
WITHOUT RENEWAL: CC 85-92									
3		$ 10	$ -	$ 4	$ 3	-$ 7	$ 2	$ 2	$ 2
4		$ 10	$ -	$ 4	$ 3	-$ 7	$ 3	$ 5	$ 5
5		$ 9	$ -	$ 4	$ 3	-$ 7	$ 2	$ 7	$ 6
6		$ 10	$ -	$ 4	$ 3	-$ 7	$ 2	$ 9	$ 8
7		$ 10	$ -	$ 4	$ 3	-$ 7	$ 3	$ 12	$ 10
8		$ 9	$ -	$ 4	$ 3	-$ 7	$ 2	$ 14	$ 11
TOTAL		**$ 58**	**$ -**	**$ 25**	**$ 19**	**-$ 44**	**$ 14**		

Values expressed in millions of COP$ per hectare.

Table 8 *Estimation of the marginal delta of a renewal project versus a non-renewal project and its interpretation.*

CUTTING	MARGINAL DELTA RENEWAL VS NON-RENEWAL	INTERPRETATION OF RESULTS
1	-$ 3,0	Non-renewal
2	-$ 1,1	
3	$ 0,6	Renewal
4	$ 1,5	
5	$ 1,5	
6	$ 2,9	

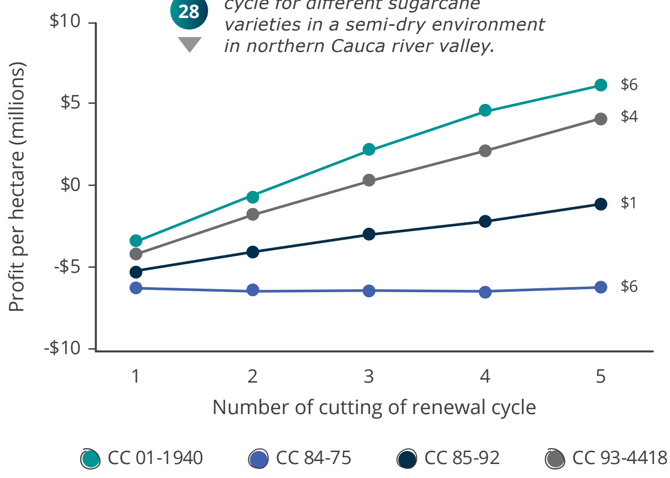
Values expressed in millions of COP per hectare.

Table 9 *Assumptions to calculate accumulated profit.*

HYPOTHETICAL CONSIDERATIONS
Sectoral commercial information: Period 2010 - 2019.
Number of cuttings until a renewal cycle: 5.
Analysis of variance for TCH and Yield and modeling of main effects and their interactions with covariates: harvest age and crop age*.
Ownership of cane and payments and/or costs and prices: Directly managed by sugar mills and sugarcane growers. Presumably there is a payment for the sugarcane grower at 58 kg sugar/t cane as well as an opportunity cost of land equivalent to 172 kg sugar/net ha per month of harvest. These values are paid at a hypothetical weighted sugar price of COP$1,400/kg.
Cost of adaptation, preparation, and planting (APP) in COP$/ha: $5.3 million/ha (Procaña).
Weighted establishment cost (plant crop and ratoon) in COP$/ha: $4 million/ha (Procaña).

* The loss of profit was calculated for cutting 1 (plant crop). This refers to the time taken in months (presumably 2 months) while adaptation, preparation, and planting tasks are carried out and which also delays the receipt of income at the end of the crop cycle.

Fig. 28 *Accumulated profit per renewal cycle for different sugarcane varieties in a semi-dry environment in northern Cauca river valley.*



Epidemiological analyses

Sugarcane yellow leaf virus (SCYLV)

- **Years and months with highest number of positive samples:** 2015, 2014, 2016 and 2017. March, October, and January.
- **Varieties with highest number of positive records:** CC 01-1940, SP 71-6949, CC 84-75 and CC 85-92.

Based on the results of spatial and temporal analyses, although the presence of SCYLV extends throughout the entire geographical area of the Cauca river valley, the greatest risk occurs in the southern part of the region. Descriptive analyses will continue to identify variables associated with the temporal dynamics of the SCYLV.

Brown rust and orange rust

Results of evaluations of 284 lots at the Sancarlos sugar mill (September - November 2019 and January - September 2020) and 196 lots at the Mayagüez sugar mill (May - September 2020) indicated the following:

- Sugarcane varieties CC 01-1940 and CC 09-702 are susceptible to orange rust, presenting the highest damage index (DI > 512).
- Sugarcane varieties CC 84-75, CC 93-4418, CC 97-7170, CC 97-7565, CC 98-72, CC 01-1484, CC 01-678, CC 01-746, and CC 03-469 presented a strong reaction to orange rust and degree of severity in at least one of the evaluated lots (DI > 512).
- Sugarcane varieties CC 85-92, CC 93-4181, CC 99-2461, CC 00-3257, CC 00-3771, CC 01-1228, CC 03-154, CC 05-230, CC 05-430, CC 06-489, CC 09-066, CC 09-535, CC 10-450, CC 10-476, CC 11-497, CC 11-595, CC 11-600, CC 11-606, SP 71-6949, and V 71-51 showed resistance to orange rust.
- Sugarcane variety CC 85-92 was highly susceptible to brown rust (DI > 512). Varieties such as CC 84-75, CC 97-7170, CC 98-72, CC 01-1228, CC 03-469, CC 11-600, and SP 71-6949 presented a high DI at least in one of the evaluated lots.
- Sugarcane varieties CC 01-1940, CC 09-702, CC 93-4418, CC 97-7565, CC 01-1484, CC 01-678, CC 01-746, CC 93-4181, CC 99-2461, CC 00-3257, CC 00-3771, CC 03-154, CC 05-230, CC 05-430, CC 06-489, CC 09-066, CC 09-535, CC 10-450, CC 10-476, CC 11-497, CC 11-595, CC 11-606, and V 71-51 showed resistance to brown rust.

Plant health surveillance and collaborative activities

As part of its ongoing collaboration with the panela-producing sector and other institutions, in 2020 Cenicaña supported Agrosavia in the establishment of agronomic efficiency trials in different panela producing areas of the country and supplied sugarcane plants from individual buds for seedbed production.

Cenicaña also supported Agrosavia in the diagnosis of diseases observed in seedbeds of sugarcane varieties in the departments of Cauca, Santander, and Antioquia. Samples positive for SCYLV were found in CC 01-1940 (Cauca) and in CC 93-7711, CC 01-1940, and CC 01-1508 (Antioquia). Leaf scald disease (5%) was reported in Santander.

Sugarcane varieties CC 01-1940, CC 93-4181, CC 84-75, PR 61-632, CC 85-92, CC 93-4418, CC 97-7170, CC 93-7711, and CC 93-7510, as well as the regional variety, were submitted to phytopathological and agronomic evaluations at the University of the Amazonia in Florencia, department of Caquetá. Variety CC 93-7510 and the regional variety were found to be susceptible to orange rust. The others showed resistance to both brown and orange rusts. Varieties CC 93-4181, CC 01-1940, CC 97-7170, and CC 93-7711 presented outstanding performances in the agronomic and factory process evaluations carried out by the university and will be submitted to further evaluations in other areas of Caquetá.

03 *Sugarcane: The basis of our agroindustry*

Seed for the Arhuaco people

As part of a project to support the development of the panela agroindustry as a sustainable alternative for the Arhuaca community of the Fundación river basin, located in the department of Magdalena, Cenicaña supplied seed of three sugarcane varieties to the United Nations Office on Drugs and Crime (UNODC) for the planting of five hectares.

Seed of varieties CC 01-1940 (1,040 packages), CC 11-600 (1,040 packages), and CC 93-7711 (520 packages) was also handed over to the Producers' Association of the Arhuaco People of the Sierra Nevada de Santa Marta (Asoarhuaco, its Spanish acronym).

Studies on the *Telchin* species complex in Colombia

Cenicaña continued to study the *Telchin* species complex in response of the attacks of the sugarcane giant borer *T. licus* on sugarcane crops in the altillanura (plateau) region. The understanding of the taxonomy of this insect group is key to establishing integrated pest management programs.

These studies evidenced the presence of larvae of the species *Telchin cacica* and particularly the subspecies *T. cacica angusta* that were larger and more robust (up to 14 cm long) than those found so far in plantain and heliconias in the department of Nariño **(Figure 29).** Although this species had already been reported in this area, there was no record of its hosts and information on its biology is also limited. Observations made by Cenicaña suggest that this species has the potential to develop in sugarcane as it was observed to complete its life cycle on cane stems.

Likewise, the molecular analysis of the sequences of the cytochrome oxidase (COI) gene of collected samples as well as those of samples from Brazil and Costa Rica evidenced that *T. licus*, particularly the subspecies *T. licus magdalena,* is the predominant species in the eastern region of Colombia (departments of Meta, Casanare, and Caquetá), whereas *Telchin atymnius* (subspecies *T. atymnius humboldti* and *T. atymnius atymnius*) and *T. cacica* and its subspecies *T. cacica angusta* are found in the Andean zone (departments ofAntioquia, Caldas, and Nariño) as well as in mountainous areas of the department of Valle del Cauca **(Figure 30).**

These collections show that the Telchin complex present in Colombia is characterized by having a wide range of hosts, several of economic importance in addition to sugarcane, which could favor its dissemination and establishment.

The presence of species such as T. cacica in plantain crops represents a risk for nearby sugarcane crops, given their wide range of hosts and possible dispersal via the transportation of plant material or migration to crops of economic interest due to the modification or destruction of its habitat.

Fig. 29 *Above. Larva of the sugarcane giant borer* Telchin cacica angusta *in the municipality of Ricaurte, Nariño, in plantain and heliconias. Below. Adult male T.* cacica angusta *in Ricaurte, Nariño. A. Dorsal view. B. Ventral view. Scale: 1cm.*

9A

9B

T. licus magdalena

T. atymnius atymnius

T. atymnius humboldti

T. cacica angusta

Fig. 30 *Different Telchin species present in Colombia, Brazil, and Costa Rica.*

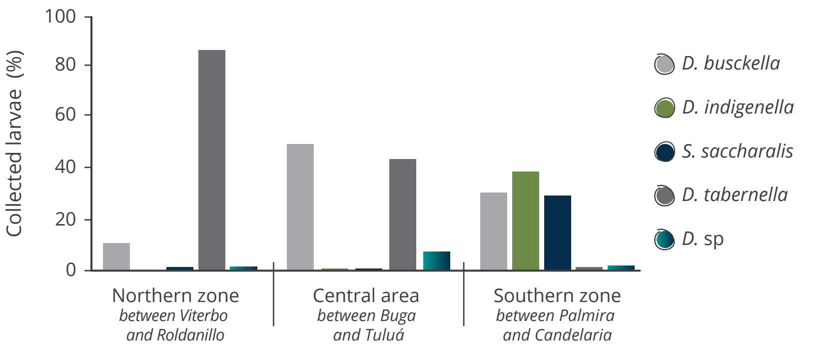
Genea jaynesi, the main parasitoid of *Diatraea* spp. larvae in the Cauca river valley

Between 2015 and 2019, Cenicaña evaluated the incidence of borers of the *Diatraea* complex in sugarcane crops and the effectiveness of the main commercial and wild parasitoids that act on these larvae.

This evaluation showed that the distribution of the *Diatraea* species varies in the Cauca river valley (northern zone: between Viterbo and Roldanillo; central zone: between Buga and Tuluá; southern zone: between Palmira and Candelaria), with *D. tabernella* and *D. busckella* colonizing areas to the north going southwards and possibly displacing pre-existing species *(D. saccharalis* and *D. indigenella*).

Based on the parasitoids found, approximately 37% of borer larvae present in the field should be parasitized. The highest parasitism for three of the four borer species (*D. busckella, D. indigenella,* and *D. tabernella*) can be attributed to *G. jaynesi* **(Figure 31).**

In addition, observations indicate that the commercial parasite *Lydella minense* showed a tendency to decrease in the three zones (northern, central, southern) between 2015 and 2019, especially in the northern zone, where the main borer species is *D. tabernella.* However, the parasitoid *G. jaynesi* dominates in the same area, evidencing the importance of the complementarity of parasitoids used to control the different *Diatraea* borers, in addition to the importance of maintaining wild parasitoids such as *G. jaynesi* in the region.



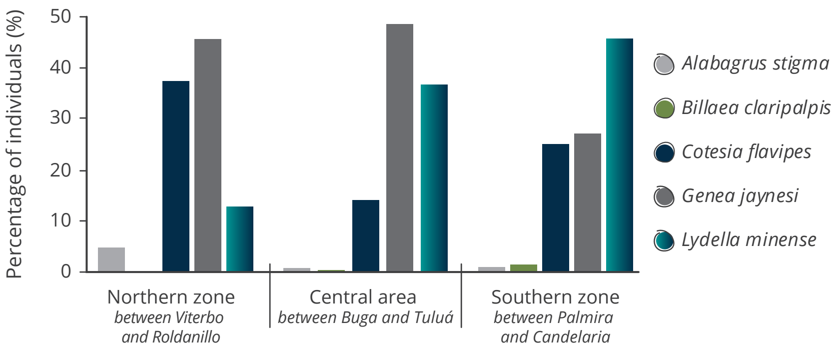


Fig. **31**

Above. *Percentage of larvae of* Diatraea *species found in three zones of the Cauca river valley.*

Below. *Percentage of parasitism (parasitism events) attributed to* Diatraea *larvae collected in each zone. Collections made between 2015 and 2019. D. sp. indicates an unidentified species.*

04

CROP MANAGEMENT KNOWLEDGE AND TECHNOLOGIES

This section presents the results of hydrological monitoring aiming to better understand the impact of conservation actions carried out by the Water for Life and Sustainability Fund Foundation (FFAVS, its Spanish acronym), headquartered in the department of Valle del Cauca, as well as the validations of different irrigation technologies to reduce crop water consumption and the advances made in creating awareness of new sugarcane varieties for crop agronomic management using a SSA approach.

New equipment was also evaluated to increase the efficiency of tasks such as soil preparation and the gathering of usable cane left in fields after harvesting. Crop management technologies were developed based on geographic information as well as on information technologies.

The Sugarcane Internet of Things (IoT) Network was expressly launched during 2020. This network aims to improve the digital interconnection in sugarcane fields of the Cauca river valley.

Impact of conservation actions conducted in watersheds

The sugarcane agroindustry, through FFAVS in collaboration with different river user associations, implements conservation and recovery strategies in watersheds and drainage areas and wetlands supplying surface water as well as groundwater to the Cauca river valley.

To determine the impact of these actions, Cenicaña studies the water balance of the Bolo river basin over time. In this pilot case study, FFAVS and the Bolo River Users Association (Asobolo, its Spanish acronym) implemented different protection and conservation actions in this river basin and then compared its status with that of another river basin where no actions had been taken.

The comparative analysis indicates differentiated patterns in the amount of rainwater that is directed to the river superficially (runoff), subsurfacely (infiltration), and by underground flow. Conservation actions show an increased underground flow that feeds the river in the dry season, recharges the aquifers, and supplies water to the roots of existing flora. In contrast, the unprotected river basin suffers greater losses of surface water (38%), with its respective adverse effect of soil loss due to dragging, with soil ending up in the rivers. As a consequence of the greater surface water flow, a lower amount of rainwater moves in the subsurface and deep layers of the soil, a condition that limits water availability in flatter areas during the dry season. **(Figure 32).**

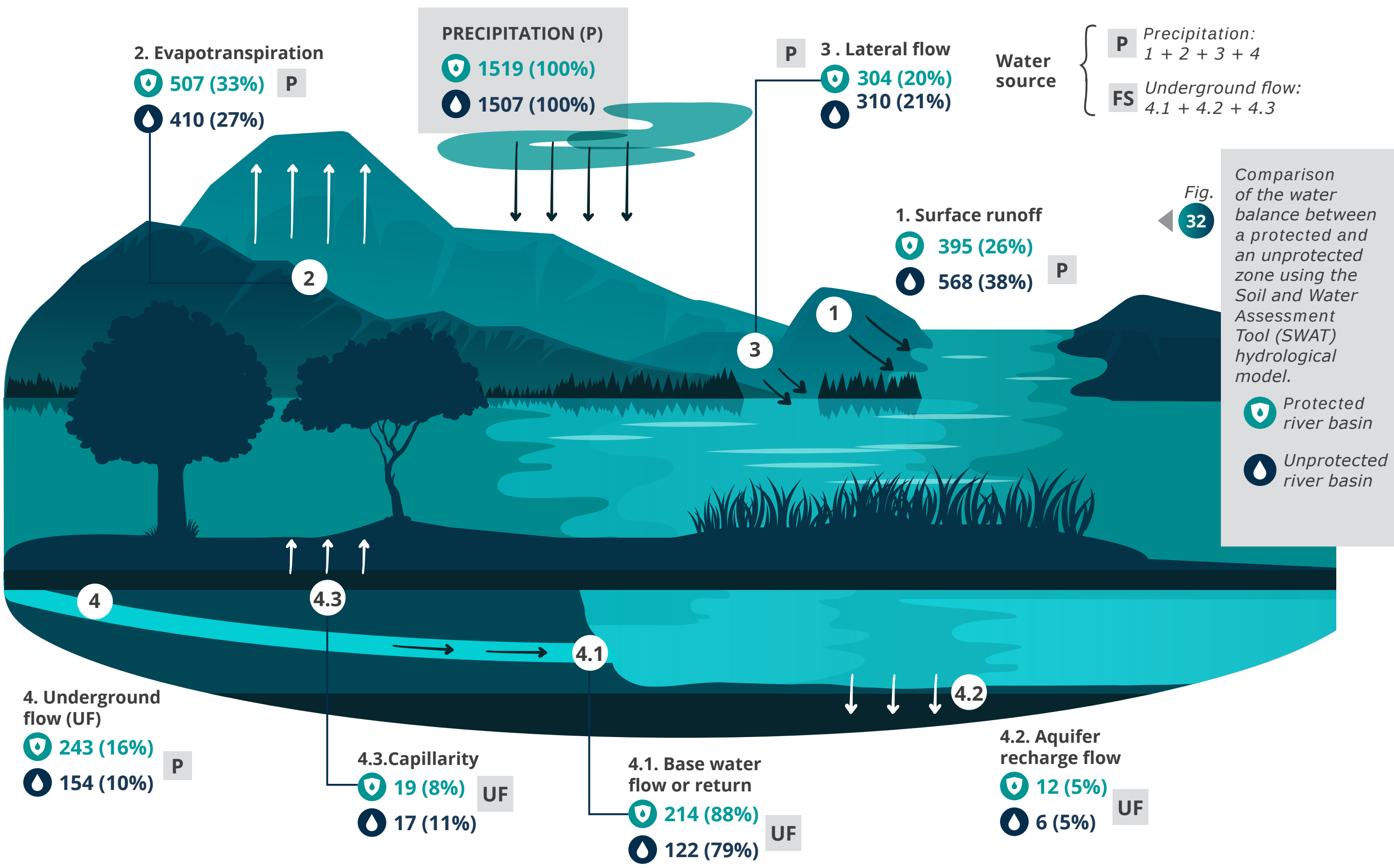


Fig. 32 Comparison of the water balance between a protected and an unprotected zone using the Soil and Water Assessment Tool (SWAT) hydrological model.

Evaluating the regulated deficit irrigation strategy

Regulated deficit irrigation or irrigation frequency suppression/reduction during a certain part of the crop cycle is a viable strategy to increase water use efficiency during crop development.

To determine the critical stages during which irrigation can be reduced, Cenicaña evaluated this strategy in a first cycle of sugarcane production (plant crop) using variety CC 01-678.

The evaluation showed that maximum TCH production was obtained when the crop was irrigated from planting up to 10.5–11 months.

The reduction in TCH was greater (70%) when irrigation was not applied in a timely manner during the maximum growth stage (3.5–9.5 months) and was lower (4%) when irrigation was suppressed in the tillering stage (1.0–3.5 months). TCH production was reduced by 30% when the supply of water was suspended in the pre-maturation stage (between 9–11 months of age) **(Table 10).**

According to these results, deficit irrigation has the potential to economize between one and two irrigations per crop cycle. Cenicaña will continue to evaluate deficit irrigation for two more cycles (first and second ratoons) and then validate results under semi-commercial conditions.

Table 10

Results of the response variables in different deficit irrigation treatments in a plant crop of sugarcane variety CC 01-678.

IRRIGATION APPLICATION STAGE	STEMS (#)	DISTANCE TO BREAKOFF POINT (cm)	TCH	WATER CONTRIBUTION (mm)	REDUCTION IN WATER CONSUMPTION (mm)	REDUCTION IN TCH
From: siembra **To:** 11 meses	24.1 a	303.5 a	132 a	1290	- - -	- - -
From: siembra **To:** 8 meses	18.4 ab	239.9 bc	93 a	800	490	39
From: siembra **To:** 3.5 meses	12.7 b	68.2 e	23 c	180	1110	109
From: 3.5 meses **To:** 11 meses	22.4 ab	293.8 ab	126 a	1100	190	6
From: 3.5 meses **To:** 8 meses	17.5 ab	215.2 d	82 a	660	630	50
From: siembra **To:** 3.5 meses **From:** 8 meses **To:** 11 meses	13.8 b	128.7 d	39 b	670	620	93
From: 8 meses **To:** 11 meses	10.9 b	109.3 d	33 bc	570	720	99
Check treatment (irrigation equivalent to precipitation)	19.5 ab	265.0 c	91 a	750	540	41

04 *Crop management knowledge and technologies*

Strategies to promote irrigation technologies

In 2020 Cenicaña continued to promote marketing strategies for irrigation technologies, making the agronomic management of sugarcane crops increasingly efficient in the use of this resource.

Different actions were carried out as part of these strategies:

Area impacted in 2020 with adoption strategies of different technologies.

12.477 ha *Impacted area*	**WATER BALANCE**
34.485 ha *Impacted area*	**ADMINISTRATIVE CONTROL OF IRRIGATION**
3.253 ha *Impacted area*	**DRAINAGE**
9.828 ha *Impacted area*	**SPRINKLER IRRIGATION USING WATER CANNONS**

Training

A presential event was held with 41 participants as well as two webinars: "Soil water (fundamentals)" and "Water as a basic input for property planning" (both in Spanish).

Scan the QR code
To consult the webinars held on water management during 2020. An access code is required.

Accompaniment

Cenicaña accompanied four farmers and the Carmelita sugar mill in the adoption of the water balance.

Market research

Water resources directors of 11 sugar mills were interviewed to obtain basic information to use to monitor and define other technology transfer strategies. The information gathered served to determine the following:

- **65%** Irrigation water from a superficial source
- **35%** Irrigation water from deep wells

- **50%** Moves water through underground pipelines
- **25%** Moves water through mobile pipelines
- **17%** Moves water through unlined irrigation canals
- **9%** Moves water through lined irrigation canals

Agronomic research on new sugarcane varieties

Nitrogen use efficiency (NUE)

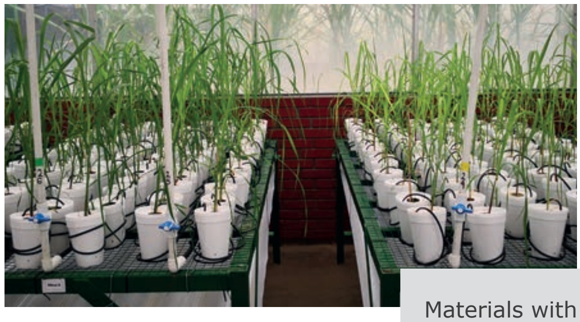
Sugarcane varieties differ in their efficiency to use the nitrogen available in the soil and also applied by fertilizers. A high nitrogen use efficiency (NUE) occurs when more biomass is produced with lower amount of absorbed N.

In an effort to make future sugarcane varieties more efficient in nitrogen use, Cenicaña is determining the relative NUE in a representative sample (220 materials) of the sugarcane germplasm bank using a stage-by-stage approach. This initiative will help identify genotypes presenting outstanding NUE and subsequently associate this characteristic with sugarcane genome regions.

A group of varieties with high dry matter (DM) accumulation at low and high N doses was identified using this measurement **(Figures 33 and 34)**. The varieties that accumulated high DM in both treatments (high and low N) are those that present a high NUE and will serve a source of this genetic characteristic for new varieties (for example, CC 93-3811).

Fig. 33

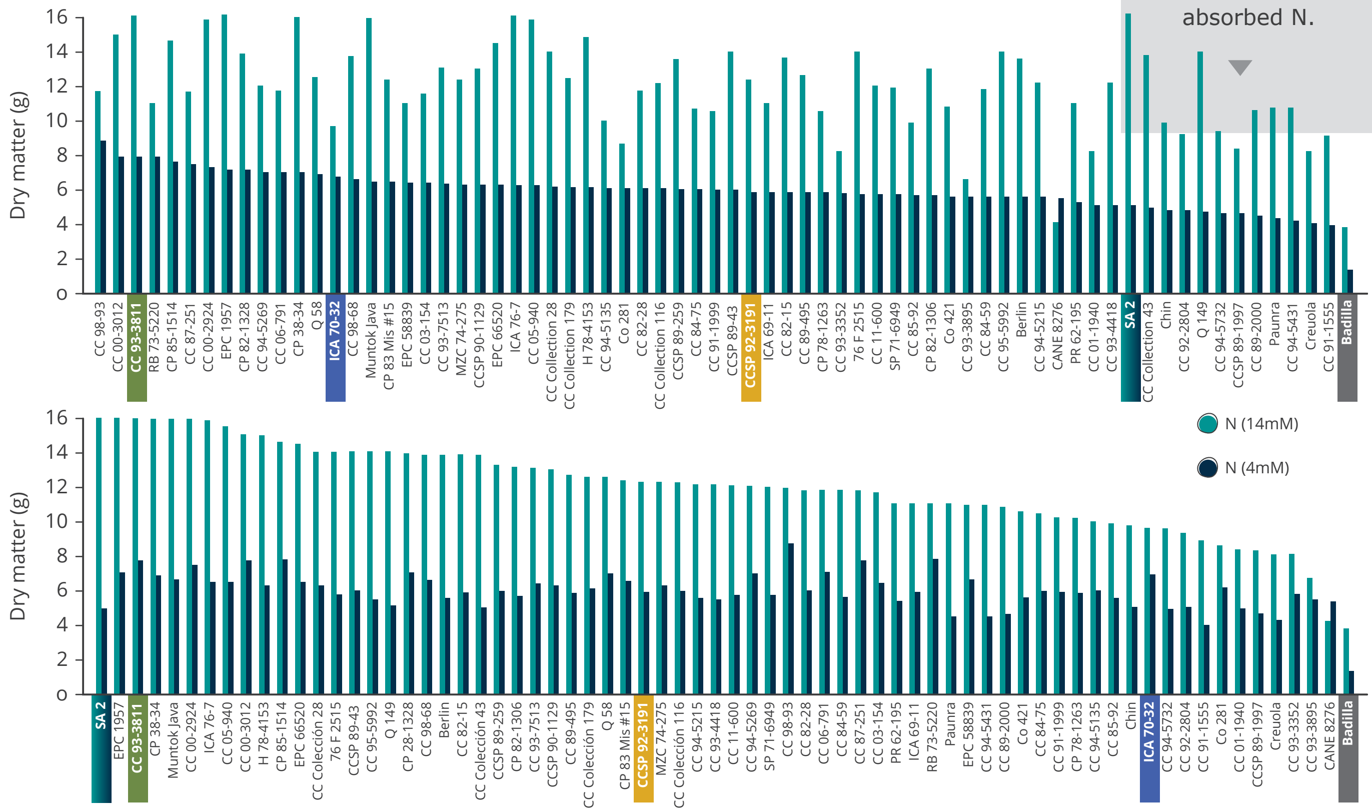
Sugarcane materials growing with high N (left) and low N (right).



Materials with high NUE are those that produce the greatest amount of biomass with the least amount of absorbed N.

Fig. 34

Dry matter (DM) accumulation of 70 sugarcane varieties at three months of age in high N (14 mM) and low N (4 mM), ranked from highest to lowest DM accumulation in low N (top) and from highest to lowest DM accumulation in high N (bottom).



Varieties with high NUE in both high and low N

Varieties with intermediate NUE in both high and low N

Varieties with high NUE in high N and low NUE in low N

Varieties with low NUE in high N and high NUE in low N

Varieties with low NUE in both high and low N

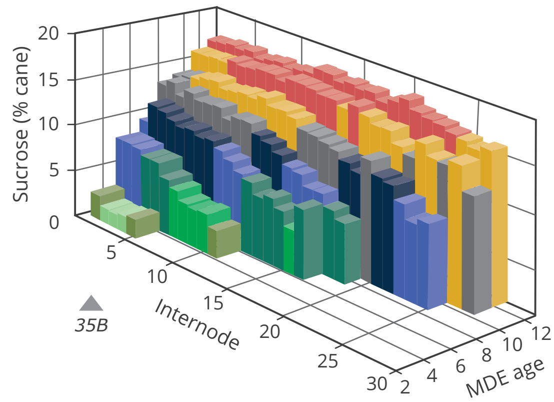
Sucrose accumulation

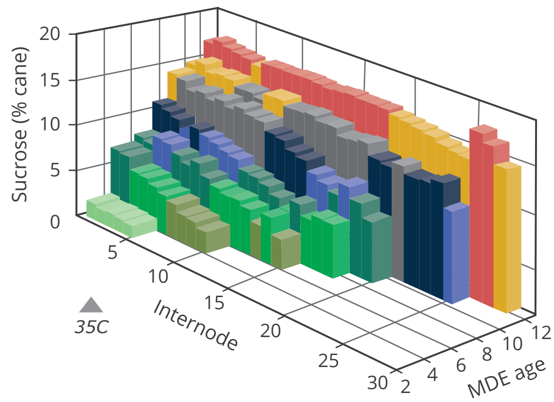
An increased understanding of the new varieties available to the agroindustry is important to streamline crop management practices. In 2020, sucrose accumulation at the levels of the whole stem and internodes was accordingly analyzed for varieties CC 05-430 and CC 01-678 and then compared with the commercial controls CC 85-92 and CC 01-1940 in the semi-dry environment of the Cauca river valley.

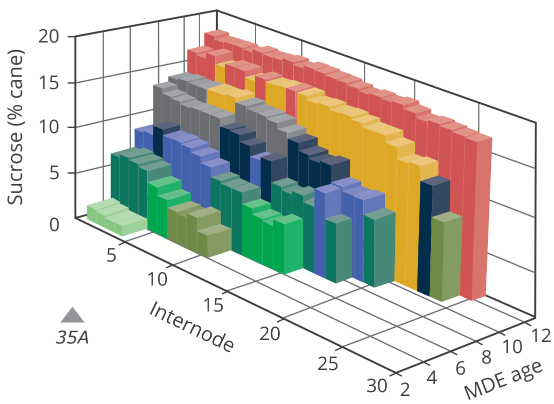
The main results were as follows:

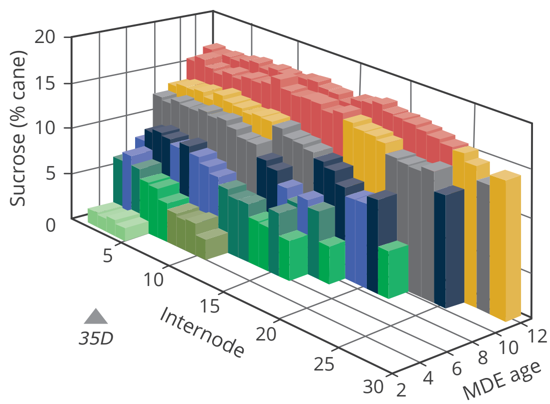
- Sugarcane varieties CC 01-1940 and CC 01-678 present a more uniform natural maturation as compared with varieties CC 05-430 and CC 85-92.
- Sugarcane variety CC 05-430 requires an extended growth period, greater than 13 months, or supplementary induced maturation to improve the natural maturation of the upper third of the stem and hence the sucrose of the whole stem **(Figure 35).**

Plans include expanding the study of sucrose accumulation dynamics in new varieties to the humid zone as well as continuing this study in ratoon I.









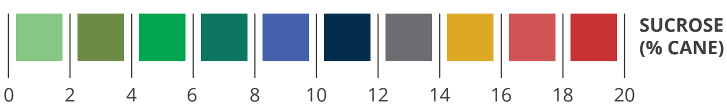


Fig. 35 *Sucrose accumulation dynamics by internode in four sugarcane varieties (CC 01-1940, A; CC 01-678, B; CC 05-430, C; CC 85-92, D) in a semi-dry environment of the Cauca river valley.*

Monitoring of harvest performance

In the process of characterizing new sugarcane varieties, it is important to know how they perform during mechanical harvesting. Ten varieties of the 2011 regional trial series were accordingly monitored for humid environments in terms of the following variables: pre-harvest agricultural residues (PHAR) (%), field efficiency (% time during which the harvester is cutting cane with respect to the total time the machine spends within the lot); and cane left in the field (TCH).

Results indicate that there are no statistical differences between the new varieties and the commercial control (CC 01-1940) for biomass (Figure 36) and sugarcane left in the field.

Variety CC 11-493 reported the highest PHAR value (29.48%) and variety CC 11-465, the lowest (19.88%). Variety CC 11-465 recorded the highest field efficiency value (77.66%), while variety CC 11-493 recorded the lowest (62.82%). A high PHAR content in the field can increase the probability of jamming of harvesters but, at the same time, can serve as a good parameter when the PHAR is considered as a by-product.

High field efficiencies are associated with varieties with low PHAR and less lodging. In the case of the variable "cane left in the field", variety CC 11-497 presented the highest value (3.51 TCH), while variety CC 11-600 presented the lowest (1.72 TCH).

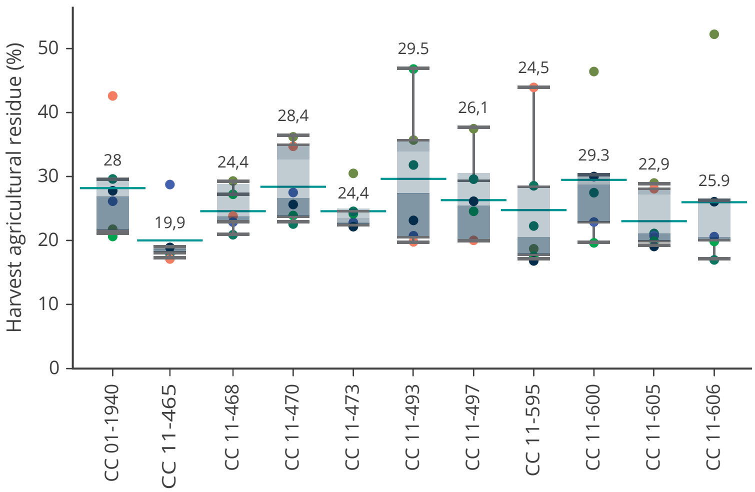


Fig. 36 Average and deviation (%) of pre-harvest agricultural residue (PHAR) by evaluated variety.

Towards a sugarcane ID code

To improve the monitoring precision of sugarcane productivity indicators, Cenicaña began to recover historical information (traceability) about different parts of the same lot. A spatial index (indexing) was generated to associate each fraction of physical space (grid) with the cartographic history of each lot. This process enables the recovery of variables such as land tenure or management of a given part of the land over time, without affecting management schemes currently in place by sugar mills.

This development allowed the recovery of an additional 30% of historical productivity data, increasing the cartographic coincidence of the commercial database from 50% to 80%.

The large volume of information that resulted, in addition to the spatial index that was generated, made it necessary to also structure a data warehouse to develop a platform to analyze the history of recovered data. This data structuring model helps explain productivity as a function of other external factors, including cartography and, shortly, soil and climate.

Cenicaña corroborated indexing efficiency and operability of this new database organization through searches that were 50% faster than those performed without indexing. Figure 37 shows an example of the historical productivity information for a lot as well as the codes used for the same lot between the years 1994–2018.

Fig. 37 Example of historical productivity information for lot RP001392000170 and how the information is recovered through indexing and the data warehouse.

01

LOT IDENTIFIED WITH DIFFERENT CODES OVER THE YEARS

HISTORICAL PRODUCTIVITY DATA

02

CODIGO DE IDENTIFICACIÓN DE LA SUERTE	AÑO	VARIEDAD SEMBRADA	ÁREA COSECHADA
RP000679000237	1994	V 71-51	5.1
CV000024000217	2008	CC 85-92	2.13
CV000024000217	2018	CC 85-92	4.03

Historical data also includes other indicators such as cutting age, total tons cane (TTC), total tons sugar (TTS), and yield.

03

A spatial coincidence (> 40%) was established throughout the time of historical codes:

04

INDEXING
Each physical space (grid) was associated with the cartographic history of the lot and given a **UNIQUE ID CODE.**

05

DATA WAREHOUSE
A platform was generated to analyze historical productivity data recovered from the geostatistical analysis.

New applications for the sector

Cenicaña is advancing in the development of an application that uses the repository of free satellite images (including historical images) from Google Earth Engine (GEE) to monitor the vegetation associated with sugarcane and which, in the medium term, will serve as input in agronomic decision-making processes to overcome delays in crop growth, for example the use of irrigation or application of fertilizers.

In 2020, the first version of the satellite tracking application was developed with a series of monitoring indices: image with estimated growth rate, maximum and minimum values, date, and historical average. In 2021 Cenicaña will continue to validate and calibrate appropriate indices for sugarcane as well as explore other indices of agronomic significance.

On the other hand, to take advantage of the opportunity offered by aerial images for tasks such as replanting, harvesting, and weed control, in 2020 Cenicaña worked on the development of the ARCROP platform that allows furrowing lines to be automatically digitized and analyzed based on a photo with high spatial resolution.

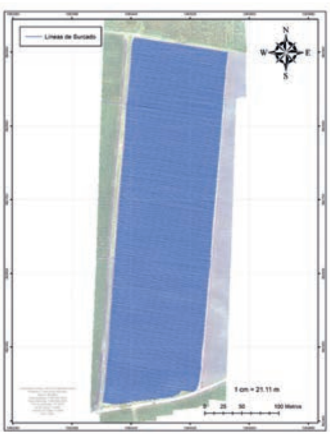
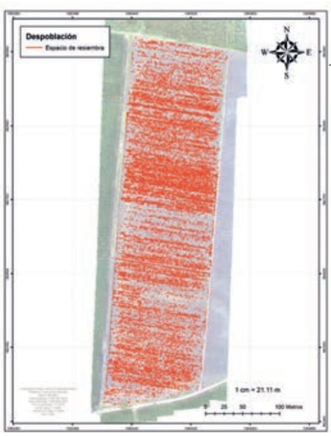


Fig. 38 Digitized furrowing lines generated using ARCORP.



Depopulation of a sugarcane lot identified using ARCROP. Fig. 39

ARCROP currently delivers the following products:

Digitized furrowing lines:
These serve as an input map to guide mechanized harvesting with a potential effect of reducing trampling and jamming. Validation results indicate a precision greater than 95% with respect to the field value **(Figure 38).**

Depopulation:
This product spatially identifies all those areas of the lot where there is no sugarcane. The minimum detection distance can be adjusted. Validation experiments showed an error of ~ 2.5% with respect to field sampling **(Figure 39).**

Depopulation by area:
This product allows the identification of those areas where depopulation is concentrated, which improves logistics by anticipating priority work areas.

Distance between furrows:
This product indicates the distance between a furrow and neighboring furrows. It also calculates the difference between the expected and the calculated distances between furrows. It has proven to be a useful variable when studying furrow deviation throughout cuttings.

Cobertura vegetal:
This product identifies areas within the crop where aerial biomass is concentrated. Areas presenting low biomass can be scheduled for monitoring, follow-up, and differentiated agronomic management.

Because the application can process RGB images (photos taken with conventional cameras), ARCORP is a less expensive alternative to the traditional methodology of using field commissions to identify the percentage of depopulation. In the future, this platform will allow rapid and accurate board-scale analysis.

The sugarcane agroindustry IoT network

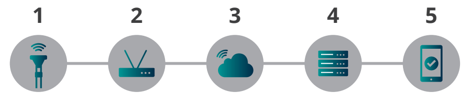
Highlights for 2020 include the implementation of digital transformation actions towards agriculture 4.0. It is increasingly common to talk about IoT, devices that send information to the cloud for processing and analysis and then convert these data into useful information for decision-making regarding agronomic and factory-related processes relevant to the sugarcane sector.

Cenicaña launched the LoRaWAN or Sugarcane Agroindustry IoT Network, consisting of 13 stations distributed throughout the Cauca river valley, from Santander de Quilichao in the department of Cauca to La Virginia in the department of Risaralda, and covering approximately 80% of the territory under the influence of sugarcane growers, sugar mills, and cane suppliers in Colombia.

Products currently being implemented under the services provided by the IoT Network include automated matric potential stations, which measure the amount of water retained in the soil and also send, in real time, the data to the cloud through the Network, thus contributing to the timely and effective scheduling of irrigation events.

LoRaWAN technology solutions now in development phase

- Distributed Control Systems (DCS) of factory processes.
- Weather stations.
- Monitoring of hydrographic basins.
- Measurement of variables associated with sugarcane cultivation.
- Monitoring of agricultural machinery.



Sensors and actuators (LoRaWAN nodes): Electronic devices with very low energy consumption that are used to control actuators and measure different types of variables and LoRAWAN communication.

LoRaWAN stations: 13 stations with LoRaWAN Gateways to cover 80% of the sugarcane-producing area of the Cauca river valley (1 stage).

LoRaWAN server in the cloud: Manages the data received and sent to the nodes installed in factory and field processes (hosted at Cenicaña).

Database service: Data storage and management service hosted at the Cenicaña data center.

Information management and display systems: Mobile applications to provide users with the most relevant information for decision-making. Responsive web applications for users to facilitate parameter configuration and product referencing.

Fig. 40 *Components of the IoT Network of the Colombian sugarcane agroindustry.*

Strategies to promote precision agriculture (PA) technologies

Cenicaña's activities during 2020 aiming to promote the adoption of technologies that lead to more innovative field processes included the following:

Market research

This involved a series of interviews with area managers and/or those in charge of precision agriculture (PA) work of 11 agroindustrial sugar mills. The data collected indicated the following:

Seven sugar mills have PA areas. The other mills carry out PA work under the leadership of the field operations areas.

Tasks carried out include the following:

- Furrowing with self-guiding system.
- Topographic survey using GNSS-RTK.
- Use of drones for monitoring activities, crop evaluation, aerial applications, furrowing, and identification of depopulation areas.
- Increase in the use of productivity maps and of harvesting using autopilot **(Table 11).**

Table 11 *Sugarcane cultivation tasks that involve the use of precision agriculture (PA) technologies (2020).*

TASKS CARRIED OUT WITH PA TOOLS	RS	RP	CC	CM	PC	MN	PR	MY	CA	CB	ML
Furrowing with self-guiding system	●	●	●	●	●	●	●	●	●	●	●
GNSS-RTK topographic surveys	●	●	●	●	●	●	●		●	●	●
Leveling using GPS		●	●	●	●	●	●	●	●	●	
Productivity maps	●	●	●			●	●	●	●		
Monitoring and evaluation using drones	●	●	●	●		●			●	●	
Harvesting with autopilot		●				●	●	●	●		
Fixed-rate fertilization		●	●			●	●		●	●	
Variable-rate fertilization		●	●				●		●		
Furrowing using drones							●	●			
Fixed-rate weed control				●		●			●		
Identifying replantings using drones						●					
Plowing using autopilot						●					
Aerial applications using drones	●	●		●	●	●			●	●	
Satellite telemetry and analysis									●		●
Soil preparation with self-guiding system			●								
Mechanized planting using autopilot						●			●		

Evaluating soil preparation equipment

Soil preparation accounts for 26%-30% of the renewal process, and takes between 50-70 days, which can be extended depending on the region's precipitation patterns. To reduce the time involved and related costs, Cenicaña studied the performance of a rotovator or rotary tiller, an equipment that integrates soil surface work (rotary hoes), deep tillage (stems) and declodding, at a sugar mill located in a semi-dry environment in terms of time required to prepare the soil, quality, sustainability, and costs incurred (Figure 41).

The degree of decompaction and the distribution of soil aggregates using the Rotavator were compared with those of conventional soil preparation methods. A similar performance was observed for the variables "apparent density" and "resistance to penetration" between the two crop renewal systems.

These preliminary results evidence the high potential of this equipment, which could also reduce soil preparation time and costs. Plans are to continue with further technical, economic, and sustainability evaluations, conducting experiments in other soil types.

Fig. 41 *Rotovator-type equipment for soil preparation.*

Estimation of harvest and transportation costs in HD 12000, HD 20000 and HD 30000 wagons

The sugarcane agroindustry seeks to optimize the fleet of wagons used to transport sugarcane. The monitoring of the cost per ton incurred in the process of cutting, lifting, and transport (CLT) of sugarcane serves to improve decision-making about replacement of equipment.

From 2015 to 2019, Cenicaña studied the use of three types of wagons at the sugar mill. The use of high-discharge (HD) wagons models 20000 and 30000 was found to have a positive impact on harvesting and transportation costs as compared with the HD 12000 wagons **(Table 12).**

Table 12 *Cost estimate for cutting, lifting, and transport (CLT) of sugarcane depending on the transport wagon (2015 - 2019).*

AVERAGE COST CLT (COP$/T)	TRANSORT WAGON			DIFFERENCE IN COST		
	HD 12000	HD 20000	HD 30000	HD 20000 vs HD 12000	HD 30000 vs HD 12000	HD 30000 vs HD 20000
Total cost	27,647	27,253	19,218	394	8,429	8,035
Cost long cane	32,396	30,351	-	2045	-	-
Cost mechanically harvested cane	19,720	19,798	19,218	-78	502	580

Machinery to lift usable cane left in fields after harvesting

Sugarcane left in the field is a logistical challenge for harvesting because its harvest is operationally inefficient and costly. To gather this cane, it is necessary to use a third type of lifting machine that differs from the cane lifter used in semi-mechanical harvesting and the sugarcane harvester used in mechanized harvesting

To find more efficient and profitable solutions for usable cane left in fields after harvesting, Cenicaña and the sugar mill designed and built a hybrid (self-dumping wagon and cane lifter) that lifts this leftover cane in less time and with lower costs and environmental impact (field compaction and CO^2 emissions). Another comparative advantage is that it only calls for one operator and can autonomously move between lots, thus avoiding the need for a low-bed wagon.

The field evaluation of this equipment began in 2020. Its performance is considered outstanding, with a productivity of 1.46 ha/ hour, which is competitive if compared with that of a cane lifter (1.74 ha/hour) and a sugarcane harvester (2.4 ha/hour) (Figure 42). In terms of fuel consumption, the transport wagon uses 3.5 gal/hour, which is less than the 7.1 gal/h needed for the lifter and the 8-10 gal/hour needed for the harvester. Under these conditions, the potential reduction in cost per hour is estimated between 50%-70%. This equipment does not involve high investment costs because its main components (wagon and lifting arm) can be recovered from equipment in stock at each sugar mill.

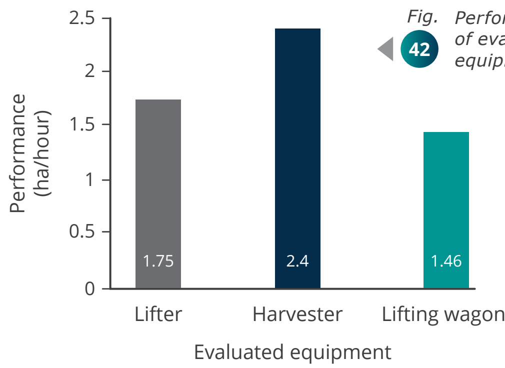


Fig. 42 *Performance of evaluated equipment.*

WE CONTRIBUTE TO THE GOAL OF BECOMING A MORE SUSTAINABLE REGION WHEN WE ALL TAKE CARE OF ONE ANOTHER AND WHEN WE CONTINUE OUR WORK EVEN WHEN TIMES GET TOUGH

05

FACTORY PROCESSES TOOLS AND DEVELOPMENTS

In 2020, Cenicaña moved forward with proposals that aimed to mitigate the impact of mechanical harvesting, sugarcane varieties, and microorganisms on factory processes, starting from the entry of the cane to the sugar mill up through the final stages that demand high-quality products.

Different technology transfer training events were also offered, and the impact of technology adoption in sugar mills was confirmed.

To strengthen the sector's diversification projections, Cenicaña continued to evaluate technological alternatives that aimed to increase energy efficiency. Studies were also extended to processes such as fermentation, production of food additives, and alternative uses of ethanol.

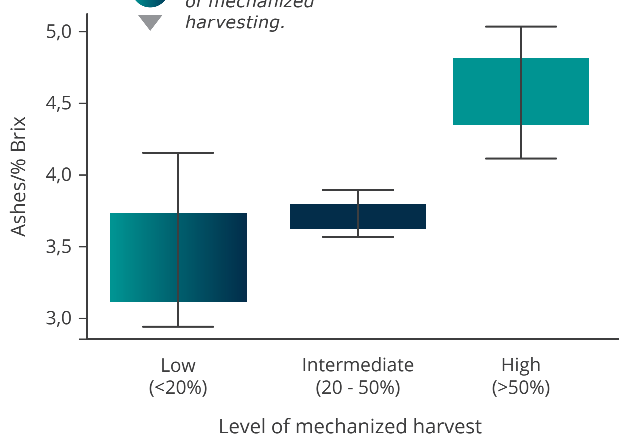
Threshold of impurities during harvest that impact sugar production

Cenicaña began the construction of a threshold of impurities that impact the sugar production process as part of an initiative to mitigate the impact of mechanical harvesting on indicators of factory efficiency and sugar quality

Quantified impurities included ashes (mineral impurities), with a higher proportion in sugar mills using mechanical harvesting (40% increases), making molasses exhaustion difficult and possibly affecting sugar quality **(Figure 43).** Polysaccharides also varied broadly, from 3,600 to 16,000 ppm/Brix base, suggesting that harvest conditions, such as field permanence and foreign matter content in sugarcane, should be revised as well as factory operations, especially residence times and cleaning practices, to help reduce the concentration of impurities in the juice extracted from sugarcane.

This threshold will also serve to determine future actions at the factory level. Cenicaña is currently working on alternatives to remove part of these impurities and improve operational controls to mitigate their impacts during the crystallization and fermentation stages.

Fig. 43 *Ash behavior depending on level of mechanized harvesting.*



Tools to characterize sugarcane fiber

In the search for alternatives to improve the milling and steam generation processes in sugarcane factories, Cenicaña developed tools to characterize different physical and mechanical properties of sugarcane fiber as well as predict the performance of varieties during the factory processing stage.

The first tool consists of a fiber separator to determine long fiber, short fiber, and pith contents, which together with total fiber content, are related to the grip capacity of both mills and transport equipment for processed cane and bagasse **(Figure 44).**

Fig. 44 *Fiber size determined using the equipment developed by Cenicaña.*

The second tool is a pendulum to determine the specific impact energy in sugarcane varieties. It serves to estimate softness of cane as well as to predict its degree of processing.

Scan the QR code
To access the video on the pendulum developed by Cenicaña to determine thespecific impact energy in a piece of sugarcane.

These characterizations are important because sudden decreases in sugar mill torque consumption have been observed in different milling scenarios, associated with roller grip capacity and the difficulty of transporting the bagasse in intermediate carriers, as well as a considerable increase in iron sulfide in juice discs, channels, and tanks, and difficulties in bagasse combustion in boilers. All the above is mainly attributed to the change from a variety with low short fiber content to one with short fiber content greater than 60% during factory processing.

Both tools are currently used in regional trials to complement the characterization of the Cenicaña Colombia (CC) varieties. **Table 13** summarizes the preliminary results of trials carried out with different commercial varieties:

	Fiber (%)	Pith (%)	SIE (J/cm²)
CC 01-1940	13.75	46.12	3.53
CC 01-678	12.03	61.87	3.16
CC 05-430	14.36	63.40	4.16
CC 85-92	14.38	45.20	4.35
CC 93-4418	13.36	48.00	3.80

Table 13 *Results of regional trials carried out to determine specific impact energy, total fiber content, and pith content.*

SIE: Specific impact energy

Pith: Pith plus short fiber

CC 01-678: *Lowest fiber content, pith content > 60%, and lowest specific impact energy.*

CC 05-430: *Pith content > 60% and high fiber content, the latter affecting specific impact energy value.*

CC 85-92: *Highest fiber value, lowest pith content, and highest specific impact energy value.*

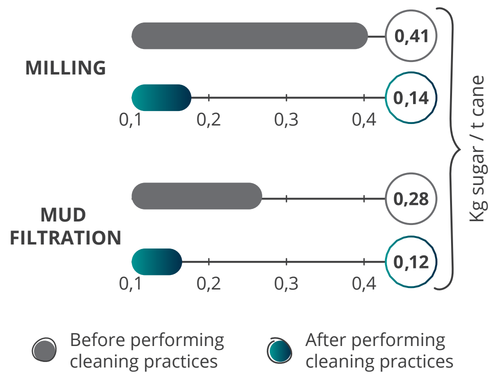
In monitorings carried out at the sugar mill, differences in mill performance were observed in the cases of sugarcane varieties CC 01-678 and CC 85-92. A first mill that processed variety CC 85-92 presented values of 10,000 klb.in (as would be expected considering the size of the mill), whereas the torque decreased 36.6% of this value in the case of variety CC 01-678, even with chute levels above 80%, absence of floatation of upper roller, and identical operating speed. This evidenced a considerable decrease in the mill's grip capacity in the case of CC 01-678. Bagasse moisture increased from 49.5% to 52.3% from one variety to another.

Cleaning and sanitization practices at the milling and filtration stations

The control of the microbiological quality of raw materials and main sugarcane processing streams is fundamental to ensure efficient process performance and sucrose recovery. Cenicaña therefore continued to promote the quantification of microbial metabolites (mannitol) as an early indicator of cane deterioration and its stability throughout the factory process. This allowed the impact of microorganisms on sucrose losses to be estimated.

Based on mannitol quantification, Cenicaña evaluated the impact of implementing cleaning and sanitization practices in the milling and mud filtration stages as these stages are the most susceptible to sucrose inversion due to microbial action. Evaluations carried out at sugar mills on a pilot scale evidenced that the proper implementation of cleaning and sanitization practices at the milling and filtration stations reduced microbial action between 50%-60% **(Figure 45).**

Fig. **45** *Sucrose losses due to microbial action estimated before and after cleaning and sanitization practices in sugar mills on a pilot-scale.*



Tools to diagnose cooling pond performance

Cenicaña found that variations in cooling pond performance can affect factory water consumption and processing capacity. A timely diagnosis can improve cooling pond efficiency using the following tools developed by Cenicaña:

- Measurement of water temperature and flow to and from the cooling pond.
- Thermography analysis to evaluate nozzle spraying.
- Spray nozzle test bench.
- Simulation with Computational Fluid Dynamics.
- Overflight with drones to identify areas presenting greater deterioration of pond components.

Cenicaña offers technical assistance to interested sugar mills, giving recommendations that involve the above-mentioned tools. These may include the re-equipment of the cooling ponds, proposals to reconfigure nozzles, and the evaluation of the economic and environmental impacts of implementing reengineering ideas **(Figure 46).**

The implementation of several of these recommendations in a pilot-scale production plant increased cooling efficiency from 19% to 54%, generating the following direct benefits:

- Reduction in consumption of injected water to the factory. → **27%**
- Reduction in consumption of electrical energy to pump water to the factory. → **33%**
- Reduction in the water captured from external sources used to reduce the temperature to the required levels. → **40%**

Fig. **46** *The before (A) and after (B) of ling pond as result of timely diagnosis.*

46A

46B

Strategies for estimating sugar grain size

In the final stage of the sugar production process, grain size uniformity is important to ensure end product quality as this reduces lumping and losses of molasses, among other reasons. In the case of losses of molasses, Cenicaña estimates that variations in sugar grain size in C massecuite can increase the purity of final molasses between 1.0–1.5 units, while losses in final molasses can increase between 5%-8%.

In 2020 Cenicaña focused efforts on consolidating the standardization of crystallization processes based on a quick reference guide of preparation recommendations for seed (also referred to as alcoholic suspension or slurry) and the Cenicristal software for measuring crystal size.

The reference guide compiles the validated conditions to improve the preparation of materials with which crystallization begins, offering the possibility of reducing the coefficient of variation of the alcoholic suspension between 2 and 5 percentage units. Cenicristal seeks to ensure crystal measurement in the different processing materials **(Figure 47)** and provides practical recommendations to minimize the ambiguity in crystal size measurement, with errors of less than 2%, which facilitates decision making to reduce sucrose losses.

Fig. 47 *The Cenicristal interface.*

Scan the QR code
To consult the quick reference guide to crystal size measurement developed for the sugarcane agroindustry.

Crystal size is a critical parameter in sugar production. Until now, the sugarcane agroindustry has used existing tools to mitigate any problems that arise.

If the crystal does not have the ideal size and shape, lumps can form more easily, which could affect, in turn, industrial processes.

Cenicristal software is currently being validated at several sugar mills on a pilot-scale and is also being socialized among the other sugar mills in the region to start its implementation.

Technological adoption in sugar production factories

Sugar production factories have access to series of tools and technologies developed by Cenicaña that aim to improve different factory processes.

These tools include Cenimol, developed in 2012, which focuses on obtaining an adequate mechanical configuration of milling units and also estimates forces and torque consumptions as well as defines safety factors for checking axes.

Between 2014-2020 control strategies were also developed to improve milling station stability and performance: application of water during milling, linear imbibition (2014), control in intermediate mills (2015), feeding to first mill by type of harvest, and linear imbibition 2.0 (2019).

Their successful implementation by several sugar mills and the results obtained have confirmed the usefulness of these tools for the sugarcane agroindustry. For example, the linear imbibition strategy 2.0, the feeding strategy by type of harvest, and the adjustments obtained using Cenimol were adopted on a pilot-scale at sugar mill 1 and its performance improved by 0.8 percentage units **(Figure 48).**

The feeding strategy by type of harvest was adopted on a pilot-scale at sugar mill 2 and its extraction performance increased by 0.6 percentage units **(Figure 49).**

In addition to the aforementioned benefits, these tools do not require the purchase of equipment and are operated autonomously. Five sugar mills adopted the strategy of feeding cane to the first mill, another five the linear imbibition strategy, and seven currently use the torque control strategy.

In 2020 Cenicaña offered a series of virtual training events to accompany sugar mills in the process of adopting tools developed to diagnose sources of indeterminate losses of sucrose, estimate the ambiguity associated with factory sucrose balance, and quantify sucrose losses due to physicochemical, microbiological, and thermal degradation.

As a result of this accompaniment, four sugar mills adopted tools as part of their routine, allowing sugar mills to devise strategies to mitigate this type of loss.

Fig. 48 Extraction performance on a pilot-scale in sugar mill 1.

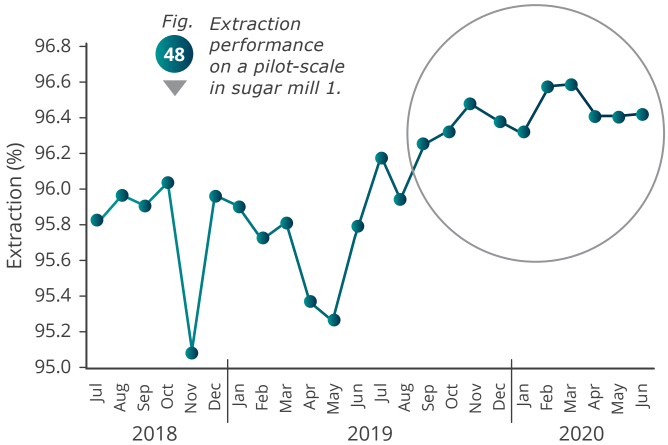
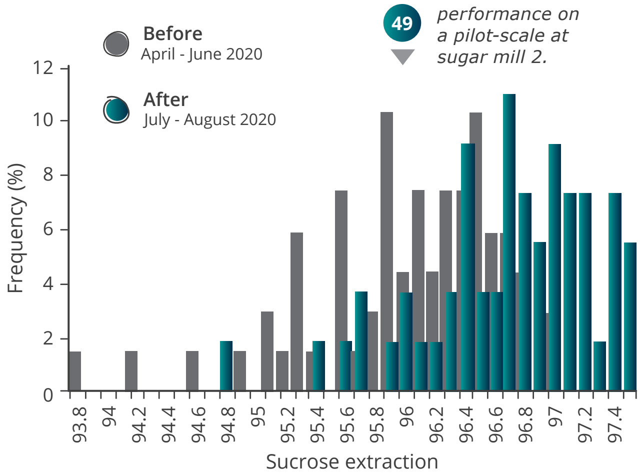


Fig. 49 Extraction performance on a pilot-scale at sugar mill 2.



Evaluation of technological alternatives to increase energy efficiencya

Energy efficiency plays an important role in the sugarcane agroindustry because it increases profitability by augmenting the amount of bagasse or surplus energy for sale. As part of Cenicaña's research initiatives to increase energy efficiency in factory-related operations in the sector, an experimental platform was developed for the stage involving the heating of cane juices and molasses—one of the stages that requires a higher amount of thermal energy (approximately 450 MJ/t cane).

The experimental heating platform serves to evaluate the technological opportunities of the heating operation, select control strategies for increased operational stability, and determine operational and cleaning practices to operate equipment more efficiently.

In 2020 Cenicaña evaluated three control strategies using this platform as well as their responses to variations in juice flow. None of the strategies served to buffer variations greater than 20% of the nominal flow. It was therefore necessary to use more robust and predictive control strategies, or stabilize juice flow to avoid variations that affect the heating in exchangers (Figure 50). In stable operational conditions, the cascade control strategy allowed outlet temperatures with variations lower than 0.5 °C and savings in steam consumption of up to 15% with respect to poor synchronization.

Plans are to use this platform on a pilot scale in studies focused on IoT implementation.

A — *Advantages* | D — *Disadvantages*

Fig. 50 *Summarized results of the evaluation of control strategies for the stage involving the heating of juices and molasses carried out with the experimental platform.*

SIMPLE CONTROL
Strategy 1

- A: Easy to implement and synchronize.
- D: Instability in final temperature of juice. High response time to disturbances.

CASCADE CONTROL
Strategy 2

- A: Stable performance in terms of temperature and steam consumption.
- D: Instability in the presence of juice flow variations. Instrumentation costs.

CASCADE CONTROL + FEED FORWARD
Strategy 3

- A: Stable performance in terms of temperature and steam consumption. Mitigation of juice flow variations.
- D: Instrumentation costs.

Advances in standardizing a methodology for biomass fuels

In 2020 Cenicaña moved forward in the standardization of different methodologies to analyze the percentage of humidity, ash content, and calorific value to streamline a standardized methodology for the sugarcane agroindustry that favors energy resource management for commercialization purposes and increased savings.

The international standards of the American Society for Testing and Materials (ASTM) and the recommendations of the International Energy Agency (IEA) were reviewed within the framework of the *IEA Bioenergy –Task 32* to conduct repeatability and reproducibility analyses and define pertinent criteria. These methodologies are now being socialized and evaluated at sugar mill fuel laboratories.

Factors affecting fermentation processes

Different factors affect the performance of fermenting yeast during the production of fuel ethanol and can trigger stress conditions, such as the acidulation of the yeast stream pending recirculation, which, over long periods of time, produces low pH.

Practices that minimize stress factors were identified and promoted based on the analysis of different acidulation conditions. These practices included preferably using acidulation times between 20-45 minutes (in no case longer than 60 minutes) and non-addition of molasses to the accumulation tank. It was also recommended to validate that the strength of acidulated yeast streams presents intermediate or high values, based on the scale defined by Cenicaña.

Results also indicated that the quality of the raw materials (molasses and juices) used affects not only fermentation performance, but also the overall operation of ethanol plants. In this sense, contamination increased, yeast fermentation performance was low, and the degree of incrustations and clogging of equipment and pipes increased. These problems can be mainly attributed to the change in composition of raw materials, which is associated with an increase in the level of sedimentable solids or muds.

Different analyses showed increases in the levels of organic impurities such as aconitic acid **(Figure 51A)** and calcium and sulfur in the molasses **(Figure 51B).** Considerable concentrations of potassium and silicon were also observed. These elements are the precursors of the formation of salts that can give rise to the formation of incrustations.

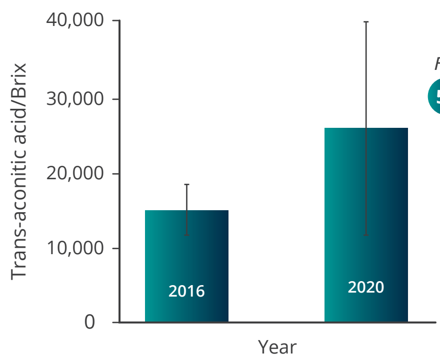
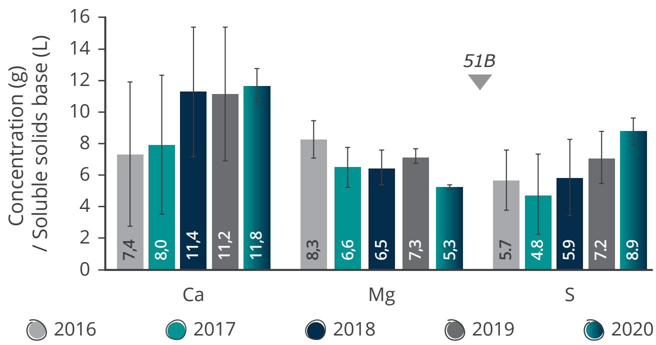


Fig. 51

(A) Aconitic acid concentration (ppm/Brix) and (B) concentrations of calcium, magnesium, and sulfur in B molasses used as raw material in a sugar distillery.

51A

51B



Lab-scale evaluations were carried out to determine the effect of different mud concentrations during fermentation. Results confirmed that, in the case of yeast, effects are indeed related to stress conditions, down-scaling fermentation performance and increasing the deviation of sugars to glycerol. The increase of each 1% of muds in molasses leads to reductions of ~ 0.4 percentage units in the degree of alcohol and scum formation, among others **(Figure 52).**

The search for alternatives to reduce impurities and their subsequent evaluation should be based on a better understanding of the nature of impurities and the quantification of the impact they have on the fermentation process.

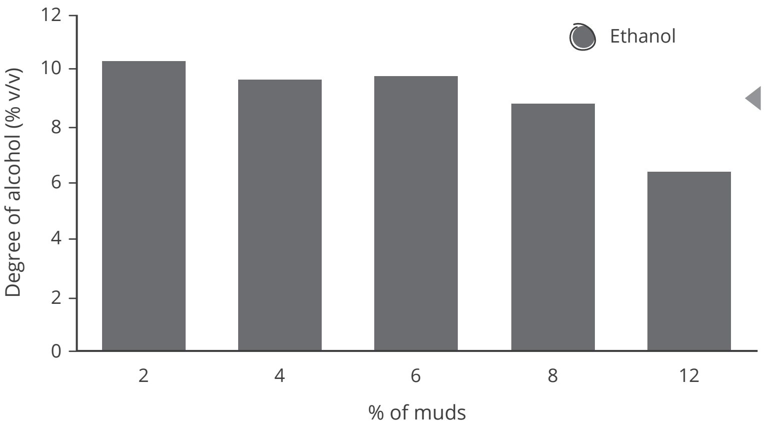


Fig. **52** *Effect of different mud concentrations on the degree of alcohol during fermentation.*

Towards the production of food additives

In the course of producing food additives, specifically sweeteners, the conditions of processing temperature and timing were established for the self-hydrolysis of agricultural harvest residues (AHR) to obtain a liquid fraction with a hemicellulose content equivalent to 90% extraction (Figure 53).

In an approximation to this liquid fraction, hemicellulose was identified in the form of xylans and oligosaccharides, in addition to other by-products (furfural and organic acids), requiring subsequent treatment for its conversion to xylose, the precursor of relevant sweeteners, and purification to remove by-products.

Advances in producing a food additive (of a polysaccharide type) with characteristics that enable it to be used as a stabilizer or

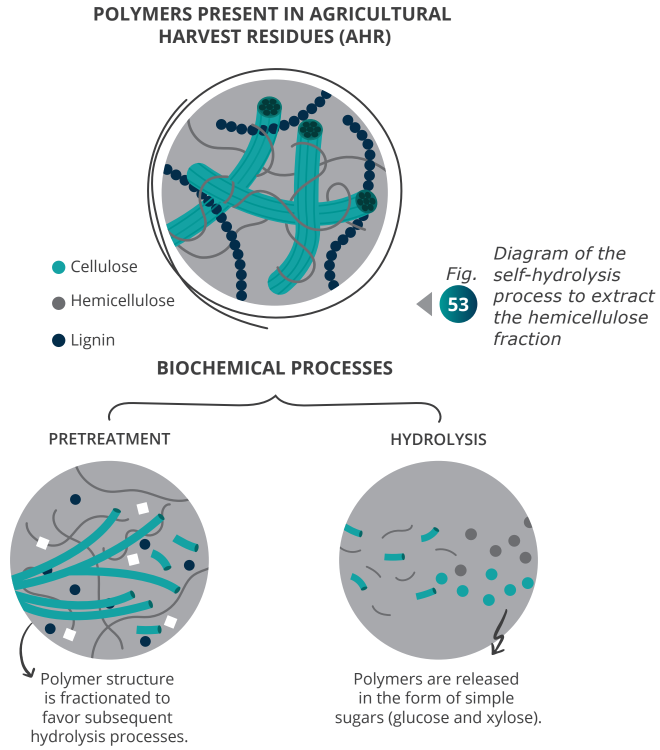


Fig. **53** *Diagram of the self-hydrolysis process to extract the hemicellulose fraction* encapsulating agent focused <<page 78>> on defining fermentation conditions and obtaining a lab-scale product, whose physicochemical characteristics showed a 36% polysaccharide content **(Figure 54).**

The use of sugar as a substrate is one of the conditions defined, presenting yields equivalent to 0.18 g polysaccharide per g sugar. The study's projections focus on evaluating new fermentation conditions, including changes in the culture medium to increase polysaccharide content.

Fig. 54 *Product obtained by fermentation with a 36% polysaccharide content.*

Alternative uses of ethanol: fumigation of turbo-diesel engines

In the search for alternative uses of ethanol, Cenicaña launched a series of trials to validate ethanol/water fumigation in the air vents of diesel and gasoline engines. According to the literature reviewed, this option can generate higher engine power, lower fuel consumption, and impact the emissions of particulate matter.

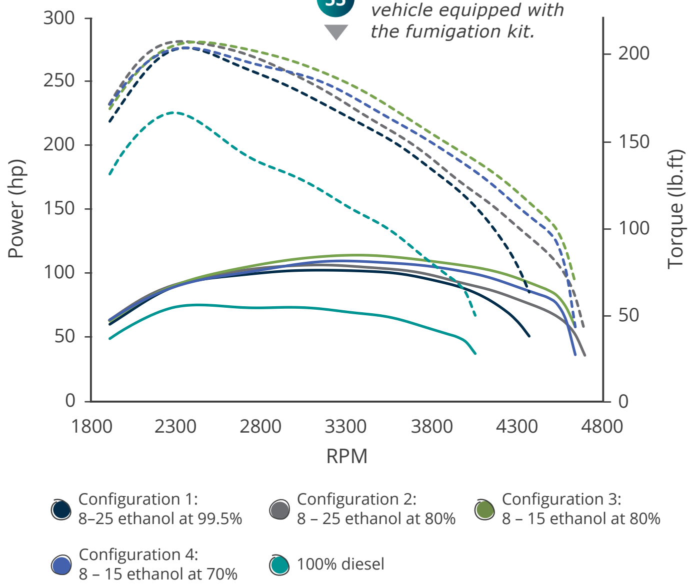
Fumigation using a mixture of ethanol/water modifies the density of air entering the engine. Combustion is favored with a greater air flow, lowering fuel consumption and, consequently, reducing emissions without losing strength or potency.

A turbo-diesel truck is used for trials such as bench dynamometer tests and path testing with a commercial ethanol/water fumigation kit.

In field and road tests, an increase was observed in engine power (42%) and torque (24%) when this mixture was used as compared with operations using 100% diesel **(Figure 55).** Similarly, an improvement was observed in fuel yields, increasing from 38.2 km/gallon with 100% diesel to 44.8 km/gallon with the ethanol/water fumigation. This difference in fuel consumption has a direct impact on greenhouse gas (GHG) emissions, reducing the gr indicator CO^{2}eq/gallon diesel by 10.6%.

Cenicaña will continue with the trials to compile more information on fuel consumption and the impact on the mechanical condition of the vehicle (condition of pistons and combustion chamber, among others), as well as evaluate the technology in more powerful equipment such as that used in field work and its potential economic benefits.

Fig. 55 *Result of trials carried out with the vehicle equipped with the fumigation kit.*



06

STRATEGIES TO PROMOTE INNOVATION IN THE SUGARCANE AGROINDUSTRY

Virtuality was the new normality imposed on training activities by the pandemic. Cenicaña accordingly adapted the events held by its Learning and Technical Assistance Program (LTAP) as well as those of the TTG network to meet the requirements of virtual events, while also implementing digital marketing strategies and tools to broaden the audience reached by the announcements of these events.

The Network

Cenicaña continued with its technology transfer activities in 2020. These included both virtual and presential meetings of the Technology Transfer Group (TTG) Network. Throughout the year, 18 GTT meetings were held (seven general meetings and 11 focused meetings) as well as a forum for 836 participants, between sugarcane providers and field staff (Figure 56).

The forum, held at the Risaralda sugar mill prior to the health emergency declaration in Colombia due to COVID-19, addressed needs expressed by sugarcane growers, especially those using mechanized harvest, and sugar mills. Topics covered at the forum included the following:

- Field design for an adequate harvest.
- Mechanized harvest using a self-guiding system.
- Post-harvest field work.
- Impact of mechanized harvesting on cane regrowth, height, and diameter.
- Effect on soil compaction.
- Projection of mechanized harvesting at the mill.

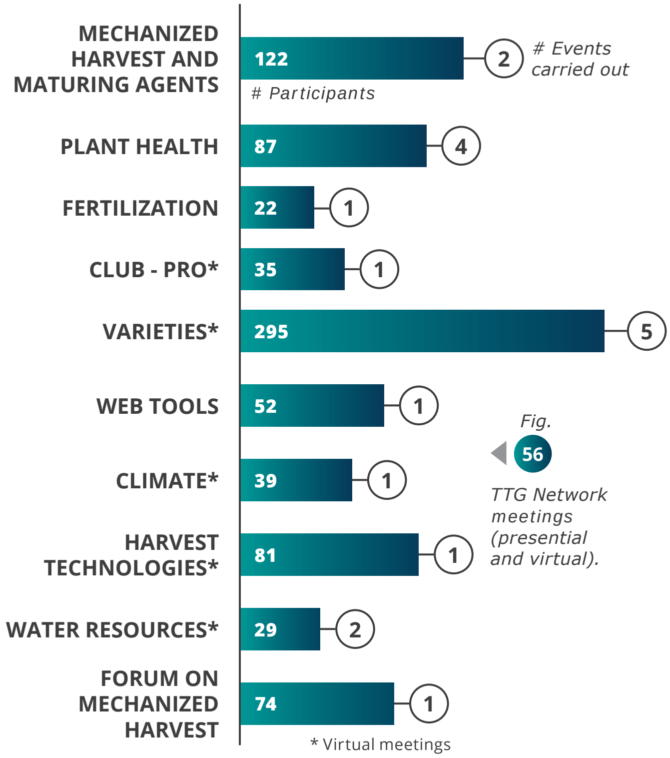


Fig. 56 *TTG Network meetings (presential and virtual).*

Forum on mechanized harvest held at the Risaralda sugar mill.

Learning and Technical Assistance Program (LTAP)

Within the framework of LTAP, Cenicaña held ten virtual and eight presential training events during 2020. Presential training events took place before the national health emergency declaration, with the participation of 368 sugarcane providers, field staff, and external technical assistants. Ten virtual trainings were also carried out (Table 14). To complement these training activities, Cenicaña also organized a series of webinars on different topics, with 1,943 participants (Table 15).

Compared to previous years, an increase was observed in the attendance and participation of sugarcane producers in presential activities carried out. The use of digital marketing tools, such as WhatsApps Business, Mailing, and Landing Page, broadened the audience reached by the announcements of these events. For example, the training event held on held on Priority Water Balance in 2020, alone gathered 52% more participants than the three similar events held in 2019.

Table 14

Presential and virtual training events carried out in 2020 and number of participants.

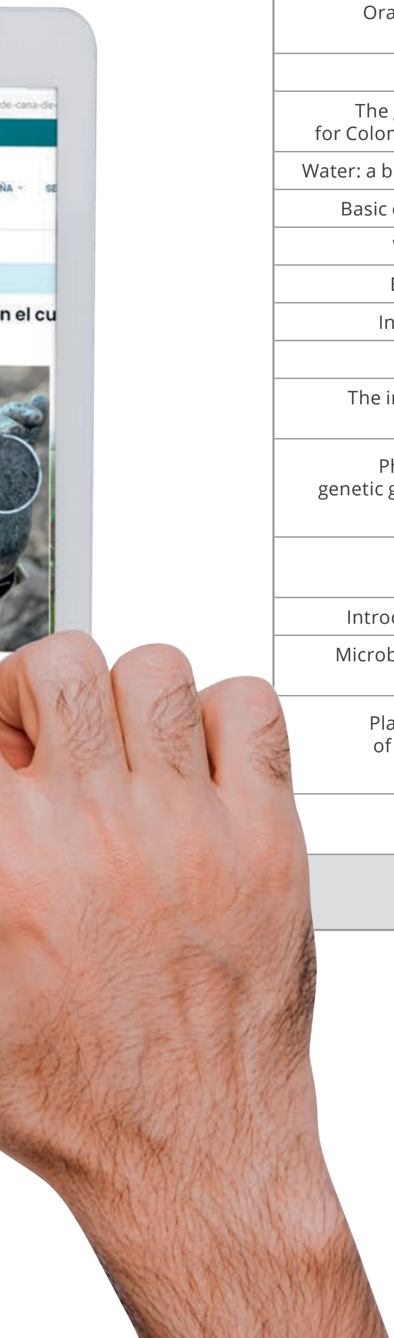
TECNOLOGÍAS	MES	PARTICIPANTES
Module 1 Geoportal: crop management support tool	Abril	52
Module 2 Meteoportal: crop management support tool	Mayo	40
Module 1 The breakeven point of my business and investment in machinery	Abril	91
Module 2 Economic criteria to support crop renewal	Mayo	98
Water balance for irrigation scheduling	Agosto	136
Estimating and reducing undetermined losses	Mayo junio julio	50*
Fundamental aspects to ensure crystallization performance: Slurry preparation and crystal size measurement	Mayo junio	28*
Technological improvements. Criteria for increasing the energy efficiency of sugar and alcohol production	Julio	67*
Implementing analysis in Ceniprof** to evaluate opportunities for improving factory processes	Julio Agosto	21*
Quality of raw material entering alcohol production plant and its impact on the fermentation process	Octubre Noviembre	19*

* Average assistance because training was carried out in different sessions.
** Ceniprof is simulation tool developed by Cenicaña to predict operational performance in factories for sugar production and cogeneration of electric power.

Scan the QR code
To access the webinars. An access code is required.

Table 15 *Webinars held in 2020 and number of participants.*

WEBINARS AND LECTURERS	MONTH	PARTICIPANTS (#)
Harvesting of sugarcane in the Cauca river valley: Its evolution and technological challenges - Alejandro Estrada	April	166
Orange rust in sugarcane in Colombia: Management strategies Juan Carlos Ángel and Joaquín Ramírez	April	116
Soil water - Edgar Hincapíe	May	180
The genome of sugarcane variety CC 01-1940 and its importance for Colombia's sugar industry - John Jaime Riascos and John Henry Trujillo	May	111
Water: a basic input for planning land use - Sandra Alarcón and Fanny Hoyos	May	110
Basic concepts of fertilization in sugarcane crops - Fernando Muñoz	May	146
Water balance for irrigation scheduling - Sandra Alarcón	May	118
Evaluation of damage caused by borers - Germán Vargas	June	64
Interpreting soil and leaf tissue analyses - Fernando Muñoz	June	120
Sugarcane physiology - Miguel Angel Lopez	June	166
The importance of soil carbon forms for sustainable management in sugarcane cropping systems - Milton Ararat	June	73
Phenomic and genomic tools: key strategies to accelerating genetic gain in crops - External lecturers: Natalia Palacios, Valerio Hoyos, Bodo Raatz, and Luis Duque	June	182
Processing and analysis of satellite images using GEE Mario Andrés Soto	June	122
Introduction to the processing of UAV images - Michael Arredondo	July	71
Microbiology applied to production processes of the sucrose-alcohol agroindustry: Sugar production – Tatiana Daza	July	81
Plate heaters. How to operate and maintain the performance of plate heaters in the sugar and alcohol production process Julio Calpa and Andrés Felipe Ospina	October	41
Climate-conditioning factors in the Cauca river valley Enrique Cortés and Luis Barreto	December	76
TOTAL NUMBER OF PARTICIPANTS		**1943**



Technologies for the new normality

To continue with our technology transfer activities during the pandemic, Cenicaña implemented and facilitated digital technologies and channels that allowed the sugarcane sector to produce and transmit virtual events and generate visual content. These included the following: Soil Profiling (TTG of the Risaralda sugar mill); Success Case in Water Management: Gravity Irrigation (TTG of the Pichichí sugar mill); and System for Scheduling Irrigation using Granular Matrix Sensors (TTG of the Sancarlos sugar mill).

The virtual training events were held in the *Google Classroom* environment and included an introductory module and at least three technical content modules. Learning materials (documents and tutorial videos) were provided.

The Inbound Marketing methodology was used to expand the scope of virtual technology transfer activities, in addition to digital tools that allowed events such as the webinars published for reproduction to reach audiences of up to 4,000 people per event. Digital contents, such as the campaigns #LeeMás (ReadMore) and #Tips para agricultores (Tips for farmers), were also produced.

Sustainability project

The sustainability project was launched to continue advancing in the proposal and implementation of innovative solutions to transform the sector's reality and generate economic value, while also conserving the environment and promoting the social well-being of Colombia's sugarcane producing areas. This initiative arose within the framework of group meetings held with different agroindustrial actors to identify sectoral needs related to sustainability.

One of the project's components is the Fénix Program, initially under the leadership of Procaña until 2019 and then under the leadership of Cenicaña as of 2020. The program aims to strengthen the ongoing transition and advance of sugarcane growers towards sustainable management and production.

07

ACTIONS TO BECOME A RECOGNIZED, BIOSECURE CENTER OF EXCELLENCE

Cenicaña continued strengthening its research, technology development, and knowledge sharing capacities with exercises of technological surveillance to identify opportunities for agroindustrial diversification, with new equipment to validate and improve the experimentation and implementation of new knowledge-sharing strategies to boost the Center’s recognition within the region and country.

In compliance with the recommendations and measures decreed by the National Government to deal with the COVID-19 pandemic, Cenicaña adopted biosecurity protocols to reduce the risk of contagion among the sugarcane sector’s collaborators and their families, as well as within the areas of influence of sugarcane agroindustry.

Technological surveillance and capacity building for research

As part of its knowledge management process, Cenicaña carried out two technological surveillance exercises in 2020 to improve our understanding of technological advances, market trends, regulations, and opportunity analysis pertinent to agroindustrial innovation (Figure 57). In addition, the Center's work specifically addressed product diversification.

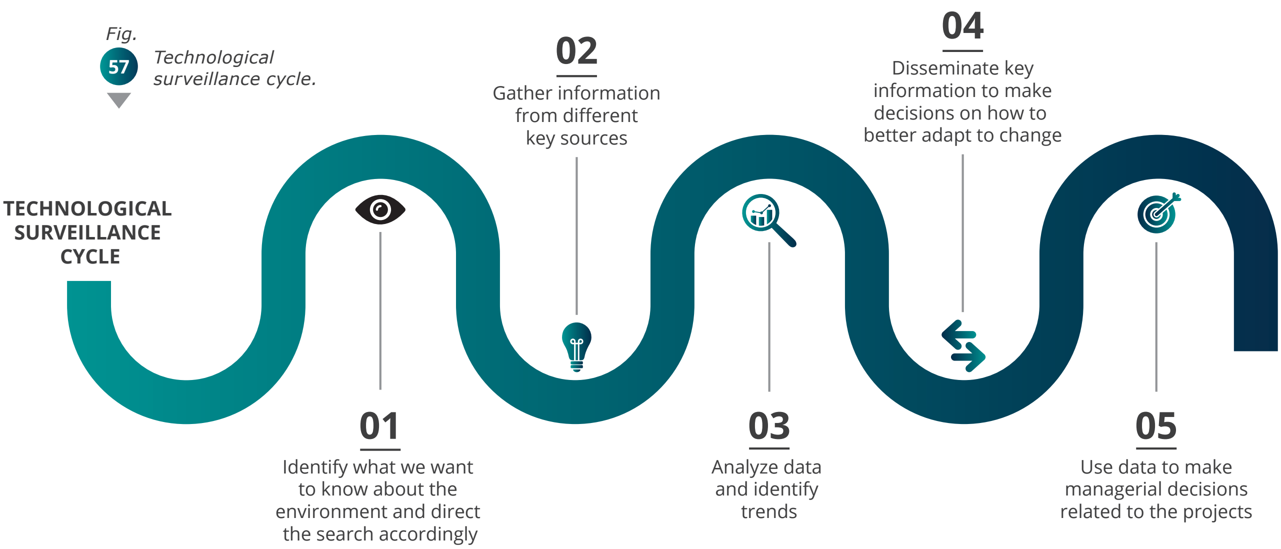
Research projects are the backbone of the Center. In 2020 efforts accordingly focused on strengthening the competencies of researchers in project formulation and management, based on the framework provided by the PMBOK Guide (6th edition) developed by the Project Management Institute (PMI), as well as in the funding of projects in science, technology, and innovation through Colombia's General System of Royalties.

Webinars were held on measurement modelling for research groups and tax benefits for sugarcane-related companies and growers, with the support of Colombia's Ministry of Science, Technology, and Innovation.

The publishing of the quarterly newsletter Incane continued in 2020. By sharing technical-scientific knowledge related to the sugarcane agroindustry generated worldwide, the newsletter aims to keep sugarcane researchers and technical staff informed on the latest advances in research and innovation in the field.

Cenicaña had 76 ongoing research projects during 2020, distributed as follows: 13 projects in Factory Processes Program, 36 in the Variety Program, and 27 in the Agronomy Program. Five research projects finalized this year.

Fig. 57 Technological surveillance cycle.



Cenicaña in international publications

TITLE	AUTHORS	SCIENTIFIC JOURNAL
The gregarious parasitoid Cotesia flavipes *displays a high level of preadaptation to a novel host,* Diatraea indigenella	C. Londoño Sánchez, J. Montoya Lerma, and G.A. Vargas Orozco	*Biocontrol 65(1): 37–46* *February 2020*
Effects of meteorological variables on sugarcane ripening in the Cauca River Valley, Colombia	C.A. Unigarro and F. Villegas Trujillo	*Pesquisa Agropecuaria Tropical 50(6): 1–8* *May 2020*
Prediction of topsoil properties at field-scale by using C-band SAR data	M.B. Domenech, N.M. Amiotti, J.L. Costa, and M. Castro Franco	*International Journal of Applied Earth Observation and Geoinformation 93 (10): 1–13* *July 2020*
Comparison of surface and subsurface water distribution uniformity under center pivot irrigation system for sugarcane in Colombia	C.J. Mendoza Castiblanco, J.A. Carbonell González, and J.J. Lasso	*Sugar Tech. 22(6): 1032–1037* *December 2020*
Regional wind pattern, a basis for defining the appropriate lapse of time for sugarcane burning in the Cauca valley (Colombia)	M. Preciado Vargas, H.A. Chica Ramírez, E. Solarte Rodríguez, J.A. Carbonell González, and A.J. Peña Quiñones	*Accepted in September 2020 for publication in Environment, Development and Sustainability.* *Published in 2021: Environment, Development and Sustainability 23 (6): 9477–9492* *June 2021*

Scan the QR code
To consult the Cenicaña digital library.

Strategies to improve corporate visibility and positioning

In 2020 Cenicaña began to work on a series of communication strategies that aimed to enhance the general public's understanding of the sugarcane crop and its related production processes. To do so, different knowledge-sharing activities were carried out, mainly content generation in different formats (especially digital) to be able to reach different audiences while also contributing to the weaving of technical and scientific stories around sugarcane, its agronomic management, and factory processes.

A campaign to share scientific information in social networks, called "Píldoras de Ciencia Dulce" (meaning "Sweetened Pills of Science"), was launched to fulfill this purpose. The campaign uses present-day issues to show different aspects of the sugarcane crop, from a scientific perspective. Cenicaña also shares the advances in its research in different national and regional social networks and mass media.

In addition to advancing in outreach activities, Cenicaña also began to explore alternatives to promote strategies for the social appropriation of knowledge, which help transform regional dialogues around sugarcane and strengthen its integration with different community actors in the co-generation of knowledge.

Scan the QR code
To access the "Píldoras de Ciencia Dulce" videos.

Strengthening of technological capabilities

A multidisciplinary team formed by different Cenicaña staff members developed the following solutions to support the technological tools proposed for sugarcane research, crop agronomic management, and factory processes:

- Matric potential sensor management platform.
- Mobile application for monitoring irrigation pumping stations.
- Installation, maintenance, and support of the LoRaWAN Network or IoT Network for the sugarcane agroindustry.
- Maintenance of the infrastructure that supports the computer platforms with which Cenicaña offers services to the public and supports research.

Institutional infrastructure for research

In 2020 Cenicaña strengthened its infrastructure with a central pivot irrigation system with the capacity to water 9.27 ha (donated by Irrivalle S.A.S.) as well as a lateral move irrigation system using ramps with the capacity to water 4.06 ha. Irrigation technologies applied to Cenicaña's experimental fields were as follows:

57% of the area is covered by hydrants to water crops with window pipes.

8% of the area is under drip irrigation.

24% of the area is watered with a central pivot irrigation system.

11% of the area is watered with lateral moving ramps.

To enable mechanical harvesting in experimental lots, Cenicaña advanced in the development and construction of a self-dumping wagon with a weighing system. The tractor-drawn wagon will have four loading bins. The Center is currently evaluating the productivity of the experimental plots using manual harvesting and weighing using cane lifters equipped with a weighing system.

The self-dumping wagon with weighing system not only serves to weigh the cane of trials harvested using a mechanical harvester, but also to obtain data on how new varieties respond to this practice. This system will streamline the gathering of data, improving harvesting efficiency and simplifying the entire process.

Scan the QR code
To see the operation video of the self-dumping wagon with weighing system.

Measures for a biosecure research center

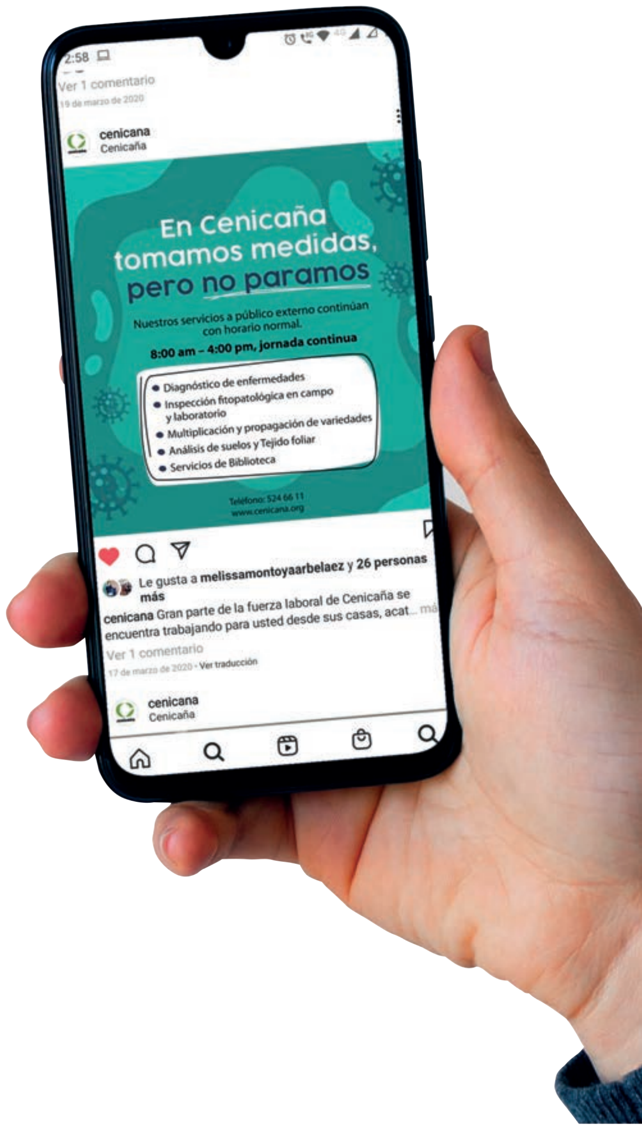
In response to the health emergency declaration issued by the National Government due to COVID-19, Cenicaña embraced the recommendations made by Colombia's Ministry of Health regarding the promotion of basic self-care measures (hand washing, physical distance, use of face masks), offering work-at-home alternatives for its collaborators as well as psychosocial support.

In compliance with these actions, Cenicaña formed *Whatsapp* messenger groups to keep collaborators informed of the advance of the virus and provisional measures, as well as to promote self-care measures. The Center distributed 3,770 face masks and 1,745 bottles of alcohol to staff members, installed 10 hand sanitizer dispensers at the Experiment Station, and implemented bio-security protocols for entering the Center's facilities, transportation, use of common areas, and field activities. Training sessions were held for specific groups and pertinent communication campaigns designed.

By the end of 2020, 288 rapid tests and 52 antigen tests had been performed, confirming 20 positive cases of COVID-19 (8%).

The health emergency drove Cenicaña to strengthen its ties internally as well as with different sectoral entities to monitor the situation and adopt coordinated measures to reduce the risk of contagion among its collaborators, their families, and other actors of the sugarcane agroindustry.

Parallel to health and self-care measures, other activities involving accompaniment, emotional and financial support, and mental health education were offered to the work team. These included workshops such as "The future arrived without warning" and "Controlling my emotions makes a difference". Thirteen staff members (6%) also received psychological counseling.



Solidarity with the community

During the mandatory preventive isolation decreed by the National Government, Cenicaña expressed its solidarity by delivering food baskets and self-care items to vulnerable families in its area of influence, specifically those of the upper Aguaclara watershed, where it carries out research activities, and rural San Antonio de los Caballeros, located in the municipality of Florida, Valle del Cauca.

WE BUILD A MORE SUSTAINABLE REGION WHEN, TOGETHER WITH SUGAR MILLS AND SUGARCANE GROWERS, WE PROMOTE AND ADOPT NEW TECHNOLOGIES AND DEVELOPMENTS AND SHARE KNOWLEDGE TO IMPROVE AGRONOMIC AND FACTORY PROCESSES PERTINENT TO THE SUGARCANE AGROINDUSTRY.

ANNEX

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01 Productivity of Cenicaña Colombia (CC) varieties during 2020.

Data corresponding to the varieties harvested in the 10 most representative agroecological zones of the Colombian sugarcane agroindustry during 2020. Data compiled from 12 sugar mills.

AGROECOLOGICAL ZONE	VARIETY	LOTS	HARVESTED AREA (ha)	TCH	TSH	TCHM	TSHM	COMMERCIAL YIELD (%)	AGE (M)	CUTTING
10H3	CC 01-1940	146	1265	117	13.2	9.5	1.07	11.3	12.3	3.8
	CC 85-92	162	983	107	12.2	8.6	0.98	11.4	12.5	9.4
	CC 93-4418	50	299	104	11.6	8.6	0.96	11.1	12.1	7.0
	CC 11-600	13	128	134	15.4	10.4	1.21	11.6	12.9	1.1
10H5	CC 01-1940	245	1395	96	10.6	7.9	0.87	11.0	12.3	4.3
	CC 85-92	133	668	97	11.5	7.8	0.92	11.8	12.5	10.5
	CC 11-595	20	117	107	11.3	8.1	0.86	10.6	13.2	1.1
11H0	CC 01-1940	372	3946	134	14.9	10.8	1.20	11.1	12.5	3.4
	CC 85-92	272	2421	117	13.0	9.4	1.05	11.2	12.4	11.3
	CC 93-4418	107	1059	115	12.8	9.3	1.04	11.2	12.4	7.0
	CC 01-746	33	390	118	13.3	9.7	1.09	11.2	12.3	5.1
	CC 01-1228	27	372	130	14.3	10.8	1.18	11.0	12.1	7.5
	CC 05-430	35	297	163	16.7	12.5	1.28	10.2	13.1	1.1
	CC 98-72	25	217	132	13.9	10.8	1.13	10.5	12.3	6.8
11H1	CC 01-1940	522	5221	128	13.9	10.2	1.11	10.9	12.6	3.3
	CC 85-92	313	2804	111	12.4	9.1	1.01	11.1	12.3	11.1
	CC 93-4418	184	1829	112	12.4	9.1	1.01	11.1	12.3	6.6
	CC 05-430	55	514	148	15.0	11.8	1.17	10.1	12.8	1.3
	CC 01-746	34	468	116	12.7	9.7	1.06	10.9	12.0	5.1
	CC 01-678	42	290	124	13.6	9.9	1.08	11.0	12.6	2.1
	CC 84-75	17	226	120	12.4	9.8	1.01	10.4	12.3	14.4
	CC 01-1228	20	202	116	13.2	9.4	1.07	11.3	12.4	7.7
	CC 98-72	28	188	117	12.4	9.5	1.00	10.5	12.4	5.7
	CC 97-7170	21	170	120	12.4	9.9	1.02	10.3	12.1	4.7
11H2	CC 01-1940	225	2020	118	12.7	9.7	1.04	10.8	12.3	3.4
	CC 85-92	134	1158	109	11.9	8.9	0.96	10.9	12.3	11.1
	CC 93-4418	73	545	106	11.5	8.9	0.96	10.8	12.0	6.1
	CC 05-430	13	149	160	15.5	12.8	1.24	9.7	12.6	1.3
	CC 11-600	12	132	134	14.2	10.9	1.15	10.5	12.5	1.5

Continúa

AGROECOLOGICAL ZONE	VARIETY	LOTS	HARVESTED AREA (ha)	TCH	TSH	TCHM	TSHM	COMMERCIAL YIELD (%)	AGE (M)	CUTTING
11H3	CC 01-1940	471	2163	102	10.7	8.8	0.92	10.5	11.7	4.3
	CC 85-92	242	1125	105	11.3	8.8	0.94	10.8	12.0	13.2
	CC 93-4418	142	806	99	10.5	8.3	0.88	10.6	11.9	6.2
	CC 11-600	36	210	131	12.6	10.4	1.00	9.6	12.7	1.6
	CC 11-595	33	187	129	12.1	11.4	1.06	9.4	11.4	1.7
	CC 05-430	29	158	142	12.9	12.2	1.11	9.1	11.7	1.1
1H1	CC 01-1940	110	957	116	13.4	9.2	1.06	11.6	12.7	3.7
	CC 85-92	42	249	109	12.5	8.6	0.99	11.4	12.7	8.2
	CC 93-4418	30	152	94	11.0	7.5	0.88	11.7	12.5	5.0
	SP 71-6949	14	104	78	8.4	6.6	0.71	10.8	11.9	4.0
5H3	CC 01-1940	86	630	117	13.4	9.2	1.05	11.5	12.7	3.0
	CC 85-92	79	386	110	12.6	8.7	1.00	11.5	12.6	8.1
	CC 93-4418	10	78	99	11.3	7.9	0.90	11.4	12.6	6.2
6H1	CC 01-1940	817	8301	134	14.9	10.8	1.20	11.1	12.5	3.3
	CC 85-92	398	3748	114	13.0	9.1	1.04	11.4	12.5	10.3
	CC 93-4418	139	1240	108	12.3	8.8	1.00	11.4	12.3	6.5
	CC 05-430	90	742	164	17.1	12.6	1.31	10.4	13.1	1.2
	CC 97-7170	34	344	117	11.8	9.6	0.97	10.1	12.3	5.8
	CC 01-678	40	293	131	14.8	10.7	1.20	11.2	12.4	2.2
	CC 11-600	31	270	138	15.5	10.5	1.18	11.2	13.1	1.2
	CC 01-1228	24	252	137	14.8	11.1	1.19	10.8	12.5	6.7
	CC 01-746	25	230	110	12.6	9.2	1.05	11.4	12.1	4.3
	CC 98-72	24	194	131	14.2	10.7	1.15	10.8	12.4	5.8
	CC 84-75	20	186	121	13.0	9.6	1.03	10.7	12.7	13.1
	CC 93-4181	13	135	129	15.1	10.4	1.21	11.7	12.5	5.2
6H2	CC 01-1940	142	1414	111	12.2	8.9	0.98	11.0	12.6	3.5
	CC 85-92	54	442	104	11.6	8.5	0.94	11.1	12.3	9.8
	CC 93-4418	54	376	108	11.9	8.9	0.98	11.0	12.2	5.9
	CC 11-595	11	95	120	12.2	10.0	1.01	10.1	12.0	1.0
	CC 11-600	10	82	121	13.1	9.4	1.02	10.9	12.9	1.0

02

Average values of the main meteorological variables for homologous climate zones in 2020.

HOMOLOGOUS CLIMATE ZONE	QUARTER	MINIMUM MEAN TEMPERATURE (°C)	MAXIMUM MEAN TEMPERATURE (°C)	GLOBAL RADIATION (CAL/CM²/DAY)	RAIN (mm)
1	1	19.0	32.5	493	150
	2	19.7	31.3	456	347
	3	18.7	31.2	472	294
	4	18.9	30.9	455	327
	Year	19.1	31.4	469	280
2	1	19.3	31.4	477	209
	2	19.6	30.4	409	285
	3	18.5	30.4	428	164
	4	18.7	30.2	431	309
	Year	19.0	30.6	436	242
3	1	19.5	31.8	488	125
	2	19.9	30.8	436	239
	3	18.8	30.6	456	139
	4	18.9	30.4	452	214
	Year	19.3	30.9	458	180
4	1	19.3	32.0	484	207
	2	19.7	30.9	426	378
	3	18.5	30.8	442	243
	4	18.8	30.5	443	422
	Year	19.1	31.1	449	313
5	1	18.9	32.6	507	196
	2	19.6	30.9	459	541
	3	18.7	30.9	476	527
	4	18.8	30.7	461	465
	Year	19.0	31.3	476	432
6	1	19.3	31.7	470	373
	2	19.6	30.7	410	430
	3	18.4	30.7	427	318
	4	18.8	30.4	433	451
	Year	19.0	30.8	435	393
7	1	19.6	31.9	469	425
	2	20.0	30.8	426	518
	3	18.7	30.6	444	278
	4	19.1	30.1	452	680
	Year	19.4	30.8	448	475

The Valle del Cauca Agroclimatic Technical Work Group (MTA, its Spanish acronym) was launched in 2020. This departmental entity gathers Cenicaña and other regional entities, offering them a space to share and discuss climate information and generate recommendations on how to better adapt to climate variability and extreme climate phenomena as well as how to take advantage of favorable climatic conditions to enhance agricultural activities.

METEO PORTAL

This tool offers interactive consultations to RMA records from 1993 to date.

The Meteoportal allows users to monitor climate variables by weather station or climate zone, compare climate variables with their respective anomalies, consult data on climate variables consolidated per different time units: daily, weekly, monthly, semi-annual, and yearly.

It also hosts climate bulletins by homologous climate zone, monthly climate forecasts by season, and weather graphs and maps for different time ranges for all recorded weather variables.

Scan the QR code
To access the Cenicaña Meteoportal web tool.

03

Quarterly and annual climate variability in the Cauca river valley.

Multi-year comparison. Period 1994 - 2020.

MEAN MINIMUM TEMPERATURE (°C)						MEAN TEMPERATURE (°C)						MEAN MAXIMUM TEMPERATURE (°C)					
Year	T1	T2	T3	T4	Annual	Year	T1	T2	T3	T4	Annual	Year	T1	T2	T3	T4	Annual
Years presenting highest mean minimum temperature						Years presenting the highest mean temperature (the warmest years)						Years presenting the highest mean maximum temperature					
1998	19.8	20.0	18.8	19.0	19.4	2015	23.7	24.1	24.6	24.1	24.1	2015	30.9	31.0	32.3	31.3	31.4
2019	19.3	19.6	18.7	19.3	19.2	2016	25.1	23.9	23.7	22.9	23.9	2017	30.2	30.1	31.2	29.9	31.3
2016	20.1	19.5	18.5	18.6	19.2	2019	24.1	23.7	24.2	23.4	23.8	2016	32.5	30.6	31.3	29.6	31.0
2005	19.4	19.5	18.8	18.8	19.1	2020	24.5	24.1	23.5	23.3	23.8	2020	32.1	30.9	30.7	30.4	31.0
2015	19.0	19.3	18.9	19.2	19.1	1998	24.7	23.8	23.1	22.8	23.6	2019	31.3	30.3	31.9	30.3	30.9
Intermediate years																	
2020	19.3	19.8	18.6	18.8	19.1	2009	23.0	23.2	24.1	23.7	23.5	2014	30.3	30.4	31.5	30.0	30.6
2009	19.0	18.9	18.8	19.1	19.0	2014	23.4	23.6	23.9	23.0	23.5	2009	29.7	29.8	31.6	30.7	30.5
2010	19.5	19.4	18.6	18.6	19.0	2002	23.6	22.9	23.7	23.2	23.4	2018	30.5	29.8	31.2	30.3	30.4
2006	19.3	19.1	18.5	19.0	19.0	1997	22.9	23.1	24.2	23.5	23.4	2012	29.5	30.0	31.3	29.7	30.1
2014	19.0	19.2	18.4	18.7	18.9	2013	23.7	23.4	23.5	22.9	23.4	2013	30.4	30.0	30.7	29.5	30.1
1997	19.0	19.1	18.5	19.0	18.9	2018	23.4	23.0	23.8	23.3	23.4	1997	29.1	29.3	31.4	30.3	30.0
2002	19.0	18.8	18.7	19.0	18.9	2005	23.5	23.5	23.7	22.6	23.3	2002	30.5	29.2	30.7	29.7	30.0
2013	19.2	19.2	18.5	18.8	18.9	2003	23.7	23.1	23.3	22.8	23.3	1998	31.9	29.8	29.6	29.0	30.0
2003	19.0	19.1	18.5	18.8	18.9	2006	23.2	23.1	23.7	23.0	23.3	2003	30.8	29.4	30.1	29.1	29.8
2007	19.1	19.3	18.3	18.6	18.8	2017	23.0	23.3	23.8	23.1	23.3	2007	31.0	29.6	30.0	28.8	29.8
2001	18.6	19.1	18.3	19.2	18.8	2012	23.0	23.2	23.8	23.1	23.3	2005	30.0	29.7	30.7	28.9	29.8
1994	18.7	18.9	18.6	18.7	18.7	2004	23.6	23.2	23.2	22.8	23.2	2004	30.5	29.5	30.3	29.1	29.8
1999	18.9	18.8	18.2	18.7	18.7	2010	24.5	23.3	22.7	22.2	23.2	2006	29.7	29.3	30.8	29.4	29.8
2004	18.8	19.0	18.3	18.9	18.7	2001	22.9	23.3	23.3	23.2	23.2	2001	29.7	29.6	30.3	29.3	29.7
2017	18.3	19.0	18.5	18.9	18.7	2007	23.8	23.2	23.1	22.4	23.1	2010	31.7	29.5	29.1	28.6	29.7
2018	18.8	18.8	18.4	18.9	18.7	1994	22.7	22.9	23.6	22.7	23.0	2011	29.5	29.3	30.3	28.7	29.5
2012	18.9	18.8	18.3	18.9	18.7	1995	23.6	22.9	22.9	22.4	23.0	1994	29.3	29.1	30.5	28.8	29.4
Years presenting lowest mean minimum temperature						Years presenting the lowest mean temperature (the coldest years)						Years presenting the lowest mean maximum temperature					
1995	18.5	19.1	18.4	18.6	18.7	2008	22.8	22.8	22.9	22.6	22.8	1995	30.8	29.0	29.5	28.5	29.4
2008	18.7	18.8	18.6	18.8	18.7	2011	22.8	23.0	23.2	22.3	22.8	2008	29.5	29.4	29.4	29.2	29.4
2000	18.7	18.9	18.4	18.7	18.7	1996	22.5	22.6	23.0	22.5	22.7	1996	28.9	28.7	29.8	28.7	29.0
1996	18.7	18.8	18.3	18.5	18.6	2000	22.3	22.6	22.8	22.7	22.6	2000	28.6	28.6	29.4	28.9	28.9
2011	18.6	19.0	18.2	18.6	18.5	1999	22.6	22.6	22.7	22.2	22.5	1999	28.8	28.6	29.2	28.2	28.7
Climate	19.0	19.1	18.5	18.8	18.9	Climate	23.4	23.2	23.5	22.9	23.3	Climate	30.3	29.6	30.5	29.4	30.0

Sea Surface temperature (SST) anomalies (°C) across the Pacific Ocean in the Niño 3.4 region. / ONI - Oceanic Niño Index / Because of its value: UOTA = ONI.

- La Niña UOTA <,= -0.5°C
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- Normal temperature for the season -0.2 °C y +0.2 °C
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This table shows that, under El Niño conditions or warm temperaturas of the equatorial Pacific Ocean, the values of mean minimum, mean, and mean maximum air temperature and the mean daily temperature oscillation (caloric climate variables), as well as those of solar radiation and atmospheric evaporation (energy-related climate variables) tend to increase in the Cauca river valley. Whereas the values of relative atmospheric humidity (hygrometric climate variable) as well as those of rain and number of days with precipitation (hydric climate variables) tend to decrease.

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EXPLANATORY NOTE:
In general terms, an increase between 2% and 5% is observed in the values of global solar radiation (direct + diffuse) for the years 2018, 2019, and 2020. This increase is attributable not only to the increase presented by this climate variable in the aforementioned triennium, but also to the upgrading of radiation sensors used during 2017. New sensors are capable of capturing a broader spectrum of solar radiation and, as a result, record slightly higher radiation values.

TEMPERATURE OSCILLATION (°C)					
Year	T1	T2	T3	T4	Annual
Years presenting greatest mean daily temperature oscillation					
2015	11.9	11.8	13.4	12.0	12.3
2020	12.8	11.1	12.1	11.6	11.9
2016	12.4	11.1	12.8	11.0	11.8
2019	12.0	10.7	13.2	11.0	11.7
2014	11.2	11.2	13.1	11.3	11.7
Intermediate years					
2017	11.9	11.1	12.7	11.1	11.7
2018	11.8	11.0	12.8	11.4	11.7
2009	10.8	10.9	12.8	11.6	11.5
2012	10.6	11.1	13.0	10.9	11.4
2013	11.1	10.8	12.1	10.7	11.2
1997	10.1	10.2	12.9	11.2	11.1
2002	11.6	10.3	12.0	10.7	11.1
2004	11.6	10.5	12.0	10.3	11.1
2007	11.9	10.3	11.7	10.2	11.0
2003	11.8	10.3	11.6	10.3	11.0
2001	11.1	10.5	12.0	10.1	11.0
2011	11.0	10.4	12.1	10.1	10.9
2006	10.4	10.2	12.3	10.3	10.8
1995	12.2	11.0	11.1	10.8	10.8
1994	10.5	10.2	12.0	10.1	10.7
2008	10.8	10.6	10.8	10.4	10.7
2010	12.2	10.1	10.5	10.0	10.7
Years presenting the lowest mean daily temperature oscillation					
2005	10.6	10.2	11.9	10.1	10.7
1998	12.1	9.8	10.7	9.9	10.7
1996	10.3	9.9	11.5	10.2	10.5
2000	10.0	9.7	11.1	10.2	10.3
1999	9.9	9.8	11.0	9.5	10.1
Climate	11.3	10.5	12.0	10.6	11.1

EVAPORATION (mm)					
Year	T1	T2	T3	T4	Annual
Years presenting the highest evaporation					
2020	517	420	465	450	1852
2019	467	400	521	429	1817
2015	446	410	485	429	1770
2018	441	392	488	449	1770
1994	415	407	488	418	1729
Intermediate years					
2009	397	390	481	460	1727
2016	476	394	463	393	1726
1997	411	381	476	434	1703
1995	485	374	439	397	1695
2012	394	393	483	415	1685
2007	466	378	447	389	1679
2014	397	397	475	408	1678
2017	409	388	463	402	1663
2006	395	381	465	404	1644
2001	417	367	448	396	1628
2002	415	350	441	398	1605
2013	402	383	430	385	1601
2008	423	391	397	384	1596
2011	405	362	431	376	1573
1998	458	349	395	366	1568
2005	376	342	454	395	1567
2010	470	359	371	354	1555
Years presenting the lowest evaporation					
1996	384	353	424	391	1552
2004	408	348	406	385	1547
2003	426	352	405	347	1530
1999	380	355	416	340	1490
2000	364	329	389	363	1444
Climate	424	376	446	398	1644

SOLAR RADIATION Cal / (cm^2xdía)					
Year	T1	T2	T3	T4	Annual
Years presenting the greatest solar radiation					
2020	488	430	452	446	454
2019	452	419	472	436	445
2018	433	407	455	443	435
1994	428	422	443	423	429
1995	459	403	429	405	424
Intermediate years					
1997	423	406	424	434	421
2015	432	405	429	413	420
2016	438	407	434	392	418
2007	449	396	431	391	416
1996	418	405	438	403	416
2009	401	392	438	431	416
2001	434	397	427	401	415
2002	443	392	410	410	414
2006	409	404	435	406	413
2017	412	401	436	402	412
2004	437	391	416	396	410
1998	437	394	404	403	410
2014	406	398	427	400	408
2005	390	394	436	409	407
2012	396	398	431	400	406
2003	439	394	404	387	406
1999	411	397	419	383	403
Years presenting the lowest solar radiation					
2008	413	404	394	387	399
2013	397	395	415	387	399
2011	410	377	412	377	394
2000	403	372	408	383	392
2010	436	379	375	368	389
Climate	426	399	426	404	414

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This table shows that, under El Niño conditions or warm temperaturas of the equatorial Pacific Ocean, the values of mean minimum, mean, and mean maximum air temperature and the mean daily temperature oscillation (caloric climate variables), as well as those of solar radiation and atmospheric evaporation (energy-related climate variables) tend to increase in the Cauca river valley. Whereas the values of relative atmospheric humidity (hygrometric climate variable) as well as those of rain and number of days with precipitation (hydric climate variables) tend to decrease.

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EXPLANATORY NOTE:
In general terms, an increase between 2% and 5% is observed in the values of global solar radiation (direct + diffuse) for the years 2018, 2019, and 2020. This increase is attributable not only to the increase presented by this climate variable in the aforementioned triennium, but also to the upgrading of radiation sensors used during 2017. New sensors are capable of capturing a broader spectrum of solar radiation and, as a result, record slightly higher radiation values.

RELATIVE HUMIDITY (%)					
Year	T1	T2	T3	T4	Annual
Years presenting the highest relative humidity (the wettest years)					
2000	87	89	84	86	87
1999	86	87	83	88	86
2001	85	86	81	86	85
2019	84	88	77	89	85
1998	79	87	83	85	84
Intermediate years					
1996	84	86	80	84	84
1995	76	85	81	85	82
2002	83	85	77	81	82
1997	83	84	74	82	81
2010	75	83	82	84	81
2011	80	82	78	83	80
1994	81	82	74	82	80
2003	77	82	79	84	80
2004	79	82	77	83	80
2008	79	81	80	82	80
2017	80	82	76	82	80
2018	79	83	76	81	80
2020	77	82	80	81	80
2007	76	82	77	82	79
2005	80	81	74	81	79
2006	79	81	73	80	78
2009	80	81	74	77	78
Years presenting the lowest relative humidity (the driest years)					
2012	81	80	72	78	78
2016	74	80	75	82	78
2013	77	80	75	80	78
2014	79	78	72	80	77
2015	76	77	71	78	76
Climate	80	83	77	82	81

PRECIPITATION (mm)					
Year	T1	T2	T3	T4	Annual
Years presenting the highest precipitation (the rainiest years)					
2010	128	513	361	656	1657
2011	356	453	220	620	1649
2008	390	545	298	398	1631
2017	391	508	222	466	1587
1996	405	471	218	379	1473
Intermediate years					
1999	426	393	220	396	1435
2007	240	456	239	472	1406
2019	301	486	187	419	1393
1994	368	424	128	429	1349
2018	320	406	190	429	1344
2000	391	399	216	292	1299
2006	341	408	101	437	1287
2016	186	434	202	437	1256
2014	330	330	132	423	1215
1998	213	424	269	304	1210
2012	391	365	114	333	1204
2013	268	380	190	350	1189
1997	370	393	106	313	1181
2020	198	354	248	356	1157
2009	396	301	126	297	1120
1995	150	371	209	373	1103
2003	185	339	184	380	1088
Years presenting the lowest precipitation (the less rainier years)					
2005	220	284	145	373	1021
2004	150	297	173	367	987
2002	232	259	168	318	977
2001	273	226	154	278	931
2015	307	242	105	275	929
Climate	293.6	387.4	189.8	391.5	1262

DAYS WITH PRECIPITATION (#)					
Year	T1	T2	T3	T4	Annual
Years presenting the highest number of days with precipitation					
2008	49	63	53	60	226
1999	59	56	41	62	217
2000	59	58	46	48	211
2011	46	57	40	62	205
1996	54	59	39	51	203
Intermediate years					
2010	24	56	55	68	203
2007	37	59	42	58	196
2017	48	55	36	53	192
2006	45	56	29	55	185
2018	43	60	32	47	182
2005	39	45	33	64	181
1998	28	55	43	55	181
1995	25	55	43	55	178
1994	50	52	28	47	177
2016	32	50	37	57	176
2014	46	49	30	50	175
2019	37	55	28	56	175
2020	31	49	46	48	175
2013	36	50	35	52	173
2009	52	43	29	43	168
2001	43	45	34	46	167
2012	50	46	24	46	167
Years presenting the lowest number of days with precipitation					
2003	31	51	35	49	165
2004	30	44	37	51	162
1997	45	48	16	40	150
2002	31	42	27	42	142
2015	36	35	23	37	131
Climate	41	52	36	52	180

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04

Plant health services*

Consolidated data of analyses carried out and services rendered in disease diagnoses, phytopathological inspections in both field and laboratory conditions, and varietal multiplication and propagation during 2020.

a.  b.  c. 

a. Phytopathological inspections in both field and laboratory conditions.

19 phytopathological inspections:

On 26 sugarcane farms (covering 359 hectares) belonging to sugar mills and sugarcane suppliers:

- Riopaila industrial
- Castilla industrial
- Castilla Agrícola
- Mayagüez
- Manuelita
- Risaralda
- Providencia
- La Cabaña.

MOST TESTED VARIETIES
CC 01-1940
CC 11-595
CC 11-600
CC 10-450
CC 09-066
CC 05-430
CC 93-4418

Variety most affected by orange rust:

CC 01-1940 (R:6 S:25%)

In less intensity:

CC 93-4418 (R:5 S:4%)

CC 09-066 (R:5 S:1%)

CC 05-430 (R:5 S:1%).

Variety CC 11-600 presented brown rust (R:5 S:10%).

b. Variety multiplication and propagation

A total of 810,289 sugarcane plants were supplied to sugar mills, sugarcane suppliers, entities that are Cenicaña's partners in collaborative agreements, and other esearch organizations.

- **46.5%** of the plants requested were for experimental trials conducted by Cenicaña.
- **36.2%** were requested by the following sugar mills: Castilla (agricultural division), Pichichí, Risaralda, La Cabaña, Mayagüez, Castilla (industrial division), Riopaila (agricultural division), Incauca, and Providencia.
- **9.5%** were requested for seedbed production (Semivalle).
- **5.2%** were requested by sugarcane suppliers (Proterra, Adro Investment, Hacienda Villa Lía).
- **0.2%** by panela-producing companies (Agrosavia and La Palestina).

MOST POPULAR NEW CC VARIETIES:
CC 05-430
CC 09-066
CC 11-595
CC 11-606
CC 11-600
CC 09-535
CC 10-450
CC 01-678

73,548 plants of the following varieties were produced by in vitro culture:

CC 05-430, CC 01-1940, CC 11-600, CC 01-678, CC 10-450, CC 85-92, CC 10-476, CC 09-066 y CC 09-535, among others, for foundation seedbeds and research purposes.

c. Disease diagnosis

Sugarcane samples collected from 6,869.5 ha, between seedbeds and commercial lots, were examined for the following diseases:

- Ratoon stunting disease (RSD)
- Leaf scald disease (LSD)
- Sugarcane yellow leaf virus (SCYLV)
- Sugarcane mosaic virus (SCMV)
- Sugarcane bacilliform virus (SCBV).

6,974 samples corresponded to external requests from sugar mills, sugarcane suppliers, and entities that have collaborative agreements in place with Cenicaña.

1,397 to Cenicaña's internal requests to support other investigations and services.

Samples processed for RSD, LSD, and SCYLV:

- Mayagüez sugar mill: 981 analyses (650.9 ha evaluated).
- La Cabaña sugar mill: 901 analyses (1292.9 ha evaluated).
- Castilla sugar mill (agricultural division): 823 analyses (864.9 ha evaluated).
- Riopaila sugar mill (agricultural division): 663 analyses (582.8 ha evaluated).
- Castilla sugar mill (industrial division): 516 analyses (345.3 ha evaluated).

Annex Annual Report 2020

Compared with 2019, the levels of incidence of SCYLV, RSD, and LSD remained stable in 2020:

SCYLV: 10.7%

RSD: 0.2%

LSD: 0.1%

- Levels of incidence of 0.5% RSD, 0.2% LSD, and 14.8% SCYLV were reported in commercial lots covering 2,309 ha.
- Levels of incidence of 0.1% RSD, 0.1% LSD, and 8.6% SCYLV were reported in seed lots covering 4,561 ha.

EVALUATED VARIETIES COVERING THE LARGEST AREAS:

CC 05-430 *(1632.32.4 ha)*

CC 01-1940 *(1215.9 ha)*

CC 11-595 *(919.5 ha)*

CC 11-600 *(796.3 ha)*

CC 10-450 *(378.7 ha)*

CC 85-92 *(257.1 ha)*

CC 01-678 *(231.5 ha).*

In the case of ***CC 01-1940****, the area evaluated decreased, and in the case of new CC varieties the area evaluated increased.*

Varieties SP 71-6949 and CC 10-450 showed high levels of incidence of SCYLV:

SP 71-6949: 35.4%

CC 10-450: 27.2%

They are followed by CC 01-1940 (19.3%), CC 00-3257 (13.8%), and CC 98-72 (11.6%).

The following varieties presented a disease incidence below 10%:

CC 01-678: 9.7%

CC 11-600: 8.1%

CC 11-497: 6.8%

CC 09-535: 5.7.8%

Scan the QR code
To access Cenicaña's plant health services.

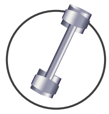
In comparison with 2019, most sugar mills and sugarcane suppliers reported a decrease in the levels of incidence of SCYLV:

- Marialuisa, from 14.4% to 4.2%.
- Castilla (agricultural division), from 13.5% to 10.2%.
- Riopaila Castilla (industrial division), from 11.2% to 9.5%.
- Riopaila (agricultural division), from 10.5% to 9%.
- Pichichí, from 10.3% to 5.5%.
- Risaralda, from 8.4% to 2.4%.
- Manuelita, from 7.5% to 5.6%.

**Data through 31 December 2020.*

05 Laboratory services*

Consolidated data of analyses carried out by the following laboratories during 2020: Soil and Leaf Analyses, Sugarcane Analyses, and Chromatography.

a.  b. 

a. Soil and leaf tissue analysis

5,950 samples processed:

- **2,030 soil samples** (74.1% corresponded to requests from donors and 25.9% to internal requests for research analyses).
- **3,920 leaf tissue samples** (18.6% corresponded to requests from donors and 81.4% to internal requests for research analyses).

b. Chromatography analysis

6,869 samples processed:

- **3,804** corresponded to the analysis of sugars such as sucrose, glucose, fructose, and glycerol.
- **3,065** corresponded to organic acids as indicators of deterioration and contamination in fermentation processes and in sucrose losses.

**Data through 31 December 2020.*

Scan the QR code
To access laboratory services.

06 Technology Transfer Group Network during 2020

Incauca sugar mill

February

- Participants: 122 sugarcane growers.
- Topics: Benefits of mechanical harvesting and the application of maturing agents; field design; use of autopilot; productivity maps; and use of drones to apply maturing agents.

July (virtual)

- Participants: 90 sugarcane growers.
- Topics: Characteristics and results of sugarcane varieties CC 05-430 and CC 11595 and insight on the overall status of Incauca varieties.

October (virtual)

- Participants: 81 sugarcane growers.
- Topics: Importance of harvest technologies and evaluation of harvest-related tasks.

Pichichí sugar mill

February

- Participants: 30 farmers.
- Topics: Process to obtain healthy seedbeds; importance of disease diagnoses; and field evaluation of variety options for semidry and humid environments.

Providencia sugar mill

March

- Participants: 75 sugarcane growers.
- Topics: Field practices to identify pests (spittlebug and *Diatraea*) and diseases as well as their control.

September (virtual)

- Topic: Launching of Club Pro – Providencia sugar mill.

Mayagüez sugar mill

March

- Participants: 22 sugarcane growers.
- Topics: Process of preparing vinasse and understanding the benefits of applying vinasse as complement to fertilization.

October

- Participants: 12 sugarcane growers.
- Topics: Identification of pests (spittlebug and *Diatraea*).

Risaralda sugar mill

February

- Participants: 52 sugarcane growers.
- Topics: Management of web tools.

March

- Topics: Forum on mechanical harvest: field design for adequate crop harvesting; mechanical harvest using a self-guided system; required post-harvest field tasks; impact of mechanized harvesting on regrowth, cane height, and diameter; effect on soil compaction; and projection of mechanized harvesting at the Risaralda sugar mill.

July (virtual)

- Participants: 38 sugarcane growers.
- Topics: Productivity results of varieties CC 05-430 and CC 09-066 apt for semidry environments as well as the advances made in the evaluation of crop maturation.

November (virtual)

- Participants: 39 sugarcane growers.
- Topics: Characteristics of homologous climate zones of the Risaralda river valley and northern Cauca river valley; current climate status; and climate forecasts for the first quarter of 2021.

Manuelita sugar mill

August

- Participants: 86 sugarcane growers.
- Topics: Productivity results of varieties CC 01-678, CC 05-430, and CC 09-066 apt for semidry environments. Varieties CC 91-1606 and CC 11-600.

Riopaila-Castilla sugar mill Castilla sugar production plant)

September (virtual)

- Participants: 51 sugarcane growers.
- Topics: Variety options for semidry and humid environments and results of variety productivity at the Castilla sugar production plant.

Carmelita sugar mill

September

- Participants: 18 sugarcane growers.
- Topics: Water balance as a tool to schedule irrigation as well as required parameters.

Sancarlos sugar mill

October (virtual)

- Participants: 11 sugarcane growers.
- Topics: Irrigation-related tasks involving measurement of flows, irrigation intervals, and preparation of future irrigated areas.

Scan the QR code
To access videos of virtual meetings of the TTG Network.

07 Documents published by Cenicaña staff in 2020 and recorded in its bibliographic database

Alarcón Ríos, A. (2020). Clarificación y filtración de jugos de caña: curvas de titulación en jugos, caracterización de insumos en la clarificación y preparación de lodos. [Informe final del Contrato estudiante en práctica, Ingeniería Química]. Universidad del Valle, Escuela de Ingeniería Química; Cenicaña.

Angel Salazar, J.S. (2020). Establecimiento de un protocolo de bioensayo para la prueba de toxicidad de proteínas extraídas de *Bacillus thuringiensis* sobre el barrenador del tallo de caña de azúcar, *Diatraea* spp. [Informe final del Contrato estudiante en práctica, Ingeniero Agrícola]. Universidad Nacional de Colombia. Sede Palmira. Faculta de Ingeniería y Administración, Cenicaña.

Aristizabal Carvajal, J.C. (2020). Instrumentación y modificación del equipo para la medición de energía específica de impacto. [Informe final del Contrato estudiante en práctica, Ingeniero Mecánico]. Universidad del Valle, Facultad de Ingeniería; Cenicaña.

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01

Research Committees during 2020

Field Committee

11 June

- Director General's Report.
- Report on climate and forecasts.
- Productivity of the sugarcane agroindustry in Colombia. Consolidated report for 2019 and comparative report for 2018 - 2019.
- Discussion of the new focus of varietal selection and development proposed.
- Discussion of crop agronomy research proposal.

16 September

- Director General's Report.
- Report on climate and forecasts.
- Productivity of the sugarcane agroindustry in Colombia.
- Population dynamics and sucrose accumulation in several sugarcane varieties.
- Strategies to improve sucrose production and accumulation.

2 December

- Regulation of appropriate use of drones in the aerial fumigation of sugarcane.
- Director General's Report.
- Report on climate and forecasts.
- Productivity of the sugarcane industry in Colombia.
- Response of varieties to mechanical harvest in humid environments, series 11.
- Advances in the screening of varieties for semi-dry environments.
- Response of varieties CC 01-1940 and CC 11-600 to potassium fertilization.

Variety Committee

17 December

- Census of promising sugarcane varieties.
- Results of screening stages for the foothill environment and the regional trial established at the San Antonio hacienda.

Harvest Committee

23 September

- Report on climate and productivity.
- Update: equipment to load chopped sugarcane.
- Update: Cane stem quality and length in mechanical harvest.
- CATE Project: 2021 forecasts.

10 December

- Climatic situation and forecasts.
- Monitoring of operative performance of the Matriarch sugarcane loader.
- Monitoring of regional trials, humid environments, series 11, template.
- Modeling of the sugarcane supply chain.
- Ethanol injection in turbo-diesel engines.

Factory Committee

26 February

- Director General's Report.
- Climate and productivity of the sugarcane agroindustry in Colombia.
- Research outputs of projects involving best operational practices and sucrose recovery.
- Impact of aconitic acid on sugar and alcohol production: initial findings.
- Factory performance indicators.
- Coordination of activities with sugar mills.
- Training carried out during 2019.
- Training planned for 2020.

20 May

- Director General's Report.
- Climate and productivity of the sugarcane agroindustry in Colombia.
- Xylitol: Technological monitoring and competitive intelligence survey.
- Project research outputs: Mitigation of the impact of the quality of raw material and processing conditions on end product color.
- Carbon footprint report.
- Training carried out during 2020.
- Factory performance indicators.

Agosto 12

- Director General's Report.
- Climate and productivity of Colombia's sugarcane agroindustry.
- Advances in training 2020.
- Cooling pools: neglect that comes at a very high cost.
- Updating methodologies for the physical -chemical characterization of biomass fuels.
- Xylitol: an alternative to use lignocelullosic residues generated in sugar production.
- Project: Analyzing the technical and environmental impact of using sugarcane biomass as fuel and the potential use of combustion ashes.
- Factory performance indicators.

18 November

- Director General's Report.
- Climate and productivity of Colombia's sugarcane agroindustry.
- Baseline of impurities that impact crystallization.
- Ethanol fumigation in turbo-diesel engines.
- Fiber and tools developed for its characterization.
- New projects: Developing tools for rapid diagnosis and control of sources of nonspecific losses of sucrose.
- Training calendar for 2021.
- Plant Health Committee.

24 June

- Phytosanitary balance of the first semester 2020.
- Current status of orange rust, yellow leaf virus, *Diatraea* borers, and the spittlebug Aeneolamia varia.

25 November

- Epidemiological tools applied to risk analysis of brown and orange rusts in sugarcane: case studies of the San Carlos and Mayagüez sugar mills.
- Risks inherent to certified organic production: policy on phytosanitary inputs and residuality in plant production.
- Support in controlling the spittlebug in sugarcane crops in the geographical valley of the Cauca river using artificial intelligence

Maturation Committee

14 July

- Current status of revalidation of application rates of maturing agents in sugarcane.
- Report on maturation 2019 presented by sugar mills.

10 September

- Current status of the revalidation of application rates of maturing agents in sugarcane (Syngenta).
- Sucrose accumulation dynamics in two new sugarcane varieties.
- Response of several new varieties in terms of maturation.

3 December

- Comparison of agronomic efficiency of maturing agents Bonus(r) and Tronnuspac in variety CC 01-1940 (Castilla Agrícola).
- Revalidation of application rates of the product Tronnuspac as maturing agent in varieties CC 01-1940, CC 11-600, and CC 85-92.
- Response of several new varieties to the application of maturing agents.

Technology Transfer Committee

15 July

- Informe del Director General.
- Avances en transferencia de tecnología.
- Situación de la asistencia técnica en los ingenios.

Diciembre 9

- Director General's Report.
- Advances made in technology transfer.
- Projection and proposals.

Scan the QR code
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Addendum Annual Report 2020

02 Staff participation in training events, exchange activities, and professional development courses in 2020

EVENTS / ORGANIZING ENTITY / VENUE	DATE	PARTICIPANTS
Internal Auditors ISO 14064 – GEI (in Spanish) / Asocaña / Cenicaña	15 January - 7 February	B. Múnera, N. Gil
Seminar on biorefineries (in Spanish) / Solenis Colombia / Cenicaña	4 February	C. Prieto, J. Rodríguez, J. Sierra
Seminar on utilities (in Spanish) / Solenis Colombia / Cenicaña	5 February	J. Lucuara, J. Sierra
Biochemical processes: biomass-based energy improvements and alternatives (in Spanish) / Icesi / Virtual	4 - 23 September	D. Yépez, B. Múnera
Measurement uncertainty in laboratories (in Spanish) / SGC LAB / Virtual	9 October	L. Arévalo
Course on regulation and economic viability of biogas projects (in Spanish) / Centro Internacional de Energías Renovables / Virtual	15, 16, 22 and 23 October	J. Lucuara, B. Múnera
Analysis of the use of RAC as alternative source for cogeneration (in Spanish) / Asocaña - Sena – Cenicaña / Virtual	5 November - 17 December	N. Gil, J. Lucuara
II Symposium for Regulating Industries: Normativity, traceability and productivity (in Spanish) / Annar / Virtual	24 - 27 November	J. Sierra
Training in orange rust morphology (in Spanish) / Universidad Nacional de Colombia - Medellín Campus / Medellín	22 January	M. Montoya
Refresher course on the ISO/IEC 17025: 2005 norm (in Spanish) / IQS Ltda / Virtual	January - June	E. Rincón, L. Donneys
Webinar: Science, technology and innovation in Colombia after the very long isolation. Realities, perspectives, and good practices (in Spanish) / UAN / Virtual	30 April	J. Vélez
IV Encounter of Research Incubators / UNAD / Virtual	15 May	Y. Sarria
Biotechnology Seminar: Molecular Studies with Viruses (in Spanish) / Universidad Nacional de Colombia / Virtual	19 May	E. Rincón, M.
Workshop on the diagnosis and detection in the lab of the new coronavirus (in Spanish) / Secretary of Health of Valle del Cauca	28 May	L. Donneys
Webinar: Phenomics and genomics tools, key strategies to accelerate the genetic gain in crops (in Spanish) / Ascolfi / Virtual	5 June	E. Rincón, Y. Sarria, M. Montoya
Training in PCR-biotechnology (in Spanish). AM Ltda / AM Ltda / Virtual	19 June	E. Rincón, L. Donneys, M. Montoya, J. Ángel, J. Pastrana
Webinar: Obtaining Capsicum spp. cultivars resistant to P. capsici L. (in Spanish) / Ascolfi / Virtual	26 June	E. Rincón, J. Vélez, J. Botina, Y. Sarria, M. Montoya, J. Ángel.
Ascolfi webinar: How to improve the sanitary quality of seed during production (in Spanish) / Ascolfi / Virtual	10 July	E. Rincón, J. Vélez, J. Botina, A. Gil, Y. Sarria, M. Montoya, J. Ángel.
Webinar; The origins of life and its relationship with viruses (in Spanish) / Ascolfi / Virtual	31 July	L. Donneys, J. Botina, J. Ángel.
Sugarcane webinar (in Spanish) / CREA - NOA region	6 August	J. Vélez
Webinar: Phytosanitary threats for Muscaceae: thinking beyond Fusarium tropical race 4 (in Spanish) / Ascolfi / Virtual	14 August	E. Rincón, J. Vélez, J. Botina, A. Gil, Y. Sarria, M. Montoya, J. Ángel.

Continúa

EVENTS / ORGANIZING ENTITY / VENUE	DATE	PARTICIPANTS
Diploma course on plant health (in Spanish) / Politécnico de Sur América	17 August	Y. Sarria
Genetic diversity in Begomovirus infecting cultivated plants and weeds in Brazil (in Spanish) / Ascolfi / Virtual	28 August	E. Rincón, J. Vélez, J. Botina, A. Gil, Y. Sarria, M. Montoya, J. Ángel.
X CIBioFi Short Course on Analysis of Microbiomes Applied to Agriculture (in Spanish) / CIBioFi / Virtual	10 September	M. Montoya
Introduction to second and third generation NGS sequencing technologies (in Spanish) / Centro Nacional de Secuenciación Genómica (CNSG) / Virtual	16 September	M. Montoya
Webinar: Introduction to NGS sequencing technologies (in Spanish) / Universidad de Antioquia / Virtual	16 September	A.
Webinar: Rusts found in Colombia, their diversity, importance, and new records (in Spanish) / Ascolfi / Virtual	25 September	E. Rincón, J. Botina, A. Gil, Y. Sarria, M. Montoya, J. Ángel.
Ascolfi webinar: Current status of corn stunting in Colombia (in Spanish) / Ascolfi / Virtual	9 October	E. Rincón, J. Botina, G. Castaño, Y. Sarria, M. Montoya, J. Ángel.
Next-generation microbiology (in Spanish) / Centro Nacional de Secuenciación Genómica (CNSG) / Virtual	14 October	M. Montoya
Webinar: New approaches to phytosanitary management in sugarcane (in Spanish) / Asociación Argentina de Fitopatología / Virtual	15 October	E. Rincón, J. Botina, G. Castaño, Y. Sarria, M. Montoya, J. Ángel, J. Pastrana.
V Plant Pathology Symposium (simFito): Conferences on virology (in Portuguese) / Universidad de Brasilia / Virtual	20 October	M. Montoya
Technical and virtual seminar on guava in the region and its agroindustry (in Spanish) / Agrosavia / Virtual	20 October	Y. Sarria.
Webinar: Main phytosanitary risks in Pinus and Eucalyptus plantations in Colombia (in Spanish) / Ascolfi / Virtual	23 October	E. Rincón, S. Henao, Y. Sarria, M. Montoya, J. Ángel.
First Argentinian Seeds Congress: Germinating New Ideas (in Spanish) / ALAP - Universidad Nacional de Córdoba.	3 November	L. Bohórquez
Use of bioproducts in sugarcane (in Spanish) / EEAOC and Brucke Agro / Virtual	5 November	J. Vélez
Productive system of citrics and management of Diaphorina citri - HLB in Colombia (in Spanish) / Agrosavia / Virtual	19 November	Y. Sarria
Soil and agronomic management of yam crops (in Spanish) / Agrosavia / Virtual	23 November	Y. Sarria
Diploma course on the application of VANT technology in agriculture / Universidad del Valle - SENA	October - December	G. Castaño
International connectivity (in Spanish) / Tecnicaña - Procaña / Virtual	3 - 6 November	M. López, F. Muñoz, M. Castro, L. Collazos, F. Hoyos, A. Cepeda, C. Muñoz, F. Villegas, A. Criales, A. García, S. Guzmán, S. Alarcón, M. Pizarro, L. Jiménez.
Convened Panel of National Evaluators: Closing the technological gaps of the agricultural sector through the strengthening of R&D&I (research-development-innovation) capacities (in Spanish) / Colombia's Ministry of Science, Technology and Innovation / Bogotá	27 - 28 February	M. Castro
Expoagro 2020 Argentina / AGTECH - Argentina / Buenos Aires, Argentina	9 - 13 March	M. Castro
Crop systematization using AgroCAD	25 - 28 May	A. Estrada
Second International Online Seminar on Persistent Organic Contaminants / Colombia's Ministry of the Environment and Sustainable Development / Virtual	November	A. Estrada

Continúa

EVENTS / ORGANIZING ENTITY / VENUE	DATE	PARTICIPANTS
Webinar: Reliability engineering (in Spanish) / ACIEM / Virtual	20 May	C.Muñoz
Webinar: Strategic maintenance management (in Spanish) / ACIEM / Virtual	12 June	C.Muñoz
Webinar: Asset management according to the ISO-55000 norm (in Spanish) // ACIEM / Virtual	21 June	C.Muñoz
Webinar: AgroCad / TecGraf / Virtual	21 June	C.Muñoz
Webinar: Biophysical model to estimate sugarcane yields (in Spanish) / Tecnicaña / Virtual	16 September	C.Muñoz
Webinar: Strategies to save energy (in Spanish)	14 October	C.Muñoz
Diploma course on project management (in Spanish) / ICESI / Virtual	October - December	F. Garcés, F. Muñoz, A. Estrada, A. Arenas, M. López, J. Riascos, L. López, F. Silva, F, Salazar, E. Anderson, J. López, L. Mosquera, J. Rodríguez, N. Gil, J. Valencia, Z. Daza, L. Arévalo, J. Lucuara, J. Calpa, D. Posada, F. Villegas, L. González. C. Viveros.
Forum on Comprehensive Monitoring of Water Resources: Amount and Quality (in Spanish) / Ministry of the Environment (Colombia), Ideam, Swiss Embassy in Colombia / Virtual	21 May	F. Hoyos
Seminar on sugarcane production costs: The value of land lies in what it produces (in Spanish) / Procaña / Virtual	3 - 4 June	F. Hoyos
Sena and Asocaña sugarcane ambassadors (in Spanish) / Sena-Asocaña Agreement / Virtual	1 - 3 December	F. Hoyos, M. Rodríguez
Monitoring as a strategic positioning tool of Colombia's Water Funds (in Spanish) / Latin American Water Funds Partnership	1 - 2 December	F. Hoyos.
Digital transformation within the environment sector: the ReiniSIACmos initiative (in Spanish) / Colombia's Ministry of the Environment and Sustainable Development / Virtual	7 - 9 October	A.
Course for sectorial leaders / Sena–Asocaña Agreement / Virtual	October - December	F. Villegas
Diploma course to form professionals in technology management and transfer (in Spanish) / BID, Alianza del Pacífico, Tecnológico de Monterrey / Virtual	November - December	S. Alarcón
Meeting-workshop on social appropriation of knowledge and its regional impact: Technical guidelines to scientific communication and dissemination / Red Colombiana de Información Científica / Icesi	27 February	M. Rodríguez
Workshop Science to Share Science (in Spanish) / Icesi / Icesi	6 - 9 March	M. Rodríguez, H. Silva
Diploma course in forming local development leaders based on science, technology, and transformative innovation. Outcome 1: General System of Royalties – Ethnic-based Differential Focus (in Spanish) / Univalle / Virtual	October - December	L. Mosquera, M. Rodríguez.
Forum on scientific journalism (in Spanish) / Forum on Scientific Journalism / Virtual	24 - 26 August	M. Rodríguez

03 Collaborative agreements subscribed in 2020

- **Fundación para la Investigación Azucarera del Ecuador (FIADE).**
  January
  Exchange and evaluation of sugarcane varieties.

- **Universidad de San Buenaventura.**
  January
  Collaborative framework agreement to establish the bases for a reciprocal collaboration that aims to promote projects and fulfill objectives of common interest in the academic, research, and extension areas.

- **Tecnología en Computación Gráfica Ltda. (TECGRAF).**
  March
  Development of collaborative and/or complementary scientific, technical and/or research programs or projects or other activities in areas of common interest.

- **Universidad del Tolima.**
  March
  Collaborative agreement to carry out academic or other types of internships and/or social services.

- **Universidad Nacional De Colombia.**
  March
  Agreement of interinstitutional support for the advancement of undergraduate and graduate internships.

- **United Nations Office on Drugs and Crime (UNODC).**
  July
  Letter of understanding for cooperation between the parties to advance goals and objectives for the socioeconomic development of regions and communities producing sugarcane and panela by promoting the production and sales of sugarcane products and panela.

04 Registrations of Plant Breeders' Rights in 2020

Cenicaña has registered before the Colombian Agricultural Institute (ICA, its Spanish acronym) plant breeders' rights for 32 sugarcane varieties. On 24 September Cenicaña was granted a consecutive 20-year certificate for the following varieties:

NO.	FILE	VARIETY	RESOLUTION
1	A182393	CC 00-3257	76462
2	A182394	CC 01-746	76463
3	A182395	CC 05-231	76474
4	A182396	CC 05-430	76465
5	A182397	CC 09-066	76466
6	A182398	CC 09-535	76467
7	A182399	CC 09-874	76468
8	A182400	CC 10-450	76469
9	A182401	CC 11-600	76470
10	A182402	CC 91-1606	76471

05 Capital humano en 2020

To carry out its different research projects, Cenicaña had 252 collaborators during 2020 as follows:

99 professionals, of which **two** had Postdoctoral degrees, **12** had Ph.D., **21** had Master's degrees, **64** had Bachelor's degrees, in addition to **51** support staff in the areas of research and services, **80** field workers, and **eight** SENA trainees. **Fourteen** students of different disciplines carried out their thesis work and internships at Cenicaña.

- Six staff members retired during 2020, having reached their retirement age. Of these, two were field workers and four, support staff in the areas of research and services.
- The long selection process for the position of Director of the Variety Program, which included both external and internal candidates, finally culminated the second semester of the year, with the appointment of **John Jaime Riascos Arcos** as Variety Program Director.

06 Personal profesional (a 31 de diciembre de 2020)

Office of the Director General

Freddy Fernando Garcés Obando. Director General. Agronomy Engineer, Ph.D

Margarita María Rodríguez. Communicator. Social Communicator-Journalist.

Dirección Administrativa

Einar Anderson Acuña. Administrative Director. Industrial Engineer.

Karen Bolaños Botello. Accountant. Public Accountant.

Andrea Patricia Castro Rebellón. Assistant Accountant. Public Accountant.

Paola Andrea Sarria Acosta. Assistant Accountant. Public Accountant.

Claudia Camargo Martínez. Head of Purchases and General Services. Business Administrator.

Maria Fernanda Zuluaga Mantilla. Coordinator, Work-related Management and Security System. Business Administrator. M.Sc..

Variety Program

John Jaime Riascos Arcos. Director, Variety Program. Biologist, Postdoctoral.

Fredy Antonio Salazar Villareal. Plant Breeder. Agronomy Engineer, Ph.D.

Carlos Arturo Viveros Valens. Plant Breeder. Agronomy Engineer, Ph.D.

Luis Orlando López Zuñiga. Plant Breeder. Agronomy Engineer, Ph.D.

Germán Andrés Vargas Orozco. Entomologist. Agronomy Engineer, Ph.D.

Gershon Darío Ramírez Sánchez. Entomologist. Agronomy Engineer.

Leonardo Fabio Rivera Pedroza. Entomologist. Biologist, Ph.D.

Yarley Ximena Granobles Parra. IAgronomy Engineer. Agronomy Engineer.

Juan Carlos Ángel Sánchez. Plant Pathologist. Agronomy Engineer, M.Sc.

Eliana Andrea Rincón. Agricultural Microbiologist. Agronomy Engineer, M.Sc.

Leidy Diana Donneys Velasco. Coordinator of the Disease Diagnosis Laboratory. Bacteriologist.

Fernando Silva Aguilar. Plant Breeder. Agronomy Engineer, Ph.D.

Jershon López Gerena. Biotechnologist. Biologist, Ph.D.

Hugo Arley Jaimes Quiñónez. Biotechnologist. Biologist.

Claudia Marcela Franco Arango. Biologist. Biologist.

Claudia Echeverri Rubiano. Biologist. Biologist.

Rocio del Pilar Barrios Méndez. Biologist. Biologist.

Alejandra Londoño Villegas. Research assistant. Biologist, M.Sc.

Isabel Cristina Ocampo Quiceno. Research assistant. Biologist.

Sandra Lorena Zapata Martínez. Temporary researcher. Agronomy Engineer.

Manuel Alexander Quintero Muñoz. Temporary researcher. Agronomy Engineer.

Melissa Montoya Arbeláez. Temporary researcher. Agronomy Engineer.

John Henry Trujillo Montenegro. Systems Engineer. Systems and Computational Engineer.

Miguel Angel Cagüeñas Parra. Agronomy Engineer. Agronomy Engineer.

Viviana Marcela Aya Vargas. Temporary researcher. Biologist

Agronomy Program

Miguel Angel López Murcia. Director, Agronomy Program. Agronomy Engineer, Ph.D..

Edgar Hincapié Gómez. Soils and Waters Engineer. Agronomy Engineer, Ph.D.

Fanny Hoyos Villada. Soils and Waters Engineer. Agricultural Engineer.

Laura Eleanor Collazos Rivera. Soils and Waters Engineer. Agricultural Engineer.

Fernando Muñoz Arboleda. Soil Scientist. Agronomy Engineer, Ph.D..

Yeison Mauricio Quevedo Amaya. Physiologist, Agronomy Engineer, M.Sc.

Jenniffer Roa Lozano. Research Assistant. Biologist, M.Sc.

Aura Mercedes Cepeda Quevedo. Temporary researcher. Agronomy Engineer.

Mauricio Castro Franco. Precision Agriculture Researcher. Agronomy Engineer, Postdoctoral.

Michael Andrés Arredondo Mendoza. Topographical Engineer. Topographical Engineer.

Juan Manuel Valencia Correa. Geographical Information Systems Analyst. Topographical Engineer.

Mario Andrés Soto Valencia. Topographer. Topographical Engineer.

Alejandro Estrada Bedón. Logistics Engineer, CATE. Agroindustrial Engineer, M.Sc.

Efraín Camilo Muñoz Montenegro. Mechanical Engineer–Harvest. Mechanical Engineer.

John Felipe Sandoval Pineda. Maturation. Agronomy Engineer. M.Sc..

Factory Processes Program

Nicolás Javier Gil Zapata. Director, Factory Processes Program. Chemical Engineer, Ph.D.

María Alejandra Gómez Duque. Chemist. Chemist.

Geyzar Alejandra Trochez Sánchez. Chemist. Chemist.

Kimberly Gutiérrez Castellanos. Chemist. Chemist.

Sylvana Posso Hernández. Chemist. Chemist.

José Sebastián Soto Girón. Chemist. Chemist.

Esteban Omar Benavides Hidalgo. Chemist. Chemist.

Sebastián Mercado Guerrero. Chemist. Chemist.

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ACRONYMS

Asoarhuaco: Asociación de Productores del Pueblo Arhuaco (Colombia).

ASTM: American Society of Testing Materials.

CIDCA: Centro de Investigación y desarrollo de la Caña de Azúcar.

EESA: Estación Experimental de San Antonio de los Caballeros.

FAI CNP: Fundação de Apoio Institucional ao Desenvolvimento Científico e Tecnológico.

GEE: Google Earth Engine.

GWAS: Genome-wide association study.

IEA: International Energy Agency.

IoT: Internet Of Things.

LoRaWAN: Low Power Wide Area Network.

MAS: Marker-assisted selection.

SSA: Site-specific agriculture.

SWAT: Soil and Water Assessment Tool.

TR: Targeted Re-sequencing.

UFSCar: Universidade Federal de São Carlos (Brazil).

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ANNUAL REPORT 2020

Remite/Cenicaña. Calle 58N No. 3BN-110 Cali, Colombia

Tarifa Postal Reducida Servicios Postales Nacional S.A
No 2020 -130. 4-72, vence 31 de dic. 2021