FRENCH SUGARCANE EXPERTISE

cirad
AGRICULTURAL RESEARCH FOR DEVELOPMENT

enhance the value of sugarcane resources
eRcane

ENHANCING YOUR PROJECTS WITH OUR EXPERTISE

Cirad, the French Agricultural Research Center for International Development, and eRcane, a research and varietal selection center based in Reunion Island, are the leading pillars of French expertise in sugarcane.

Our two organizations are long-standing partners, serving to complement each other's roles in supporting stakeholders of the sugarcane industry in both France and abroad.

Cirad is a French organization working in sustainable development in tropical and Mediterranean regions, and has a number of sugarcane specialists involved in a wide range of multidisciplinary research programs. Their fields of expertise include: a) knowledge of the plant itself, such as research in genetics, physiology, pathology; b) agroecological practices including weed control and integrated pest management; c) supply chain management, remote sensing and data management.

Located in Montpellier, in the south of France, far from any sugarcane production area, the sugarcane quarantine of Cirad, called 'Visacane', supplies healthy cane varieties to the sugar estates and to breeding centers worldwide. It also benefits from a plant pathology laboratory, and is the only entrance point for any variety brought onto French territory. In Reunion Island, which is also Europe's leading sugarcane producer, eRcane has been a sugarcane breeding center since 1929, implementing a multi-local selection strategy in order to create varieties which are adapted to a diverse range of soil and climate environments. Teams work across seven experiment stations, hybridizing and selecting cane varieties that contribute to improving the sector's productivity, while conducting genomics research with the main objective of accelerating the genetic progress.

The agronomists and researchers at eRcane and Cirad are working together to understand and improve the development of sugarcane. Furthermore, eRcane has also developed skills in automation and innovative industrial processes in sugar factories. For its part, Cirad has also been developing its skills for several years, as shown by the many scientific and technical collaborations with many cane and sugar-producing countries in the tropics and around the Mediterranean.

This document details the key aspects concerning our expertise and know-how, which we look forward to sharing with you on your projects.

Enjoy your reading!

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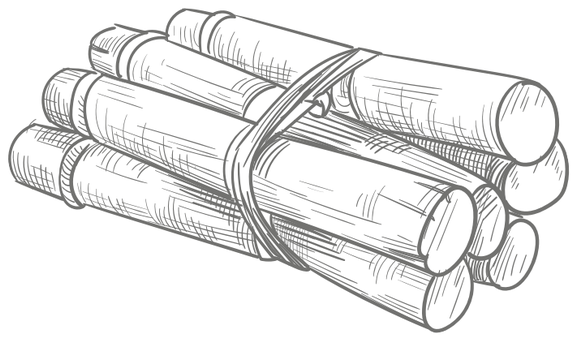


ERCANE'S ELITE VARIETIES GETTING THE BEST OUT OF OUR SUGARCANE RESOURCES

eRcane provides Reunionese sugarcane growers with varieties adapted to the island's highly contrasting ecological zones. Nowadays, 100% of the sugarcane area in Reunion is planted with eRcane varieties.
eRcane's catalogue is composed of 12 elite "R" varieties which have been commercially released, and that are adapted to highly contrasting agro-climatic zones.

SUPPLY OF ELITE VARIETIES WORLDWIDE

Elite varieties are clones that have gone through eRcane's selection program and have reached the last selection stage. Each variety proposed has been well characterized (yield, sugar content, flowering, growth habits and morphological appearance) and their environmental adaptation is known, as all elite varieties are tested in the different agro-climatic areas of Reunion (rainfed and irrigated, rainfall from 500 mm to 5000 mm/year, 0 to 1000 m altitude, different soil types). A particular strength of R varieties is their rather good ratooning ability. Elite varieties are also tested in Reunion for their resistance to Smut, Leaf Scald, brown and orange Rust. eRcane has developed long-term partnerships with sugarcane estates in order to provide elite varieties. Each year, eRcane proposes from 5 to 10 elite varieties to its partners for testing, and the best are then grown on a commercial scale.
Moreover, eRcane supports its partners by providing specific advice when choosing the varieties to be imported and proposes on-site expertise missions.

To date, eRcane has signed variety supply agreements with 20 sugarcane producing countries.

R 570 AND R 579: TWO SUCCESS STORIES

R varieties are well known for their good adaptation ability and their vigour, especially in Africa.
R 570 is a well-known variety developed in several countries, which is still planted in Chad, Burkina Faso, Ivory Coast, Republic of Congo, Democratic Republic of Congo, Zambia, Malawi, Mozambique, Tanzania, Mauritius, French Caribbean islands (Guadeloupe and Martinique), Papua New Guinea and Vietnam.
R 579 has also started being developed in different countries and is flourishing in Senegal, Ivory Coast, Zambia, Mozambique, Malawi, Mauritius, Tanzania, French Caribbean islands, Vietnam and Sudan. The sugarcane area planted with R 579 is growing rapidly.

SETTING UP SELECTION SCHEMES

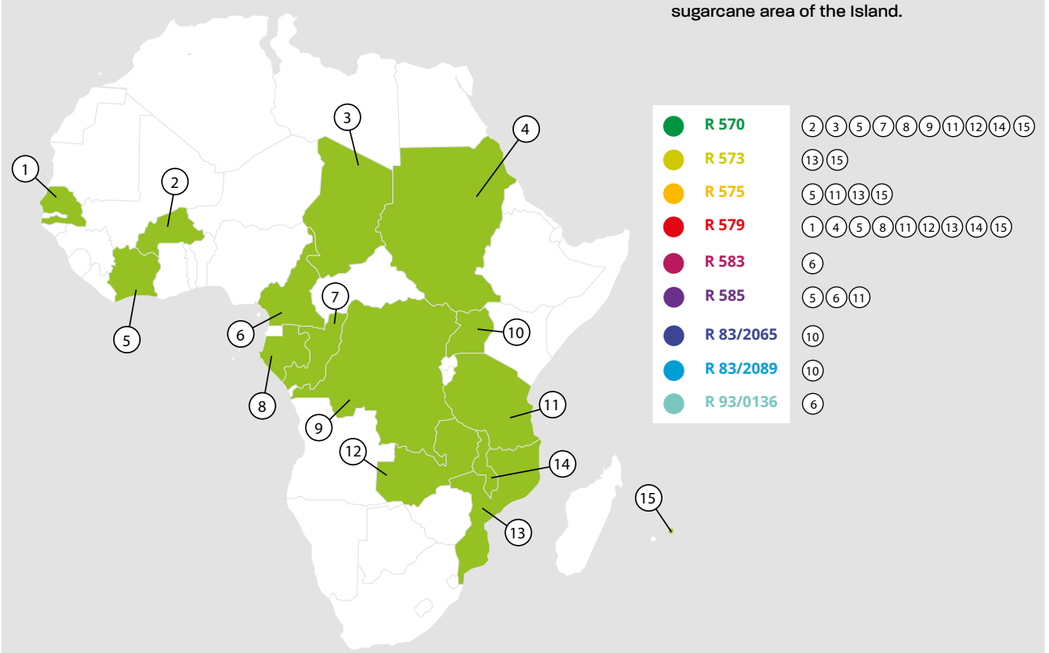
Since 2005, eRcane has also developed partnerships with five African countries (Chad, Cameroon, Republic of Congo, Senegal and Ivory Coast) to assist them in developing their own selection programs. Each year, fuzz for these selection schemes is provided thanks to crossbreeds that have been specifically targeted for the agricultural conditions of each site. Varieties from this collaboration are jointly owned. These partnerships include specific training courses provided either in Reunion, or on-site for personnel who are in charge of these projects.

R VARIETIES AND THEIR ADAPTATION AREAS IN REUNION ISLAND

VARIETY	IRRIGATED	RAINFED	DROUGHT TOLERANCE	ALTITUDE	OBSERVATION
R570	YES	YES	YES	NO	**Adapted to various conditions**
R575	YES	YES	NO	NO	**Early maturing**
R577	YES	YES	YES	YES	**-**
R579	YES	YES	NO	NO	**Low fibre, hight yield potential**
R581	NO	YES	YES	YES	**Hardy**
R582	YES	YES	NO	NO	**Good canopy**
R583	NO	YES	YES	YES	**Cold tolerant**
R584	YES	YES	YES	NO	**Large diameter**
R585	NO	YES	YES	YES	**High fibre, cold tolerant, high vigor**
R586	NO	YES	YES	YES	**Cold tolerant**
R587	YES	YES	NO	NO	**High tillering**
R588	NO	YES	YES	YES	**Cold and drought tolerant**

COMMERCIAL PRODUCTION OF R VARIETIES IN AFRICA

Nowadays more than 100 000 ha have been planted with R varieties away from Reunion Island, representing more than 4 times the sugarcane area of the Island.




R570 in Malawi

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VISACANE A SAFE WAY TO TRANSFER VARIETIES


Visacanne's greenhouse

For sugarcane, quarantining is the safest way of importing/exporting varieties between producing countries without the risk of spreading diseases. Visacane, Cirad's sugarcane quaratine service, is located in Montpellier, in southern France, outside any sugarcane production area, and is part of a plant pathology research unit. Visacane offers a comprehensive service for supplying international varieties: a wide origin of varieties, disease-free status and respect of plant breeders' intellectual property rights.

DISEASE-FREE STATUS

Depending on the geographical origin of the sugarcane varieties, Visacane will detect the local viruses and bacteria responsible for major sugarcane diseases, generally considered as quarantine organisms (see table below).

Special emphasis is placed on latent diseases, when plant infection often does not induce visible symptoms. Visacane is constantly improving its detection tools.

- *Xanthomonas albilineans* (Xa): leaf scald
- *Leifsonia xyli subsp. xyli* (Lxx): ratoon stunting disease
- Sugarcane yellow leaf virus (SCYLV): yellow leaf
- Sugarcane mosaic virus (SCMV): mosaïc
- Sorghum mosaic virus (SrMV): mosaïc
- Sugarcane streak mosaic virus (SCSMV): streak mosaïc
- Fiji disease virus (FDV): Fiji leaf gall
- Sugarcane streak virus (SSV), sugarcane streak Reunion virus (SSRV), sugarcane streak Egypt virus (SSEV): streak
- Sugarcane white streak virus (SWSV)
- Peanut clump virus (PCV): red leaf mottle
- Ramu stunt virus (RmSV): Ramu stunt
- Phytoplasmas: grassy shoot and white leaf
- Some maize viruses (mastrevirus and polerovirus)

Recently, three new, potentially pathogenic sugarcane viruses (2 mastreviruses and 1 ampelovirus) were discovered and studied to improve diagnosis. Whenever possible, diseases are eliminated by long hot water treatment, or by meristem culture. The Visacane quarantining process takes 2 to 5 years to guarantee the disease-free status of varieties.

COMPLIANCE WITH BREEDER'S RIGHTS

Visacane offers more than 150 varieties each year, of which about 30% are new varieties that have completed the quarantine process. These varieties are made available to the sugarcane estates and the variety breeding stations.

- International varieties free of rights can be supplied to all users for testing.
- Elite varieties are covered by licensing agreements with the plant breeder.

With appropriate contracts, Visacane guarantees that all variety transfers protect the intellectual property rights of the breeders.

Cirad:
Philippe ROTT
Jean-Heinrich DAUGROIS

VISACANE'S INTERNATIONAL NETWORK

Visacane imports sugarcane varieties from many breeding stations all over the world, including Argentina, Australia, Barbados, Brazil, USA, Ecuador, Reunion Island, Mauritius, Philippines, Sudan, and exports varieties to sugarcane estates and plant breeding centers in Africa, the Middle East, Latin America, the Caribbean and the Mascarene Islands. In addition, Visacane's managers carry out expert assessments of plant pathology in the field on request.

WORLDWIDE DISTRIBUTION OF ERCANE VARIETIES

eRcane has developed partnerships with sugarcane estates in 16 African countries, The French Caribbean islands, Brazil, and Papua New Guinea.
As a result, R varieties are commercially grown today in many countries (Burkina Faso, Chad, Republic of Congo, Democratic Republic of Congo, Gabon, Guadeloupe, Ivory Coast, Malawi, Martinique, Mauritius, Mozambique, Papua New Guinea, Senegal, Sudan, Tanzania, Uganda, Vietnam and Zambia).

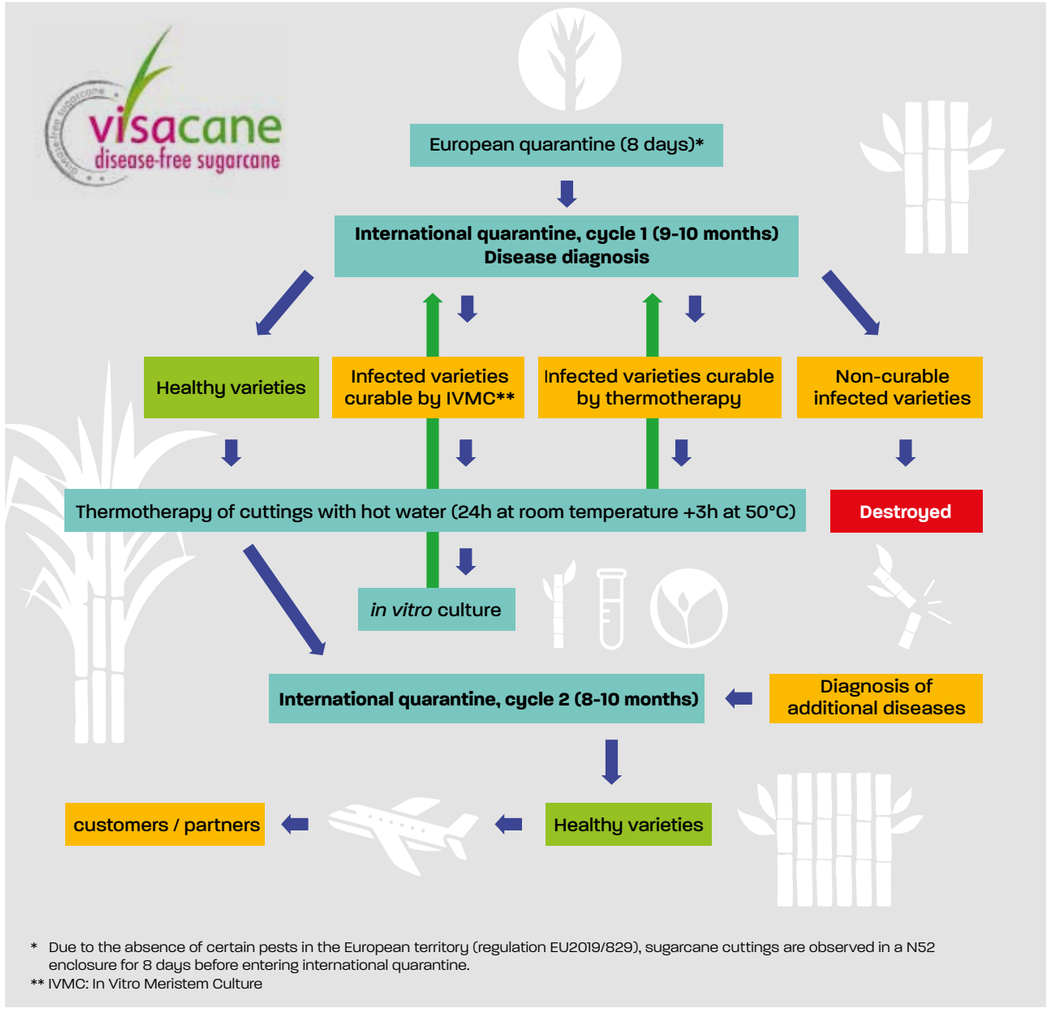
To guarantee the supply of very safe and high quality cuttings for its elite R varieties, eRcane systematically uses the facilities of Visacane, such as for exchanges with breeding stations worldwide.


Quarantine 2nd cycle


Streak mosaic (SCSMV)


Yellow leaf (SCYLV)


Leaf scald (*Xanthomonas albilineans*)



* Due to the absence of certain pests in the European territory (regulation EU2019/829), sugarcane cuttings are observed in a N52 enclosure for 8 days before entering international quarantine.
** IVMC: In Vitro Meristem Culture

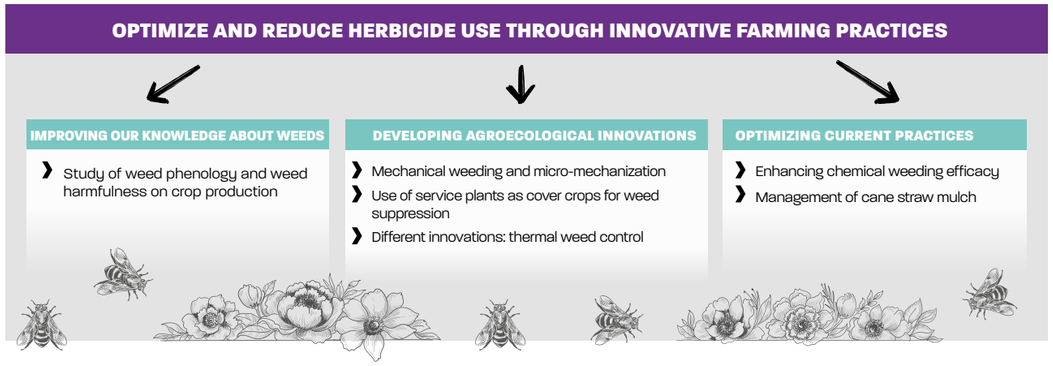
VITROPIC, A CIRAD SUBSIDIARY, PARTNER OF ERCANE AND VISACANE

Vitropic is Europe's largest laboratory for in vitro culture of tropical plants.

When sugarcane varieties are no longer available as cuttings at Visacane or when the demand requires a large quantity of plant material, Vitropic is able to provide vitro-plants of eRcane «R» varieties with all the sanitary quality guarantees.

WEED MANAGEMENT RESEARCH TO INCREASE SUGARCANE CROPPING SYSTEM SUSTAINABILITY

Sugarcane cropping systems are rather environment-friendly, but weed control remains a key factor to achieve both technical and economic performances in sugarcane farms. Agroecological weed management has become crucial due to the increasingly strict European regulations and high societal expectations. Cirad and eRcane have been assessing more sustainable, rational and responsible weed management approaches for several years.

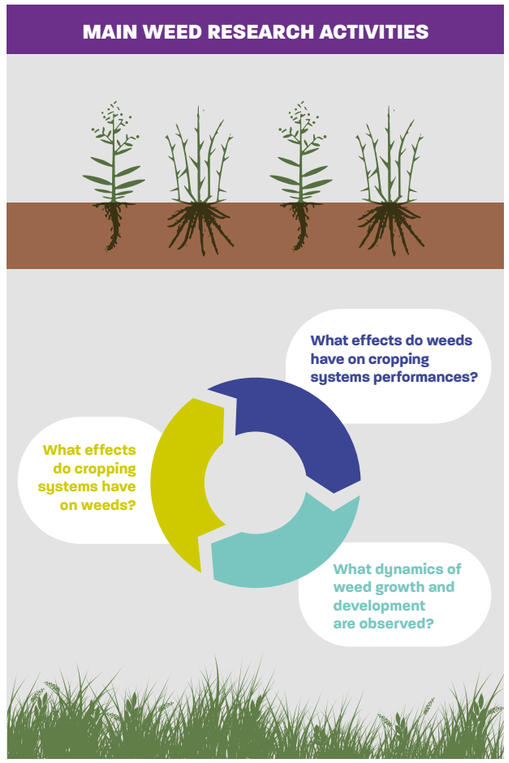


IMPROVING OUR KNOWLEDGE ABOUT WEEDS

Further insight into the biology of weed species and their harmfulness for sugarcane production is required to improve weed control practices and, more generally, weed population management. For farmers, these data will ultimately help to develop weed management strategies based on the species present and their growth and reproductive cycles. Artificial intelligence approaches for weed identification and prediction of their presence and abundance in sugarcane fields are also being implemented.

DEVELOPING AGROECOLOGICAL INNOVATIONS

Mechanical weed control practices are being tested to limit weed growth and infestation, due to the ban on most herbicides. With or without tillage and mulching, several tools are being assessed under micromechanical conditions: Rolofaca roller, brushes, disc harrow, mower shredder, dual-bladed mower, harrow, etc. Companions plants and cover crops are also being tested to reduce herbicide treatments as intercrops between sugarcane rows or as short fallow between two sugarcane crop cycles. Finally, other innovations are being evaluated, such as thermal weeding with water vapor.



OPTIMIZE CURRENT PRACTICES

Cane straw mulch management is also being studied and optimized for weed control: importing this mulch during the crop planting year, mixing it with different tools, and distributing it in different ways throughout the plot. Finally, research on herbicide efficacy and selectivity is also under way to optimize the use of these compounds and provide solutions for the failures and limitations of some agroecological practices. Data from these trials conducted by eRcane are used to obtain marketing authorization for crop protection products.


Weed control by hot water steam on sugarcane row


Disk harrow – interrow weeding


Ageratum conyzoides seeds


Oxalis corniculata seeds


Centrosema pubescens seeds


Senna occidentalis seeds

Imported sugarcane trash mulch applied on rows

Crop association: White lupin (*Lupinus albus*) as companion plant in sugarcane intercropping

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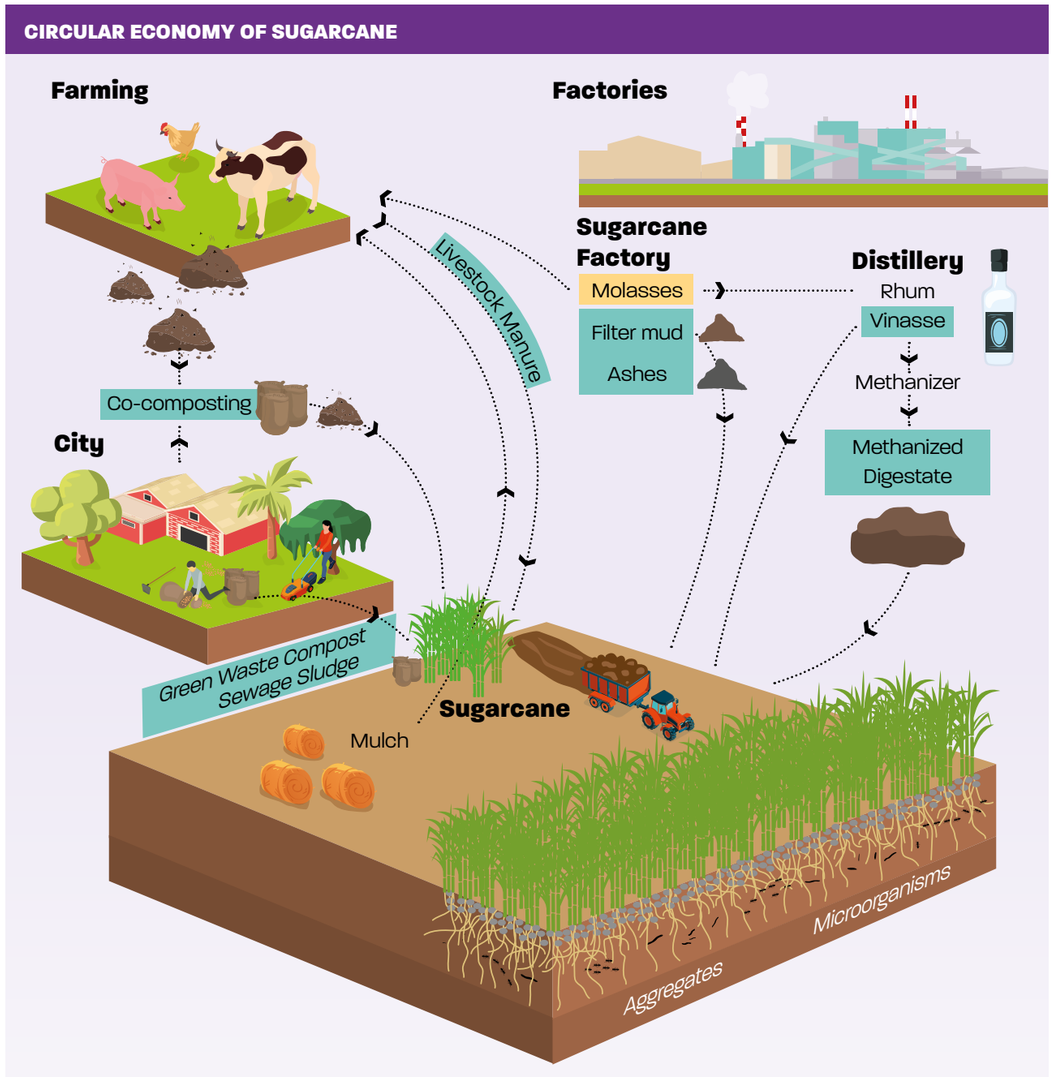
Transfer of innovation

Agricultural plot monitoring

SUSTAINABLE MANAGEMENT OF CROP FERTILIZATION AND SOIL FERTILITY

Fertilization practices have a major impact on sugar yields, while also being the source of multiple forms of pollution. Enhancing the planning and management of fertilization practices to boost the efficacy of fertilizers is crucial for the eco-environmental sustainability of sugarcane farms. Agricultural recycling of Exogenous Organic Matter (EOM) provides an alternative to chemical fertilizer applications. This agroecological practice helps mitigate global warming while improving soil fertility and must be managed localy in a circular economy setting.



BOOSTING THE AGROENVIRONMENTAL PERFORMANCE OF FERTILIZATION PRACTICES

The challenge in fertilization planning and management is to determine the optimum dose and methods for chemical fertilizer and Exogenous Organic Matter (EOM) application, and to meet sugarcane crop needs while limiting losses into watercourses and the atmosphere. Research is thus under way in Réunion (SOERE PRO project) to gain insight into the biogeochemical cycles of nitrogen (N), carbon (C) and phosphorus (P) in sugarcane agrosystems fertilized with different types of material (step sludge, pig manure and poultry litter).

PROMOTING EOM AS A FERTILIZER SUBSTITUTE

Substantial balanced fertilizer applications are essential to maintain and even improve sugarcane production levels. Research is currently under way on various fertilizers and amendments to help cost-effectively meet this need while ensuring environment-friendly production. This work is focused on both mineral fertilisers—which still fulfil most of the sugarcane crop nutritional needs—and various EOMs, which are local sources of nutrients that could eventually replace mineral fertilizers. Other work is also being carried out to hamper nitrogen volatilization by burying fertilizers under cane straw mulch. The substitution of chemical fertilizers by EOM is highly dependent on the availability, transport and transformation of organic matter on a territorial scale. Work is hence under way in Réunion to promote synergy between stakeholders with the aim of providing the agricultural community with access to EOMs tailored to their specific needs.

IMPROVING SOIL FERTILITY

Minimum tillage is a strategic means of improving soil fertility. During planting, different practices and tools for destroying sugarcane stumps have been tested and proven: the use of glyphomulch, localised stump chopping machinery and direct furrowing save time, reduce costs and help safeguard the soil.

Finally, the BioFuncTool® soil health assessment tool is being implemented to assess the impacts of agroecological practices on the chemical, physical and biological components of soil fertility.


Long-term organic fertilization experiment – TERO project


Biofunctool® - basal soil respiration


Pig manure spreading - TERO project


Fertilizer drill machine


Biofunctool®: Installation of Bait Lamina > indicator of the activity of the soil mesofauna


SOERE PRO

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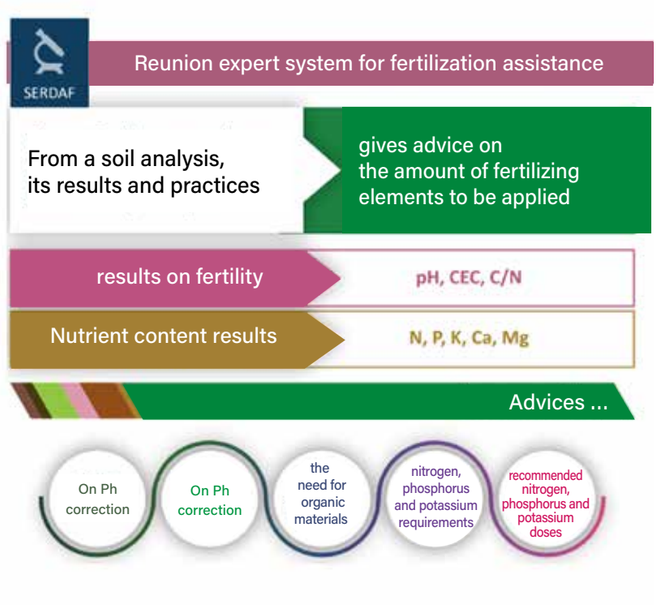
Vladimir BARBET-MASSIN

DECISION SUPPORT AND SYSTEM ASSESSMENT TOOLS

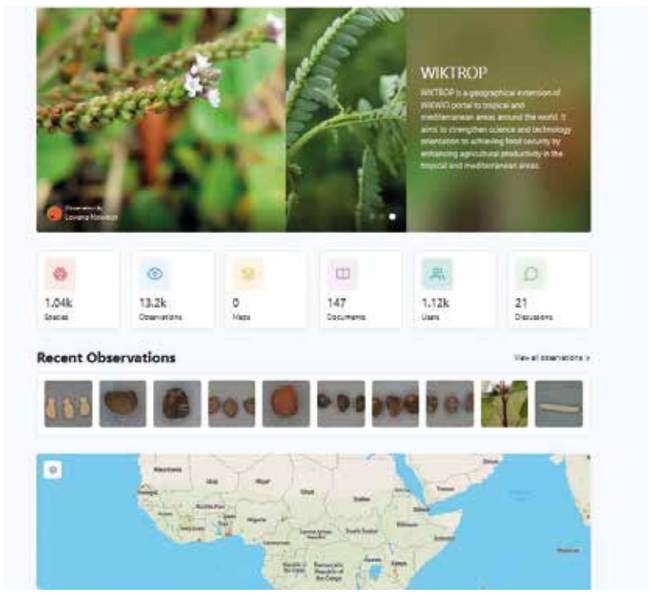
SERDAF

Based on soil analysis, crop plot geolocation and crop yield expectations, the Expert System for Fertilization Support in Réunion (SERDAF) produces an assessment of the nutritional status of target soils. While taking into account the harvesting method and irrigation status of the plot, SERDAF produces recommendations regarding organic matter input, liming and NPK fertilizer doses to be applied at planting and then over the next six ratoons.



WIKTROP

The WIKTROP v2.0 portal aims to build and develop a network of stakeholders to consolidate and share existing scientific and technical knowledge on weeds and weed control in tropical and Mediterranean cropping systems. This portal also offers IDAO software to help in the identification of the main weeds found in tropical and Mediterranean cropping systems.
The WIKTROP platform is available via open access at:
https://portal.wiktrop.org



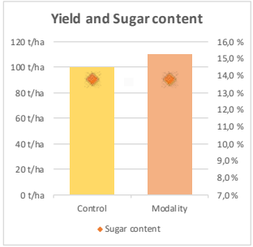
screenshot of the app

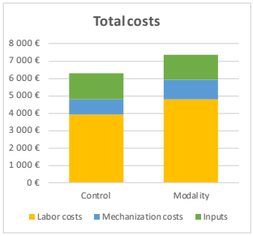
OTECAS

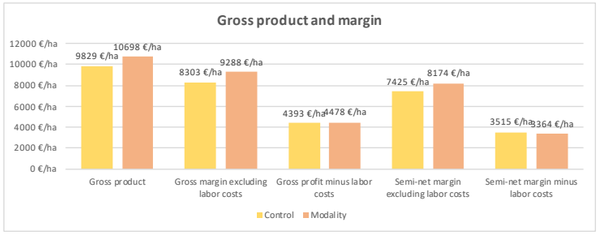
OTECAS is a technical and economic tool focused on sugarcane to support testers, researchers and technicians in Reunion. It is free of charge and available online. It is designed to compare two crop management sequences, one of which is innovative: herbicide treatment reduction, organic matter input, varietal changes, irrigation optimization, etc. The tool is simple and quick to use, and generates tangible economic results (products, mechanization and input costs, labour, gross and semi-net margins, etc.).

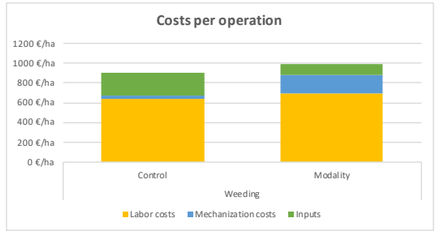
OTECAS
Outil Technico-Économique en Canne À Sucre.

General data				
	Control	Modality	Balance sheet	
Yield	100 t/ha	110 t/ha	10 t/ha	10%
Sugar content	13,8 %	13,8 %	0	0%
Treatment Frequency Index (TFI)	5,27	2,63	-2,63	-50%
Working time	287 h/ha	353 h/ha	66 h/ha	23%
Gross product				
Gross product	9829 €/ha	10698 €/ha	869 €/ha	9%
Inputs				
Total	-1527 €/ha	-1411 €/ha	116 €/ha	8%
Fertilizers/amendments/biostimulants	-1295 €/ha	-1295 €/ha	0 €/ha	0%
Herbicides	-232 €/ha	-116 €/ha	116 €/ha	50%
Water	0 €/ha	0 €/ha	0 €/ha	0%
Other	0 €/ha	0 €/ha	0 €/ha	0%
Labor costs				
Total	-3910 €/ha	-4810 €/ha	-900 €/ha	-23%
Gross margin				
Gross margin excluding labor costs	8303 €/ha	9288 €/ha	985 €/ha	12%
Gross margin per hour of work	29 €/h	26 €/h	-3 €/h	-9%
Gross profit minus labor costs	4393 €/ha	4478 €/ha	85 €/ha	2%
Mechanization costs				
Total	-877 €/ha	-1113 €/ha	-236 €/ha	-27%
Semi-net margin				
Semi-net margin excluding labor costs	7425 €/ha	8174 €/ha	749 €/ha	10%
Semi-net margin per hour worked	26 €/h	23 €/h	-3 €/h	-11%
Semi-net margin minus labor costs	3515 €/ha	3364 €/ha	-151 €/ha	-4%









Screenshot of the econnomic results on the app

PLANT'ASSO

Plant'Asso is a French mobile application tool that compiles all data and experiments on the use of service plants in the agricultural sector in French overseas departments. The main information is summarized in technical factsheets for growers, highlighting the benefits and drawbacks of plant associations, contraindications and advice on the establishment and management of service plants. Over time, Plant'Asso will progress and be enhanced with new knowledge acquired by field operators (technicians, farmers, engineers and researchers).

Plant'Asso is available via open access on the RITA InterDom COATIS platform:
https://coatis.rita-dom.fr/plantasso/

Canavalia ensiformis

Jack bean
Sugarcane

Reunion Island
Sainte-Marie

Service Plant characteristics

Fabaceae
Exotic
Annual
Priority service: Weed management
Secondary services:
Biological and chemical soil fertility
TKW: 2190 g
Root system: Shallow tap root system
aboveground biomasse: semi-erected

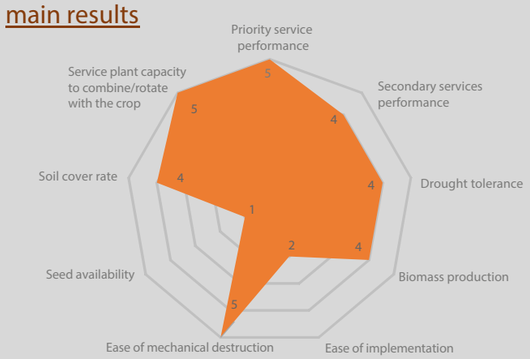
Crop management technique

Seeding rate: 146 kg/ha
Number of plants: 33 300/ha
Sowing date: 04/09/2018
Sowing depth: 2 cm
Crop system: combined
Irrigation system: spray

Environment

Altitude: 50 m
Soil pH: 5.5
Soil type: Ferralitic

main results



Service Plant data

DM biomass:
3.5 t/ha

Service Plant
Fertilisation: none

Germination
rate: 100%

Positives

- Extensive cover capacity
- Dies in the inter-row shade
- Not so sensitive to pests/diseases
- High nitrogen content
- Can be used as food
- Drought-resistant

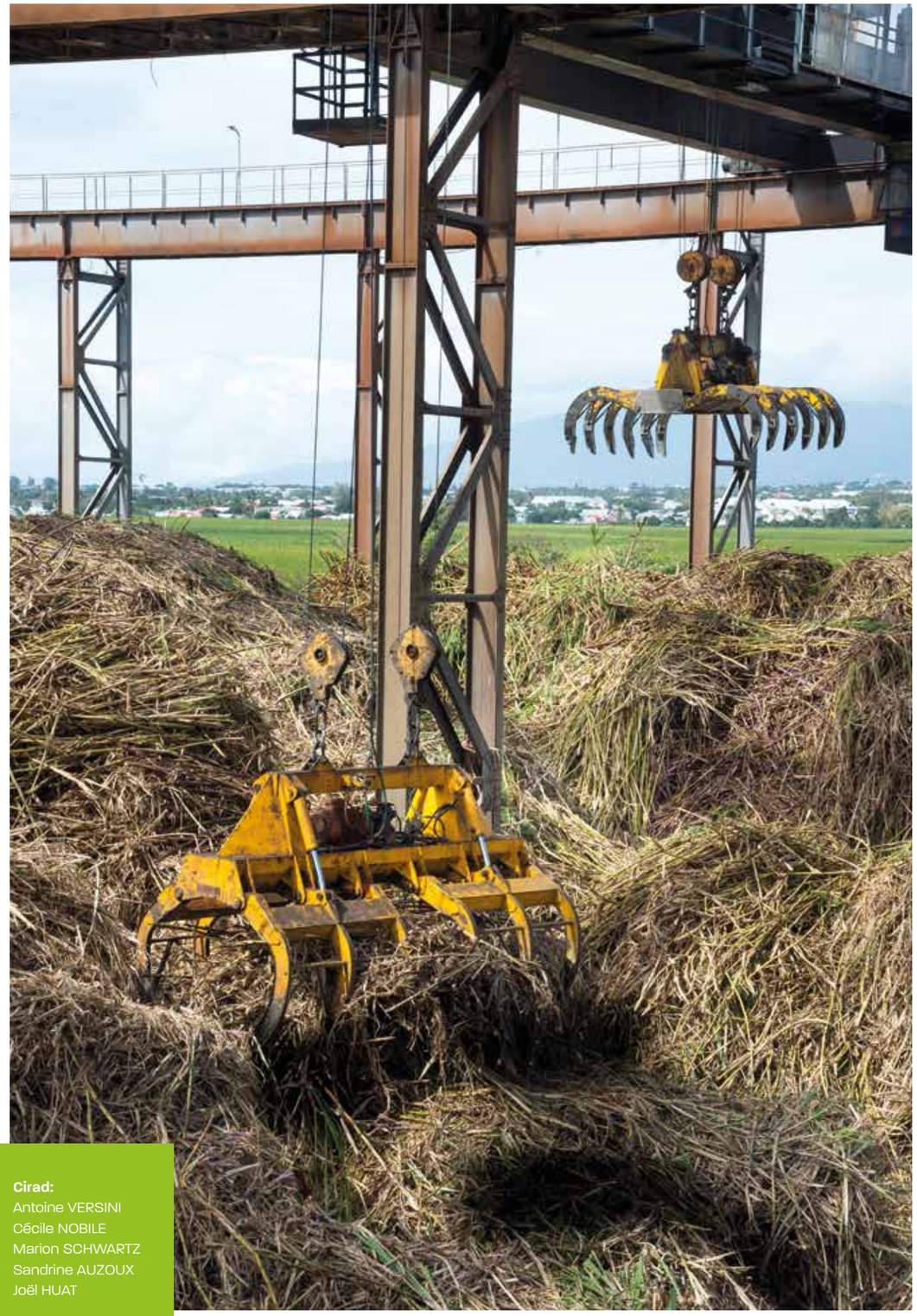
Negatives

- High TKW
- Almost no seed availability

Recommendation

Sow along 2 inter-row sugarcane lines, 45 days after ratooning or 70 days after planting

Plant'Asso factsheet on Canavalia ensiformis



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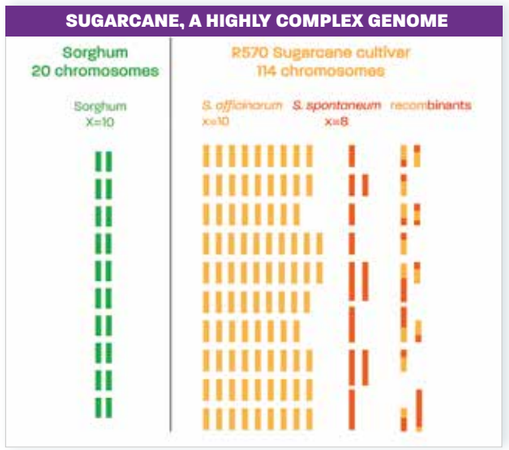
A NEW ERA FOR SUGARCANE BREEDING

SUGARCANE, A HIGHLY COMPLEX GENOME



SUGARCANE GENOME FINALLY SEQUENCED AND ASSEMBLED

Sugarcane was the last major crop to have its genome sequenced and assembled, due to the huge complexity of its genome. This complexity results from its interspecific origin and polyploidy: each chromosome is present in 10 to 12 copies, with a total of more than 100 chromosomes. In 2018, an international team coordinated by Cirad achieved this milestone in producing the first reference sequence assembly of the sugarcane genome. Sugarcane geneticists will now benefit from modern molecular tools to untangle the complex genetics and origin of sugarcane and initiate molecular breeding strategies.

A NOVEL AND ORIGINAL SEQUENCING STRATEGY

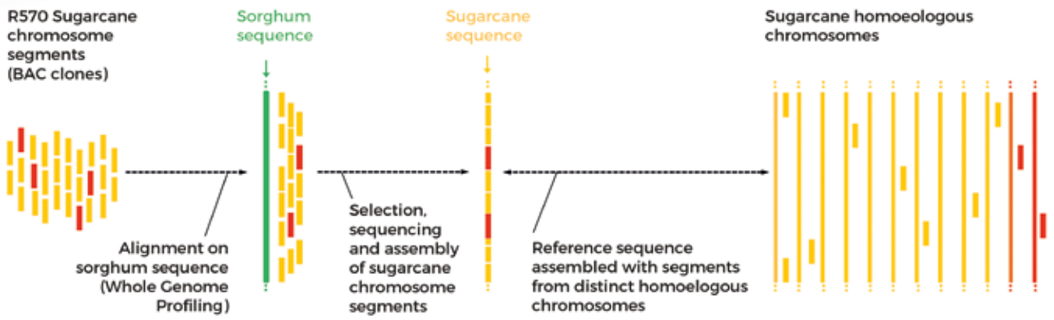
The sugarcane genome is so complex that conventional sequencing methods have proved ineffective. Cirad researchers took up the gauntlet using a novel and original sequencing strategy based on a previous discovery: sugarcane and sorghum genomes have a similar organization, with large collinear chromosome segments bearing numerous genes occurring in the same order. The available sorghum genome was thus used as a template to select and sequence around 5,000 sugarcane chromosome segments. Thanks to this original strategy, a reference sugarcane genome was assembled from the well-known cultivar R570, a hybrid created by eRcane in Reunion Island. A new version of the R570 genome assembly including all chromosome copies is underway in collaboration with the Joint Genome Institute (USA). This cultivar has broad adaptability and is still used as genitor in many breeding stations worldwide.

A KEY STAGE TO INITIATE MOLECULAR BREEDING STRATEGIES

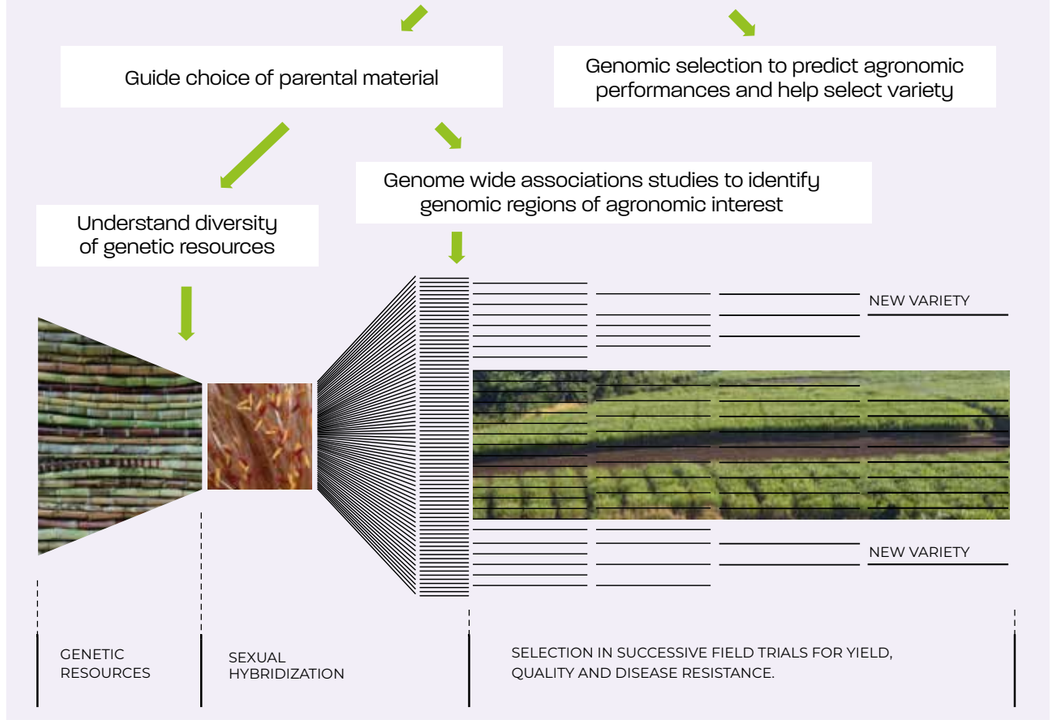
This reference sequence is an invaluable stepping-stone toward developing molecular assisted breeding to speed up genetic progress. It will allow the development of genome-wide molecular marker strategies based on single nucleotide polymorphism (SNP) to:

- understand the genome structure and the diversity of sugarcane genetic resources and guide their use in breeding programs;
- identify genes or chromosome regions involved in important agronomic traits (disease resistance, quality, yield, etc) and keep track of their incorporation in breeding materials;
- develop genomic predictions of agronomic performance, in order to supplement field trials with genomic selection to speed up genetic progress.

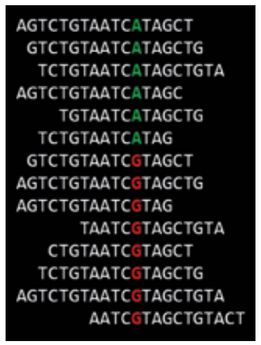
SEQUENCING STRATEGY BASED ON THE OVERALL COLLINEARITY CONSERVATION BETWEEN SUGARCANE AND SORGHUM

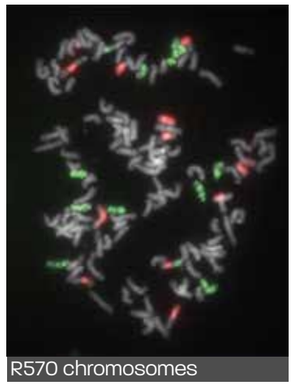


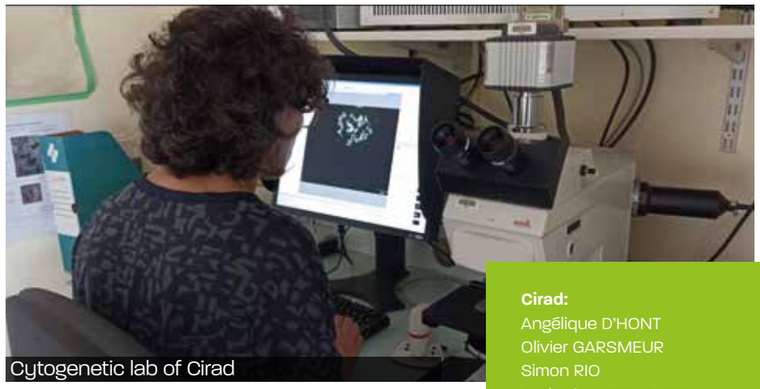
PERSPECTIVES OF GENOME WIDE MOLECULAR MARKER APPLICATIONS IN SUPPORT TO BREEDING PROGRAM




Genotyping lab of Cirad




R570 chromosomes


Cytogenetic lab of Cirad

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Jean-Yves HOARAU

ERCANE'S EXPERIMENTAL NETWORK

In Reunion Island, sugarcane is grown from sea level to an attitude of 1000 m. At altitude, temperatures can drop to 10°C in winter, and reach 35°C on the coast in summer. The west coast is dry with less than 500mm of rain, whereas the east coast is per-humid with more than 5000 mm of rain. Finally, soils are also highly contrasted: from recent volcanic to ferralitic soils, and from deep to shallow rocky soils. To be able to breed sugarcane with a specific adaptation to the different conditions of growing, eRcane has developed a multi-local selection network.

HYBRIDIZATION

eRcane's collection is composed of around 1000 genitors (60% of local R varieties, 40% of foreign varieties), enabling 2000 targeted crosses to be made every year. Each year, 100 000 new clones are created through conventional hybridization to start the selection program.

Hybridization lantern

Seedlings rearing

MULTILOCAL SELECTION PROGRAM

The new clones are tested through a breeding program composed of 5 selection stages that are implemented in seven experimental stations across the Island. The location of the stations was defined to be representative of the island's contrasted ecology.

Around 15 000 seedlings from specific crosses are planted per year in each station. This multi-local strategy has proven relevant and efficient with the registration of sugarcane varieties revealing their own potential in their specific area of adaptation (R 582, R 583, R 584, R 585, R 586, R 587 and R 588).

The key selection criteria are: sugarcane tonnage, sugar content, economic index, ratooning ability and disease resistance (Brown and orange rust, smut, leaf scald and gumming).

To improve certain criteria such as hardiness, resistance to stress and dry matter content, wild genetic resources are used in a specific program. The high level of resistance to local diseases has been instrumental in keeping the field in excellent sanitary conditions.

PARTNERSHIP WITH FARMERS

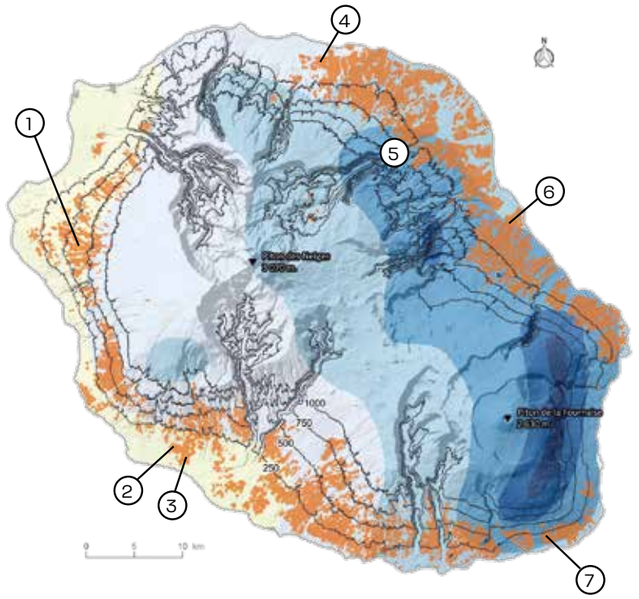
Partnerships with farmers are also strategic for eRcane and are developed on two levels:

- Final selection stages can be planted in farmers' fields, to specify the adaptation zone of the varieties in more contrasting conditions than in eRcane's stations
- Pre-industrial trials are also conducted in eRcane's partners' fields, to multiply the varieties before the release. These trials are also a way to train extension technicians and growers about new varieties.

More than 50 Reunionese farmers make up eRcane's network of partners.

Weighing of a variety trial

SELECTION PROGRAMS LOCATED IN MAJOR GROWING ZONES



Average annual rainfall (m):

1. **VUE-BELLE**
   Dry high lands
   Andic brown
   Deep soil
2. **ETANG-SALÉ**
   Irrigated dry coastal zone
   Fine alluvium
   Deep soil, no stones, slightly hydromorph
3. **LE GOL**
   Irrigated, coastal zone, water stress
   Fine alluvium
   Deep soil, no stones, slightly hydromorph
4. **LA MARE**
   Humid coastal zone
   Ferralitic
   Deep soil, few stones
5. **MENCIOL**
   Per-humid high lands
   Andosol
   Shallow soil
6. **BEAUFONDS**
   Per-humid coastal zone
   Andic brown
   Rocky shallow soil
7. **BARIL**
   Per-humid coastal zone
   Andosol
   Recent volcanic and rocky soil

Contour line at 250, 500, 750 and 1000m

Area under cane

Average annual rainfall (m):

0.0-1.0 | 1.0-2.0 | 2.0 -4.0 | 40-7.0 | 40-7.0 | > 10.0

Cirad / eRcane · 2023

eRcane:
Laurent BARAU
Thomas DUMONT
Mathilde MELLIN

AGROECOLOGICAL MANAGEMENT OF SUGARCANE PESTS

Agroecological management of sugarcane pests is going to play a key role in pest control solutions. This control strategy appears more complicated to implement in the field, as agroecology is based on fine knowledge of ecological processes (e.g. pest-crop-natural enemy interactions), and of how agricultural and environmental factors influence population dynamics. Here are some examples of what could be done to control insect pests, which cause 10 to 30% of crop losses, depending on infestation levels.

MANAGEMENT OF THE STEM BORER

Erianthus arundinaceus: a trap crop for the spotted sugarcane stem borer

Using trap crops is an agroecological protection strategy for regulating populations of sugarcane stem borers.
The grass *Erianthus arundinaceum* is a close relative of sugarcane. The females of the spotted sugarcane stem borer *Chilo sacchariphagus* prefer to lay their eggs on *E. arundinaceum* rather than on sugarcane, while the survival of the larvae on that grass is very low. Studies on Reunion island have shown that planting a row of Erianthus around sugarcane plots reduces damage in the cane.

Nitrogen and silicon are key elements affecting borer infestation

Recent studies on three borer species, *Eldana saccharina* (Ivory Coast, Senegal, South Africa) *Diatraea* spp. (Argentina and Panama) and *Chilo sacchariphagus* (Indonesia) have shown that these pests are very sensitive to silicon and nitrogen contents in the plant. For example, using silicon-based products in our experiments significantly reduced borer damage levels by up to 50%, confirming the positive effect of silicon as a physical barrier to borer penetration. On the other hand, excessive nitrogen rates applied to the soil led to a reverse situation, attracting borer populations and increasing damage. Over-application of nitrogen is common in sugarcane growing and it is essential to conduct soil analyses to check nitrogen levels in the soil before applying this fertilizer.

KNOWLEDGE OF FUNCTIONAL BIODIVERSITY IN CANE FIELDS

As part of the Sustainable Territory project, data are being collected on arthropod fauna present in cane fields, thanks to a trapping device, installed on several sites in Petite-île (South of Reunion Island).
Predators and parasitoids involved in the biocontrol of cane pests, including stem borers, will be studied in terms of richness and abundance, in relation to cultural practices and crop diversification.

BIOCONTROL OF THE WHITE GRUB

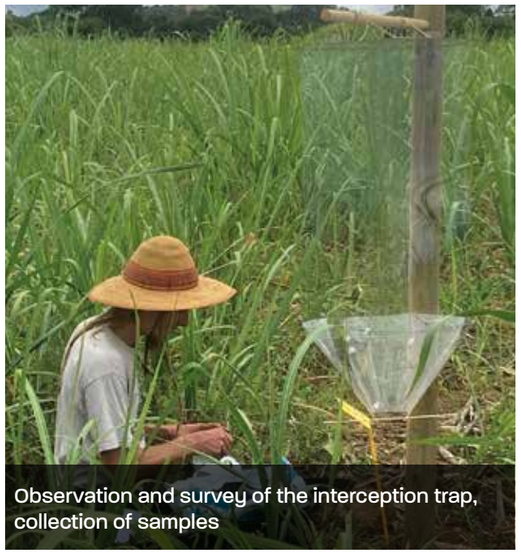
Tracking a myco-insecticide in the field

The persistence and diffusion of myco-insecticides in agroecosystems are poorly known. Cirad Reunion has been developed to describe the genetic diversity of a commercial strain of the fungus *Beauveria hoplocheli* and keep track of fungus populations in the soil. This entomopathogenic fungus was introduced on Reunion Island and used throughout the sugarcane growing area for 30 years to control the white grub *Hoplochelus marginalis*. The work at Cirad Reunion involved spatio-temporal monitoring of the myco-insecticide in sugarcane fields over successive sugarcane crop cycles, providing key information on the durability of this biological control strategy.

The sugarcane white grub, *Hoplochelus marginalis*

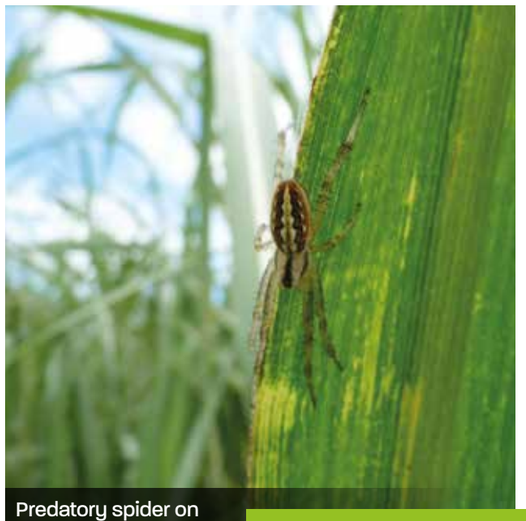
White grub *Hoplochelus marginalis* mummified by the entomopathogenic fungus *Beauveria hoplocheli*

Pitfall trap (Barber pot) for the capture of crawling insects. The stone prevents the plastic shelter from flying away



Observation and survey of the interception trap, collection of samples

Ladybug aphid predator - *Cheilomenes sulphurea* in Congo



Predatory spider on cane leaf - *Neoscona moreli* in Reunion

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Laurent COSTET
Samuel NIBOUCHE
François-Régis GOEBEL

SPATIAL INFORMATION ANALYSIS FOR DECISION SUPPORT

LAND USE MAPPING

Access to Earth observation satellite images has increased in recent years: since 2013, NASA has been releasing images acquired by Landsat satellites free of charge, the French National Space Agency (CNES) provides access to very high spatial resolution images of Reunion Island, and the European Space Agency (ESA) launched the Sentinel-2 optical satellites into orbit in 2015 and 2017. The short revisit time of these satellites makes it possible to monitor crop growth, but also to partially overcome cloud cover in the tropics. Image processing software is also developing, and free remote sensing tools are constantly improving.

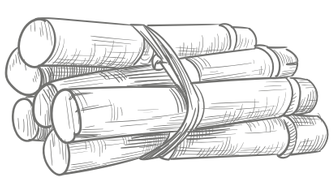
Cirad is working on developing land use mapping methods adapted to the specific conditions of southern countries: high within-field variability, small field size, presence of fallow land, associated crops, agroforest, etc. The Moringa processing chain was tested in the Reunion Island agricultural conditions, including both large fields (for major crops, such as sugarcane and grasslands) and small fields (for orchards and market gardening).

The relief of the island is also a key factor, since crops are arranged depending on the altitude, and mountains tend to retain clouds, masking part of the territory. Using data from the French National Institute of Geographic and Forest Information, a SPOT 6/7 or a Pléiades image, and Sentinel-2 or Landsat-8 images, land cover maps have been produced since 2016 to identify and map crops in Reunion. The Moringa chain is also being tested in Madagascar, Burkina Faso, Brazil, and Cambodia.

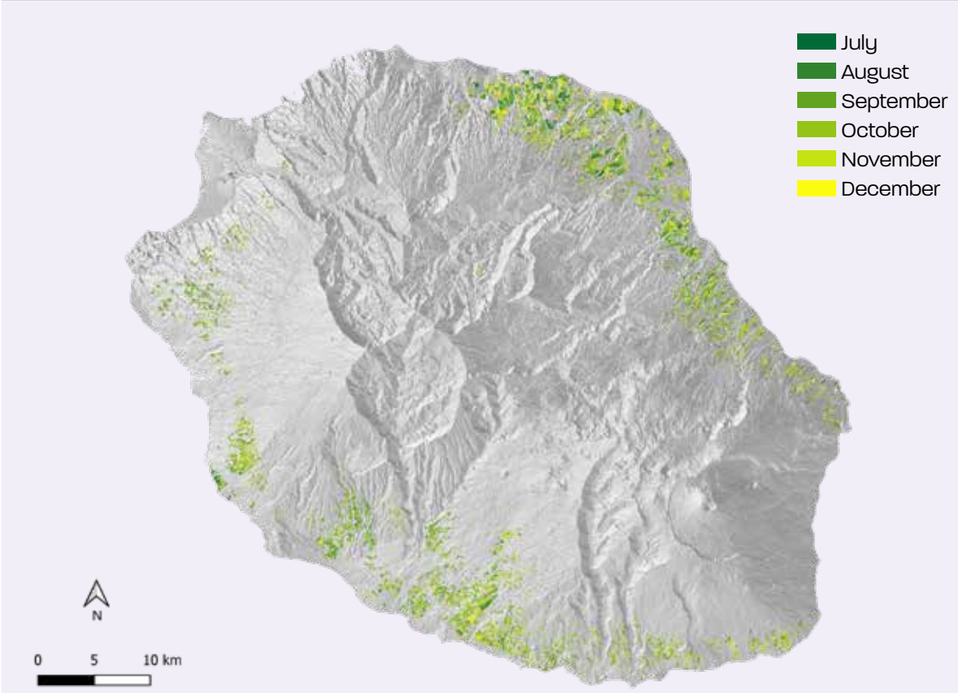
MASH: REAL TIME SUGARCANE HARVEST PROGRESS MAPS

In countries where sugarcane is grown by thousands of small farmers, i.e. in most producing countries, knowing the harvested sugarcane area and the unharvested area in near real time is an impossible task. However, this information is crucial for adjusting crop forecasts, and for the operation and the cash flow of sugar mills, human resources and harvesting logistics. A Cirad research team specializing in spatial information analysis developed a sugarcane harvest mapping method based on free images from European Sentinel satellites. With systematic acquisitions of the continental surface every 5 to 12 days, these allow near real-time detection of harvested areas and the production of synthetic harvest maps showing harvested fields and still standing cane fields throughout the 5 months of the campaign.

These maps are produced by an automated processing chain that downloads the relevant satellite images each day. It combines both the optical images of Sentinel-2 satellites and the radar images of Sentinel-1 satellites, which can see through clouds, even at night. The algorithm has been used in particular to monitor the harvesting of sugarcane areas in Thailand (400,000 ha) and South Africa (120,000 ha). It is currently used in La Réunion (24,000 ha), and is being deployed by the start-up GeoWatch Labs to implement it on a very large scale for its clients.

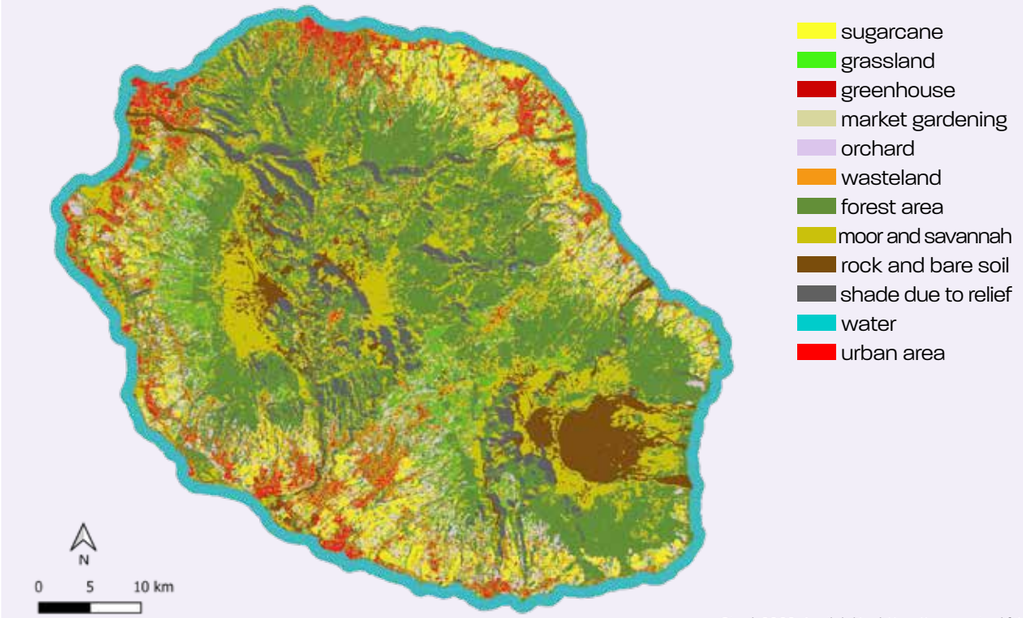


HARVEST DATE OF SUGARCANE FIELDS IN REUNION ISLAND DURING THE 2018 CAMPAIGN



Cirad 2019 Base map: BD Topo IGN 2019

2021 REUNION ISLAND LAND USE MAP



source: Cirad, 2022. Availability: https://aware.cirad.fr/

MODELING THE VARIABILITY OF SUGARCANE YIELD IN CURRENT AND FUTURE CLIMATES

Crop models can help understand and predict the effects of climate, soil, and management on crop growth and yield.

In particular, yield gap analysis based on differences between several types of yields - potential, water-limited or actual - provides a basis for identifying the main factors affecting crop yields.

This analysis provides information to guide the interventions of producers, researchers, and public bodies.

In Reunion Island, modeling studies are underway at Cirad and eRcane to understand and quantify the spatial and temporal variability of sugarcane yield gap differences.

Particular attention is paid to the influence of extreme events (cyclones, intense droughts) on sugarcane yields and how climate change will influence yields in the future.

These analyses make it possible to foresee the necessary adaptations for crop management to maintain production, particularly irrigation management.

PREDICTION OF SUGARCANE YIELD BY REMOTE SENSING

Yield forecasting is both crucial to optimize harvest conditions, and therefore producers' incomes, anticipate the risks of food shortages, develop import and marketing strategies, and difficult because there is no universal solution applicable to all scales, all crops and in all socio-economic contexts.

Predicting production by expertise at the level of each plot or farm is unreliable and often too expensive. Satellite imagery is a very accessible source of information today, and harvest forecasting one of the most widespread applications.

Cirad has developed a yield prediction method of sugarcane fields based on the normalized difference vegetation index (NDVI) estimated from Sentinel-2 free optical satellite images.

A calibration equation was established between the NDVI value measured 1 month before harvest by satellite images and the yield of the field at harvest. Calibrated from 120 reference plots, with different cane varieties and in different climates, it is nevertheless not very precise (error of about 20% at the scale of the field). This is why we use it to predict 1- the expected yield variation between the upcoming harvest and the previous harvest: this approach removes systematic errors from the equation, and 2- yield at more aggregated levels: the production basin, or the territory.
In Reunion Island, the errors found are 5% and 1.5% respectively.

SPATIAL GHG BALANCE OF LAND USES AND LAND USE CHANGES

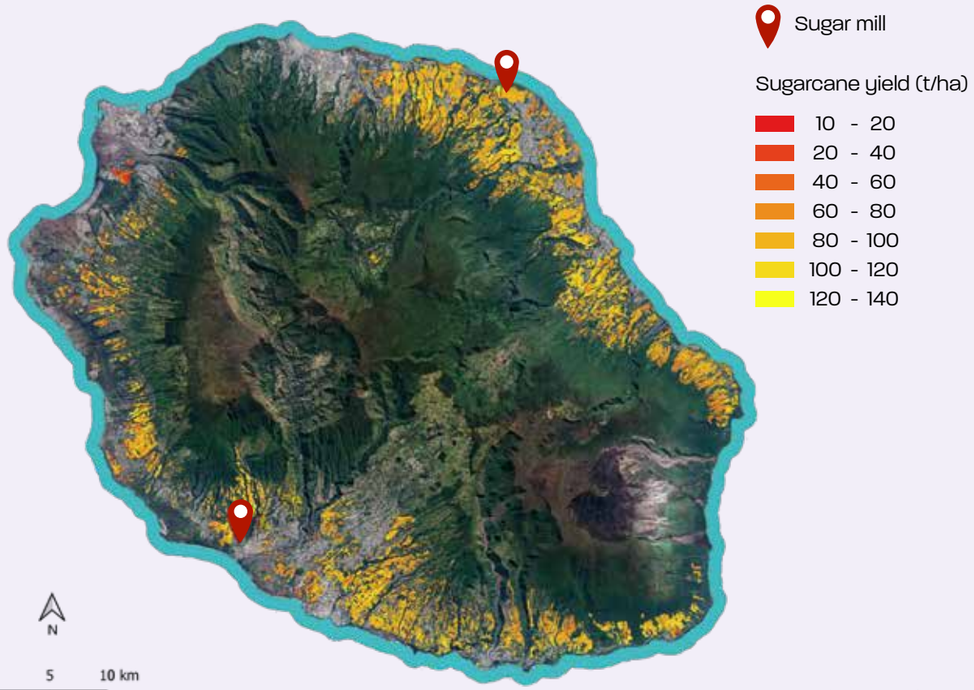
Globally, agriculture and land-use change produce 23% of total anthropogenic greenhouse gas (GHG) emissions. They are therefore major elements in the development of climate change mitigation strategies of countries that signed international agreements on climate change, and in particular in the calculation of Nationally Determined Contributions (NDCs).

To make the use of GHG balance calculators for uses or land use planning projects more accessible to decision-makers, while adapting them to tropical territories and their geographical heterogeneity, we developed a spatialized "turnkey" tool that implements IPCC guidelines to carry out a GHG balance in these territories with contrasting pedoclimatic conditions.

Based on FAO's EX-ACT calculator, our tool uses the current land use map of a territory, and a specific calibration of the model for that territory. To this end, we developed fast and inexpensive methods for estimating the values of the model's territory specific parameters (e.g. soil carbon stocks) using innovative measurement methods such as infrared spectroscopy, or spatial analysis.

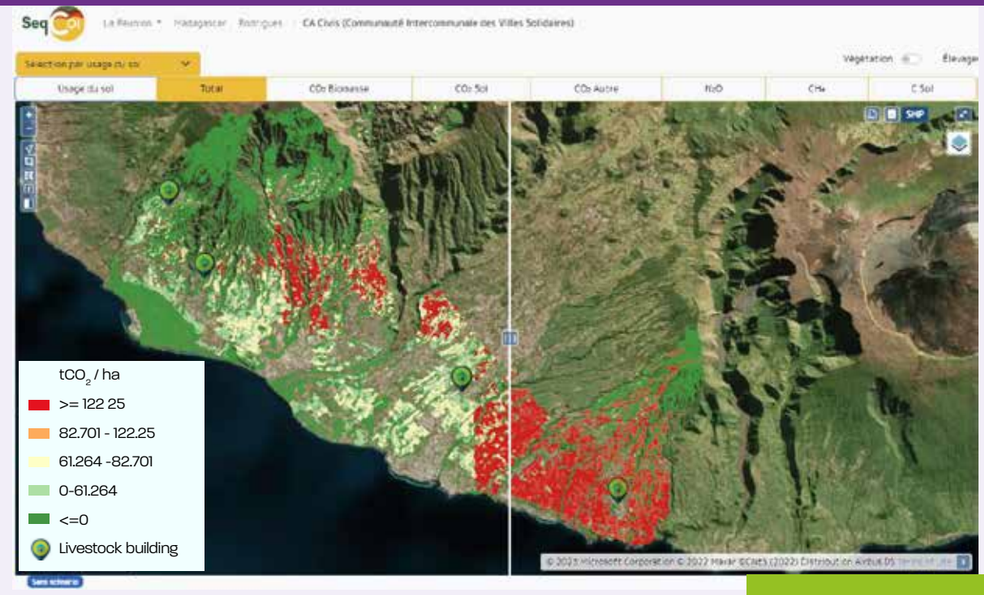
From the calculator's webmapping interface, the user can estimate the current GHG balance of the territory or of each of its land use geographical entity, in the different compartments of the balance, and by type of GHG. The user can actually easily define, with the mouse on the land use map, a scenario of land use changes, and evaluate with one click their impact on the GHG balance.

SUGARCANE PREDICTED YIELD FOR THE 2020 HARVEST



Source: https://smartis.re/SEQCOI

GHG BALANCE WEB APPLICATION



GHG balance web application interface, showing the GHG fluxes of land uses without (on the right) and with (on the left) a land use changes scenario, in the south of Reunion Island

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Mickaël MEZINO
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LABORATORY, PROCESSING AND AUTOMATION EXPERTISE

A TEAM OF SPECIALISTS DEDICATED TO SUPPORTING THE SUGAR INDUSTRY

eRcane's technologists are available to provide expertise on various topics related to the sugar industry: laboratory, sugar processing, cane quality, automation and biorefinery.

LABORATORY ANALYSES

eRcane's Laboratory, called "Emile Hugot" is equipped with modern devices. All the methods applied comply with International Commission for Uniform Methods of Sugar Analysis standards (ICUMSA). eRcane's service proposal includes:

- Sugar industry sample analysis (based on ICUMSA Methods)
- On-site support and training courses
  - Good laboratory practices
  - Development of lead-free analysis (based on pressure filtration)
  - Methods training
- Inter-laboratory ring test: since 2007, eRcane has undertaken a ring test between sugar processing laboratories around the world. Currently about 20 laboratories are involved in this ring test. Samples of sugars and molasses are sent to the participants and eRcane's team collects, analyses results and sends a report providing advice whenever it is required.

In addition, the "Emile Hugot" laboratory obtained ISO 9001 certification issued by AFNOR in 2019, testifying our commitment to our customers and the rigor of our work.

SUGAR PROCESSING

eRcane's experts may support sugar production worldwide through a wide range of applications:

- On-Site audit of process: Mainly based on sample analyses coupled with mass balance computations on themes such as:

sugar losses, extraction characterization, evaporation (heat balances, fouling characterization), crystallization (masse-cuite exhaustion)

- Tailor-made training sessions: on site or based on study trips in Reunion Island where training stays are split between periods of training, visiting eRcane's facilities and meeting local technicians.

SUGARCANE QUALITY CHARACTERIZATION

eRcane's team has developed specific skills at the border between agronomy and industrial fields: sugarcane quality and its impact on sugar recovery. Usually, sugarcane composition assessment is poorly mastered by technicians. Moreover, agronomy and factory themes are usually clearly split whilst there is a common area in between. Thanks to eRcane's expertise, it is possible to better understand this common field:

- Audits and support to methods dedicated to cane analysis (Wet-Disintegration, Hydraulic press, NIR-Spectroscopy)
- Expertise on sugarcane quality impacts on farmers' revenue and on industrial performance
- Sugarcane quality training.

BIOREFINERY AND INNOVATION

The Industrial Processes and Innovations Department conducts various R&D programs, factors of innovation in the sector. These programs focus on the adaptation or development of analytical methods adapted to all cane products, and the creation of new products.

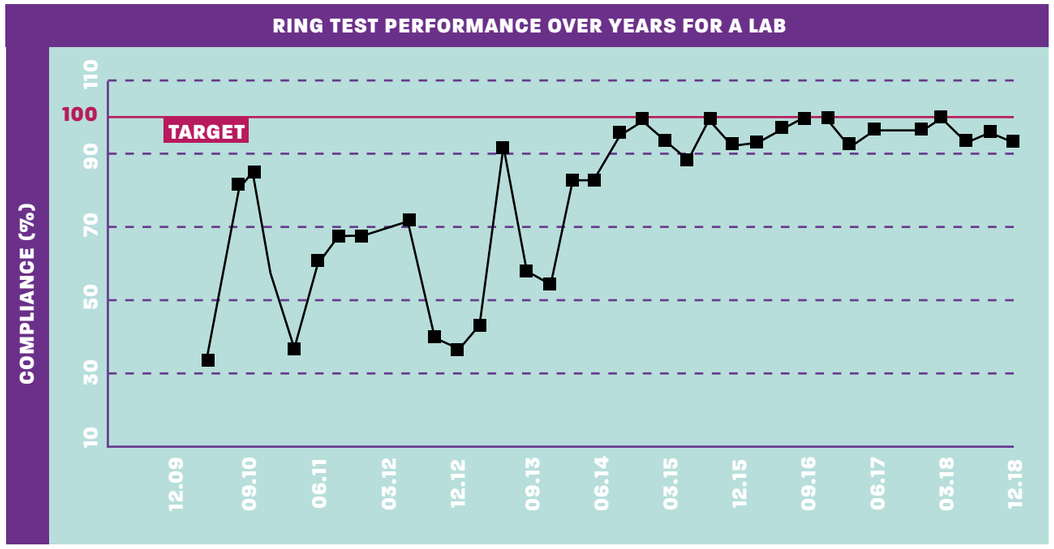
INDUSTRIAL AUTOMATION AND ELECTRONICS

Created in 1973, this department of eRcane launched the automation revolution in the Reunionese sugar industry. The Reunionese sugar process is optimized with reliable and consistent automation systems while reducing operators' workloads.

This expertise relies on the ABB Digital Control System (DCS) and ranges from feasibility studies to program design, implementation and includes staff training before on-site installation.
Specific transmitters dedicated to the sugar industry are also manufactured by eRcane's specialists (Donelly chute level transmitters, conductivity meters, etc.)

THEY TRUSTED US

For more than 30 years, eRcane's expertise has been mainly developed in the French Caribbean and west Africa, and recently in TPC in Tanzania, Fuel in Mauritius, Mex-Sugar in Mexico, Guarani in Brazil, and Grays Distilling in Mauritius.



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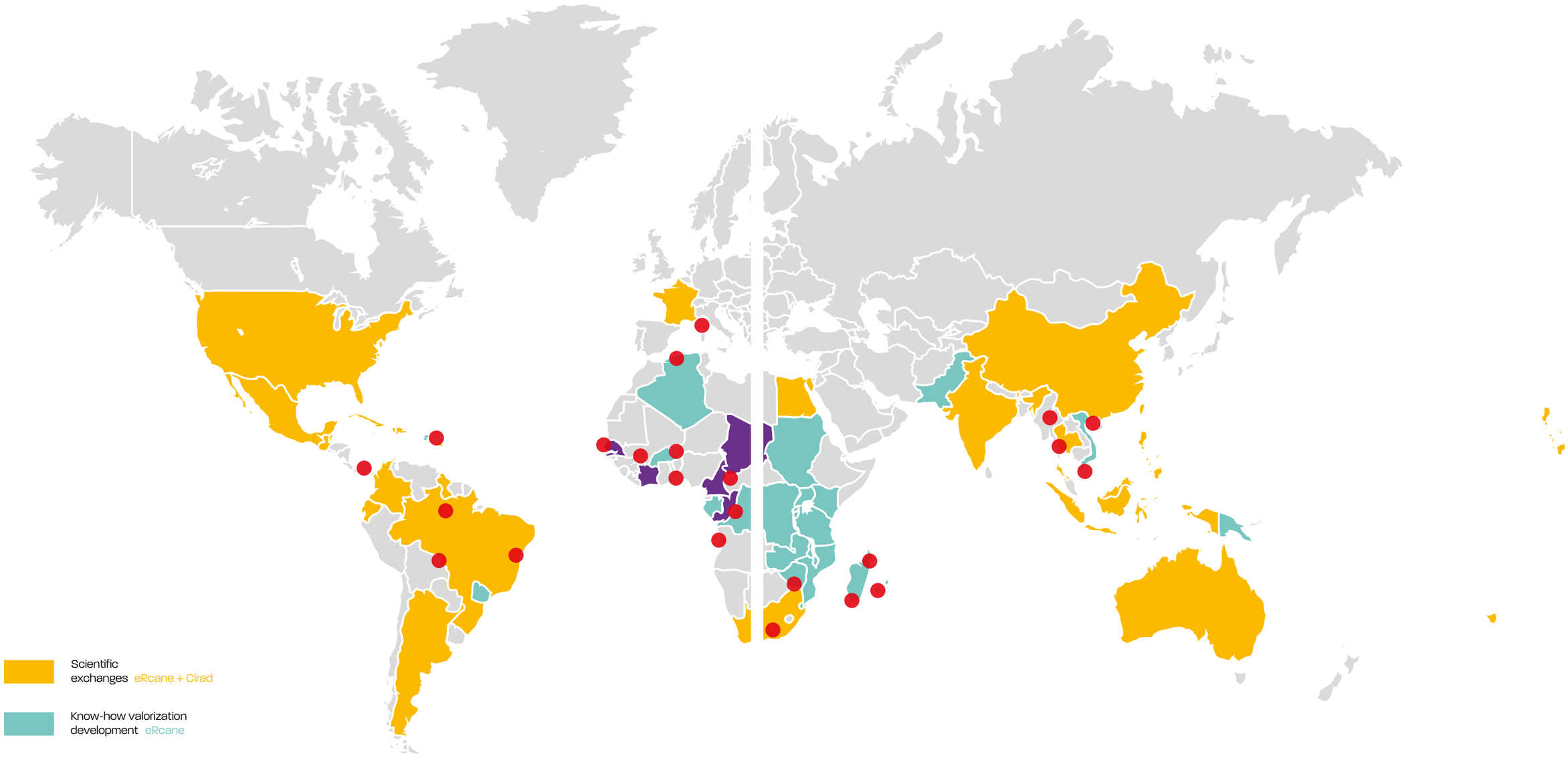
Serge HOAREAU
Didier LAMY

ERCANE AND CIRAD
AROUND THE WORLD



Scientific
exchanges eRcane + Cirad

Know-how valorization
development eRcane

Selection from fuzz produced by eRcane
and know-how development

Platforms in partnership
for research and training Cirad
https://www.cirad.fr/en/worldwide/platforms-in-partnership

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

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eRcane is the French sugarcane breeding center located in Reunion Island. Created in 1929, its main objective is to develop sugarcane resources and accelerate the genetic progress worldwide.

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