

# Research and Development Plan 2016-2020

*for a resilient Mauritian cane industry*



**MAURITIUS SUGARCANE INDUSTRY RESEARCH INSTITUTE**

**MAURITIUS CANE INDUSTRY AUTHORITY**



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**Mauritius Sugarcane Industry Research Institute (MSIRI)**  
**Mauritius Cane Industry Authority**

Réduit, Mauritius  
Tel: (230) 454 1061 Fax: (230) 454 1971  
email: [contact@msiri.mu](mailto:contact@msiri.mu)  
<http://www.msiri.mu>

## Research and Development Plan 2016-2020

### CONTEXT

The past decade has witnessed a major transformation of the Mauritian sugar industry into a cane cluster following the European Union (EU) Sugar Regime reform whereby the guaranteed preferential access to the EU, as well as the guaranteed minimum price had been revised with a consequent drop of 36% in sugar prices. The measures taken by industry, in partnership with government, have prompted the industry to re-engineer itself and to maintain its competitiveness. Despite the profound reforms implemented, new challenges have arisen, the most prominent ones being the fluctuating sugar price on the European market and the abolition of internal quotas of sugar on the EU market scheduled for 2017.

In order for the sugar cane sector to prepare itself to meet the challenges of a completely liberalized market, the Ministry of Agro Industry and Food Security commissioned a study on the '*The Economic, Social and Environmental Impact on Mauritius of Abolition of Internal Quotas of Sugar on the EU Market*', which was undertaken by LMC International and the findings were submitted in May 2015.

The LMC International report comprehensively addressed all aspects pertaining to the industry and its functioning, including institutions, one of them being the Mauritius Sugarcane Industry Research Institute (MSIRI), which operates under the aegis of the Mauritius Cane Industry Authority (MCIA) since September 2011.

The MSIRI R&D Committee discussed in-depth the comments made in the report and substantial reform was recommended for R&D to achieve rationalization, research focus and effectiveness so as to lift productivity for a sustainable sugar and co-products industry. Consultations were also held with stakeholders to gather their views.

Stakeholders were unanimous that Research and Development (R&D) is fundamental for increasing productivity and ensuring sustainability. In response to the views for a restructuring of research activities at MSIRI, it is deemed necessary:

- To undertake research strategies that are strongly demand driven by producers and viewed as important in resolving constraints

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- To maintain strong linkages with industry for rapid adoption of new technologies
- To enhance collaboration and partnership with local and international institutions.

The R&D objectives outlined in this 2016-2020 Plan aim at contributing to the long-term sustainability for a resilient Mauritian cane industry and capitalizing on the multi-faceted potential of the sugar cane plant to deliver a multitude of components, either naturally or industrially with limited impact on the environment. The Plan aims at bringing improvements in breeding, cane growing and milling to contribute to industry diversification and profitability taking into account major global challenges such as climate change, emerging diseases and pests, costly energy supply and water scarcity. The use of effective technologies relevant to the sugar cane industry is incorporated in the Plan to keep producers' interest and profitability in cane growing and restrain land abandonment.

### **RESEARCH FOCUS AREAS (RFAs)**

The R&D Plan is distilled into seven themes or Research Focus Areas (RFAs) for a coherent and innovative programme to address areas likely to impact on producers in terms of increasing productivity, cost reduction and having access to services. They are considered essential in solving current and future challenges and each RFA will be implemented by multi-disciplinary teams. The RFAs are:

1. Enhanced variety improvement through plant breeding and biotechnology for new cane varieties with high cane yield and sucrose content
2. Safe phytosanitary status with respect to existing and emerging diseases and pests
3. Improved efficiency of inputs through integrated nutrient management for sustainability
4. Improved production systems to increase yield
5. Valorisation of sugar cane and co-products
6. Services and links with industry for active collaboration
7. Enhanced partnership with research institutions abroad and locally.

### **RFA 1: ENHANCED VARIETY IMPROVEMENT THROUGH PLANT BREEDING, AND BIOTECHNOLOGY FOR NEW CANE VARIETIES WITH HIGH CANE YIELD AND SUCROSE CONTENT**

#### **Targeted outputs**

- ❖ **Higher number of improved varieties released**
- ❖ **Optimally adapted varieties for the local context**
- ❖ **Shortening of selection cycle and fast-tracking of varieties**

#### **Breeding and selection**

Plant breeding, a main driver to increase profitability, holds tangible promises for increasing cane, sugar and biomass yields per unit area and per unit time. The Mauritian sugar cane industry, like other sugar cane industries worldwide, will continue to rely upon variety development in order to realize gains and ensure viability. The development of new and more productive varieties to increase competitiveness is a major thrust of the R&D programme. Coupled with biotechnological advances, sugar cane breeding and selection are set to provide a fast and reliable route for harnessing the

potential of the crop to ensure viability, sustainability and profitability of the sugar cane industry.



The primary objectives are to seek forthcoming varieties with high cane and sugar yield with known sucrose accumulation profile, along with the additional desirable characteristics such as good ratooning ability, rapid and uniform germination and good ground coverage. Varieties with low to shy flowering aptitude will be targeted. Resistance to major diseases remains an essential attribute, particularly for yellow spot in the super-humid zone where there is a lack of varieties because of susceptibility to the disease.

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Emphasis is to be placed on early maturing varieties as well as those for late harvest and for adaptation to the mosaic of local environments, soil types and mechanization, in line with the needs of the industry. The varieties are to be screened through family selection methodology, which is now proven. Varieties will be sought for non-irrigated regions to mitigate the effects of climate change and limited water. Highly promising varieties will be evaluated to major herbicides so that the reaction of the varieties are known prior to release.

Selection for high biomass or enhanced fibre content selection, in view of bioenergy production, will constitute a satellite programme. It is proposed to develop an index for varieties based on their sugar, fibre, or both contents.

Close and active collaboration with sugar estates to lay down trials, assist in monitoring and data collection is envisaged.

National production level, per unit area, is expected to increase when such more productive varieties are exploited in replacement of the older ones. It is considered that one or two superior varieties will be released annually.

The objectives are to be met through the following actions:

- Creation of genetic variation by importing more new parents for evaluation and characterization
- Use of characterized parents with disease resistance attributes
- Utilization of newly selected parents for early ripening and high sucrose issuing from the ACP-Sugar Research Programme (ACP-SRP) to develop precocious varieties
- Construction of an automated photoperiodic treatment glasshouse for artificial induction of flowering in order to induce flowering in shy and non-flowering varieties (provided that funding is available- see project under competitive Grants and funding)
- Annual production and efficient screening of some 50 000 seedlings for the different sectors, encompassing the main agro climatic zones, including some 5000-7000 seedlings for biomass/high fibre
- Import of fuzzi of specific crosses from other breeding stations
- Upgrading of IT systems and adoption of new statistical analysis packages to increase efficiency of data handling, retrieval, analysis and interpretation

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- Adoption of simple, yet robust experimental designs for more efficiency and precision
- Judicious use of the Near Infrared Technology (NIR) to improve the quality, quantity and speed of cane analysis of experimental cane samples and in monitoring the crop throughout the year.

It is envisaged to analyse historical data, available in MSIRI selection databases over several decades, coupled with new statistical approaches, in order to derive more precision on the pertinence of ratoon testing at the early and advanced clonal stages of the selection cycle. Reviewing the relevance of Stage 2 and shortening of Stage 4 are further warranted in an attempt to shorten the selection cycle and gain in efficiency.

The use of ripeners is to be re-evaluated in an attempt to boost sucrose accumulation, particularly in situations such as the adverse climatic conditions that prevailed during the 2015 harvest, with one of the lowest sucrose recovery in history. Application through existing irrigation system or new technology is to be tested.

The application of the system for autonomous unmanned aerial vehicle (UAV) flight and spectral analysis to extract relevant growth parameters and shoot development in the field is envisaged through partnership with other institutions.

To allow rapid multiplication of clean material, tissue culture techniques are to be enhanced so as new varieties are available in sufficient quantity for nurseries.

### **Climate Change**

Climatic conditions such as rainfall, temperature and solar radiation are the main drivers of biomass synthesis and accumulation. On average, temperature has increased over Mauritius by 0.7°C to 1.2°C since 1950 coupled with a decrease in annual rainfall of 63 mm per decade. Global warming is expected to further increase the intensity and frequency of drought in the coastal and low-lying areas. Climate data will be updated to redefine the different climatic zones of the island, and to produce a new agro-climatic map, which would be useful for selection and recommendation of optimally adapted varieties to the various agro-climates.

### **Biotechnology**

The crop improvement programme is to be supported by biotechnological tools such as molecular markers to enhance the efficiency of selection with the view to reduce the time for producing new varieties.

It is expected to complement the conventional variety improvement programme with the application of molecular markers for the following traits: early ripening, high sucrose, resistance to yellow spot disease, resistance to brown rust disease and resistance to *Sugarcane yellow leaf virus*. Clones (about 200-300) having reached the mid stage of selection are to be screened with the markers.

Genomic selection is a new promising activity to be initiated to determine the breeding values of progenies. This strategy represents a holistic approach to selection and promotion of genotypes, whereby individuals with superior estimated agronomic values would be identified early in the breeding cycle and promoted. It is expected that this strategy will allow discarding poor performing varieties early and hence resulting in gain of resources and time. Genomic selection is dependent on the collection of field data of desirable traits from cultivated varieties and germplasm collection and on large volumes of single nucleotide polymorphic (SNP) marker data derived from high throughput DNA profiling systems. The analysis of these data necessitates powerful statistical tools supported by high performance computing (HPC) systems. Partnership will be sought from other local institutions for the service of HPC.

The use of **DNA** fingerprinting in quality control of parental sugar cane clones, in polycrosses, and for the choice of distant parents in order to further bring diversity will continue to be applied for efficient and more precise breeding activities.

Gene editing, a highly promising and new technology will be followed for eventual integration with the objective to address specific problems through precise and targeted modifications in the sugar cane genome.

### **RFA 2: SAFE PHYTOSANITARY STATUS WITH RESPECT TO EXISTING AND EMERGING DISEASES AND PESTS**

#### **Targeted output**

##### **❖ Successful disease and pest management**

The main strategy for the control of the most important diseases of sugar cane in Mauritius, that include gumming, leaf scald, yellow spot, brown rust and smut, remains the use of resistant varieties. Disease resistance trials are to be conducted to provide information on their reaction to the major diseases. In order to prevent introduction of diseases in imported clones, the quarantine facility will be reinforced.

The quarantine system has proved to be efficient in intercepting major pathogen entry such as mosaic. Disease surveillance, nurseries, advice to growers, and diagnostics, aided by the applications of molecular diagnostic tools, are to be improved and enhanced.



For the main pests of sugar cane, research solutions are to be found for their control to supplement current measures, as given in Table 1.

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**Table 1. New control methods to be investigated for pest management**

Pest	Current control measures	Research activities to be investigated
<i>Chilo sacchariphagus</i>	Biological control	Sterile insect technique
<i>Heteronychus licas</i> and <i>Alissonotum piceum</i>	Chemical control	Use of biopesticides, endophyte interactions
<i>Pulvinaria iceryi</i>	Biological control/cultural practices	Effect of host induced plant volatiles (secondary metabolites) to enhance activity of natural enemies
<i>Aulacaspis tegalensis</i>	Biological control/cultural practices	Varietal resistance
<i>Mythimna</i> spp.	Chemical	Enhancement of activity of natural enemies. Use of attractants/deterrents
<i>Tetramoera schistaceana</i>	None	Introduction of parasitoids from Thailand/ South East Asia
<i>Fulmekiola serrata</i>	None	Biological control, studies on varietal characteristics
<i>Numicia dorsalis</i>	None	Biological control, studies on varietal resistance

It is proposed to establish a Biological Control Facility, through external funding, where natural enemies would be reared for release in case of infestations and for introduction of new species.

One of the pre-requisites of a successful pest management programme is the accurate and prompt identification of pests involved. Traditional approaches, including morphological identification are at times uncertain due to close resemblance of species and misidentification may hinder the introduction of more environment-friendly technologies including biopesticides. On the other hand, nucleic acid based techniques are becoming increasingly important for identification of

pests. It is proposed, to further use DNA barcodes for identification and characterisation of the main sugar cane pests in Mauritius and their natural enemies.

### **RFA 3: IMPROVED EFFICIENCY OF INPUTS THROUGH INTEGRATED NUTRIENT AND SUSTAINABILITY**

#### **Expected outputs**

- ❖ **Significant improvement in fertilizer recommendations to avoid any wastage and to improve cost-effectiveness and sustainability**
- ❖ **Integrated nutrient management and cost-effectiveness**

#### **Development of alternatives to the conventional synthetic/mineral fertilizers**

Low nitrogen (N) use efficiency (25-30%) and the high cost of synthetic fertilizers are priority issues. Developing a soil N availability index to predict soil N mineralization potential is to be investigated.

The efficiency of phosphorus (P) use will be investigated so as to fine-tune P fertilizer recommendations by measuring the rate of replenishment of plant-available P from both inorganic and organic phosphorus pools. The potential use of phosphate solubilizing microorganisms to release P will also be explored. A similar approach will also be implemented for potassium.



In order to reduce reliance on conventional synthetic fertilizers, minimize negative environmental impacts and making integrated nutrient management a part of normal practice for sugar cane production, biofertilizers, soil conditioners, growth promoting substances and organic sources of nutrients are to be evaluated. In the light of these investigations, the rates of N, P and K will be amended, if necessary.

## RFA 4: IMPROVED PRODUCTION SYSTEMS TO INCREASE YIELDS

### Targeted output

#### ❖ Improved agricultural management practices

##### Improved Cropping System

The assessment of the Improved Cropping System (ICS) to address the issue of yield decline is to focus on completing on-going trials, promoting seed production of leguminous plants to integrate in the system on an industrial scale, new land clearing and preparation techniques at replanting for reduced tillage. Recommendations are to be made for adoption of the ICS to attain adoption on at least 25% of land area by 2020.



##### Optimizing Production Systems

MSIRI will collaborate with estate agronomists to better master and broaden the adoption of mechanical preparation of planting material. For mechanical harvesting, this will be fine-tuned and in parallel assessed for cane losses *in situ*.

New cane harvesting equipment, if available, will be tested and extended to land that cannot be harvested using conventional harvesters. The ultimate objective is to develop a cropping system for mechanizing harvest in small planters' fields and in difficult areas. The collaboration of sugar estates and other partners will be sought to pool resources for such investigations.

### **Management of weeds: development and recommendation of management practices and pre-emergence herbicide treatments including herbigation**

MSIRI has been actively involved in finding effective means of controlling weeds in sugar cane fields and this will be reinforced with available new technologies (e.g. new herbicide molecules, application systems) and biological control. Investigations will be conducted to determine whether certain weed species are developing resistance to currently used herbicides in order to tackle any such phenomenon.

Studies carried out on the biology and ecology of vine weeds have enabled a better understanding of the problem in sugarcane fields. The main outcome of these studies is that development and recommendation of management practices will have to be based on new approaches such as herbigation and drenching. A review of the post-harvest trash management practices, particularly in Green Cane Trash Blanketing fields, is warranted to alter the prevailing agro-ecological conditions that favour the development of vine weeds. In addition, new herbicide application technologies are to be introduced to make the control of vine weeds more effective, particularly through the use of higher volumes of water.

### **Developing an Expert Weed Management System (integrating WIKWIO)**

An expert Weed Management System to facilitate sugar cane growers in optimizing their herbicide applications, by taking into consideration various agronomic and environmental parameters, is to be developed. This will be in the form of a user-friendly application integrating acquired wide knowledge and experience on weed control. It will also include the vast information acquired on weeds and their identification under the Weed Identification and Knowledge in the Western Indian Ocean (WIKWIO) project.

### **Environment and sustainability**

Adoption of best crop management practices meeting requirements such as Fair Trade will be a priority. Herbicides not authorized in EU will be phased out gradually so that the industry can meet regulatory norms. A particular focus will be placed on awareness of growers for a more rational and judicious use of herbicides.

Studies will be undertaken to assess varieties that require less water in the context of climate change where less rainfall and higher temperatures are expected.

Abandoned land accounts for over 9000 ha. GIS tools and ground-truthing surveys will be undertaken to map the areas of land abandonment. The map could then be used, as a means for decision-making and with appropriate policies, for reversion to cane cultivation.

### **Soil health and yield decline**

Development of local soil health indicators, for use as a basis for soil health and plant health management, will be investigated to take into account yield decline, and decrease in the productive capacity of sugar cane soils. Whereas classical soil tests look mainly at soil chemical attributes, soil functional state (soil health) integrates physical, chemical, and biological properties and processes. The ultimate goal is to develop management practices to address soil depletion and yield decline through the development of soil health indicators and establishment of target values and thresholds.

### **Green manuring**

As part of the development of the Improved Cropping System (ICS) and making legume green manuring an integral part of the ICS, identification of constraints to adopt legume green manuring will be identified in order to propose appropriate solutions and recommendations.**upport and technologies to assist the industry in better managing the crop**

It is proposed to use remote sensing/GIS with UAV technology to develop applications for crop monitoring, e.g. nutrient status, weed infestation, water-stress, gappiness, yield forecasting, harvest monitoring, diseases and pests. The appropriateness of such technology will be evaluated.

### **RFA 5: VALORISATION OF SUGAR CANE AND CO-PRODUCTS TO BRING ADDITIONAL RESOURCES**

#### **Targeted output**

##### **❖ Increased revenue for the industry**

Evaluation of different types of canes for various end uses such as juice quality, rum quality and direct consumption of floral parts (*Saccharum edule*) as a means of bringing value addition.

Three research proposals have been accepted for support under the Collaborative Research and Innovative Grant Scheme (CRIGS) under the Mauritius Research Council. The technical aspects of converting cane trash to energy is being undertaken to study the system of collection, transport and processing. Trash removal is also under investigation to determine any negative impact on agronomic aspects and soil properties.

The two other research projects will look at the valorisation of Mauritian sugars and are also being supported for the period 2016-2017 at the tune of some 10 million Mauritian rupees.

Bioplastics have been produced from trash at laboratory level in a project of the ACP-Sugar Research Programme. Pilot scale-up of production will be investigated provided funding is secured. Other utilisation of by-products, such as cane fibre utilisation will be studied in case collaborative projects become available.



In collaboration with sugar estates, MSIRI will participate in enabling the production of premium quality sugars to generate additional revenues, and for this purpose, high quality cane would have to be sent to the mill.

## RFA 6: SERVICES AND LINKS WITH INDUSTRY FOR ACTIVE COLLABORATION

### Expected output

#### ❖ Improved interaction with industry for solutions

#### Infrastructure

During the last five years, through the ACP Sugar Research Programme (2010-2015), the Institute has built up its infrastructure. More specifically a full-fledged international quarantine station is available and tools for molecular diagnostics, molecular breeding and analytical instruments (NIR cane analysis, GC-MS, LC-MS) have been acquired. The up to date operating environment will be a plus for services to be provided to the industry. It is expected that with additional investment in new infrastructure such as an automated greenhouse for inducing flowering and acquisition of state-of-the-art equipment, including NIR/MIR, the research activities

could be enhanced to better meet the needs of the industry. MSIRI will also strive to equip itself to mechanically harvest its trials.



#### Monitoring and improving sugar factory/refinery performance

The Institute will provide support to the mills in conducting laboratory experimentation for the replacement of lead acetate for repeatability tests on juice and molasses. Alternative methods for juice preservation will be evaluated to replace mercuric iodide.

Support will also be given for process optimization in sugar factories and refineries by conducting technical audits of factory processing performance through mass/energy balance as well as process improvements with respect to sucrose recovery and energy optimization.

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It is proposed to investigate the effect of harvest to mill delays on sugar processing so that measures could be taken to improve cane quality.

MSIRI will continue to provide analytical services for heavy metals, pesticides and microorganisms in sugar and water to the industry and act as a certification body to meet the stringent quality standards.

### **Development of spectral analytical methods as diagnostic tools for rapid and reliable assessment of soil, plant and sugar**

Current soil and plant testing methodologies are both time- and resource-consuming and can only provide a partial indication of soil functional capacity. The aim is to use state-of-the-art technology for provision of analytical services that will increase the efficiency of analytical laboratory and improve turn-around time. Near Infra-Red (NIR) and Mid Infra-Red (MIR) techniques for the determination of soil, plant nutrient status and sugar quality will be developed once necessary equipment is made available. As a result, the industry will benefit from a comprehensive analytical package.

Possibilities of performing new quality analyses including ash % cane, sugar quality, sizing of sugar particles, sugar cane leaves, quantification of macro (N, P, K, Ca, Mg) and micronutrients (Cu, Zn, Mn, Fe) in soil, will be investigated using NIR. Its potential use to quantify the composition of different sugar cane products would be investigated as it meets the criteria of being accurate, reliable, rapid, non-destructive, and relatively inexpensive.

### **Communication with the planting community**

The Institute will continue to promote awareness on and encourage adoption of sound agronomic practices that will enable the sugar cane producers achieve competitiveness and sustainability. To attain this objective, linkage with the planting community is to be strengthened and targeted interventions for the different planter categories are to be privileged.

The sugar cane planting community comprises the miller- and non-miller planters, each with an established management team and cultivating more than 500 ha, and the other planters, comprising the large-, medium- and small-planters as shown in the Table 2.

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Table 2. Figures are provided for 2014		
Planter's category	Number	Area harvested (ha)
Small (< 10 ha)	15,531	17,707
Medium and Large (> 10 ha)	63	
Millers and Non-Millers	28	32,986
<b>Total</b>	<b>15,622</b>	<b>50,693</b>

Linkages with miller- and non-miller planters will be maintained through regular field visits, Regional Committees, and meetings with their field staff. Seminars, fields days and group meetings will be organized on specific themes and research activities to enable better interaction between the researchers at the Institute and the estate personnel. The adoption of a sound sugar cane variety strategy will be promoted through the establishment of variety trials, large-scale observation plots of promising varieties and establishment of nurseries to ensure varietal purity. In order to reduce production costs, efforts will not be spared to encourage the adoption of cost-cutting strategies and good management practices such as better irrigation management decisions based on research results on crop water requirements.

The other planters, around 15,600, harvested a total area of over 17,707 hectares in 2014 with an average cane yield of 69.9 tonnes cane per hectare compared to 85.1 tonnes per hectare for the corporate growers. There is urgency to improve production levels among the other planters, which comprise the large-, medium- and small-planters. The Institute will continue to collaborate with the Farmers Service Agency and the Planters' Advisory Units on sugar estates to address their specific problems as and when needed. The Pierre Halais Soil Laboratory will continue to offer the soil analysis service to the small-planters.

In order to establish links and accountability to the industry, it is proposed that a Research Advisory Committee be set up to provide a mechanism for the industry and researchers to interact in order to optimise efforts in the research undertaken, examine strengths and weaknesses and to determine how best to disseminate results for the benefit of the Industry.

It is also envisaged to set up a Knowledge Management Unit to provided services, resources and information in support of research as well as for knowledge transfer to the industry. This Unit

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would act as a communication arm for maintaining liaison with local and foreign institutions, disseminate findings to the industry, marketing MSIRI services and for outsourcing services where necessary. It would also coordinate specific demand-driven research, which would be separately funded.

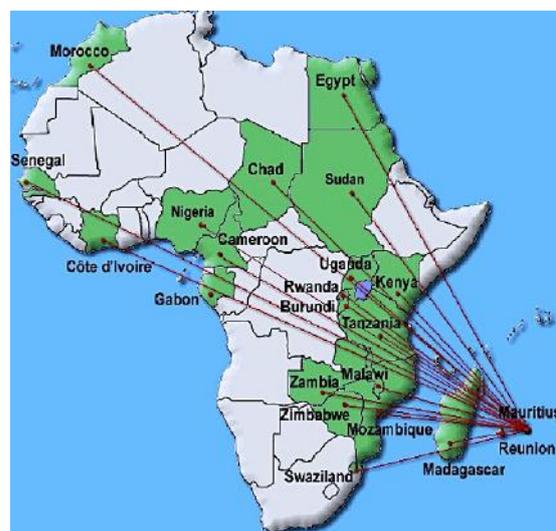
### **RFA 7: ENHANCED PARTNERSHIP WITH RESEARCH INSTITUTIONS ABROAD AND LOCALLY**

#### **Targeted output**

##### **❖ Strengthening R&D for the benefit of the industry**

Proactive partnership with local, regional and international research institutions for the development, early testing and exchange of promising varieties and fuzzi material will take place. MSIRI will continue to import foreign varieties for breeding and for direct evaluation in variety trials. Reciprocal exchange or purchase of fuzzi with research centres will be conducted. The collaboration will counteract the inability to cross non-flowering varieties locally and the broadening of the genetic base of varieties for selection to the various biotic and abiotic constraints.

With the interest of the Mauritian sugar cane industry to invest in mainland Africa, new varieties will be proposed/developed in partnership. MSIRI will continue to provide consultancy services locally and abroad on aspects of sugar cane cultivation and husbandry. Such services will contribute towards generating funds for the Institute.



It is contemplated that some projects e.g. formulation of new products such as biopesticides, could be conducted in partnership with industry/private sector, local or international institutions.

### **COMPETITIVE GRANTS AND FUNDING**

MSIRI will depend on cess money for its functioning. However, it will strive to generate revenue through analytical services, sale and royalties on varieties, sale of harvested cane, sale of fuzzi, consultancy services amongst others. It will tap funds from funding agencies for some projects. Full project proposals of the following 10 projects have been submitted in the context of the ACP-Sugar Research and Innovation programme, with MSIRI as leading institution. The titles of the projects are:

#### ***Crop Improvement***

1. Contributing towards the competitiveness and sustainability of the sugarcane industry through the characterization of high biomass/fibre canes for sugar, energy and ethanol production.
2. Use of artificial induction technology to enhance sugar productivity of ACP countries through the use of better parent varieties during crossing
3. Greenhouse gas emission in the sugar cane industry: assessment, mitigation measures and carbon footprint in ACP sugar producing countries.
4. Climate change in ACP sugar producing countries: assessment of impact on productivity and mitigation measures in enhancing resilience.

#### ***Biotechnology***

5. Accelerating the breeding strategies of sugar cane using sequence-based genome wide association studies (GWAS)
6. Enhancing the breeding efficiency through diversity studies and germplasm exchange programmes in ACP countries.

#### ***Crop Protection***

7. EcoCane: A green approach to pest control.

### *Crop Production*

8. Assessing soil persistence of herbicides used over last 40 years in ACP States and recommendation of weed management practices to minimize costs and environmental risks
9. Agronomic potential of sugar cane biomass for energy production: optimizing and comparing production systems with development of a decision making tool to improve income of sugar industry in ACP States
10. Exploring Interaction between sugar cane root system and nitrogen dynamics in the rhizosphere to improve N use efficiency to decrease cost of production in ACP states.

In addition, the following four proposals with MSIRI, as partner, have also been pre-selected:

- Industrie sucrière: valorisation des co-produits (vinasse, CO<sub>2</sub>, effluents) en nouvelle biomasse à visée énergétique – ALGOCANNE (Leader- CIRAD)
- Development of early detection and rapid response actions for pest and disease incursions into African Sugarcane (Leader- SASRI).
- Web-based and smartphone operational applications for improving productivity and water use efficiency using remote sensing technology (WAPSUP-Web Applications for Sugarcane Productivity) (Leader- CIRAD)
- Networking for marker-assisted diversification cane breeding (Leader-CIRAD).

### **IMPLEMENTATION AND REVIEW OF THE R&D PLAN 2016-2020**

The 2016-2020 R&D Plan will be developed and formulated into project proposals within the themes that will allow prioritisation and resource allocation. For its materialization, sustained resources, both human and financial, would be essential.

Progress will be monitored via annual reviews to determine whether Key Performance Indicators (KPIs) have been achieved and outcomes disseminated to the industry. Results will be disseminated in seminars, workshops and international conferences.

The Plan will be subject to a formal review at mid-term to assess progress and determine any changes in strategic vision, if necessary.

### **ACKNOWLEDGEMENTS**

This R&D Plan has been developed after extensive consultations with stakeholders, and discussions at the level of the MSIRI R&D Committee. Their contribution in the formulation of the Plan is gratefully acknowledged.

### Major expected Key Performance Indicators (KPIs)

#### **RFA1: Enhanced variety improvement through plant breeding and biotechnology for new cane varieties with high cane yield and sucrose content**

- At least one superior sugar cane varieties released annually
- Increase potential of new varieties for sugar
- Varieties with improved yellow spot resistance developed for the super-humid zone
- Review of stages 2 and 4 completed and decision taken on whether selection cycle could be further shortened
- New agro-climatic map developed, following update of climatic data
- Reaction of promising varieties to major herbicides established
- Molecular markers applied to complement conventional selection programme
- Genomic selection studies initiated and precise field data available for a population of varieties
- Fuzz and varieties imported from abroad and undergoing selection
- Adoption of new varieties by growers

#### **RFA2: Safe phytosanitary status with respect to existing and emerging diseases and pests**

- Effective quarantine system in place to prevent entry of exotic organisms
- Prompt identification of pests and diseases using conventional and molecular tools
- New methods of control developed for targeted pests

#### **RFA3: Improved efficiency of inputs through integrated nutrient management for sustainability**

- Soil N availability index developed
- P fertilization fine tuned and recommendations proposed
- N, P and K applications reassessed and recommendations proposed
- Biofertilizers and organic sources of nutrients evaluated and recommendations proposed

### **RFA4: Improved production systems to increase yield**

- Adoption of improved cropping system extended
- New harvesting equipment for small farmers' fields tested
- New herbicides tested to replace older ones not recommended by EU
- Control of vine weeds improved
- Post harvest trash management practices reviewed and recommendations proposed
- Soil health indicators developed and used for fertiliser recommendations
- Increase in adoption of green manuring
- Remote sensing/GIS/UAV technology tested for application in crop monitoring
- Abandoned cane lands mapped

### **RFA5: Valorisation of sugar cane and co-products**

- Information available on conversion of trash into energy: collection, transport, processing
- New sugars proposed for manufacturing
- Pilot scaling-up project for bioplastic production from sugar cane biomass evaluated

### **RFA6: Services and links with industry for active collaboration**

- MIR equipment purchased and in use to service the industry
- Support and linkages enhanced with the industry
- Collaborative projects with the industry in place
- Research and Advisory Committee set up and interaction with industry enhanced
- Knowledge Management Unit set up

### **RFA7: Enhanced partnership with research institutions abroad and locally**

- MOUs signed with local and foreign institutions, centres, companies
- Funding tapped from competitive grants.