SOUTH AFRICAN SUGARCANE RESEARCH INSTITUTE

100th Anniversary

1925 – 2025

A DIVISION OF THE SOUTH AFRICAN SUGAR ASSOCIATION

Contents

SASRI Director's Message

On behalf of the South African Sugarcane Research Institute, welcome to reflections of our journey over the past 100 years, and a future of possibilities!

Dr Shadrack Moephuli

The theme, "**SASRI 100 years – a century of achievement, a future of possibilities**", is apt indeed. This publication provides insight into the basis for the establishment of SASRI, and highlights a century of accomplishments that have enabled a sustainable sugar industry.

Sugarcane remains an important crop for the economic growth of several tropical and subtropical countries, including South Africa. The crop is highly efficient in converting solar energy, soil nutrients and water into chemical energy (which is stored in its stem as sucrose) and in the accumulation of biomass, making it an important source of food and bioenergy. Cultivating sugarcane for harvesting both sucrose and biomass has been critical for food security and the sustainable growth of the industry.

More than 100 years ago, the sugar industry experienced agricultural crop yield reductions, mainly due to biotic stresses (pest and disease infestations) and abiotic stresses (drought, salinity, high temperatures, etc). In a quest to mitigate the adverse impacts of these stresses on the cultivation of sugarcane, the South African Sugar Association (SASA) established the South African Sugar Experiment Station (SASEX). The aim was to develop sugarcane varieties adapted to local agroclimatic conditions, and with resilience to pests and diseases.

Since its establishment, the primary purpose of SASEX, now known as the South African Sugarcane Research Institute (SASRI), has been to develop scientific solutions for the sustainable cultivation of sugarcane locally. As reflected in the founding mandate, SASRI remains focused on the needs of growers for sustainable sugarcane production. In this publication, we reflect on how SASRI has developed and deployed scientific solutions, technologies and knowledge to enable the sustainable growth and development of the sugar industry.

The achievements of SASRI can be attributed to the dedicated scientists employed by the institute over the past 100 years. This skilled workforce has contributed significantly to innovations at SASRI, while also ensuring knowledge exchange with large and small-scale growers, including miller-cum-planters. Over the years, the invaluable feedback from growers has served to refine the relevance and quality of research and development, further enhancing confidence and trust in the scientific endeavours and boosting the adoption of scientific solutions by growers.

Although SASRI focusses on the agricultural aspects of the industry, millers have also been instrumental in providing insights into the harvesting of sucrose and other by-products from cane. This has influenced the breeding and development of new varieties suitable to both growers and millers, thus creating value for the whole industry.

To achieve its objects, SASRI depends on dynamic exchange of scientific information, technology and other insights through collaboration with a wide range of stakeholders. Key among such collaboration have been various education and training institutions that served as a source of skilled scientists, technicians and engineers. SASRI's value is further enhanced by the outcomes of collaboration with research and development organisations in South Africa, such as the Universities of Pretoria, KwaZulu-Natal, Free State, Stellenbosch, the Agricultural Research Council and the Council for Scientific and Industrial Research, to name a few. Global partnerships and collaborations have also been instrumental in SASRI's success to date, including collaboration with the International

Consortium for Sugarcane Biotechnology (ICSB); the French Agricultural Research Centre for International Development (CIRAD); Sugarcane Research Australia (SRA); the International Centre for Genetic Engineering and Biotechnology (ICGEB), among others.

SASRI remains relevant to all its stakeholders, mainly by remaining focused on its purpose, which is to:

- Develop and deliver sugarcane varieties suitable for increased economic returns for all in the industry;
- Provide expertise and knowledge through research and development that improves sugarcane productivity and profitability;
- Through research, technology development and knowledge exchange, provide services that advance nutritional and agronomic practices, and crop biosecurity (pest and disease) measures;
- Facilitate the adoption of best management practices and technologies for sustainable land use with optimal productivity and profitability; and
- Explore and exchange scientific information on the potential for broadening the scope of products that can be derived from sugarcane through diversification for a future sustainable industry.

To date, SASRI has successfully incorporated biotechnology tools for sugarcane improvement, such as the use of in vitro tissue culture, molecular pest and disease diagnostics, cryobiology, micropropagation, mutation breeding and genetic modification. Sterile Insect Technique is being actively explored as part of an area-wide integrated pest management initiative. The use of digital agriculture has enabled the development and deployment of decision support tools such as geographic information systems, crop modelling and unmanned aerial vehicles (drones).

The future for the sugar industry will depend on how best it harnesses, adopts and utilises new scientific knowledge, technologies and skills. This will require continuous resourcing of SASRI as the primary instrument for sugarcane-focussed agricultural scientific research and development. A well-resourced sugarcane research and development institution is the key to stimulating innovations that enable diversification for a reimagined industry throughout the value chain.

Contributions from the sugar industry, specifically, the South African Sugarcane Growers Association (SACGA), the South African Farmer Development Association (SAFDA) and the South African Sugar Millers Association (SASMA), seamlessly functioning in concert with SASA, are vital for the success of SASRI. Over the past century, continuous support from these stakeholders has enabled SASRI's research and development to impact positively on food security and livelihoods in the industry.

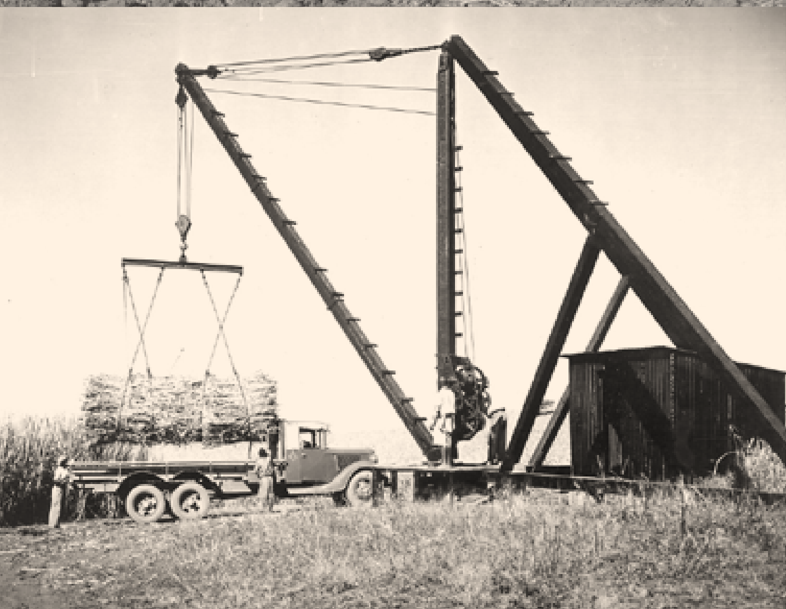
SASRI acknowledges all stakeholders, and, in particular, its collaboration partners, growers, millers, government and international organisations. Special thanks to all SASRI employees for their continued contributions to the goals, outputs and outcomes of the organisation. We also express appreciation to all the sponsors of this centennial celebration.

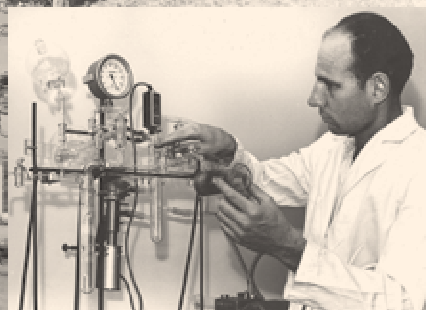
Future successes will require continued seamless engagements and interactions with growers, collaboration partners, skilled employees and other stakeholders. SASRI looks forward to continuing its contribution to the success of a sustainable sugar industry.

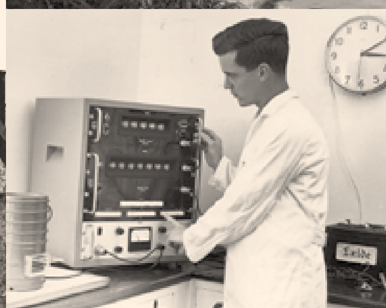
SASRI Directors Over the Years

Mr HH Dodds (1925-1950)
Dr A McMartin (1951-1958)
Mr J Wilson (1958-1974)
Dr GD Thompson (1975-1990)
Dr PH Hewitt (1991-2002)
Dr FC Botha (2003-2007)
Dr CD Dettman (2008)
Dr CM Baker (2009-2021)
Dr TK Stanger (2021-2024)
Dr SR Moephuli (2024-current)

In the Beginning...







The first official expression of interest in the establishment of an Experiment Station for the SA sugar industry appeared in a circular of the Natal Sugar Association in June 1915. However, the matter soon fell into abeyance—probably due to the outbreak of World War I, but also as a result of the prioritisation of other industry issues.

After the South African Sugar Association was established in 1920, negotiations to form an Experiment Station were revived. Around the time, an urgent need for scientific support for the industry became increasingly evident with the emergence of numerous pests and diseases, including trashworm, red rot, root fungoid disease, stalk borers, leaf binder, cane aphids, mealy bug, black beetle, rind fungus, ringspot, and eyespot.

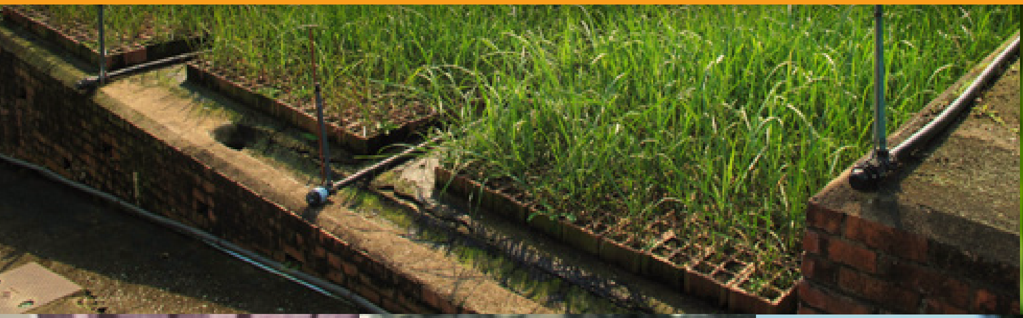
A significant event in 1923 catalysed the sugar industry's decision to establish its own Experiment Station: Harold Storey, the Natal government mycologist, issued a forceful caution that sugarcane mosaic disease posed a serious threat to the industry. While *Uba*—then the dominant commercial variety—was resistant to mosaic, several other promising test varieties were susceptible. Storey had hoped that limiting commercial planting to *Uba* would eliminate the disease. However, these hopes were short-lived as *Uba* began to decline due to streak disease, reinforcing the need for alternative varieties.

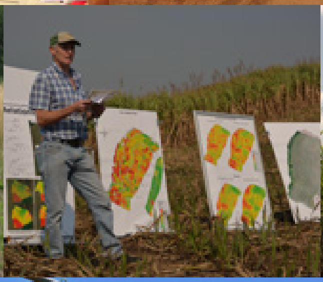
Further motivation for establishing an Experiment Station was the advice of Dr William Cross, Director of the Tucumán Research Station in Argentina, who was invited, along with other international research leaders, to assess the South African sugar industry's research needs. He recommended that the industry should not rely on the limited support from government-employed agricultural scientists, whose efforts were spread across multiple crops. Instead, he urged the industry to employ dedicated scientists across various disciplines, focused solely on sugarcane.

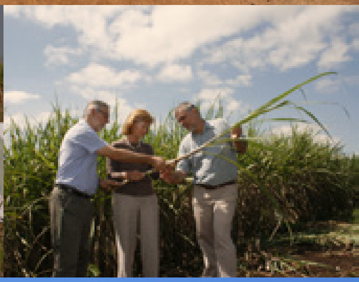
After almost a decade of prevarication, a significant initial step was taken in April 1924 when HH Dodds was appointed director of the proposed Experiment Station. Dodds, who had worked previously as a chemist in the explosives industry, was also a joint owner of a sugarcane farm in Shakaskraal and had undergone training in sugarcane agriculture at Louisiana State University Experiment Farm.

After evaluating the suitability of several sites for the establishment of the Experiment Station, Mount Edgecombe was selected in July 1924. Land clearing commenced in May 1925, and in July 1925, a temporary camp was set up to accommodate the field manager and seven labourers, pending the construction of permanent buildings.

Highlights Over the Past 100 Years







With the disease onslaught at the time the Experiment Station was established, there was increasing pressure to find varieties more suited to local conditions. The need to import and control new varieties was the impetus for the construction of a Department of Agriculture Quarantine Facility at the Durban Botanic Gardens in 1925. This enabled the beginnings of a selection programme at the new South African Sugar Experiment Station (SASEX), which today has grown into one of the top plant breeding and selection programmes globally.

Now known as the South African Sugarcane Research Institute (SASRI), it caters for all the agricultural research and development requirements for the sugar industry. Not only renowned for its plant breeding and selection programme, SASRI is now recognised for its pioneering role in the physiology of sucrose accumulation in the sugarcane plant and its contributions to sugarcane genetics and marker-assisted breeding. Agronomically, SASRI's contribution to ripener research and on-farm cane quality management is internationally recognised, along with its leadership role in crop modelling. The institute's research into pest and disease management remains the cornerstone that informs the control of biosecurity risk in the sugar industry.

Given the scope and breadth of SASRI's research programmes, it is impossible to outline all its accomplishments since its inception in 1925. Nevertheless, in the pages that follow, some of the key challenges, highlights and milestones in SASRI's 100-year history are elaborated.

Variety Improvement

PLANT BREEDING

Most existing imported varieties were not adapted to South Africa's sub-tropical growing conditions and succumbed to pests and diseases. Hence, SASRI was established with the objective of importing, testing and recommending new varieties adaptable to South African sugarcane growing conditions.

To provide varieties adapted to local conditions, SASRI embarked on establishing a selection programme based on crosses imported from tropical countries such as India, where natural flowering was prolific and enabled the production of hybrids. Of the several crosses imported, only one, made at the Sugarcane Breeding Institute in Coimbatore, India (Co421 x Co312), produced four released varieties: NCo293, NCo310, NCo334, and NCo376. Among these, only NCo310 and NCo376 were widely successful in South Africa, Southern Africa and several other countries across the world. Since then, SASRI has **produced many varieties** (Table 1) that form the basis of sugarcane production in South Africa and Southern Africa. Of the varieties produced, 26 have been released for the irrigated regions, 45 for the coastal areas and 16 for the midlands regions.

Table 1: Cultivars released over the decades.

1940s	1950s	1960s	1970s	1980s	1990s	2000s	2010s	2020s
NCo310	NCo293	N51/168	N7	N13	N22	N36	N52	N76
	NCo376	N51/539	N8	N14	N23	N37	N53	N77
	NCo334	N53/216	N9	N15	N24	N38	N54	N78
	NCo382	N55/805	N10	N16	N25	N39	N55	N79
	N50/211	N6	N52/219	N17	N26	N40	N56	N80
			N11	N18	N27	N41	N57	N81
			N12	N19	N28	N42	N58	N82
				N20	N29	N43	N59	
				N21	N30	N44	N60	
					N31	N45	N61	
					N32	N46	N62	
					N33	N47	N63	
					N34	N48	N64	
					N35	N49	N65	
						N50	N66	
						N51	N67	
							N68	
							N69	
							N70	
							N71	
							N72	
							N73	
							N74	
							N75	

The failure of several early imported crosses to produce successful cultivars indicated the need to start a crossing programme aimed at producing more progenies adapted to local growing conditions. Initial attempts at making crosses at SASRI failed because of pollen infertility due to the cooler winters. Further research showed pollen fertility was maintained when flowers were kept in a glasshouse at temperatures higher than 20°C. In addition, photoperiod treatments ensured the production of more and uniform flowers every year. Hence, crossing facilities comprising the glasshouse, constructed in 1966, and the photoperiod house (1971) formed the basis of modern sugarcane breeding at SASRI. Annually, the number of crosses produced ranged from 1000 to 2000 from 1972 to 2012, ensuring enough crosses for SASRI regional breeding programmes, and export of excess crosses to other countries such as Zimbabwe.

SASRI operates the largest sugarcane breeding programme in Africa and among the largest in the sugarcane breeding world. Because of the diverse sugarcane growing conditions in South Africa, SASRI produces widely adapted varieties with high ratooning ability, many of which are cultivated under licence across several African countries (Figure 1). Countries planting SASRI varieties pay royalties on production, thereby supporting the cost of variety development. SASRI varieties (known as N varieties) produce high yields on average and good soils under rainfed and irrigated growing conditions, and their **high ratooning ability** enables an average of 10 crops per planting cycle. Consistently high yields from more than 30 crops per planting cycle have been recorded in Eswatini, Malawi and Zimbabwe.

N varieties have been **exported** to 69 countries across the world, a testimony to the demand for these varieties because of their wide adaptability and good genetics for sugarcane breeding.

SASRI also **imports** varieties from several countries to diversify the genetic background of parent genotypes. The largest number of varieties have been imported from the USA because of the matching sub-tropical environment. Australia is another source of breeding varieties because its coastal environments match South African coastal conditions.

All the foreign sugarcane germplasm that comes into South Africa is housed in the SASRI **quarantine glasshouse facility**, where they are thoroughly tested for the presence of diseases. Once given the ‘all clear’, they are released for use in the plant breeding programme.

Figure 1: A map of Africa showing countries (white circles) with Variety Licence Agreements to test and commercialise South African N varieties: Eswatini, Mozambique, Malawi, Zambia, Zimbabwe, Tanzania, DRC, Uganda, Kenya, South Sudan, Mali, Cameroon, Nigeria, Sierra Leone, Senegal.

BIOTECHNOLOGY

The Biotechnology Department was established in 1994 to introduce a suite of modern molecular technologies as a toolbox to implement innovative ways to improve sugarcane and detect diseases.

For decades, SASRI, in partnership with the Institute for Plant Biotechnology at Stellenbosch University, was the world leader in research into the physiology of **sucrose accumulation** in sugarcane. Investigations focused on the mechanisms controlling the proportions of sugar that were produced in the plant that went into sucrose storage, fibre and growth. If this could be manipulated, the amount going to storage could be increased, resulting in sugarcane with much higher sucrose content. Ultimately, three key controlling enzymes in the plant were identified, whose activity was then changed using cutting-edge biotechnology techniques to enhance sucrose accumulation. Results obtained in the greenhouse and small field trials were extremely promising. However, in 2020, the industry decided to prioritise research into developing varieties with insect resistance, herbicide tolerance and drought stress tolerance, so the sucrose accumulation research was curtailed. Regardless, the research was highly productive, leading to ground-breaking knowledge, scores of post-graduate students and countless scientific publications.

The first field trials with **genetically modified** (GM) sugarcane containing herbicide tolerance traits were conducted in the late 1990s and firmly embedded SASRI's expertise in this area in the global sugarcane community. Our industry gave the green light to proceed with commercial development in 2013 for lepidopteran stalk borer resistance via the insecticidal CRY proteins produced by the soil bacterium, *Bacillus thuringiensis* (Bt). A pipeline for the development of genetically modified sugarcane is now well established, and all the necessary legislative requirements are adhered to.

A tissue culture micropropagation technology, trademarked in 2005 as **NovaCane®** and branded as 'the pain-free seedcane', was developed as a mechanism to bulk-up and release new varieties. SASRI researchers transferred this expertise to several commercial laboratories, which enabled growers to order directly from those facilities. Seedcane production, especially for newly released N varieties, has been revolutionised using this approach.

Since 2017, various *in vitro* techniques have enabled long-term storage of germplasm via **cryopreservation** (i.e. storage at ultra-low temperatures of -196°C) of shoot tips. More recently, in 2025, this approach was used for virus elimination in a process called **cryotherapy** (i.e. using extremely cold temperatures to freeze and destroy abnormal tissue).

International teaming efforts, mainly through the International Consortium for Sugarcane Biotechnology, of which SASRI is a founder member, have ensured massive strides in sugarcane genetics and marker-assisted breeding, with the genome finally being sequenced and published in 2024.

SASRI now uses cutting-edge technology for **variety fingerprinting**, a powerful technology developed in 2013, which plays a pivotal role in ensuring the integrity and quality of sugarcane varieties in the industry. Much like the unique fingerprints on human hands, each sugarcane variety has a distinct DNA marker profile. Sugarcane DNA fingerprinting uses a set of DNA molecular markers to create a unique genetic marker profile for each variety. By comparing a sample's genetic marker profile against a reference database, researchers can confirm the identity of a sugarcane variety. This diagnostic technique is essential for everything from breeding and selection to quality control of seedcane and pest and disease management.

Looking to the future, SASRI scientists are preparing for a hotter and drier climate using specialised breeding techniques in the laboratory to create sugarcane that will better tolerate environmental stresses, such as drought and heat, as well as tolerance to high soil aluminium and salt. The technique, called **mutation breeding**, uses physical or chemical agents to purposefully create changes in sugarcane DNA without introducing foreign genes. Ionising radiation is the most common agent used, whilst other chemical agents such as Ethyl methanesulfonate (EMS) have also been successfully used. In 2020, SASRI released a herbicide-tolerant sugarcane variety, N12 Zapyr, using EMS.

By using various agents, our biotechnologists can either create changes in gene DNA sequences that can be beneficial or create changes in the way genes are expressed (without changing the DNA sequence). In this way, both forms of mutation result in altering the way sugarcane responds to environmental stresses, such as drought and heat.

The benefits of using mutation breeding for crop improvement are varied: refining the resilience of plants without introducing foreign genes; reducing the time and cost of developing new cultivars compared with conventional breeding or genetic engineering; and improving an otherwise elite cultivar for a desired trait.

Soil Health and Nutrient Management

Since the South African sugar industry is spread across a wide range of biogeographical regions, the system of **soil classification** developed in the 1940s was key to mapping the soils in the industry. This, together with a systematic aerial soil survey of the whole industry in the 1950s, facilitated all subsequent agronomic research.

MULCHING

Until about 1951, fertiliser was scarce and nutrient applications in the SA sugar industry were extremely low, averaging approximately 11 kg nitrogen/ha, 14 kg phosphorus/ha and 3 kg potassium/ha. Growers, therefore, had to rely on recycling organic matter as a source of nutrients, and 'trashing' (green cane harvesting or mulching) was common. The benefits of mulching were varied including reduced weed pressure and increased water availability for crop growth.

The first **burning and mulching trial** (BT1) in the sugar industry was established in October 1939 at SASRI. The objective was to compare the long-term effects of crop management, including burning or mulching at harvest, and fertiliser application, on soil health and crop yield. Meticulous records were kept of management, crop yield, and soil and leaf analyses, providing the source data for the first PhD study in 1965, which quantified the benefits of mulching.

To date, data collected from BT1 have yielded 45 articles, 40 of these having been written since 1998. This publication record includes five PhD theses and one MSc; all except for the first PhD (1965) were completed between 2003 and 2019. Additional information collected in later years includes arthropod population counts and mulch decomposition rates. Notably, eighty-six years later, BT1 is still managed by SASRI and is the world's oldest sugarcane trial.

ORGANIC MATTER

Since the 1990s, renewed interest in adding organic matter to soils to improve soil health has led to growers securing new sources of organic matter and **organic fertilisers**. Popular sources included green manures, chicken manure, condensed molasses stillage (CMS) and sugarcane residues following burning at harvest. Extensive research at SASRI into the effects of a full mulch blanket in various agro-climatic zones, including the KZN coastal region, KZN Midlands and the Northern irrigated areas has helped to quantify the amount of mulch produced (according to cane yield), the effects of mulching on soil temperature, and the areas and times of year where mulching is likely to produce the best results for growers, including significant savings in water and electricity costs. The economic impact of mulching on harvesting, haulage, sugar extraction and weeding was also investigated.

Despite the improved yield potential of newer varieties, lower-than-expected yields during the 1970s to 1990s were partly attributed to the monoculture nature of sugarcane farming. To break this trend, an old and almost-forgotten practice of **green manuring** was promoted by SASRI in 1998. The objective was to introduce a crop other than sugarcane in the period between plough-out and replant of sugarcane, and to extend this fallow period to at least three months. Popular green manure species included sunn hemp, various bean types and oats. Uptake of green manuring in the sugar industry has been good in many regions and remains a common practice.

CONTROLLED TRAFFIC

Before 1998, it was common practice for loaders and in-field haulage vehicles to drive freely in fields. This resulted in accelerated ratoon yield decline. Contributing factors from a soil health point of view were compaction, waterlogging and stool damage. A SASRI PhD research project consisted of a meta-analysis of local and international compaction trial research to quantify the impact of infield traffic on sugarcane yield losses. This led to the strong motivation for more sustainable field practices and the introduction of a controlled traffic system, which aimed to keep wheels off the cane rows. The compacted interrow favoured wheel traffic, while the uncompacted crop production area favoured root distribution and water infiltration. Stalk yield response due to compaction and stool damage effects can be as high as 50%, depending on soil type and water content at the time of travelling, vehicle characteristics and previous management of infield traffic.

SOIL EROSION

The steep nature of large parts of the sugar industry, together with heavy rainfall events, often caused severe soil erosion, especially during the fallow period whilst preparing for replanting. To address this, a **minimum tillage system** was developed by SASRI in 1976. The system involves killing the last crop with herbicide and then ridging and planting in the interrow area, leaving the dead stools firmly anchored in the soil to reduce erosion. To assist growers with the installation of contour banks at the correct intervals, taking slope, soil type, tillage type, replant method and burning versus mulching into account, SASRI developed a nomograph in 1987. This nomograph was improved with the development the Contour Spacing Design Tool for the design of soil and water conservation structures. Methods used in this tool were published internationally in 2021.

SOIL SALINITY AND SODICITY

By the 1960s and 1970s, salt accumulation in soils of the irrigated region had become a problem. SASRI scientists at the time did excellent work identifying the source and type of salts and formulated effective strategies to reclaim sodic soils. When salt problems resurfaced in the late 1990s, SASRI investigated new methods to determine the distribution and severity of salts in soils. One of these involved scanning fields for their electromagnetic properties, which proved useful in determining the lateral and vertical distribution of salts in soils. Another method involved the analysis of satellite-derived data obtained daily, providing near real-time identification of the development of spots within the field exhibiting poor growth. This latter method, though useful, remains largely cost-prohibitive.

To simplify the wealth of soil knowledge collected over the past 100 years into more user-friendly formats, a modular course was developed in 2016, and two books were published, both aimed towards better understanding and managing soils in the industry.

THE FERTILISER ADVISORY SERVICE (FAS) AND SOIL FERTILITY RESEARCH

Established in 1954, SASRI's Fertiliser Advisory Service (FAS) is an independent soil and leaf-based fertiliser diagnostic service that serves not only the sugar industry but other commodities as well. The development of standardised soil sampling methods and soil and leaf threshold values for nitrogen, phosphorus and potassium, made it possible to calculate optimal fertiliser application rates for improved yields.

From the early manual operations in the laboratory, advancements in analytical instrumentation and automation, including using near-infrared (NIR) and X-ray fluorescence spectroscopy, significantly improved turnaround times for sample analysis. In the early 2000s, major changes were introduced to the FAS service to improve analytical efficiency and accuracy, and to provide growers with more comprehensive reports.

Over the years, significant developments include the following:

- Introduction of volume-based analyses to eliminate errors associated with wide textural differences in soils when analysed on a mass basis.
- Use of a multi-nutrient extraction method to improve laboratory throughput and enable micro-nutrients to be determined and reported routinely at no extra cost.
- Replacement of the Truog method for soil phosphorus measurement, which limited reliability on neutral and alkaline soils, by the vastly more reliable resin extraction method.
- Adoption of mid-infrared technology for accurate and rapid determination of a range of soil properties, including organic matter, texture and levels of non-exchangeable potassium.

Upgrading of nutrient recommendation packages in response to field research findings progressed hand-in-hand with laboratory developments. Nitrogen recommendations were modified to account for contributions from green-manure crops. Levels of 'reserve-potassium' were included in the calculation of crop potassium requirements, thereby creating opportunities for massive savings in fertiliser. In addition, field research together with the interrogation of FAS databases indicated that **soil acidity** levels in industry soils had increased markedly, particularly in subsoils. As a result, recommendations for using gypsum were introduced, while a more rigorous approach to liming was also followed.

These and other improvements have resulted in the FAS providing the most detailed analytical reports of any soil testing service in Southern Africa. Further, over the years, the accumulated data from soil and leaf analyses has enabled the provision of fertiliser recommendations for not only the plant crop, but for four succeeding ratoons as well.

Demand for the analysis of samples from non-sugarcane crops has increased sharply in the last decade, and the service now provides basic recommendations for several of these crops, including macadamias, avocados, bananas and maize.

FAS has maintained ISO 9001 certification through the South African Bureau of Standards (SABS) for the past 11 years, demonstrating a long-standing commitment to quality management and customer satisfaction. The laboratory has also recently achieved ISO/IEC 17025 accreditation through the South African National Accreditation System (SANAS) for leaf and Fertiliser analysis, which represents a mark of global credibility and scientific excellence.

Pest, Disease and Weed Management

ELDANA

Eldana (*Eldana saccharina*) was first noticed as a pest of sugarcane in 1939, when an outbreak occurred in a two-year-old crop of variety POJ2725 on the Umfolozi Flats. Since then, it has remained the most damaging pest in the industry. Two varieties introduced from India, Co281 and Co301, that were particularly successful during the 1940s and early 1950s, appeared resistant to eldana and their widespread adoption is thought to have contributed towards the pest's apparent "disappearance" by 1953. However, in the late 1940s and early 1950s, yields of Co281 crashed inexplicably, most likely due to Ratoon Stunt (RSD), which was first identified in 1952. Co301, which was particularly suited to recent sands, succumbed to smut in 1952.

NCo310 then became the dominant variety between 1955 and 1965, before NCo376 took over in 1966, a position it would retain for 40 years. The first variety bred wholly at the Experiment Station, N50/211, was released before the end of the 1950s. In 1965 N55/805 was released primarily for sandy soils and, along with NCo310 and NCo376, eventually proved susceptible to eldana. It is likely that collectively, these varieties contributed towards the reappearance of eldana as a pest in the 1970s in northern KwaZulu-Natal, and its spread southwards to Port Shepstone in 1980. Another probable contributing factor in the 1960s was the development of Richards Bay that necessitated drainage of extensive *Cyperus papyrus* wetland areas to facilitate the construction of a major port and other infrastructure. Papyrus is the main natural host of eldana.

While **varietal resistance** remains key to overcoming eldana infestations, **insecticide research** began in the mid-1970s entailing extensive field trials. The discovery of seasonal cycles in eldana's life cycle enabled targeted delivery of insecticides during moth peaks. In 2003, the pyrethroid insecticide Fastac® was registered for spraying carry-over cane. Since 2015, three additional insecticidal modes of action have enabled insurance against the possible development of resistance to any one mode of action by eldana, provided that they are used in rotation.

The use of **biocontrol agents** as an additional method of controlling eldana prompted the introduction of two exotic parasitoids (*Descampsina* sp and *Trichogramma* sp) in 1975. In 1980 the Eldana Bio-Control Centre was established at SASRI, where a local eldana parasite *Goniozus natalensis* was reared and released at 26 coastal cane belt sites in 1986. Despite its establishment in the field, this parasitoid did not colonise the sugarcane habitat in the long term.

Establishment of the **Insect Rearing Unit** (IRU) in 1988 enabled research into the biology of eldana and candidate biocontrol agents, premised on the ability of SASRI scientists being able to rear eldana on

artificial diet. The first such diet was formulated during the 1940s, consisting simply of cooked maize meal inoculated with the common food spoilage mould (*Mucor hiemalis*), the presence of which induced better development of the larvae. Since the 1970s, eldana has been reared on ever-improving artificial diets with numerous innovations in the rearing procedure.

In 1998, the exotic eldana parasite *Sturmiopsis* parasitica was reared in the IRU and released at sites in Melmoth, Entumeni and Umfolozi, again with short-term establishment. It became apparent that the sugarcane monoculture and the practice of burning disrupted the long-term establishment of parasitoids. Consequently, in the 2000s, researchers looked towards developing **Integrated Pest Management** (IPM) approaches to control eldana.

Soil health and plant nutrition research revealed that silicon amendments strengthened plant tissues, creating a physical barrier, making it harder for eldana larvae to penetrate sugarcane stalks. Introduction of a habitat management strategy known as 'push-pull' that manipulated the distribution of eldana populations and their natural enemies through understanding the chemical ecology of the agroecosystem, was rolled out in 2011: the grass *Melinis minutiflora* (melinis) was used as a 'push' or repellent plant whilst simultaneously attracting beneficial natural enemies of the pest; and because eldana moths were shown to have a significant ovipositional preference for the indigenous wetland sedges, *Cyperus papyrus* and *Cyperus dives*, were used as 'pull' plants. In 2014, an IPM manual was published which integrated all management practices impacting eldana.

In 2005, a project exploring the interaction between eldana and the fungus *Fusarium* revealed that certain strains of *Fusarium* are beneficial to eldana. Incorporating *Fusarium* into the eldana rearing diet proved beneficial, echoing the use of *Mucor hiemalis* more than 50 years earlier. Recently, the strong correlation between sugarcane varietal resistance to eldana and resistance to *Fusarium* has led to a new project in collaboration with the University of Pretoria, to develop genetically modified sugarcane resistant to *Fusarium* through a process known as RNA interference.

Since 2006, research on the **Sterile Insect Technique** (SIT), the mass rearing and area-wide release of irradiated sterile eldana moths, began at SASRI. Proof of concept was achieved in large cages, and in 2025, field releases are being trialled.

OTHER PESTS

Plant parasitic **nematodes** were first recognised as a problem in the 1950s, prompting the commencement of nematology research in 1957. Significant yield losses on sandy soils prompted recommendations for the application of nematicides and organic amendments. Further, SASRI's plant breeders released varieties suited to sandy soils such as Co301, N55/805, N12 and more recently N52, N58 and N79.

In 1999, SASRI scientists confirmed the presence of the spotted sugarcane borer ***Chilo sacchariphagus*** on sugarcane in northern Mozambique. While chilo is native to Southeast Asia, it has spread to other sugarcane-growing regions. Since this pest presents a serious biosecurity risk to the South African industry, SASRI initiated a pheromone trap monitoring grid on our borders.

Sugarcane **thrips** (*Fulmekiola serrata*) was first recorded damaging sugarcane in the Umfolozi area in 2004. It most likely arrived from Madagascar on wind currents and rapidly spread throughout the industry. A similar industry-wide invasion occurred in 2013, when the **yellow sugarcane aphid** (YSA) (*Sipha flava*), which originated in the Americas, was first recorded in the Pongola region. SASRI varieties are regularly screened for resistance to these pests, and research supports increased habitat diversity to promote biocontrol by natural enemies. Several insecticides have been registered for their control.

In 2024, research exploring the use of *Bacillus thuringiensis* insecticidal genes began, specifically acting against thrips and aphids, in genetically modified sugarcane.

An outbreak of the **longhorn beetle** (*Cacosceles newmannii*) was detected for the first time on sugarcane in the eNtumeni area in 2015. SASRI's research (based on similar outbreaks of longhorn species in China, Thailand, Indonesia and Brazil) established that, in South Africa, the insect is likely to prefer cane on sandier soils and that the natural host plants are trees of the Fabaceae family, including wattle. Given the devastating effects of this pest and the likelihood of further establishment and spread in sugarcane, the industry agreed on a containment fund to cover the costs of premature harvest and cane eradication as well as a fallow rental for three years in affected areas. While this was successful, in 2023, an additional outbreak of the longhorn beetle was detected 45 km to the north-east of eNtumeni in the Melmoth area, resulting in the preparation of a comprehensive IPM plan in 2025.

DISEASES

The first official record of a disease on sugarcane in the industry was of **smut** (*Sporisorium scitamineum*) on the north coast of KwaZulu-Natal in 1877. This was also the first report of sugarcane smut worldwide. Before 1927, few restrictions were imposed regarding the varieties grown in the industry, but with the upsurge in diseases at this time, particularly mosaic (sugarcane mosaic virus: SCMV), all varieties except for an Indian variety (*Uba*) were required to be eradicated. Subsequently, *Uba's* susceptibility to sugarcane streak (sugarcane streak virus) led to its failure and prompted the importation of suitable varieties for South African conditions.

Amongst the fungal diseases, smut has caused serious yield losses in the industry. Consequently, SASRI implemented extensive changes to the smut screening programme in the 1980s, resulting in the release of varieties with improved resistance to the disease. Recognition that, besides spore transmission, the disease is also spread in seedcane led to the use of the fungicide triadimefon in hot water treatment tanks when establishing certified nurseries. Current research is focused on the following: developing methods to screen varieties more efficiently and at an earlier stage in the selection programme; providing evidence of the efficacy of broad-spectrum fungicides in reducing smut incidence and improving yields; and, developing more effective methods to reduce inoculum levels in the field.

Since imported varieties would require quarantining, a quarantine glasshouse built in 1925 at the Durban Botanic Gardens served as the facility for receiving selected imported sugarcane varieties. This was later replaced by a **quarantine facility** at SASRI in 1984. Today, this facility enables the exchange of sugarcane genotypes with many different countries, including Australia, Barbados, Brazil, Colombia and the United States of America, to increase the genetic diversity of parents for breeding new varieties. Stringent quarantine protocols to ensure elimination of any potential disease threat include thermotherapy, fungicides and an apical meristem tissue culture technique that is in use under the registered trademark NovaCane®. Novel cryo- and osmo-therapy techniques for sugarcane shoot meristems provide further means of virus elimination. These techniques limit the introduction and spread of known pathogens, as well as unknown pathogens, for which there are no molecular tests. A suite of molecular diagnostic assays introduced in the 1990s, which are continuously evaluated and improved, together with selected serological assays and regular visual inspections, limit the risk of introducing known pathogens into the industry. Further, in vitro germplasm conservation protocols are used to enable storage of local and imported germplasm: either cryopreservation (-196°C) of shoot tips for long-term storage, or minimal growth (18°C) of shoots for the medium term.

Mosaic has remained one of the most important viral diseases in the industry, resulting in the development of effective mosaic resistance screening trials in the late 1970s. Research on the disease vectors and the effect of planting date on disease incidence and yield loss was conducted in the 1980s, followed by the development of a range of detection methods: an enzyme linked immunosorbent assay in 1986; a reverse transcription polymerase chain reaction (RT-PCR) test in 1997; genetic sequencing for detecting different strains of SCMV; and a real-time quantitative PCR test. In 2019, it was established that the yellow sugarcane aphid *Sipha flava*, which arrived in southern Africa in 2013, does not transmit SCMV.

Yellow leaf syndrome, first reported in South Africa in 1994, was determined to be caused by two pathogens, sugarcane yellow leaf virus (SCYLV) and sugarcane yellows phytoplasma. Precautions are taken to prevent the introduction of new strains of SCYLV, through molecular testing of imported material and tissue culture procedures. **Maize streak** (maize streak virus) was detected in 2007, requiring the eradication of N44, the most susceptible variety.

Ratoon stunt (RSD: *Leifsonia xyli* subsp. *xyli*) that is easily spread on cutting implements and in seedcane, has been extensively researched, resulting in a suite of management practices including hot water treatment of seedcane at 50°C and routine diagnosis using a serological method. PCR and loop-mediated isothermal amplification (LAMP) assays specific for the RSD bacterium have been developed, and research on near-to-field diagnostic methods is in progress. A tissue blot-enzyme immunoassay is used to evaluate varietal susceptibility to RSD.

While RSD has always been considered the most important bacterial disease in the industry, several others have been identified, including **leaf scald** (*Xanthomonas albilineans*) and **gumming** (*Xanthomonas vasicola* pv. *vasculorum*).

SASRI has been instrumental in facilitating the registration of foliar fungicides for the management of **brown rust** (*Puccinia melanocephala*) and has developed a rust risk model to inform growers on optimal timing for the application of fungicides. Another rust species detected on sugarcane in southern Africa in 2008 was named *Macruropyxis fulva*, the causal organism of **tawny rust**. A close relative of sugarcane, *Miscanthidium capense*, is thought to represent the native original host of *M. fulva*. Further, monitoring of aerial rust *inoculum* on spore traps was introduced to provide an early warning of novel rust presence; it enabled SASRI to notify the industry when **orange rust** (*Puccinia kuehnii*) spores were first detected in the industry in 2016 before the disease was observed on sugarcane in February 2022.

While **red rot** (*Glomerella tucumanensis*) caused considerable damage in the industry in the 1940s, it was controlled using resistant varieties. Research showed that the reddening associated with eldana damage throughout the industry was more commonly caused by several *Fusarium* spp.

In 1998, another stalk rot affecting sugarcane in the midlands was identified as **sour rot** (*Phaeocytostroma sacchari*). It causes severe rotting of the internal tissue of mature cane stalks after a prolonged dry period. The disease continues to be problematic in stressed sugarcane, primarily in areas with long growing cycles.

WEED CONTROL

Chemical weed control research at SASRI began in the late 1940s with 2,4-D and compounds such as pentachlorophenol and trichloroacetic acid. However, it was not until the 1960s that these weedkillers were used commercially to an appreciable extent. Until this time, weed control was by hand, repeated interrow cultivations and the use of a mulch blanket. In 1930, approximately 55% of the industry was mulched, declining to only 10% by 2005.

The first **herbicide screening** trial was conducted by SASRI in 1962, and, during the 1960s, other herbicides such as paraquat, diuron, ametryne and atrazine were used. Herbicide use increased 15-fold from 1961 to 1970, and the growing importance of herbicides necessitated the appointment of a full-time specialist agronomist in 1967.

During the early 1970s, eight trials were conducted to evaluate the efficacy of the new herbicide glyphosate for killing sugarcane before replanting, leading to its registration in 1975.

The earliest **SASRI Herbicide Guide** from 50 years ago provided recommendations for using only ten active ingredients. During the 1980s and 1990s, this number increased to 27 active ingredients and 50 available generic products. Today, there are 32 active ingredients, with an explosion in the number of generics, currently around 300. To manage these data, the Herbicide Guide was adapted to a new electronic format in 2019, and the Herbicide Selector was developed to enable treatments to be filtered according to selected criteria. All legislative requirements are considered and SASRI maintains an up-to-date listing of recommended chemicals.

In 2001, a book (*Weeds of the South African Sugar Industry*) was published to assist growers in identifying troublesome weed species in sugarcane fields. This was followed by the Integrated Weed Management of Creeping Grasses in 2017, which provided a series of tactics for managing these problematic weeds.

BIOSECURITY INSPECTORATE

Given the numerous sugarcane pests and diseases affecting sugarcane, it is unsurprising that a significant part of SASRI's research programme has focussed on identifying and developing measures to mitigate their impact. However, during the 1970s, the realisation that poor management of pests and diseases was an industry-wide problem resulted in the introduction of industry legislation (both in the Sugar Act and Sugar Industry Agreement) to manage these threats. This legislation required the appointment of Local Pest Disease and Variety Control Committees (LPD&VCCs) in each mill area, comprising growers and millers. Pest and Disease Officers and field inspection teams (the Inspectorate) were appointed to provide LPD&VCCs with data and technical support and were attached to the Extension Department at SASRI. Informed by SASRI research, it was the LPD&VCCs that set the rules and hazard levels for each major pest and disease in their control areas, also specifying the necessary control measures should hazard levels be exceeded. In 1987, however, the Inspectorate was regionalised and became funded by levies on local growers.

While implementation of local rules led to containment of immediate threats, LPD&VCCs soon realised that the control of pests and diseases rested ultimately with resistant varieties and planting disease-free seedcane. To this end, several seedcane schemes were established to ensure sufficient LPD&VCC-certified or approved seedcane was always available to growers. In 2000 the responsibility for bulking and release of new SASRI varieties was given to LPD&VCCs.

In 2015, the Biosecurity Inspectorate was re-integrated into the South African Sugar Association (SASA) under SASRI management, and Extension Officers assumed the statutory role of Pest and Disease Officer including the line management functions within the Inspectorate. A set of industry-wide LPD&VCC rules and minimum standards was drafted and approved by the SASA Council, providing the standard for local rules and regulations. Notably, target dates for the mandatory use of LPD&VCC-certified and approved seedcane for commercial plantings were set, prompting the development of several regulated seedcane schemes. In 2016, a new LPD&VCC control area was established in the Mkhuze Makhathini region, bringing to 12 the number of LPD&VCC regions across the industry.

The Inspectorate has played an important role in the identification and control of several new incursions since its inception, including sugarcane thrips, tawny and orange rust, yellow sugarcane aphid, longhorn beetle, and maize streak virus. Through the prompt and decisive action by LPD&VCCs and the Inspectorate, these threats have been contained, avoiding serious consequences.

Significant progress with other long-standing pest and disease challenges has also been made: resistant varieties have all but eliminated the threat of sugarcane mosaic virus; strict implementation of control measures in the irrigated northern regions has contained the threat of smut; the focus on seedcane quality dramatically reduced the prevalence of ratoon stunt in several regions; while the various rusts continue to emerge under favourable conditions, effective fungicides have been registered for their control; and the development and registration of new chemistries to control eldana has played a prominent role in controlling the pest, allowing growers to increase harvest age of their crop to an economically optimum level.

Farming systems

CANE QUALITY MANAGEMENT

One of the noteworthy technological advances at SASRI during the 1970s was the introduction of research on **chemical ripening** to improve cane quality at harvest. This research was prompted by the diversity in South African agroclimatic growing conditions and variety characteristics, which complicate cane quality management. Ripening research gained further impetus during the 2000s following the introduction of the relative value (RV) cane payment system, which placed far greater emphasis on high cane quality. The ripening research at SASRI led to the local registration of different active ingredients with contrasting modes of action to cater for the diversity in cane quality management situations. Two combination ripener treatments were also registered, both world-first innovations in sugarcane, resulting in greater profitability to growers. As the adoption of chemical ripening gained traction, the need for variety-specific ripening recommendations escalated, leading to multi-location field trial testing of all new varieties from 1990.

Another world-first technological advancement in sugarcane research at SASRI, which enabled on-farm cane quality management decision support, was achieved through the launch of the **PurEst®** mobile application in 2016. The PurEst® application, used in conjunction with a hand-refractometer, allows growers to test sugarcane fields for their suitability for chemical ripening, and later, to decide on the harvest readiness of fields. The adoption of the PurEst® application by large-scale growers gained good traction and is used by the miller as a tool to guide ripening subsidy decisions in certain mill supply areas.

Due to the nature of small-scale sugarcane farming in South Africa, which often involves small fields and fragmented field layouts, **small-scale growers** could not reap the benefits from chemical ripening due to practical limitations in aerial spraying technology. A breakthrough was made when crop spraying drones were commercially legalised in South Africa. In response, SASRI reached out to small-scale growers and embarked on a drone ripening demonstration project in 2020 to showcase the potential of chemical ripening in the small-scale sector through precision drone ripening. The success of this project triggered pilot implementation initiatives in small-scale grower communities at the mill supply level in Mpumalanga and KwaZulu-Natal.

CROP MODELLING AND CLIMATE CHANGE

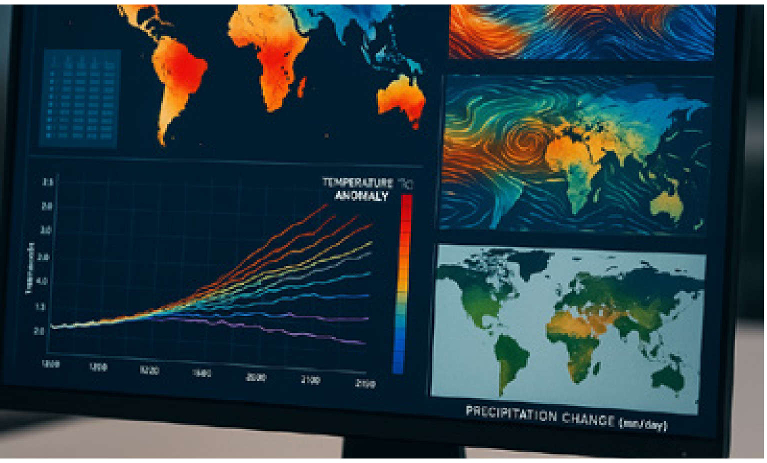
Advances in **weather data** collection and processing have benefited both crop modelling and climate change research. Over the years, and before 1997, SASRI's network of weather stations transitioned from being exclusively manually operated to having more than 90 automatic weather stations (AWSs), which include collaborations and mutually beneficial partnerships with other local players beyond the sugarcane producing areas of South Africa, and internationally with sugarcane producers within the SADC region. Data collection and processing procedures have changed from the initial once-a-day AWS data collection and processing to the current scenario where users access near-real-time data, updated every five minutes through the Real-Time Weather Data facility, an integral part of the SASRI WeatherWeb (https://sasri.sasa.org.za/weatherweb). Work is currently underway to develop a user-friendly mobile app.

Crop modelling is an essential tool in sugarcane research and crop management, playing a complementary role with other digital technologies, such as remote sensing and precision agriculture, to enhance sugarcane farming.

At SASRI, crop modelling has supported an improved understanding of many aspects of crop development and growth, including sugarcane water relations, genotypic and environmental control of biomass growth and sucrose accumulation, and climate change impacts on the crop. Modelling has also played an important role in improving crop water use efficiency, increasing the adoption of irrigation scheduling and improving the accuracy of crop forecasts. It has also enabled better medium and long-term planning of sugarcane production.

With the rapid advancement of computational technologies in the 1980s, SASRI embraced the potential of crop modelling as a powerful tool to guide research, fill knowledge gaps, predict crop growth dynamics, optimise agronomic practices, and assess risks associated with climate variability. Decades of prior excellent crop physiology and agronomy research at SASRI served as a solid knowledge base for the development of **crop growth models.** This culminated in the publication of the **Canegro** sugarcane model, a world-first, in 1991. It was used mainly as a crop research tool to estimate yield potential and water requirements.

This was followed by the development of **Canesim** in the late 1990s, (a simplified version of Canegro) and several computerised decision support tools to assist with irrigation and fertiliser management, replant decisions and crop residue management. Canesim has been used operationally for industry crop forecasting since 2003 to inform production logistics and marketing.



A user-friendly version of the Canesim model was also implemented on the internet from 2005 and as a smartphone app in 2020 to enhance accessibility of modelling technology for crop research and management. These are linked to Southern African historic and real-time weather data, enabling site-specific estimation of yield potential and crop water requirements.

Growing global demand for sugarcane crop modelling led to the establishment of the **International Consortium for Sugarcane Modelling** (ICSM), which was led by SASRI scientists. Collaborative projects under the ICSM banner included the incorporation of the Canegro model into the international **DSSAT crop modelling platform** (2006) and the strengthening of sugarcane crop models to simulate Genotype by Environment interactions (2010s), to support plant breeding programmes.

Continuous improvement of the Canegro model in the new millennium to reflect newly discovered knowledge of crop response to environmental factors has ensured its position as one of the most prominent and widely used sugarcane models in the world.

Research associated with **climate change** between 2011 and 2020 has resulted in an improved understanding of the sugarcane plant's response to high temperatures and elevated atmospheric CO_2 through collaboration with the North West University and using their open-top CO_2 chambers; improvements to the algorithms within the DSSAT-Canegro sugarcane simulation model for high temperatures and elevated atmospheric CO_2 levels; and an exploration, using modelling, of the effect of adaptation options including variety traits, row-spacing, age at harvest, date of harvest and water application efficiencies. Further, the application of the DSSAT-Canegro and APSIM-sugar models in conjunction with an ensemble of Global Circulation Models (GCMs), explored probable climate change impacts of elevated atmospheric CO_2 levels and water stress on sugarcane yield, sucrose yield and water use. This work formed part of the international **Agricultural Model Inter-comparison and Improvement Project** (AgMIP). Findings indicated that, in future climates, the presence of elevated atmospheric CO_2 concentrations might partially mitigate the negative impact of periods of limited soil water availability on sugarcane production.

DIGITAL AGRICULTURE

In the period 2000 to 2025, SASRI moved towards researching and promoting digital technologies in its research and services to growers, including spatial information systems; in-field digital data collection; imaging using drones; application of satellite remotely sensed data; and use of artificial intelligence and machine learning in data analysis.

The **Geographic Information Systems** (GIS) office, established in the early 2000s after the dissolution of the Farm Planning Department, became fully operational in 2007. Initially focused on providing GIS services to the sugar industry and digital farm planning, the office expanded in 2019 to support digital agriculture by developing near-real-time data collection workflows for Extension and Biosecurity services. Today, the GIS office provides essential spatial analysis and technological support to SASRI research, leveraging advanced geospatial technologies to drive data-informed decisions that improve the efficiency and sustainability of agricultural practices.

SASRI's journey into airborne digital agriculture began in 2016 with collaborative research using drone-based multispectral imaging to screen sugarcane breeding populations. Since then, SASRI has significantly expanded its in-house capabilities by training pilots, acquiring state-of-the-art drone systems and integrating advanced analytics, positioning itself at the forefront of **high-throughput phenotyping** in sugarcane research.

Building on this foundation, SASRI formalised its commitment to digital agriculture by establishing a **Strategic Digital Agriculture Framework** in 2021. The aim was to explore the utility of ground- and aerial-based spectral imaging and non-imaging technologies coupled with machine learning and artificial intelligence to provide actionable insight and decision support to growers. Within the Digital Agriculture programme, research is ongoing regarding the utility of satellite, drone, and field sensor data for estimating sugarcane yield, detecting and monitoring pest- and disease-induced stress, monitoring cane quality, crop nutrition, soil condition, and variety selection. SASRI scientists engage with local and international companies, universities and research institutes to facilitate knowledge exchange and skills development.

MECHANISATION AND TRANSPORT

In the 1920s, there was little mention of mechanisation in the industry. At that time, the use of the traditional cane knife and sparsely located hand gantry cranes for loading cane into wagons were in use. The use of motor lorries to transport cane from field to mill appears to have only become readily adopted in the 1930s, with infield loaders coming into use in the 1940s, and widespread tractor use by the 1960s. A growing realisation of the need for mechanisation support to growers led to the establishment of grower – and later industry – mechanisation committees. This was followed by on-farm research centres being established, with the first one on SASRI's Shakaskraal farm, and then at La Mercy in the 1970s.

From the mid-1970s to the early 1980s, SASRI developed and tested many whole-stalk semi-mechanised, low-cost **harvesting systems** suited to the industry's varied terrain, including a modified brush cutter that was developed into the Mini-Mech cutter, and a walk-behind sickle-bar cane cutter called the Cane Thumper.

Prototyping and testing these various machinery systems, tractor attachments and implement modifications enabled the provision of advice and recommendations on mechanisation alternatives and associated costings. The accumulation of these data resulted in the annual preparation of **Mechanisation Reports** in the late 1990s. These provide growers and other industry stakeholders with information to establish work rates and total costs of operating specific machines or complete machinery systems for land preparation, planting, ratoon management and harvesting.

The industry decision in the 1990s that mechanisation research be conducted on a full recovery or 'User Pays' basis resulted in the discontinuation of the mechanisation and design programmes at SASRI. However, the mechanisation reports are still published annually, and mechanisation experts continue providing advice to the industry through user-pays **Specialist Advisory Requests** (SARs). Further, advice on policy development and implementation also continue, contributing to the following: legalisation of the haulage tractor; road transport sugar industry self-regulation; and development of performance-based heavy vehicle standards (PBS).

Modelling of in-field traffic during sugarcane harvesting, loading and haulage operations was completed in 2019, with the aim of improving the sustainability of in-field mechanised operations by managing compaction and stool damage.

IRRIGATION AND WATER MANAGEMENT

The marginal production conditions and limited water supply for irrigation in the industry initiated research into water management and irrigation. Groundbreaking lysimeter research at Shakaskraal and Pongola in the 1960s and 1970s led to the formulation of **crop evaporation coefficients (crop factors)** for sugarcane that enabled more accurate estimation of crop evapotranspiration (ET) and

irrigation scheduling worldwide. At this time, the robust mathematical relationship between cane yield and ET was formulated to estimate potential yields for both irrigated and rainfed cane.

Crop factors for the FAO Penman formula for ET were further refined in 1996 to account for different growth stages, and later to account for different irrigation systems, planting densities and ground covers. This enabled accurate estimation of situation-specific crop water use that is essential for accurate irrigation scheduling and efficient use of water for cane production.

Innovative bin trial research in the 1990s explored the **effects of water deficit** on crop processes. This paved the way for further research using the rainshelter facility at Mount Edgecombe, as well as field trials at the Pongola and Komati research stations. The knowledge gained enabled better management of limited irrigation water during times of short supply and improved recommendations for irrigation management during cane maturation.

Between 2002 and June 2010, **research collaboration** with the Water Research Commission (WRC), the National Research Foundation (NRF), and various consulting firms focused on creating and integrating innovative tools and management systems. These ranged from field-level interventions to catchment-scale solutions, to optimise water use and improve crop yields at a time when water supply constraints and evolving government water allocation reforms were reshaping the agricultural landscape.

Some key developments during this time include the following:

- Development of a **catchment-scale irrigation systems model** in collaboration with the University of KwaZulu-Natal for evaluation of how variations in water availability within dams and rivers affected irrigated sugarcane and, conversely, how irrigation practices impacted water resources.
- Creation of a novel irrigation system (**Automated Short Furrow, ASF**) engineered to minimise water losses and reduce energy requirements. This system has shown promising results in commercial pilots and a large-scale application on a sugarcane estate in Africa. It has since been combined with surface and sub-surface drainage and named **Synergistic Surface Irrigation and Drainage**. In benchmarking tests, the original ASF system met and slightly exceeded the performance of traditional drip irrigation and was recognised by a South African patent.
- Development of **remote monitoring systems** for soil water and plant growth.
- Development of refined **irrigation scheduling tools**.
- Leveraging on data from in-field irrigation performance evaluations and water balance studies, **improved guidelines for the design and operation of irrigation systems** were published in collaboration with the WRC; and
- Advanced **economic analysis tools** and innovative water allocation models, which supported efficient water management practices (in partnership with SA Canegrowers and DHI South Africa).

Rapid technological advances in the 2000s in computing, telecommunication, automated weather and soil water monitoring stimulated the development of various irrigation scheduling tools and services. This included the award-winning **MyCanesim®** real-time irrigation scheduling service to small-scale growers.

The year 2008 marked the start of rapid increases in electricity tariffs in South Africa, affecting the cost of irrigation. Research resulted in the development of a modelling framework and **irrigation cost calculators** to quantify the impact of the tariff increases, and to investigate the revised tariff options (Landrate, Ruraflex and Nightsave), as well as mitigative irrigation design and management strategies related to off-peak pumping, tariff conversion and deficit irrigation.

In 2012, research was initiated to **improve the adoption** of irrigation scheduling tools. Complex systems methodology and social science research paradigms were used to investigate the community and social dynamics influencing behavioural choices. As a result, along with the high costs of electricity and the severe drought experienced in 2015 and 2016, the research and extension efforts increased the adoption of irrigation scheduling tools from 11% in 2014 to 65% in 2020 in the Pongola Mill Supply Area.

Advances in **remote sensing** in the 2010s enabled high resolution, near real-time spatial estimates of crop ET and crop water status. A WRC funded project in Mpumalanga evaluated this technology and showed great potential for monitoring large areas to support water management.

Knowledge Exchange

COMMUNICATION TECHNOLOGY

Over the years, SASRI has kept pace with advances in communication technology.

The knowledge generated at SASRI is captured and shared primarily through various publications, including information sheets, manuals, illustrative guides, reports, newsletters, and course notes. In the early years, these materials were distributed via the postal service or handed out at field events. With the onset of the digital era, SASRI transitioned to electronic distribution of its publications.

In the late 1990s, SASRI began distributing an annual compilation of its publications on CD and DVDs as the '**SASRI Info Pack**'. This ensured growers had convenient access to a comprehensive information resource. As optical disks became outdated and increasingly impractical to post, SASRI launched an '**eLibrary**' on its website. In addition to publications, the website provides growers and millers easy access to a wide range of resources and links to tools and services relevant to sugarcane production. Furthermore, the website lists ongoing research projects by programme, offering insight into SASRI's key focus areas and how they support its mandate.

SASRI has also embraced **audio and video communication** technologies. Every article published in our IsiZulu newsletter, *Ingede*, is converted into an audio podcast, which is then shared via smartphone technology (currently using WhatsApp) and posted on the SASRI website. SASRI contributes regularly to broadcasts on community radio stations and the public service's most popular station, Ukhozi FM. These programmes are targeted at the industry's small-scale growers. A dedicated YouTube channel hosts a variety of videos produced by SASRI, covering different aspects of sugarcane agriculture.

In addition to using WhatsApp to distribute audio podcasts, the platform is increasingly used to share concise information updates with grower groups. SASRI also maintains an active presence on LinkedIn to share updates on research developments, publications, grower events, and other achievements.

Beyond communication platforms, SASRI has made significant progress in developing **decision-support tools** that assist sugarcane farmers with various aspects of their farming operation, such as variety selection, herbicide and fertiliser application, ripener use, and yield estimation and benchmarking. These tools are available as desktop applications or smartphone apps.

The value of SASRI's vast knowledge repositories is realised through knowledge exchange between growers and researchers. This interaction enables research to be effectively targeted towards the needs of all growers. Through rapid communication of new technologies and knowledge, the profitability and sustainability of the industry are enhanced. While all communication technology is readily available to growers, it is the locally based extension service that provides the essential link between the research institute and the grower.

EXTENSION

In the 1950s, the appointment of **regional extension representatives** facilitated closer contact between the research institute and growers, enabling one-on-one contact with growers, organisation of annual regional symposia, grower meetings and training courses.

Later, as the industry expanded into Mpumalanga, Pongola and the KwaZulu-Natal midlands, a fully-fledged **Extension Department** was established in 1964. The early years of extension emphasised soil conservation and land use planning in addition to advice and support in general sugarcane agronomy. Extension officers also communicated with growers through regular newsletters, and *The Link* newsletter had its origins at this time.

Throughout its existence, the extension service has helped facilitate and support the various functions and services offered by the institute. This included the release and promotion of new SASRI varieties, the use of the Fertiliser Advisory Service (FAS) and assistance in establishing local trial sites for SASRI specialists to conduct formal and **participatory research**.

An explosion of eldana in the 1970s, together with a dramatic increase in smut in the irrigated northern regions and mosaic in the rainfed southern regions, necessitated a shift in the focus of extension to containing and managing these serious threats.

With the introduction of industry legislation to counter these emerging biosecurity threats in 1982, Pest and Disease Officers were appointed and joined the extension officers in an expanded extension department. In terms of the legislation, Local Pest and Disease and Variety Control Committees were appointed, and extension fulfilled a vital role in technical support and strategic guidance to these committees. Additionally, and in support of the aims of controlling pests and diseases, extension was key in encouraging and supporting the establishment of seedcane schemes.

The extension service to small-scale growers in KwaZulu-Natal was established in the early 1980s and steadily expanded until, in 1996, the first **Extension Venture Agreement** with the KwaZulu-Natal Department of Agriculture was signed. This joint venture significantly increased the sugarcane extension support to small-scale growers through a link with the Department's extension staff. Under this agreement, a team of SASRI sugarcane extension specialists provide technical support and training for government advisors. Recently, in 2024, an Extension Venture Agreement with the Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs was signed, further expanding this successful model of extension **support to small-scale growers**.

A significant change in the funding of extension occurred in the mid-1990s, when extension to large-scale growers changed from an industry-funded to a levy-paid service, resulting in a closer relationship and accountability to those growers paying for the service.

Research, Development and Extension (RD&E) committees were established to facilitate the flow of research needs from the regions to the institute, ensuring that research remains relevant and responsive. Regular interaction with growers through these forums is coordinated by extension and serves as an important driver for the institute's annual programme of work.

Further changes to large-scale grower extension came with the integration of the **Biosecurity Inspectorate** into SASRI in 2015. Here, SASRI large-scale grower extension specialists were tasked with statutory, oversight and line management functions within the Inspectorate.

SUSTAINABILITY

SASRI has been a long-standing proponent of sustainable sugarcane cultivation, supported by decades of research outcomes. Recommendations resulting from laboratory, glasshouse and field trials over the years have considered not only the economic advantages of a practice, but also how socially and environmentally responsible these practices are.

In 2008, the increasing pressure to demonstrate sustainable farming practices that also address food safety and quality concerns, as well as ethics and social responsibility, culminated in the development of the sugar industry's **Sustainable Sugarcane Farm Management System** (SUSFARMS®). It was designed as a tool to reduce the negative impacts on the environment whilst ensuring economic sustainability and social responsibility through the implementation of **better management practices** (BMPs).

Since BMPs are based on knowledge derived from scientific studies, or in the absence of such data, on best available knowledge, they require upgrading as new technology, thinking and methods are developed. Now in its 4th edition, SUSFARMS® incorporates a progress tracker that enables growers to assess their farming practices, taking into account both their legal obligations and their implementation of BMPs. Looking to the future when certification of sugar may become a requirement, implementation of SUSFARMS® is the avenue through which the sugar industry can demonstrate how their farming practices reduce the environmental impact of sugarcane production and promote fair treatment of workers and engagement with local communities, whilst ensuring farms are profitable in the long term.

CAPACITY BUILDING

Over the years, SASRI has made a significant contribution towards the development of young scientists. Vibrant **intern and postgraduate programmes** have enabled young scientists to conduct research at Mount Edgecombe under the supervision of SASRI scientists that are affiliated with several leading South African universities, including the University of KwaZulu-Natal, University of Pretoria, University of the Free State and Stellenbosch University. The standing of SASRI scientists and their research programmes has been recognised through their honorary appointments at South African universities and has also attracted significant **external funding** through agencies such as the National Research Foundation (NRF) and the Water Research Commission (WRC). In addition to managing and supervising postgraduates, SASRI scientists have also attracted several postdoctoral research fellows whose contribution towards various research programmes has been invaluable. Each year, two symposia are held to showcase the work done by these young researchers: a postgraduate symposium and an intern symposium.

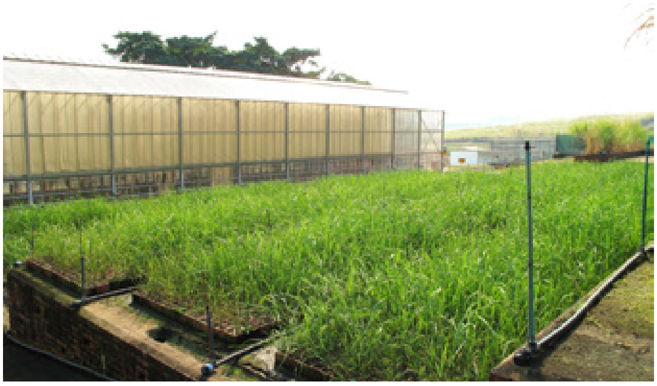
Recognising the demand for **agricultural training and education** in the late 1970s, a training department was established at first mainly to provide support to farm employees to improve productivity, and later, with the development of two Certificate Courses in Sugarcane Agriculture aimed at growers to enhance their farming practices, one for junior farm managers and the other for farm owners and managers. Today, SASRI delivers the Senior Course only, with education for Junior farm staff undertaken by the industry's Shukela Training Centre. To further enhance access to the senior course material, SASRI modular courses provide regional training on demand with the course content customised for local conditions.

SASRI Today

Since its establishment in 1925, SASRI has undergone numerous changes and has now grown into a world-renowned research facility which provides agricultural solutions for the South African sugar industry. While its headquarters remain at Mount Edgecombe, there are now four additional research stations across KwaZulu-Natal and another in Mpumalanga. The institute's name changed in 2004 from SASEX to SASRI, recognising the shift in research tactics from its initial experimental approach to a modern inter- and cross-disciplinary one.

RESEARCH PROGRAMMES

Research at SASRI is conducted in four research programmes.



The **Variety Improvement** programme conducts research and implements strategies for the continual release of high-yielding, adaptable, pest- and disease-resistant varieties that add value and enhance industry productivity. Key research areas include commercial breeding, variety characterisation, introgression breeding, trait development, and genomics.

The **Systems Design and Optimisation** programme investigates, develops and transfers innovative systems that optimise industry agricultural performance. Research, development and innovation are conducted in five main areas: production sustainability, water management, technology development, remote sensing, and small-scale sugarcane farming.

The **Crop Performance and Management** programme develops models and better management practices to sustain and enhance sugarcane production within the following broad areas: physiology, nutrition, soil health, residue management, cane quality management, and climate change.

The **Crop Protection** programme develops integrated management strategies that minimise the effects of pests and diseases on crop production in a sustainable manner. Key research areas include biosecurity, biology and ecology, resistance, cultural and environmental practices, and agrochemicals.

STRATEGIC FOCUS AREAS

The existing portfolio of research, technology development and knowledge exchange projects is designed to address industry strategic needs within six focus areas: sustainable sugarcane production; small-scale grower (SSG) sustainability; enhancing and enabling adoption; biosecurity; smart agriculture; and commercial opportunities. Within each focus area, a series of strategic objectives is delineated and reviewed annually.

Current strategic objectives associated with **sustainable sugarcane production** include development of new and improved varieties; development, refinement and support for implementation of sustainable farming practices; provision of advice on specific cropping systems; provision of guidance on mitigation of potential production and quality risks; and demonstration of potential value that could be derived from fourth industrial revolution (4-IR) technologies.

To address **SSG sustainability**, the focus is on development and support for implementation of customised technologies and better management practices that increase crop yield and reduce biosecurity risks; identification of additional methods that improve grower access to varieties and seedcane; implementation of solutions tailored to extension, biosecurity, education and training needs of SSGs and relevant industry role-players; implementation of customised farming systems in partnership with industry stakeholders and associations; and, identification of complementary on-farm opportunities to increase household income.

To make the most of SASRI technologies and better management practices, the focus on **enhancing and enabling adoption** includes development and implementation of effective marketing strategies, and the refinement of knowledge exchange methods.

The **biosecurity** strategic objectives include development and implementation of digital, real-time, and geo-referenced systems for pest and disease data management; a focus on cost-effective seedcane production technologies; promotion of incursion risk awareness and mitigation planning; modelling risk and epidemiology of specific existing and potential new pests and diseases to inform incursion risk mitigation planning; development and support for area-wide integrated approaches for pest and disease management; promotion of good biosecurity practice amongst all growers through education and training; and, engaging in policy advocacy and actively maintain stakeholder relationships with relevant government departments to retain and maximise the value of legislated self-governance.

In **smart agriculture,** the focus is on applications for aerial sensing technology, machine learning, mapping, decision-making and scheduling; 4-IR technologies and geo-spatial informatics for use in economic modelling, real-time monitoring and technology value assessments that improve productivity; and, development and implementation of smart decision-support systems that enable customisation of better management practices.

ADVISORY AND SUPPORT SERVICES

The importance of providing advice to the industry has not lessened, and today, SASRI continues to deliver advice in support of sugarcane agriculture, some of it on a user-pays basis. Where specialist capacity is available, **Specialist Advisory Services** (SARs) provide guidance on a range of issues to both local and international clients. These include variety choice and evaluation, data analysis, crop nutrition, irrigation, pest and disease management, crop forecasting, ripener applications, soils management and crop performance and management.

The **Fertiliser Advisory Service** routinely analyses soil, leaf, fertiliser and water samples for both South African growers and customers outside South Africa. While sample numbers vary from year to year, requests for soil analysis predominate.

SASRI operates two cane testing laboratories, one based at Mount Edgecombe for all Midlands, Coastal and Hinterland research trials, and the other on the Pongola research station for all Pongola and



Mpumalanga research trials. These provide a near-infrared (NIR) based **cane-testing service** for all SASRI field trials, but mainly for the Plant Breeding project.

The **disease diagnostics** service for local and SADC growers assists in mitigating risk and preventing yield loss associated with several diseases. Current focus areas of the disease diagnostic services are Ratoon Stunt (RSD) and Yellow Leaf Virus (YLS).

In 2016, SASRI's newly constructed **tissue culture** facility was opened in which proprietary tissue culture technology (NovaCane®) is used to propagate superior sugarcane genotypes in the final stage of the Plant Breeding programme to ensure that sufficient planting material is available for bulking upon variety release. It provides cane growers with true-to-type, disease-free planting material of all new varieties. Additionally, entities using the NovaCane® technology are audited to ensure that sugarcane plant product integrity and quality are maintained throughout the production process.

In the **quarantine** facility, NovaCane® technology is used routinely on all imported and exported varieties. While imports are generally less common, exports are regularly sent to many countries, including Brazil, Barbados, Tanzania, Kenya, the Democratic Republic of Congo, Mozambique and Eswatini. Through Variety Evaluation and Licence Agreements, SASRI controls the distribution of N varieties into Africa to protect SASRI's Plant Breeders' Rights.

A **genetic analysis** service is provided internally to SASRI researchers, Quarantine and Biosecurity, and to external clients as a specialist advisory request (SAR) service. Genetic analysis includes DNA sequencing and DNA fragment analysis which has enabled all South African commercial varieties to be fingerprinted. DNA sequence analysis is used to identify pathogens infecting sugarcane, as well as insects collected from sugarcane fields.

When requested, SASRI provides advice and recommendations on **mechanisation** alternatives, as well as on costings and system optimisation. Two mechanisation cost reports are prepared for the industry annually. When necessary, SASRI investigates the need for machinery development and, where appropriate, initiates and collaborates in its development.

SASRI plays a role in **policy development and implementation** by offering specialist advice on the development and implementation of the national government's water policy on behalf of the sugar industry, and by monitoring and providing comment on the development, amendment, and implementation of transport-related legislation.

Meteorological data are collected from the SASRI automatic weather station (AWS) network, consisting of 80 AWSs within and beyond the sugarcane growing regions of South Africa. The records are made available to various users via the SASRI WeatherWeb, www.sasri.org.za/weatherweb, which is updated every five minutes (real-time function), to help with decision-making and planning for various operations. SASRI also offers AWS installation and maintenance services within and outside the borders of South Africa.

SASRI produces operational monthly **forecasts of the sugarcane crop** at a mill and industry level. These are derived from weather and irrigation water supply data, climate forecasts and the Canesim® crop model. Detailed cane yield forecast information is made available to registered users, while industry estimates of cane production are shared widely within the industry. Information from Canesim® crop forecasts is also used by the SASA RV Forecast Committee to guide Mill Group Boards in providing monthly forecasts of seasonal average RV content of cane for each mill area. These estimates are used to calculate growers' remuneration for cane deliveries.

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