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Sugarcane roadmap summary

The road to sustainable sugarcane growing [2023-2033]

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Sugarcane, a tropical giant grass from the family Poaceae, is increasingly being grown worldwide. In addition to being used to make sugar, of which global consumption is rising, it has a growing range of uses, including for energy production. How can we tackle the many economic, social and environmental challenges posed by the expansion of sugarcane growing? CIRAD presents its vision for a future in which sugarcane will contribute to sustainable development. ■

Global sugarcane output totalled more than 1.96 billion tonnes in 2021, with 27 million hectares planted on farms and estates covering as little as one and as much as several thousand hectares. The leading producers are Brazil (752 million tonnes, of which 36% is used for sugar and the remainder for ethanol), India (405 Mt), Thailand (131 Mt) and China (110 Mt). Those four countries account for more than 70% of global output. While sugarcane production figures for France might look very low in relation to the global total (2.8 Mt in 2018 in the French overseas regions – Réunion, Guadeloupe and Martinique), it plays a major role in the economies of those territories by providing jobs and preserving arable land. Sugarcane is planted in the form of stalk cuttings placed horizontally a few centimetres below the soil surface. The first cane stalks are ready for harvesting within 14 to 16 months, and regrowth is harvested annually. Stalks are cut, transferred to the mill or the distillery and crushed. This produces juice and bagasse. Several products can subsequently be made: sugar and rum, obviously, but also ethanol, pharmaceutical products, paper, plastics, wine bottle corks and textiles. Bagasse is primarily used as a solid fuel to generate steam for industrial purposes, but also as a raw material for making chipboard or building bricks.

A range of challenges, a range of visions

Between the early 1960s and 2020, the total area planted with sugarcane worldwide increased fourfold, with numerous impacts on the territories concerned: displacement of activities and communities, land tenure and fresh water supply issues, risks of exclusion for vulnerable population groups and threats to food security. In a context of global change and climate change, the sugarcane value chain also faces a number of challenges. On a biophysical and technological level, there is a need to adapt sugarcane growing methods, to preserve soils, biodiversity and water resources and reduce chemical and atmospheric pollution. From a socioeconomic, political and institutional point of view, developing new sugarcane products changes traditional structures and raises a range of questions in terms of economic and social sustainability. There are many different visions of sugarcane cultivation: numerous countries (the US and Latin American countries) rely on continued intensive pesticide use, with the creation of genetically modified varieties resistant to pests and diseases or glyphosate (herbicide) for instance. Europe (in its ultra-peripheral regions) favours more environmentally friendly agriculture, with ever less pesticide use and the development of agroecological practices, along with molecular marker-assisted breeding operations to produce orange rust-resistant varieties, for instance. The situation varies in Africa, according to how dependent producing countries are on the sugar market, to their production structure (sugar companies, small-scale producers, or a mix of the two), to how developed the industrial and research sectors are, etc. ■

| Sugarcane (variety R579 in Réunion)

© P. Rott, CIRAD

| Ranking sugarcane innovations according to their potential for change

© S. Freguin-Gresh, CIRAD

| Selection before planting out pre-germinated cuttings (PGCs)

© S. Freguin-Gresh, CIRAD

Promoting the sugarcane sector of the future: four ambitions to frame operations

CIRAD is a historic sugarcane research player, and also a leader in terms of international plant material exchanges. We have built international collaborations with numerous research centres and other partners. Fourteen research units from all three of our scientific departments are working on sugarcane, focusing on biological systems (BIOS department), tropical production and processing systems (PERSYST department), and environments and societies (ES department).

Ambition 1

Promote sustainable, agroecological sugarcane growing in the French overseas regions

This ambition aims to boost and broaden CIRAD's work on sugarcane sustainability and agroecology, with three objectives: i) zero synthetic input use; ii) integrating the value chain into its landscape and territory; iii) developing new digital tools and methods to support that transition. This first ambition is intended to make sugarcane growing economically and environmentally sustainable and make growers' work less arduous in the specific context of the French overseas regions. It also involves exploring new potential to build innovations aimed at greater sustainability that can be rolled out beyond those regions.

Ambition 2

Help stakeholders complete the agroecological transition | Focus on Africa

This ambition aims to adapt and roll out solutions for the agroecological transition developed in the French overseas regions to African contexts, particularly to smallholders and their organizations. Climate change, limited access to healthy genetic resources, the emergence of new pests and diseases, the stopping of the practice of burning before harvesting, the need to save irrigation water, market competition and new uses are some of the main challenges facing growers in Africa. CIRAD favours a multidisciplinary approach, ranging from biological science to human and social science, to work with its partners to build solutions.

Ambition 3

Use knowledge of sugarcane diversity and that of its parasites to ensure sustainable sugarcane growing

The sugarcane genome is complex. Creating new varieties by hybridization, and breeding those varieties, is still often done empirically. Hundreds of thousands of potential candidates obtained through hybridization are produced each year, but after ten to 15 years of screening, just one or two clones are disseminated as commercial varieties. Few countries have the means to fund such long-term, costly operations. CIRAD's third ambition concerns the development of knowledge and methods to support sugarcane genetic improvement. This particularly concerns the characterization of pest resistance using genomics tools and sugarcane adaptation to abiotic constraints. This objective is framed by multidisciplinary dialogue and multi-stakeholder collaborations with research and production partners, to ensure greater relevance and efficacy when it comes to identifying targets for improving the productivity of future varieties.

Ambition 4

Opportunities for multifunctional sugarcane

With this ambition, CIRAD proposes looking into uses for sugarcane other than to make sugar, and making it a priority to study the potential and feasibility of "energy sugarcane", along with its limitations. In recent years, two projects – Rebecca (Guadeloupe) and Sypecar (Réunion) – have looked at the potential for burning high-fibre sugarcane to generate electricity. This fourth ambition intends to pursue the exploration of sugarcane genetic resources with high energy production potential. In particular, that exploration will entail case studies with partners keen to develop energy production using either bagasse or the whole plant, by combustion or other renewable energy production processes. ■

| Pre-germinated cuttings being acclimatized before planting out

© S. Freguin-Gresh, CIRAD

Details

Achieving sustainable sugarcane in the French overseas regions, supporting the agroecological transition in Africa, promoting sugarcane genetic, genomic and functional diversity, multifunctional sugarcane, etc... a look at the key details of the roadmap with Christophe Poser, CIRAD sugarcane research coordinator.

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What are the main levers for making sugarcane growing sustainable in the French overseas regions?

Pressure to reduce input use in the French overseas regions for environmental reasons is growing. For CIRAD, the aim is to contribute to reducing herbicide use by developing and implementing agroecological practices, and to regenerate soil fertility and restore biodiversity. Our work centres on various levers, such as adapted varieties, biological control, growing service plants between two cropping cycles or in interrows, micro-mechanization, agropastoralism, etc. The solutions for making sugarcane more sustainable lie in combining several of those levers. We are working on this with our research and development partners, on plantations or experimental stations. We also need to combine those technical levers with economic and social levers, to facilitate transitions. The challenge posed, and the opportunity presented by such approaches is being able to implement them under the umbrella of partnerships between overseas regions.

Why do we need an agroecological transition, and what is the situation in Africa?

The sugarcane agroecological transition is less advanced in Africa than elsewhere, as burning is still commonly practised. Setting sugarcane plots alight before harvesting serves to destroy the straw without damaging the canes. The downside is that such practices also kill insects and give off both greenhouse gases (GHGs) and ash that settles over a wide area. Moreover, they rule out the benefits of crop mulch for biodiversity, moisture retention and controlling soil erosion. CIRAD is keen to use its results in the French overseas regions as a source of inspiration for developing solutions in Africa. Sugarcane is an industrial crop that is not widely covered by national research. CIRAD's research in partnership has to offer a global approach encompassing varietal improvement, soil health, sustainable pest management using varietal improvement and biological control, and more efficient water management. It also needs to cover a wide range of production systems, from family farms to agroindustrial structures.

Genetic diversity: what is the state of play?

CIRAD is widely recognized internationally for its knowledge of the complex sugarcane genome, notably via the International Society of Sugar Cane Technologists (ISSCT). At the Society's last congress, in India in 2023, a CIRAD research team shared the latest knowledge acquired, using molecular cytogenetics, of the sugarcane cultivar genome structure and of the species behind those cultivars. CIRAD also presented the latest progress on sequencing the genome of the cultivar R570 created in Réunion, which is now a model for sugarcane genomics. The end purpose of this genomics and genetics work is to supply breeders with information and tools they can use to develop new cultivars suited to the biological and environmental constraints on sugarcane cultivation, within the framework of a range of international breeding programmes.

Why should we and how can we define the priorities in terms of multifunctional sugarcane?

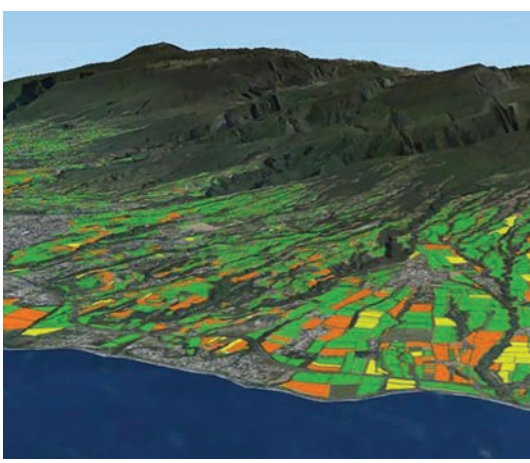
The CIRAD roadmap for the coming decade aims to step up and accelerate research on the multifunctionality of sugarcane. This raises a number of issues, notably surrounding energy production. Those issues include that of competition over land that could also be used to grow food. There are plans to make use of multi-criteria environmental assessment tools including life cycle assessments (LCA). Could we make use of the very broad interspecific genetic resource available to supply new products, possibly on new land? CIRAD also intends to work on other energy extraction processes than combustion, to make conversion more efficient. ■

Find out more: **sugarcane@cirad.fr**

MASH: using mapping to improve management

MASH (Mapping Sugarcane Harvest) is an app for mapping sugarcane harvest progress using optical remote sensing and radar. It satisfies a vital need to determine the sugarcane areas already harvested (or not) in virtually real time, in order to adjust harvest forecasts and optimize operations, cashflow, human resources and logistics. MASH automatically processes free, open-access European Sentinel satellite images. Each pixel of a sugarcane plot is categorized according to harvest status. Synthetic maps are then compiled to highlight the proportion of each plot already harvested, in addition to tables per supply base or per mill, allowing operators to monitor harvest progress. The tool has been rolled out by CIRAD in Réunion, Thailand and South Africa, and by the Geowatch Labs start-up in the leading producing countries. It can be adapted to local conditions and used worldwide. MASH serves to optimize sugarcane harvesting and is helping to ensure its sustainability by gathering information right down to a very small scale, in very small plots.

Find out more:



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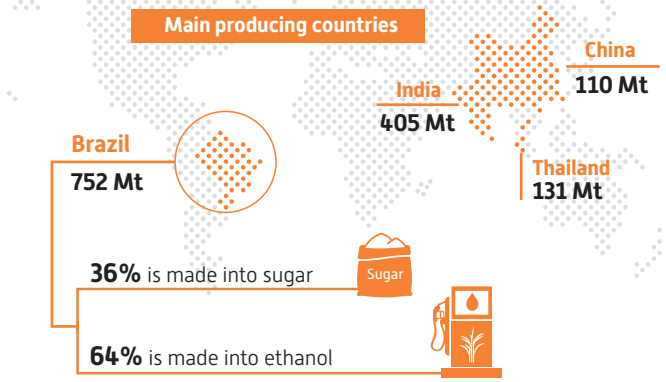
Inventing the sugarcane sector of the future

CIRAD is addressing the challenges facing the value chain

Sugarcane, the main source of sugar worldwide

Global sugarcane production
1.96 billion tonnes from 27 million hectares



Global sugar production in 2023: **177 Mt,** including

80 % from sugarcane

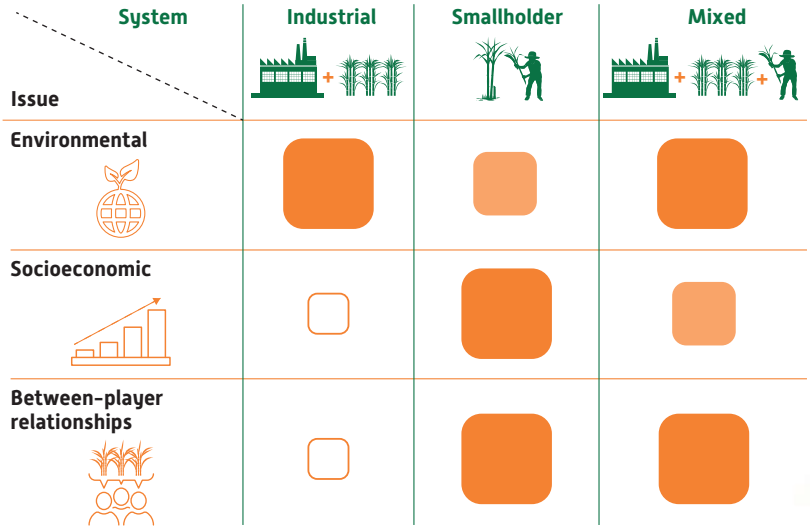
20 % from sugar beet

Increase in sugar consumption worldwide between 2010-2011 and 2022-2023 (in Mt)

2010-2011 2022-2023

or + 13.4%

Three types of cropping systems, a range of sustainability issues



Our ambitions...

Promote sustainable, agroecological sugarcane growing in the French overseas regions

Support the agroecological transition of the sugarcane sector in Africa

Use knowledge of sugarcane genetic diversity and that of its parasites to ensure sustainability

Opportunities for multifunctional sugarcane

... in partnership

1 **historic partnership** with eRcane, a research centre in Réunion specializing in varietal breeding

Le Cirad participe à **plusieurs réseaux internationaux,** dont

International Consortium for Sugarcane Biotechnology (ICSB)

International Consortium for Sugarcane Modelling (ICSM)

International Society of Sugar Cane Technologists (ISSCT)

Our means and resources

30 **scientists** from **ten** research units

139 **publications** between 2019 and 2023, including **ten award winners**

1364 **sugarcane varieties** despatched over the past five years via **Visacane**, the CIRAD quarantine facility

1st sugarcane **genome sequence obtained by CIRAD in 2018**

30 **years of biotechnical data and decision support tools** produced and disseminated by CIRAD

335 **sugarcane varieties in collections** managed by CIRAD at the Guadeloupe BRC

Partnerships, the core of CIRAD's research

In addition to its historic partnerships with eRcane in Réunion and the Centre technique de la canne à sucre (CTCS) in Guadeloupe (which still exists despite the halting of breeding operations in 2008), CIRAD's research partnerships in the sugarcane sector have focused on the main sugar estates in French-speaking countries, due to strong demand for its expertise. This has involved CIRAD's agronomists, soil scientists, plant pathologists, entomologists, hydrologists, breeders and agricultural machinery specialists, some of whom have been assigned to experimental facilities at sugar estates in West Africa. These close, sustained links have gradually become more diverse and globalized, thanks to CIRAD's experience of scientific project design and its ongoing, ever-greater participation in the International Society of Sugar Cane Technologists (ISSCT). ■

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A word from our partners

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Interview with Mor Talla Sall,

Plantations Manager for Compagnie Sucrière Sénégalaise (CSS)

What do you think about the ambitions set out in the CIRAD sugarcane roadmap, particularly ambition 2, agroecological transition in Africa?

This priority is particularly relevant to us for several reasons, as we are keen to help players make the agroecological transition. In the current context in Senegal, which is marked by substantial increases in chemical input costs in particular, we are looking for alternatives that are both environmentally friendly and cheap. Agroecology fits the bill. It involves using organic fertilizers such as compost or crop residues, and adopting virtuous irrigation practices (drip irrigation), mechanized weeding with fewer herbicide treatments, etc. Our potential to produce organic matter has already been high for the past three or four years, with a platform producing 10 000 t of compost a year. We are working to promote fodder crops, part of which is fed to cattle and the rest used as an organic fertilizer, dug directly into the soil. Our partnership with a CIRAD researcher based in Saint-Louis, close to CSS, is proving very fruitful. Speaking of which, we have also benefited from CIRAD's advances and experience in the French overseas regions, and we have plans for exchanges about its work in East Africa. For our part, we already have partnerships with South Africa. When I was doing my thesis, I did a lot of work on integrated water resource management and the water-food-energy-ecosystems nexus, two approaches being used in Senegal that fit perfectly with CIRAD's ambition 2. We also work with Visacane, the CIRAD quarantine facility, which provides us with varieties adapted to climate change.

What are relations like between CSS and small-scale growers?

CSS is faced with land issues: we are keen to extend, but there is no available land. We are therefore looking into an option that would mean our neighbours, who until now practised shifting market gardening (sweet potatoes and onions), becoming small-scale growers. We are inviting them to settle and grow sugarcane, using environmentally friendly practices. As leaders in the zone, we must set an example, and are therefore offering training courses in CSS's teaching plots. We have helped Senegalese small-scale growers visit Ivory Coast, where such practices already exist. However, while the experiment has so far proved popular with small-scale growers, it is still at the test stage. CIRAD's knowledge of such farmers in the French overseas regions is of great interest to us, and we have plans to exchange our experiences. ■

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Interview with Nadège Guilbot,

Head of the Centre Technique Interprofessionnel de la Canne et du Sucre (CTICS), Réunion

What are the links between CTICS and CIRAD and how do you see the future of that collaboration ?

Our links with CIRAD go back a long way. We work together on anything that could use the progress made by research to benefit growers and the sugar sector in Réunion. Our agricultural service has helped CIRAD and eRcane with various field research activities, notably on fertilization, and also, every year, with harvest forecasts. Soil analyses prior to planting are vital for ensuring the efficiency of the plantations we coordinate across the island. The main aim today is to relaunch sugarcane production in Réunion in order to return to an acceptable level of production that guarantees the sector's economic stability. Under the recovery plan initiated by the Comité Paritaire interprofessionnel de la Canne et du Sucre (CPCS), we are keen to continue our collaboration with CIRAD in favour of growers, notably on soil fertility, irrigation, and the provision of decision support tools.

What do you think about the ambitions set out in the CIRAD sugarcane roadmap, particularly ambition 1: promote sustainable, agroecological sugarcane growing in the French overseas regions?

We are totally in sync with ambition 3, to develop digital agriculture in order to improve working conditions and resource management. I think that in this digital age, it is vital to do innovative things with sugarcane estates. For instance, from 2024 onwards, our work with CIRAD to supplement our extensive database on those estates will give growers direct access to all the technical information they need. Technicians with digital tablets will be able to send targeted advice to each zone and each grower. Lastly, we will be continuing to work together on the development and use of near infrared spectroscopy (NIRS), notably with CTICS's agricultural trials team. CIRAD is drafting a sampling protocol for field teams and the data gathered should serve to improve reliability. Digital and other new technologies have a vital role to play in the agricultural world of the future, and our close collaboration with CIRAD is hugely important for the development of the sugarcane chain in Réunion. ■

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Interview with Clovis Ernest Bony (l.) and Koffi Théodore N'Dri (r.)

from the Fédération des producteurs de canne villageoises de Côte d'Ivoire, representing Ivory Coast within the World Association of Beet and Cane Growers (WABCG)

Could you tell us about your organization; what are the problems facing your members?

The Fédération des producteurs de canne villageoises de Côte d'Ivoire (Ivory Coast small-scale sugarcane producers' federation) comprises ten cooperatives and represents around 3000 growers with a total area of some 7000 ha. Our role is to support our members in terms of supplies of inputs and other production factors, shared equipment, and fostering relations with the authorities, millers, private organizations and development partners. Small-scale sugarcane producers in Ivory Coast currently face a range of issues: impoverished soils, low-yielding varieties, climate change, rising input prices, and so on. Whereas costs are constantly increasing, sugarcane prices have not budged and producers are becoming poorer. They also face growing demand from consumers and the Ivorian government for more sustainable, less chemical-intensive production systems. At the same time, the State has withdrawn from the sector and the dialogue with industry is non-existent.

What are you expecting from CIRAD?

In the light of climate change, we need to practise climate-smart agriculture, which means using new techniques and a new approach to produce sugarcane. We are willing to make the necessary transition in terms of how we produce, provided we have such new techniques and approaches, to guarantee both high productivity and environmental protection. CIRAD is a reference for sugarcane on a global level. Ambition 2 of the roadmap – agroecological transition in Africa – fully satisfies our expectations. We need support in terms of varietal improvement and cropping practices, of how to organize the profession, and of training. Support from CIRAD could be really useful for us. ■

CIRAD is the French agricultural research and international cooperation organization working for the sustainable development of tropical and Mediterranean regions.

CIRAD works with its partners to build knowledge and solutions and invent resilient farming systems for a more sustainable, inclusive world. It mobilizes science, innovation and training in order to achieve the sustainable development goals. Its expertise supports the entire range of stakeholders, from producers to public policymakers, to foster biodiversity protection, agroecological transitions, food system sustainability, plant, animal and ecosystem health, and sustainable development of rural territories and their resilience to climate change.

CIRAD is a public establishment (EPIC) under the joint authority of the Ministry of Higher Education and Research and the Ministry for Europe and Foreign Affairs.

CIRAD hopes that multi-stakeholder partnerships and alliances will discuss, share and support its four ambitions for sustainable sugarcane growing. Contact us to find out more:

sugarcane@cirad.fr

Working together for tomorrow's agriculture

Find out more about the sugarcane value chain at CIRAD

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CIRAD is a founding member of: