South African Sugarcane Research Institute

Progress Report

2020/21

Contents

Chairman's Report

Suresh Naidoo

Against the backdrop of discussions on the development of a sugar industry Sugarcane Value Chain Master Plan that is aimed at stabilising the industry and positioning it on a trajectory towards long term sustainability, continued financial constraints in the past year placed considerable pressure on the SASRI budget. This together with the impact of the COVID-19 pandemic posed further strain on the institute.

Nonetheless, SASRI managed to continue producing high quality research outcomes that delivered significant value to all growers. Its approach was influenced by the three primary communities of learning in sugarcane production, namely all sugarcane growers, the grower and miller associations and SASRI. This resulted in the development of what was termed a 'transitional programme of work' based on the existing research, development and extension (RD&E) mechanism for identifying grower's research requirements, but that also interrogated its suitability in enabling equitable alignment of the programme of work (POW) with the requirements of all growers and small-scale growers in particular. The POW placed considerable emphasis on developing suitable approaches to improve understanding of small-scale grower research needs and the appropriate knowledge exchange mechanisms that would lead to successful adoption of new technologies. As always, this annual report highlights many of these achievements.

SASRI's response to the constraints and difficulties posed by COVID-19 was commendable. Not only did the institution ensure the safety and welfare of all its employees by introducing a hybrid working model that enabled a large staff complement to work safely and remotely, it also ensured that all research station operations and laboratory work could proceed without much interruption. The main impact was during the initial hard lockdown when the biosecurity service was suspended since survey teams could not be deployed to conduct their work. Further, some of the institute's repairs and maintenance programme was negatively impacted mainly by availability of contractors, many of whom were unable to perform their functions during COVID. However, it is often said that in the face of adversity, resilience and innovation is tested – and it is undoubted that SASRI successfully rose to this challenge and sustained its research and extension programmes.

The Sugarcane Research and Sustainable Agriculture (SRASA) Committee met on five occasions during the year to provide necessary guidance and oversight to SASRI's Management team. In view of the impending termination of SASRI's existing strategic plan in March 2021, considerable effort was devoted to developing a new five-year strategic plan for the institute. Accordingly, the SRASA Committee requested that SASRI Management provide guidance to the SRASA Working Group on potential directions for research, development and knowledge exchange that would enable the institute to innovate in support of industry sustainability in the years to come. In a series of six workshops and taking into account, the developments in the draft Sugarcane Value Chain Master Plan, the Agriculture and Agro-processing Master Plan Value Chain Deep Dives and also information contained in the June 2020 presentation prepared by the national Department of Agriculture, Land Reform and Rural Development entitled *"Agriculture and Agro-processing Master Plan"*, as well as various discussions with SRASA Committee members and their constituencies, a new strategic plan was formulated, agreed by the SRASA Committee and presented to Council for approval. This was subsequently approved in June 2021.

As one of its primary functions, the development and release of new and improved varieties that takes up a considerable portion of SASRI's budget and manpower, is key to the success of the South African sugar industry. The value of these N varieties is recognised not only in our industry, but also in various other sugar industries in Africa, where they have long served as the backbone to their production. During this past year an approach by a Brazilian company to partner with them and select, evaluate and release N varieties in their vast sugar industry has been a first. Accordingly, a Variety Evaluation and Licence Agreement that secures SASRI's intellectual property was approved and should a variety be produced and be successful, the ensuing commercial arrangements would generate considerable revenue for SASRI. Additionally, the insights into the mechanisms employed in the proposed rapid evaluation programme in Brazil would be of significant value for SASRI researchers.

Ongoing discussions and developments associated with achievement of the 2023 target for deployment of only certified or approved seedcane for all new sugarcane plantings has seen rapid and pleasing progress in some areas of the industry towards achieving compliance. Undoubtedly, SASRI's role in guiding some of these developments has been significant, but monitoring the implementation of this regulation in 2023 will pose some challenges. Whether or not SASRI is suitably resourced to manage this process will likely become a subject of debate going forward.

The range of successes and advances outlined in this annual report is testimony to the value that is delivered by a research institute that is dedicated to serving a single crop. While there is some diversification in production on many farms in the industry, and some suggestions that the research effort at SASRI could be diversified accordingly, this might be deleterious not only because SASRI researchers are sugarcane specialists but also because it would likely result in dilution of the research value that might be achieved. Research conducted over the past 95 years dedicated to sugarcane production has enabled the sugar industry in South Africa to thrive. It is this legacy that is very precious and should be nurtured and sustained so that our sugar industry survives into the future.

In conclusion, I wish to report on the retirement of our SASRI Director Dr Carolyn Baker, effective end of March 2021. Carolyn, who has been at the helm as Director for the past 12 years, assumed the SASRI leadership role at the time when the institute was still undergoing teething pains due to their recently introduced matrix organisational structure. With great care and determination, she facilitated the bedding down of the structure, that resulted in SASRI becoming more dynamic, flexible and better able to respond to stakeholder needs than before the advent of her custodianship. Importantly, Carolyn also saw the institute through many very lean years of industry austerity, adapting and moulding SASRI into the lean and efficient institute it is today. Striving always to ensure that SASRI serves the industry in the best possible way, she has guided SASRI along the pathway to several notable and tangible accomplishments which remain a lasting legacy to her leadership. Not only has Carolyn been an extraordinary leader, she has always been a warm and caring colleague to her staff and the SRASA Committee members. Carolyn, I THANK YOU!

In bidding farewell to Carolyn, I would also like to welcome Dr Terry Stanger who takes over the helm at SASRI. Terry brings with him a wealth of experience from the Timber Industry.

Director's Report

Dr Carolyn Baker

In a year dominated by the COVID-19 pandemic, SASRI devoted considerable effort to ensuring continuity of its operations and preparing the workplace to be safe for its employees. As a declared an essential service provider to sugarcane agriculture, we were fortunately able to continue our research programme throughout, apart from the first 'hard' lockdown when only essential activities were maintained. All field operations on the research stations and at Mount Edgecombe were planned and conducted by live-in employees. As far as possible all staff that were able to work remotely did so, and this practice has been continued following termination of the lockdown, while all other on-site work resumed in accordance with regulations. While delivery on the full Programme of Work was obviously affected, it was remarkable that SASRI managed to sustain all key activities, and indeed through adopting alternative work practices, learned how to conduct its work in novel and exciting ways.

Considerable progress was made in developing a new strategic plan for the institute, with specific emphasis on ensuring that it reflected the requirements of all stakeholders. Following the Sugarcane Research and Sustainable Agriculture (SRASA) Committee directives, SASRI provided guidance on potential focus areas for research, development and knowledge exchange that would enable the institute to innovate in support of industry sustainability in the ensuing years. Through a series of engagements with members of the SRASA Working Group, an agreed strategic plan was finalised at the end of the year and recommended to SASA Council for adoption. Given the dynamic nature of the sugar industry at present and in view of potential directives that might emanate from the Sugar Industry Master Plan, this five-year strategic plan will likely require some flexibility with respect to some of the stated goals.

Industry austerity measures implemented in previous years continued, with increasing emphasis being placed on SASRI to enhance its external income. Historically this income has emanated from several sources associated with the licencing and use of SASRI-developed "N" varieties, mostly amongst our SADC counterparts but also in other countries in Africa. Since the varieties have proven to be very successful in Africa, considerable demand for them exists. Increasingly, however, other variety developers have been successfully targeting the African market, although at vastly higher commercial rates. This knowledge enabled SASRI to review its existing licencing provisions and demand higher royalties for the suite of services that are provided and offer these services at competitive rates. Considerable efforts were also put into increasing income from specialist advisory services, although the limitation imposed by resource constraints, restricted the extent of this income.

As always, SASRI succeeded in making remarkable research progress with several outstanding achievements, all of which are outlined in this Progress Report. Some of the notable successes included approval for bulking and gazetting of two new coastal short-cycle varieties that were selected on the Empangeni Research Station (N76 and N77). Additionally, and representing the culmination of research conducted over 11 years, our specialist team successfully induced herbicide tolerance in a variety using a mutagenic approach. This methodology, which is quite different from a GM approach, resulted in production of a number of variants of N12 that were herbicide tolerant. One of these (N12 Mut6) was identified as the most suitable for commercial production and is being produced under the name N12 Zapyr.

Work in support of Biosecurity in the fields of chemical ecology of both eldana and the longhorn beetle are ongoing, as is the proof-of-concept work associated with sterile insect technology in eldana. Agrochemical research associated with identifying new chemistries for control of sugarcane diseases was promising and monitoring for any likely incidence of orange rust along our northern borders continued without any spore detection. The GM programme to develop an insect-resistant and herbicide-tolerant variety successfully delivered a number of genetically engineered plants that are being assessed for their level of resistance to eldana.

During the year considerable emphasis on developing a participatory approach in support of small-scale growers resulted in numerous engagements with growers, which despite restrictions imposed by COVID-19, were very successful in providing them with a number of new technologies to enhance their production practices.

Investigations into improving sugarcane crop growth models revealed that, in order to be successfully applied to sugarcane breeding, they would require additional inputs associated with the germination, growth and canopy development processes that would collectively increase the ability to simulate accurate genotype-by-environment interactions affecting growth and yield.

Development of tools and decision-support technologies continued and significant progress into designing and producing an interactive variety selector tool was made. With the intention of facilitating variety choice and determining suitability of varieties in specific growing conditions and in any region, the tool will provide an invaluable system to Extension, in particular, to offer support and guidance to all growers.

In a year where the industry remained under increasing financial constraints, it was not surprising that budgetary pressure required some restructuring at SASRI with specific attention on improving efficiencies and streamlining some activities. Refinement in the approach to weeds management and a change in emphasis in our agrochemical research resulted in several changes in the organisation in addition to some reorganisation of existing functions. This process while unsettling for everyone, was completed in a transparent manner as possible, enabling SASRI to continue to focus and deliver on its core functions of research, development and innovation.

This past extraordinary year will surely be remembered by everyone for several reasons, but not all of them were marred by the COVID-19 pandemic. At SASRI, our complement of remarkable employees showed exceptional resilience and resourcefulness in sustaining their work and dedication throughout, is reflected in the quality of their outputs and outcomes during the year. The full extent of their achievements is reflected in this report, and I encourage you to engage with the forthcoming pages.

Towards the end of the period under review, SASA successfully recruited a new Director for SASRI. Coming from the forestry sector, Dr Terry Stanger has a very astute understanding of the agricultural landscape in South Africa and will undoubtedly succeed in leading the research institute in support of sugarcane agriculture over the next few years. As I wish him every success, I bid you all farewell and look forward to my retirement. I have immensely enjoyed leading SASRI over the past 12 years and will keenly await its new successes in the years to come.

Research, Technology Development and Knowledge Exchange

Dr Derek Watt
(Research Manager)

SASRI research, technology development and knowledge exchange activities during 2020/2021 continued to deliver outcomes to support sugarcane growers in their efforts to maintain and improve the profitability of their farming enterprises. Despite initial disruptions from the COVID-19 lockdown measures, progress was good, with advances made in the development of several technologies, including those relating to the support of

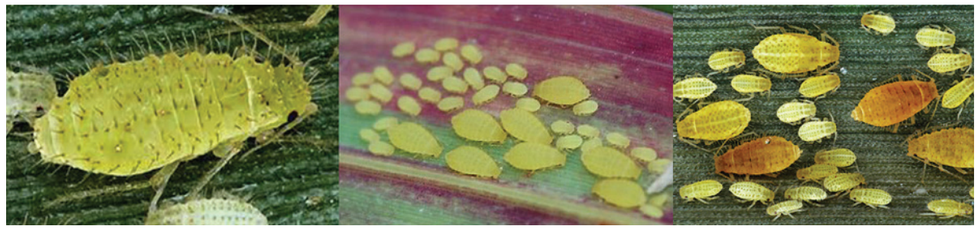
(a) biosecurity functions;
(b) the agro-technical self-sufficiency of small-scale grower communities;
(c) grower decision-making; and
(d) growers in the effective management of their crops through improved access to refined and updated recommendations.

Key Focus Areas

BIOSECURITY ENABLING TECHNOLOGIES

SASRI research, technology development and knowledge exchange activities play a crucial role in enabling and supporting the effective operation of the SASRI Biosecurity Inspectorate through the development of knowledge resources, management tools as well as monitoring and diagnostic technologies.

Emphasis in 2020/2021 was placed on the yellow sugarcane aphid, with two new projects initiated to complement ongoing and completed research, technology development and knowledge exchange projects.



Yellow Sugarcane Aphid: A topic of ongoing focus in research, technology development and knowledge exchange in 2020/2021.

SMALL-SCALE GROWER ENABLING TECHNOLOGIES

Being guided by a top-down industry mandated strategic plan and bottom-up grower engagement processes, the SASRI annual programme for research, technology development and knowledge exchange is designed to represent the interests of all cane growers. However, over the years, a level of uncertainty has arisen as to whether existing grass-roots grower engagement processes were effective at surfacing accurate and representative views of the agro-technical priorities of the small-scale grower sector. As a result, SASRI completed a study during 2020/2021 that interrogated grower engagement processes from a small-scale grower perspective (Developing a Participatory Research, Development and Extension Process for Small-scale Growers in the South African Sugar Industry [SASRI Project Reference 14SD02]), the outcomes of which have informed the adoption by SASRI of empowering participatory research methodologies to assist small-scale growers in increasing their self-sufficiency in the agro-technical management of their crops.

Emphasis in 2020/2021 was placed on producing research, technology development and knowledge exchange outcomes aligned with the specific circumstances of small-scale grower communities, with four new projects initiated to complement ongoing and completed work.

Technologies and knowledge products for small-scale growers: An area of ongoing focus for research, technology development and knowledge exchange activities in 2020/2021.

GROWER DECISION-SUPPORT TECHNOLOGIES

Decision-support technologies, including smartphone apps and online tools, have the potential to be of value to growers wishing to implement tactics to improve efficiencies, reduce production costs and proactively manage adverse production conditions. In this area, SASRI undertakes research, technology development and knowledge exchange in response to:

(a) requests that have been identified as being of priority during informal and formal grower consultation processes;
(b) the direction provided through by the mandate and strategic objectives set for the institute by the grower and miller leadership; and
(c) international and national technological developments within other commodity crop or sugarcane industries that have been identified by SASRI specialists as having the potential to add value to local growers who cultivate cane on either a small- or large-scale.

VARIETY Guide | WeatherWeb | MyCANESIM Lite | PurEst™ | FertiCalc | RustCalc

Grower decision-support technologies: An area of ongoing focus for research, technology development and knowledge exchange activities in 2020/2021.

ENHANCING GROWER ACCESS AND USE OF THOUGHTFULLY CURATED KNOWLEDGE ASSETS

Since the inception of the institute in 1925, SASRI has accumulated a vast wealth of valuable scientific data that serve for the ongoing development of knowledge assets to guide growers towards maximising the profitability and sustainability of their sugarcane farming enterprises. Encouraging the adoption of these recommendations by growers remains an ongoing priority for SASRI. To this end, ongoing activities during 2020/2021 included:

(a) empowering SASRI research, biosecurity and extension staff, though skills development, to plan and conduct effective knowledge exchange activities with their growers; and
(b) maximising the accessibility and value of existing knowledge assets for growers to ease their implementation of best practice.

Refinement and curation of knowledge assets: An area of ongoing focus in 2020/2021.

Research and Knowledge Exchange Highlights

Major highlights in 2020/2021 were the approval for gazetting and bulking of two new varieties for the industry, ongoing demonstration of the good performance of new varieties and progress in the development of a borer-resistant GM variety.

- Two new rain-fed, coastal short-cycle varieties (N76 and N77) with superior yield, pest and disease resistance characteristics and agronomic performance were approved by SASA Council for gazetting and bulking.
- Testing of newly-released varieties under commercial conditions continued to demonstrate their superior performance compared with that of older varieties.
- In developmental research, sugarcane plants were genetically-engineered with selected Bt genes, many of which were demonstrated to successfully express the insect-resistance Bt protein.

BIOSECURITY ENABLING TECHNOLOGIES

- Two additional investigations were initiated to address the yellow sugarcane aphid management challenges faced by growers:
  (a) species diversity of natural predators of yellow sugarcane aphid; and
  (b) the susceptibility of sugarcane varieties to the pest.
- Evidence was obtained that Bandito® may provide yellow sugarcane aphid intermediate or susceptible varieties with protection against the insect when compared with more resistant varieties, in which the effects of the chemical may be masked by the endogenous resistance of the variety.
- A mechanical harvester decontamination procedure was developed and shown to reduce RSD spread into healthy cane from infected stools, although it is lengthy and unable to completely eliminate the risk of transmission.
- An ongoing proof-of-concept study yielded promising preliminary results regarding the efficacy of the novel F1 sterile insect technique developed by SASRI in managing eldana damage to sugarcane grown within containment cages.
- No spores of brown, orange and tawny rust were detected in 2020 during routine monitoring on the SASRI Komati Research Station.

SMALL-SCALE GROWER ENABLING TECHNOLOGIES

- Three trial sites on the South Coast were secured to demonstrate the possibilities for chemical ripening that crop-spraying drones have opened for small-scale growers.
- Small-scale grower Extension Specialists and KZN DARD Agricultural Advisors were capacitated in soil conservation theory and practice with a view to promoting small-scale grower learning in this critical area of crop management.
- SASRI specialists were trained in empowering participatory research methods with a view to instituting community engagements aimed at ultimately increasing the self-sufficiency of small-scale growers in their management of varieties, pests, diseases and irrigation.

GROWER DECISION-SUPPORT TECHNOLOGIES

- Infrared spectroscopy was shown to have potential to replace certain wet chemistry laboratory techniques as a rapid, low-cost diagnostic method for soil and leaf fertility testing.
- A digital Variety Guide was developed to enable Extension Specialists to guide their growers in comparing variety information to ease their decision-making regarding variety choice.
- A customisable Excel-based tool was developed to enable Extension Specialists to advise their growers on the effects of various lodging scenarios on revenue.
- Tools and knowledge resources were developed to assist growers in improving their awareness of the negative effects of salt build-up in soils under irrigated sugarcane production.
- The SASRI WeatherWeb online tool was modernised and an application to enable use of the site on smartphones is to be released during 2021/2022.

ENHANCING GROWER ACCESS AND USE OF THOUGHTFULLY-CURATED KNOWLEDGE ASSETS

- Seven projects were instituted to review and subsequently update, consolidate or develop, as necessary, new knowledge resources encapsulating SASRI recommendations within seven key areas of crop management:
  (a) insect pests;
  (b) diseases;
  (c) weeds;
  (d) planting and harvesting;
  (e) irrigation;
  (f) varieties; and
  (g) cane quality management.
- Guidelines were developed as a knowledge resource for growers and their advisors on the management of fields to optimise root development.
- As part of an ongoing initiative, a training programme was conducted to upskill and develop SASRI staff in the theory and practice of knowledge exchange. The programme was designed to promote learning and stimulate new knowledge exchange practices based on well-established cognitive principles.

Programme Management for Outcomes Delivery

Delivery of outcomes from research, technology development and knowledge activities during 2020/2021 was managed within five programme areas.

VARIETY IMPROVEMENT

Developing and releasing sugarcane varieties with high sugar yield, achieved through increased biomass and sucrose yield, which have pest and disease resistance, adaptability, ratooning ability and agronomic and milling characteristics desirable to both millers and growers.

CROP PROTECTION

Developing integrated management strategies that minimise the effects of pests, diseases and weeds on sugarcane production in a sustainable manner.

CROP PERFORMANCE AND MANAGEMENT

Developing models and recommendations that sustain and enhance sugarcane production.

SYSTEMS DESIGN AND OPTIMISATION

Developing and sharing innovative systems that optimise industry performance.

KNOWLEDGE EXCHANGE

Facilitating the exchange of agro-technical knowledge through the design and implementation of a variety mechanisms and interventions in collaboration with industry participants and stakeholders.

Variety Improvement Research

Dr Sandy Snyman
(Programme Manager)

Developing and releasing sugarcane varieties with high sugar yield, achieved through increased biomass and sucrose yield, which have pest and disease resistance, adaptability, ratooning ability and agronomic and milling characteristics desirable to both millers and growers.

Research Focus Areas

BREEDING AND ASSOCIATED ENABLING TECHNOLOGIES

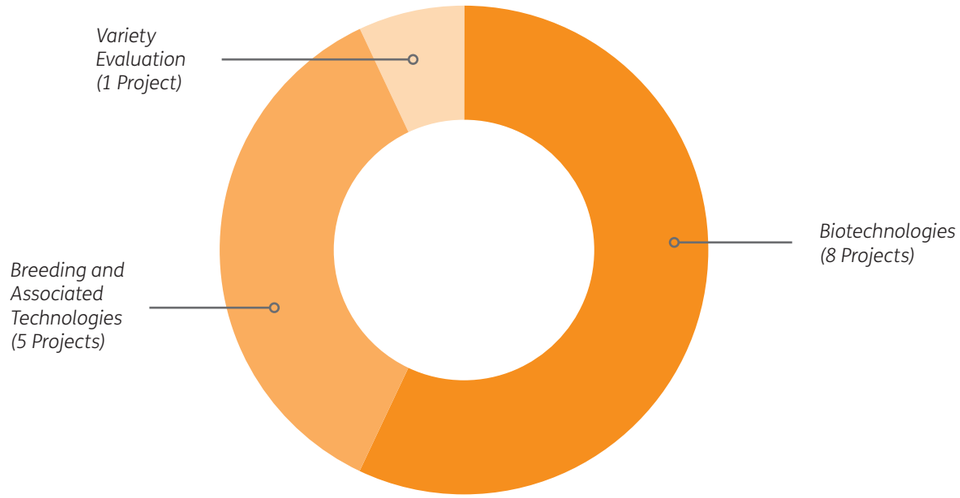
- Developing and releasing varieties with sucrose, yield, pest and disease, agronomic and milling characteristics desirable to both millers and growers.
- Developing innovative technologies to expedite breeding, including genetic markers and introgression breeding.

VARIETY PERFORMANCE EVALUATION

Providing accurate, comprehensive and timely variety information that assists growers in making the best variety choices.

BIOTECHNOLOGIES

Developing key innovations, including those involving genetic engineering and mutagenic breeding that enable the production of varieties with novel and improved traits.



Research Highlights

- Two new rain-fed, coastal short-cycle varieties (N76 and N77) with superior yield, pest and disease resistance characteristics and agronomic performance approved by SASA Council for gazetting and bulking.
- Ongoing testing of newly released varieties under commercial conditions continued to demonstrate their superior performance compared with that of older varieties.
- Sugarcane plants genetically-engineered with selected Bt genes, many of which were demonstrated to successfully express the insect-resistance Bt protein.

- Follow-on research commenced in the ongoing development of new knowledge for the preparation of a regulatory dossier needed for the future potential release of a Bt GM sugarcane variety.
- Genetic engineering and mutation breeding approaches explored the potential for improving sugarcane water-deficit stress tolerance, some of which yielded promising preliminary results under glasshouse and poly-tunnel conditions.
- Promising results revealed the successful development of several gene promoters that can drive preferential foreign gene expression in leaves (nine promoters) and roots (four promoters).
- With SASA Council approval, in-house capacity was expanded for the cryo-preservation of valuable germplasm, including that of genetically-modified insect-resistant sugarcane lines and core breeding material.

New Research

BREEDING AND ASSOCIATED ENABLING TECHNOLOGIES

Investigation of genome structure, diversity and phylogenetic relationship of Saccharum species, and assessment of diversity incorporated into modern cultivars (Research Contract: Dr Angélique D'Hont, CIRAD, France) (Project Reference: 19VI1C)

Generating new knowledge of the genome structure, origin and phylogenetic relationships of the Saccharum species involved in modern cultivars for introgression breeding applications and facilitating exploitation of available sugarcane genome sequence information for variety development purposes.

This new research project is to be conducted by Dr Angélique D'Hont and her team at the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) in Montpellier, France. The project is co-funded by ten member countries and organisations of the International Consortium for Sugarcane Biotechnology, which includes SASA/SASRI.

Genetically modified sugarcane: Preparative research for regulatory dossier requirements (Project funded by Biosafety South Africa which is operated by the Technology Innovation Agency of the Department of Science and Innovation) (Project Reference: 19VI1E) (Project Manager: Dr Sandy Snyman)

Developing new knowledge for use in the preparation of the regulatory dossier that will be required for the future potential release of Bt GM sugarcane in a multi-institutional partnership project funded by Biosafety South Africa, which is a unit of the Technology Innovation Agency of the national Department of Science and Innovation.

The project involves close collaboration with researchers who have expertise in logistics modelling (Dr Linke Potgieter, Stellenbosch University) and science communication (Professor Janice Limson, Rhodes University). The investigations will generate new knowledge required for the preparation of a regulatory to support a future application for the release of an insect-resistant and herbicide-tolerant genetically-modified sugarcane variety (Bt GM sugarcane), including:

- evaluating of the likelihood of gene flow from commercial sugarcane hybrids to compatible wild relatives (follow-on research) and potential cross-hybridisation in the field and via human intervention (SASRI Project Reference: 00VI05);
- planning refugia for a Bt GM sugarcane scenario in combination with implementation of the sterile insect technique (follow-on research) to reduce the risk of the development of resistance within the populations of target insects;
- developing an eldana risk index to inform: (a) the roll-out Bt GM cane to regions most at risk; and (b) the development of a monitoring system for pest numbers once GM cane is deployed (SASRI Project Reference: 16TD04); and
- developing a communication strategy for GM cane that is aimed at engaging industry stakeholders in the first instance and the general public in the long-term.

Outcomes from Completed Research

During 2020/2021, three projects were completed, one of which developed technologies to enhance sugarcane breeding and two that aimed to improve sugarcane through the deployment of biotechnologies based on genetic engineering and mutagenic breeding approaches.

BREEDING AND ASSOCIATED ENABLING TECHNOLOGIES

Transcript-based stress-response markers for breeding applications (Project Reference: 17VI01) (Project Manager: Dr Shailesh Joshi)

Gene expression in sugarcane may be reliably and cost-effectively determined using high-throughput microscope-slide based arrays based on a novel design developed by Cambridge Sequence Services (CSS) (Cambridge, UK). Two genes were identified that are expressed consistently in different genotypes and under different conditions, which enables their use as controls for expression-based marker technologies.

The hypothesis underlying this research was that effective marker-assisted breeding (MAB) in sugarcane is dependent on the availability of genetic markers that depict genes of known functions, and which are either expressed in response to the stimulus of interest (e.g. drought stress, smut infection, phytotoxic soil aluminium concentrations) or the metabolic pathway that is responsible for the biosynthesis of the plant component of interest (e.g. lignin). The use of these so-called 'perfect' markers[1] contrasts to the approaches most routinely used in crop MAB that rely on anonymous markers[2] in which the identity of the gene is unknown.

The Terms of Reference of the 2017 external review of the Variety Improvement Programme requested specific comment from the Reviewer, Dr Phil Jackson of the CSIRO in Australia, on SASRI MAB research. In his report,

Dr Jackson indicated that the current SASRI quest for perfect markers would require extensive additional research investment to enable potential implementation of the technology in the breeding programme. Given the downward budget pressure faced by SASRI at the time, SASRI management made the difficult decision to discontinue this area of research to enable ongoing investment in other aspects of the research programmes of work. Hence, the research results reported are from the final project (Project Reference: 17VI01) in a series of previous projects (Project References: 12VI01[3] and 12VI06[4]). The research undertaken in Project 17VI01 yielded several important outcomes that will be of value to the SASRI research and technology development programme despite the disinvestment in research to discover perfect markers.

The research made use of quantitative real-time PCR (qRT-PCR) technology to elucidate the relative expression of genes of known functions in different sugarcane genotypes. However, to do this accurately, stably-expressed reference transcripts were needed to enable comparisons between genotypes and responses to different environmental stimuli. This research successfully identified two genes (QKY and P4H) that are expressed at the same level in different genotypes and under different conditions, which enables their use as controls in the qRT-PCR technology. The identification of these reference (control) genes represents a significant step forward in identifying the differences in gene expression in the tissues of complex polyploids such as sugarcane.

An interesting outcome of this research was identification of cross-over between heat/water stress pathways and cold stress pathways, which may explain the observation that tropical and drought-adapted plants still retain some measure of cold tolerance.

The research further demonstrated that gene expression in sugarcane may be reliably and cost-effectively determined using high-throughput microscope-slide based arrays based on a novel design developed by Cambridge Sequence Services (CSS) (Cambridge, UK). This array technology allows for greater throughput in a considerably shorter time than qRT-PCR, which would make large-scale genotyping of entire populations not just viable, but relatively simple to do with a true high-throughput platform. If routine screening of SASRI germplasm for various gene transcripts via this technology were to be considered in future, a partnership or collaborative agreement with CSS would be required. Furthermore, the study is the first to report on the derivation and utilisation the sequence of the genes in sugarcane along with their transcripts. Should the technology be implemented at a future date, this expression-based marker system would offer significant cost and delivery benefits over any of the currently-available marker technologies.

[1] The term 'perfect marker' is sometimes used when tests are performed to detect a single nucleotide polymorphism (SNP) or other DNA polymorphism in the gene of interest, if that SNP or other polymorphism is the direct cause of the trait of interest.

[2] An 'anonymous marker' is a segment of DNA not known to correspond to a named gene that can be used as a marker in the construction of genetic maps.

[3] Project Reference 12VI01: Synteny analysis and genome mapping in sugarcane by identifying genes present on trait-associated haplotypes through exploitation of the sorghum genome sequence.

[4] Project Reference 12VI06: Genetic variation and phylogeny of *Saccharum spontaneum*: A resource for developing cold and drought tolerant sugarcane cultivars for biofuel and energy production.

BIOTECHNOLOGIES

Field deployment of N12 Zapyr imazapyr-tolerant sugarcane (Project Reference: 16VI02) (Project Manager: Dr Sandy Snyman)

In demonstration plots of N12 Zapyr, developed by SASRI by mutation breeding and planted at various locations, imazapyr herbicide efficacy was demonstrated by foliar application at four months after planting, although field deployment is aimed at planting in Arsenal® GEN 2-treated soil without the recommended waiting period.

Imazapyr is a registered herbicide in South Africa (no. L8817; Arsenal® GEN2; BASF South Africa [Pty] Ltd) for the control of grass and broadleaf weeds prior to sugarcane re-planting. It gives good control of weeds such as *Cynodon* and *Rottboellia* species which are a major problem in sugarcane production. Imazapyr acts by inhibiting acetolactate synthase (ALS) which is a key enzyme in the biosynthesis of essential amino acids in plants.

Previous research projects at SASRI resulted in the generation of imazapyr tolerant sugarcane by mutation breeding and line N12 Mut 6, now known as 'N12 Zapyr', was chosen for further research.

The aim of this project (Project Reference: 16VI02) was to develop an integrated weed management programme for deploying imazapyr-tolerant sugarcane by:
(a) creating imazapyr-tolerant green manure plants such as winter oats;
(b) creating additional imazapyr tolerant sugarcane lines using both mutagenic breeding and genetic engineering approaches; and
(c) planting grower demonstration plots using imazapyr-tolerant sugarcane.

The main outcomes of the research are described below.

- Molecular characterisation of the mALS gene in the N12 Zapyr sugarcane line revealed various DNA nucleotide base-pair changes resulting from the application of the mutagenic protocol. The nucleotide base change from guanine (G) to Adenosine (A) at nucleotide position 2 184 imposed a S622N mutation which prevents imazapyr from binding to the ALS enzyme, thereby conferring tolerance to the herbicide in the N12 Zapyr line.
- Genetically-modified (GM) sugarcane was produced using the sorghum mALS construct (provided by Professor F. Altpeter of the University of Florida). In vitro selection of the GM material was not successful on herbicidal compounds but plants generated on the standard antibiotic selection regime were hardened-off and imazapyr tolerance was evaluated under glasshouse conditions through the application of the herbicide at 0.25 times the cane/cynodon eradication rate (equivalent to a typical "Clearfield®"[5] rate). This proof-of-concept[6] of establishing imazapyr tolerance will inform current research within Project 00VI06 (Commercial development of insect resistant and herbicide tolerant GM sugarcane).
- A protocol for mutating oats seed was developed. Unfortunately, climatic conditions for harvesting viable seed are not ideal in Mount Edgecombe and the process for bulking up this material and the subsequent recovery of mutated imazapyr tolerant oat seed was unsuccessful.

Various demonstration plots were established using N12 Zapyr. Herbicide-tolerance efficacy was demonstrated by foliar imazapyr application (at 0.25 cane/cynodon eradication rate: 300 g a.i./ha) to N12 Zapyr four months after planting. N12 Zapyr sugarcane was planted in soil treated with the full cane/cynodon eradication rate in two plots at Eston and Oribi. However, N12 was unaffected at both sites suggesting that the soil applied imazapyr had rapidly dissipated. Consequently, neither trial showed superior performance of N12 Zapyr compared with N12 (possibly also due to old N12 Zapyr seedcane). The trials are in the process of being replanted.

[5] 'Clearfield®' is a non-genetically modified (non-GM) trait for herbicide tolerance, developed by BASF, and it is incorporated in several different crop species, including canola, sunflowers and rice. The rate of herbicide used for weed control is typically a quarter to half of the rate recommended for the eradication of sugarcane infested with cynodon (kweek).

[6] Clearfield® Sunflowers are in use in South Africa and there are registered herbicides (Euro-Lightning® Plus from BASF and Captora from Syngenta) and SASRI is investigating their use on N12 Zapyr, potentially as a label extension.

Sugarcane sucrose enhancement by genetic modification (Stellenbosch University Contract: Professor Jens Kossmann, Institute of Plant Biotechnology) (Project Reference: 14VI1C)

Modification through genetic engineering of the expression of genes coding enzymes involved in sugarcane primary carbon and energy metabolism in some instances results in enhanced sucrose concentrations in the stalk but these improvements do not persist over successive ratoons in the field. Consequently, research in this area has been terminated.

The Industry, through SASA/SASRI, entered into a series of research agreements with the Institute for Plant Biotechnology (IPB) at Stellenbosch University (SU) spanning over two decades. The main goal of this contracted-out research was to investigate the feasibility of increasing the sugar content of sugarcane by genetic engineering, while a further goal was to assess whether the sugarcane plant could be used as a bio-factory for producing alternative high-value products through the expression of genes not native to sugarcane. The research conducted by the IPB in these areas proceeded with a high level of autonomy, apart from a comprehensive review of progress conducted annually by SASRI.

The industry-funded sucrose enhancement research programme at the IPB has been productive over the years, having resulted in a minimum of 34 MSc dissertations, ten PhD theses, 52 scientific journal articles and five patents. The SASA/SASRI-held patents have subsequently been allowed to lapse. Strong evidence emerged over the course of several years indicating that enhancing the sucrose content of sugarcane through the genetic engineering of primary carbon and energy metabolic pathways was not as viable or stable as originally hypothesised, in that the metabolism of the sugarcane plant displayed an unanticipated degree of plasticity which enabled the circumvention of the intended changes brought about by genetic engineering.

The extreme metabolic plasticity of sugarcane was first observed in 2002 when the high sucrose phenotype observed under glasshouse conditions from the down-regulation of the gene encoding the enzyme pyrophosphate-dependent phospho-fructokinase, was not sustained under field conditions. Subsequently in 2007, transgenic sugarcane lines in which the activity of the enzyme UDP-glucose dehydrogenase was reduced by genetic engineering failed to deliver the high-sucrose phenotype under field conditions, despite very promising results from glasshouse- and polytunnel-based studies. In 2016, the Industry received notification from Syngenta indicating that the company was terminating the licencing agreement with SU and SASA/SASRI for the sugarcane sucrose-enhancing technology based on the genetic manipulation of the activity of the enzyme uridine mono-phosphate synthase due to the instability of the high-sucrose phenotype under field conditions.

The challenges experienced by the IPB with the instability under field conditions of phenotypes produced by the genetic manipulation of sugarcane carbon metabolism are not without precedent; similar observations have been made by other international sugarcane biotechnology programmes. For example, the highly promising sugarcane SugarBooster technology developed by the University of Queensland in association with the Australian sugar industry was abandoned in 2010 due to similar problems with phenotype instability over ratoons under field conditions.

The SRASA Committee was informed by SASRI management in November 2016 of the view that continued Industry investment in the IPB-based sucrose enhancement research programme carried a risk that had become unacceptably high. The Committee approved the recommendation that the investment be phased out between 2017/2018 and 2019/2020. Consequently, SASRI Management engaged with SU to negotiate the terms of contract withdrawal with termination on 30 September 2020.

Biotechnological investigations to improve sugarcane drought stress tolerance (Stellenbosch University Contract: Dr Christell van der Vyver) (Project Reference: 17VI1C)

Genetic engineering and mutation breeding approaches are being used to explore the potential for improving sugarcane water-deficit stress tolerance, some of which have yielded promising preliminary results under glasshouse and poly-tunnel conditions. The research is to continue for a further three-year funding cycle, from 2021 to 2024.

SASRI contracted the Institute of Plant Biotechnology (IPB) at Stellenbosch University to conduct research on enhancing sugarcane drought-stress tolerance using mutation breeding and genetic modification (GM) approaches. During the contract cycle from April 2017 to March 2020, several projects were undertaken by post-graduate students, the findings of which are as described below. A further three-year funding cycle from April 2021 to March 2024 has been approved by SASA Council.

- *Over-expression of a late-embryogenesis abundant protein from the resurrection plant Xerophyta humilis in sugarcane to promote stress tolerance*

The objective of this research is to genetically-engineer drought tolerance in sugarcane through the over-expression of a gene coding a late-embryogenesis abundant (LEA) protein isolated from desiccated leaves of the resurrection plant *Xerophyta humilis*.

To-date, enhanced drought tolerance has been observed in a one sugarcane transgenic line subjected to pot trial assessments in which water was withheld and recovery recorded after re-watering. The degree of tolerance was assessed by examination of leaf appearance and measurement of photosynthetic efficiency. Sugarcane stalk height and sucrose content were negatively affected in transgenic line and untransformed control line.

In further research, the LEA transgene is to be placed under the control of a stress-inducible promoter so that expression will only take place when the plant experiences drought. This may alleviate the observed yield penalty associated with constitutive gene expression.

- *Over-expression of stress-responsive nuclear-binding transcription factors in sugarcane*

The objective of this research is to investigate whether the over- and stress-inducible expression in sugarcane of genes coding selected nuclear factor Y (NF-Y) transcription factors derived from *Arabidopsis thaliana* results in improved drought tolerance.

To-date, no enhancement of sugarcane drought tolerance has been observed in transgenic plants generated to express the transcription factor gene AtNFY-B1 from *A. thaliana.*

Further research will use a more targeted approach by identifying and characterising NF-Y transcription factors native to sugarcane, rather than genes isolated from *A. thaliana*. The research is to be undertaken in collaboration with the SASRI Bioinformaticist, Mrs Robyn Jacob, who will participate in the creation of the new genetic transformation vectors for introduction into sugarcane and subsequent evaluation in water-deficit studies.

- *Investigation of the role of selected transcription factors in sugarcane stress tolerance*

The objective of this research is to evaluate the effect on sugarcane drought tolerance of the over-expression of two selected transcription factors:
(a) a B-box gene (BBX29) from *A. thaliana*; and
(b) members of the multifunctional plant transcription factor gene family (SINAC) from *Solanum lycopersicum*.
Both genetic constructs have been provided to the IPB under the terms of a material transfer agreement with a collaborator in India.

Over-expression of the *A. thaliana* B-box gene AtBBX29 resulted in the recovery of transgenic sugarcane plants after 21 days of water-deficit stress. Proline concentrations were observed to be significantly higher in

transgenic plants than in the control plants, which may have contributed to the improved stress tolerance. Over-expression in sugarcane of the tomato *SlNAC2* transcription factor gene resulted in delayed leaf sensecence and increased survival in water-deficit pot trials.

Although preliminary results were promising, the research has been terminated by the IPB for technical reasons.

- ***Manipulation of cytokinin levels to enhance sugarcane drought tolerance***

The objective of this research is to enhance sugarcane drought tolerance by delaying leaf senescence though the silencing of the cytokinin dehydrogenase gene (CKX), which would affect plant cytokinin levels.

A 'quick-recovery' phenotype has been observed in transgenic lines in which cane re-sprouted 14 days after re-watering following a water-deficit stress treatment. Under field conditions, it is plausible that this genetically-engineered phenotype could promote stool survival and ratooning after excessively dry conditions.

Ongoing research is to focus on the completion of the physiological and biochemical analysis of the transgenic lines.

- ***Investigation of the role of small ubiquitin-like modifier gene elements in sugarcane stress tolerance***

The objective of this research is to investigate the possible link between small ubiquitin-like modifier-mediated modification (SUMOylation) of proteins and drought stress tolerance in sugarcane. The methodology used in the study is based on the manipulation of the SUMOylation pathway through the over-expression of SUMO protease genes, *OTS1* and *OTS2*.

Physiological studies conducted on water-stressed transgenic and control plants revealed that those expressing *OTS1* retained significantly higher stomatal conductance, photosynthetic rate (Fv/Fm), chlorophyll content and relative water content than the untransformed control plants. Protein profiling detected changes in protein conjugate binding to SUMO in the *OTS1*-expressing transgenic when compared with the control plants.

A doctoral thesis on this research is currently in preparation.

- ***Investigation of the role of selected volatile organic compounds in sugarcane growth promotion and stress tolerance***

The objective of this research is to over-express genes encoding the pre-curser enzymes a-acetolactate decarboxylase (ALDC) and acetoin 2,3-butanediol dehydrogenase (BDH) and monitor drought-stress responses.

The results of the study revealed that the transgenic lines did not perform better under water-deficit conditions than the control plants in pot trials conducted under glasshouse conditions. The relative water content, stomatal conductance, chlorophyll fluorescence and chlorophyll and catalase content were observed to be similar in the transgenic and control plants during the stress period.

The research is to be terminated due to the absence of evidence that the transgenes were effective in alleviating drought stress.

- ***Inducing sugarcane stress tolerance though mutagenesis by gamma irradiation***

The objective of this research was to investigate whether gamma-irradiation is a superior approach for sugarcane mutagenic breeding than chemical mutagenesis.

In testing gamma ray dosages the 10-40 Gy range, the radiation was observed to negatively affect somatic embryo development. When a dosage in 20-40 Gy was used in combination with osmotic selection, very few plantlets were obtained and none survived hardening-off.

The approach is not to be progressed for further investigation as the radiation was shown to negatively affect the regenerative capacity of embryogenic cells and subsequent *in vitro* plantlet survival.

- ***Inducing sugarcane stress tolerance though mutagenesis by application of chemical mutagenic agents***

The objective of this research is to use the chemical, ethyl methanesulfonate (EMS), to induce mutations in sugarcane that confer improved drought tolerance.

A protocol for inducing mutations in sugarcane callus with EMS, with subsequent *in vitro* selection of suitable mutagenised cells on an osmoticum, was established. Mutant lines were successfully regenerated and three lines have been demonstrated to have improved drought tolerance under glasshouse conditions.

The results of the study are forming the basis of a doctoral thesis that is in preparation and follow-on field-based investigations at SASRI are to be undertaken as a post-doctoral research project, subject to the outcome of a fellowship application to the National Research Foundation.

Highlights from Ongoing Research

BREEDING AND ASSOCIATED ENABLING TECHNOLOGIES

Classical Breeding

Applying breeding methodologies designed and adapted to the South African context to the development and release of superior sugarcane varieties that aim to enhance industry sustainability.

- Two new varieties (N76 and N77) with superior yield and agronomic performance were approved by SASA Council for gazetting and bulking. Both varieties were selected on the SASRI Empangeni Research Station and are recommended for rain-fed, coastal short-cycle growing conditions under twelve-month harvest cycles. The best features of the varieties are the high cane and RV yields that may be achieved in both high and low potential soils and environments, good pest and disease tolerance, as well as good ratooning.
- Genotype differences in yellow sugarcane aphid (YSA) damage observed in Mpumalanga plant breeding trials have revealed the existence of YSA resistance amongst the breeding populations. The SASRI plant breeders and selection teams are to focus on the collection of data to further evaluate the potential to increase YSA resistance in breeding populations.

Introgression Breeding

Developing and implementing breeding strategies to broaden the genetic base of South African sugarcane varieties to improve pest and disease resistance, stress tolerance, vigour and yield.

- Introgression crossing undertaken at the Central Sugarcane Breeding Station in Barbados in the West Indies forms an essential component of the SASRI genetic base-broadening (introgression) strategy for improving yield and stress and the pest and disease tolerance of varieties bred for South African conditions. This ongoing collaboration resulted in the re-importation from Barbados of the offspring from several introgression crosses which are currently under testing in multi-location trials along the South African sugarcane belt. A further fifteen genotypes, including three recently released SASRI varieties, were sent to the West Indies Central Sugarcane Breeding Station for introgression crossing.
- A 'superbarcode' was developed to distinguish between closely-related species, which will serve as an important tool in parent selection for introgression breeding.
- Novel evidence emerged from SASRI research regarding the ancestry and origin of modern sugarcane hybrids which will inform approaches to introgression breeding.

Germplasm Cryopreservation

- Developing technologies for the long-term preservation of valuable breeding-related germplasm, including that derived from the application of novel genetic engineering and mutation breeding methods.
- Upon receipt SASA Council approval, SASRI in 2020/2021 expanded in-house capacity for the cryo-preservation of valuable germplasm to accommodate an increasing requirement for the safe long-term storage of genetically-modified insect-resistant sugarcane lines, germplasm derived from introgression breeding and core breeding material for classical breeding.
- SASRI cryopreservation research has two further novel aims: (a) to develop cryotherapeutics to eliminate sugarcane viruses and simultaneously cryopreserve sugarcane germplasm; and (b) to develop cryopreservation techniques for the long-term storage of sugarcane pollen. Once optimised, these novel techniques will be implemented routinely in sugarcane variety improvement activities at SASRI.
- SASRI also developed a methodology for medium-term, slow-growth storage of valuable germplasm that is currently being used to successfully maintain 151 important lines of sugarcane germplasm.

VARIETY PERFORMANCE EVALUATION

Developing knowledge resources relating to the performance of newly released varieties under commercial conditions and under a variety of agro-climatic conditions to assist growers in selecting varieties most appropriate for cultivation under their particular circumstances.

- Sixteen varieties were tested under frost conditions and results from the third ratoon crop demonstrated the superior performance of the newer varieties N61, N52, N48, N59 and N54 over the most commonly cultivated varieties, N36 and N41. The gains offered by these newer varieties range from 0.61 t RV to 0.04 t RV. Variety N61 performed consistently well over the four crops, reflecting the potential it has for cultivation in areas prone to frost.
- In a trial conducted in Pongola on a sandy soil, which had been treated with a nematicide, the second ratoon crop demonstrated the superior RV yield of N57, N36 and N40 when compared with N41. Variety N57 has the potential for cultivation as a late-season variety on sandy, low potential sites.
- In a Zululand North (Empangeni) trial of a plant crop receiving supplementary irrigation, N60 produced higher cane yield at 16 months than all the other varieties tested, including N59, N25, N17, N64, N39, N46, N41, N58, N53, N57, N42, N67, N49 N55 and N36.
- In a carry-over trial conducted in Empangeni, varieties N51 and N58 outperformed all the other varieties in terms of cane yield, including N17, N47, N55, N12, N63, N45, N41, N59, N19, N64, N36, N39, N27, N65, N42 and N56.

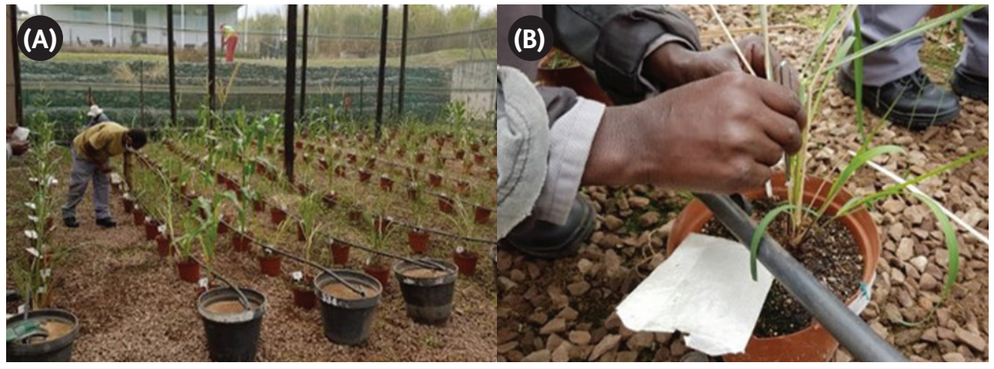
BIOTECHNOLOGIES

Genetic engineering is an important tool for improving crop yields in adverse environmental conditions or in increasing tolerance of agricultural crops to pests and diseases. The genetic constructs that are introduced to provide these advantages are made up of three important regions: the promoter region (which drives transgene expression), the transgene(s) (encoding the protein(s) conferring the desired trait(s)), and a terminator region (to terminate the translation of the gene). Promoter regions play a key role in the regulation and location of gene expression. They can be constitutive (express in all tissues), inducible (expressed under certain conditions i.e. light/temperature) or tissue specific (express only in certain tissues). Tissue specific promoters are desirable components in genetic engineering programs as they allow the targeted expression of transgenes in only those tissues in which the transgenic trait is required. An important focus of the promoter research at SASRI has been the identification of promoters, especially tissue specific ones, that are not subject to any licensing agreements and for which SASRI has total freedom to operate.

Bt GM Sugarcane Variety

Developing a genetically-modified sugarcane variety that has improved insect resistance and herbicide tolerance for potential commercial release.

- Progress has been made in: (a) assessing the amenability of selected varieties as recipients of the Bt gene; and (b) in the introduction of two Bt genes into N67 (rainfed), N71 (irrigated) and 08F1386, a promising pre-release genotype for the irrigated regions.
- One hundred and forty-nine of sugarcane plants were genetically engineered to express the Bt Cry protein.
- Thirty-two plants are under assessment in a pot-based bioassays to determine the level of resistance to eldana.
- Testing of the plants with EnviroLogix™ antibody lateral-flow dipsticks has revealed the presence of the insecticidal Bt protein in most parts of the transgenic plants.

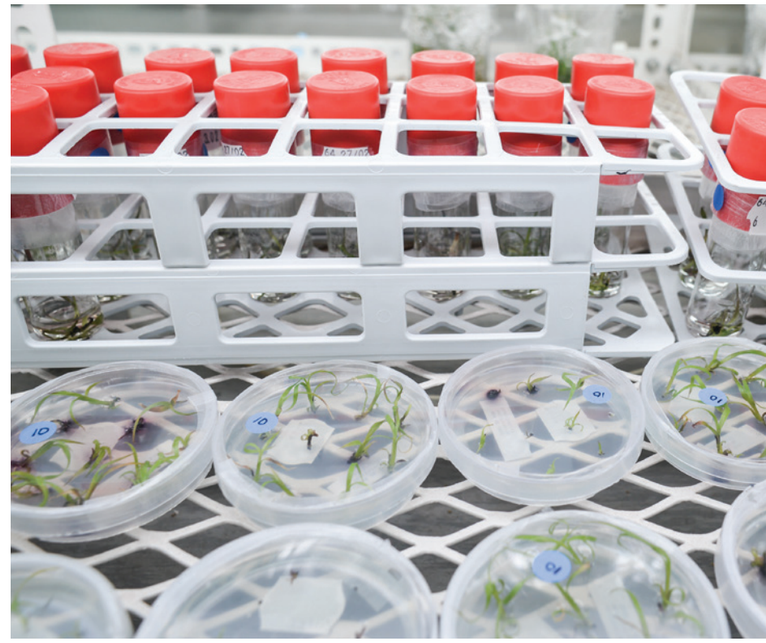


Testing of GM Bt Sugarcane for Eldana Resistance:
(A) trial of potted GM Bt sugarcane lines, non-GM sugarcane controls and commercial Bt maize lines; and
(B) inoculation of the sugarcane plants with eldana eggs behind the leaf sheath.

Gene Promoters

Developing tissue-specific promoters to target expression of transgenes in only those tissues in which the transgenic trait is required.

- Recent promising results revealed that SASRI has successfully developed several gene promoters that can drive preferential foreign gene expression in leaves (nine promoters) and roots (four promoters).
- These promoters will be valuable in future genetic engineering projects that aim to target the expression of useful foreign genes to these parts of the sugarcane plant.



Crop Protection Research

Dr Stuart Rutherford
(Programme Manager)

Developing integrated management strategies that minimise the effects of pests and diseases on sugarcane production in a sustainable manner.

Research Focus Areas

BIOSECURITY AND ASSOCIATED ENABLING TECHNOLOGIES

Developing: (a) improved procedures to ensure that varieties released or introduced into the industry are free of pests and diseases; and (b) proactive threat-specific counter-measures and biosecurity incursion plans.

AGROCHEMICALS FOR PEST AND PATHOGEN CONTROL

Partnering with relevant stakeholders to facilitate the registration of effective pathogen and pest control agents that are agriculturally, environmentally, ecologically and economically sustainable.

SUGARCANE RESISTANCE TO PESTS AND PATHOGENS

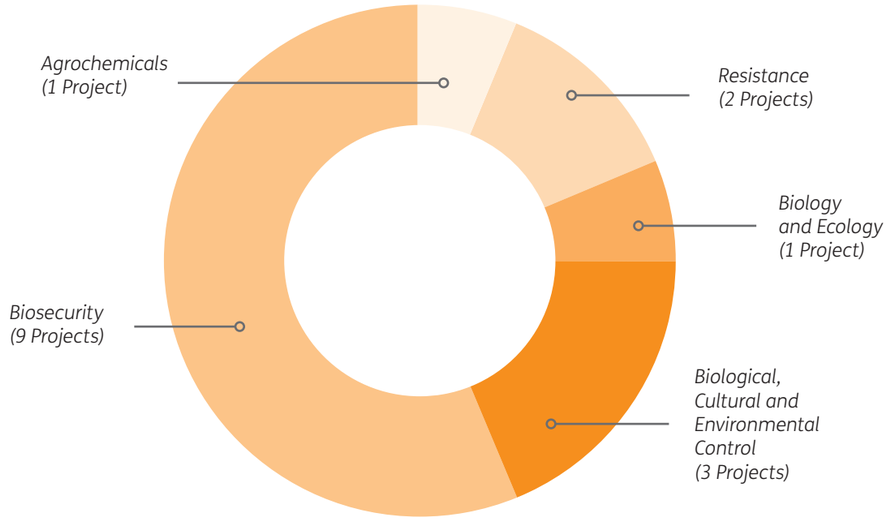
Generating knowledge of the biological basis of resistance to pests and diseases and developing improved resistance screening techniques for commercial breeding.

BIOLOGY AND ECOLOGY OF PESTS AND PATHOGENS

Generating knowledge on the biology and ecology of pests and diseases and facilitating knowledge exchange.

BIOLOGICAL, CULTURAL AND ENVIRONMENTAL CONTROL PRACTICES

Developing effective integrated management strategies and models that combine variety choice, optimal nutrition, use of agrochemicals and biological control agents with beneficial cultural and environmental management practices.



Research Highlights

- Increased focus on yellow sugarcane aphid with two further projects initiated to address management challenges:
  (a) species diversity of natural predators of yellow sugarcane aphid; and
  (b) the susceptibility of sugarcane varieties to the pest.
- Data from a trial conducted on an 8% clay soil in the Midlands region of the industry revealed that Bandito® can provide yellow sugarcane aphid intermediate or susceptible varieties with protection against the insect when compared with more resistant varieties, in which the effects of the chemical may be masked by the endogenous resistance of the variety. The data further revealed that that Bandito® is also effective against sugarcane thrips.
- A mechanical harvester decontamination procedure was developed and shown to reduce RSD spread into healthy cane from infected stools, although it is lengthy and unable to completely eliminate the risk of transmission.
- An ongoing proof-of-concept is yielding promising preliminary results regarding the efficacy of the novel F1 sterile insect technique developed by SASRI in managing eldana damage to sugarcane grown within containment cages.
- Insect-rearing and insect transport arrangements for off-site irradiation developed to support proof-of-concept demonstration of the efficacy of a novel F1 sterile insect technique (SIT) for eldana population management.

New Research: Special Focus on Yellow Sugarcane Aphid Management

Two new projects commenced in 2020/2021 to address the management of the yellow sugarcane aphid: (a) species diversity of natural predators of yellow sugarcane aphid; and the susceptibility of sugarcane varieties to the pest.

Species diversity of natural enemies of yellow sugarcane aphid (Project Reference: 19CP03) (Project Manager: Dr Iona Basdew)

This research aims to enable more effective management of the yellow sugarcane aphid through widening the knowledge base regarding: (a) key predator species present in different agro-ecological regions; and (b) effects of insecticide usage on these predator communities.

By means of widespread surveying, rain-fed and irrigated regions and commercial and small-scale sugarcane farming operations are to be compared to enable the development of sustainable area-wide integrated management solutions.

Yellow sugarcane aphid varietal susceptibility (Project Reference: 19TD02) (Project Manager: Dr Malcolm Keeping)

This research aims to develop updated information on variety susceptibility to the yellow sugarcane aphid using a flexible and dynamic research methodology.

Given the sporadic and highly mobile nature of the yellow sugarcane aphid in sugarcane, traditional specifically-designed yield-loss trials undertaken since the emergence of the pest have not produced reliable results. In a new, more dynamic approach, intensive surveying is to be undertaken of existing SASRI research trials located throughout the KwaZulu-Natal and Mpumalanga sugar belt to enable the development of pro-active and sustainable area-wide integrated management solutions for the pest.

Outcomes from Completed Research

Two technology development projects were completed, which aimed to:
(a) develop a method of mechanical harvester decontamination to prevent the spread of ratoon stunt; and
(b) optimise insect rearing and transport technologies required for demonstrating proof-of-concept of the efficacy of a novel F1 sterile insect technique (SIT) for eldana population management.

BIOSECURITY AND ASSOCIATED ENABLING TECHNOLOGIES

Decontamination of mechanical harvesters to minimise RSD transmission (Project Reference: 16TD02) (Project Manager: Sharon McFarlane)

Although the lengthy mechanical harvester decontamination procedure developed and tested reduces RSD spread into healthy cane from infected stools, it is unable to completely eliminate the risk of transmission.

Ratoon stunt (RSD) caused in sugarcane by the bacterium *Leifsonia xyli* subsp. *xyli (Lxx)* is a manageable disease provided the recommended integrated management strategy is followed. Once a field has been planted, the main risk of spread is at harvest. While it is possible to decontaminate cane knives easily and effectively during the harvesting operation, mechanical harvesters pose more of a challenge. A suitable method to decontaminate mechanical harvesters is required to minimise the risk of RSD spread, particularly between fields and farms. Three disinfectants, all containing a quaternary ammonium compound and used in food and agricultural industries, were effective against *Lxx in vitro*. One was selected for the decontamination of the mechanical harvesters used in three field trials. The trials confirmed that mechanical harvesters transmit RSD from infected to healthy stools at harvest. The decontamination procedure took up to one hour to complete and while it reduced spread into healthy cane in all the trials, it did not eliminate the risk. Management strategies to accommodate this risk will need to be implemented. The disinfectants that were identified to be effective against *Lxx* in this study will provide suitable replacements for the current standard Jeyes Fluid, for the disinfection of farm implements.

BIOLOGICAL, CULTURAL AND ENVIRONMENTAL CONTROL PRACTICES

Improved field performance of sterile male Lepidoptera to ensure success in SIT programmes (funded by the International Atomic Energy Agency) (Project Reference: 15CP2E) (Project Manager: Dr Des Conlong)

Insect-rearing and insect transport arrangements for off-site irradiation have been developed to support proof-of-concept demonstration of the efficacy of a novel F1 sterile insect technique (SIT) for eldana population management.

This research formed part of an international project entitled, "*The application of conventional sterile male moth quality control parameters: Do they apply to a male calling system?*" that was coordinated and funded by the International Atomic Energy Agency (IAEA). Specialists in the application of the sterile insect technique (SIT) to the management of lepidopteran (moth) pests were drawn from around the globe and included Dr DE Conlong of SASRI. The project was structured to encourage cross-country discussions and collaboration on improving the field performance of sterile male moths to ensure the success of moth pest SIT programmes, which included workshops and field visits at the start, during and at the end of the project. The several multi-authored outputs from the project attest to the successful collaborations that were forged during the project.

During the project, two improved *Eldana saccharina* (eldana) diets were developed. The first diet developed produced higher numbers of good quality pupae and moths (89%) compared with the conventional sugarcane diet (16% pupae). Time to pupation on the former diet was shorter (27 days compared with 33 days) and

production costs were lower (R0.05 per larvae produced). The second diet formulations were based on comparative slaughter diets and were found to be as good as the first diet, although females were significantly more fecund. Furthermore, with the addition of sterols, the second diet shortened the larval development time to pupation to 20 days.

In the SASRI Insect Rearing Unit, replacement of multi-cell trays with higher volume (four litres) plastic trays, together with the new, more nutritious diets, reduced the mass of diet consumed by each eldana larva from approximately five to an average of three millilitres. Under these revised conditions, the new diets were able to support the production of sufficient high-quality individuals for the SASRI proof-of-concept eldana SIT study (Project Reference: 14CP08).

As no irradiator is available in KZN, a contract with XSIT (Pty) Ltd in Citrusdal for access to the cobalt irradiator used in the false codling moth SIT programme on citrus enabled the continuation of the eldana SIT proof-of-concept study. Despite many initial hurdles, this approach is showing promise, in that the F1 adults produced from the partially fertile eggs from the crosses made between irradiated males and unirradiated females were male-biased, a feature of F1 sterility in moths. In the ongoing proof-of-concept study, newly constructed treatment and control cages have provided the consistency of conditions amongst cages that are required to demonstrate the efficacy of SIT in limiting the negative effects of eldana populations on sugarcane.

Highlights from Ongoing Research

BIOSECURITY AND ASSOCIATED ENABLING TECHNOLOGIES

Molecular Diagnostics for Improved Detection and Identification of Phytoplasmas

An improved PCR test for phytoplasmas is under development for application to the screening of sugarcane imported and exported through the SASRI Quarantine Facility. Initial testing of the improved protocol on poinsettia and cynodon leaf material is promising, with the detection and high-fidelity identification of several phytoplasmas.

- To determine the phytosanitary status of sugarcane imported or exported from South Africa, the SASRI Quarantine Facility uses a PCR test to determine the presence or absence of phytoplasmas[7].
- As the existing diagnostic test was not producing results as conclusive as needed, an investigation of a new protocol has been undertaken based on the current-state-of-the-art as reported in the international science literature.
- Poinsettia and cynodon have been used to test the efficacy of the new DNA test, which makes use of an improved DNA extraction method and nested PCR[8] to improve specificity and sensitivity.
- Initial results from application of the improved protocol to poinsettia and cynodon are promising, with the detection of the following phytoplasmas:
- Candidatus phytoplasma cynodontis strain 305/13 in cynodon (98.75 – 99.40% identity match);
- Poinsettia branch-inducing phytoplasma, sugarcane yellows phytoplasma type I strain ScYP I-Afr and walnut witches'-broom phytoplasma strain 11-2 in poinsettia green leaves (100% identity match).

[7] Phytoplasmas are obligate bacterial parasites of plant phloem tissue and of the insect vectors that are involved in their plant-to-plant transmission. Sugarcane is severely affected by yellows and decline diseases caused or contributed to by phytoplasmas. These diseases, which are of considerable economic importance, cause similar symptoms but differ in the identity of the associated phytoplasmas, vectorship, and geographic distribution.

[8] Nested PCR is a modification of PCR that was designed to improve sensitivity and specificity. Nested PCR involves the use of two primer sets and two successive PCR reactions. The first set of primers is designed to anneal to sequences upstream from the second set of primers and are used in an initial PCR reaction.

Spore Traps for Assessing Rust Risk

No spores of brown, orange and tawny rust were detected in 2020 during routine monitoring on the SASRI Komati Research Station.

SASRI operates a Burkard spore trap at the automatic weather station site on the SASRI Komati Research Station. The tape is replaced weekly and sent to Mount Edgecombe for analysis. DNA is extracted from the tape and analysed for *Puccinia kuehnii* (orange rust), *P. melanocephala* (brown rust) and *Macruropyxis fulva* (tawny rust) using specific PCR protocols. General rust primers are also used to confirm that the DNA extraction has been successful in the absence of sugarcane rusts. No rusts that are known to infect sugarcane were detected in 2020.

Eldana Chemical Ecology

Eucomis comosa (pineapple lily) may produce eldanolide and, if so, has the potential to serve as a feedstock for the biopharming of the compound for pheromone trapping of eldana, although further research would be required.

Studies have revealed that *Eucomis comosa* (pineapple lily) appears to produce eldanolide as a floral volatile to attract wasp pollinators. Investigations are required to determine whether *E. comosa* could serve as a pull plant in the eldana push-pull approach or even as a potential feedstock for the bio-pharming of eldanolide for pheromone trapping of eldana. Floral volatiles from *E. comosa* are involved in attracting Pompilid wasp pollinators and the role of eldanolide as a component of these volatiles remains unknown.

The pineapple lily is an indigenous summer-growing perennial bulb belonging to the Asparagaceae found on grassy hillsides and in swamps in KwaZulu-Natal.

AGROCHEMICALS FOR PEST AND DISEASE CONTROL

Research into the identification of agrochemicals for pest and disease control is conducted in collaboration with manufacturers and suppliers of agrochemical products, the Agricultural Inputs Control Directorate of the Department of Agriculture, Land Reform and Rural Development[9] and cane growers to register new active ingredients for the sustainable integrated management of current and emerging pests and diseases. Current emphasis is on the testing and registration of blue- and green-label active ingredients to enable IRAC[10] -compliant spray programmes that are compatible with the objectives of area-wide integrated management programmes.

- Data from an eldana x insecticide trial conducted at Gingindlovu and a smut x fungicide trial at Pongola have enabled the refinement of the estimated impacts of eldana and smut on yield. The calculations have revealed:
  (a) 2.4% of RV was lost per 1% internodes bored by eldana, which is more than twice the often quoted 1% of RV lost per 1% internodes bored; and
  (b) 1.0% of RV was lost per 1% stalks infected with smut.
- A trial conducted in Pongola to assess the effect of a Tebuconazole : Azoxystrobin : Prochloraz fungicide and a Flutriafol : Fluoxastrobin fungicide, which are both as yet unregistered for use on sugarcane in South Africa, revealed that both result in significantly lower smut incidence when compared with the untreated controls. Both also show promise for smut control either as a ten-minute cold soak or in-furrow spray.

SUGARCANE RESISTANCE TO PESTS AND PATHOGENS

Yellow Sugarcane Aphid Varietal Susceptibility

Recent data from a trial conducted on a 8% clay soil in the Midlands region of the industry revealed that Bandito® is able to provide yellow sugarcane aphid intermediate or susceptible varieties with protection against the insect when compared with more resistant varieties, in which the effects of the chemical may be masked by the endogenous resistance of the variety. The data further revealed that that Bandito® is also effective against sugarcane thrips.

Off-station variety trials conducted by SASRI on sandy soils are replicated with and without nematicide. These trials are now routinely treated with the recently-registered Bandito®, a product that controls nematodes, thrips and yellow sugarcane aphis (YSA). During the reporting period, ratoon crop data from a trial undertaken on a 8% clay soil in Harburg in the Midlands was assessed for thrips and YSA damage.

Of particular interest is that leaf damage by thrips and YSA was significantly reduced by the Bandito® treatment: in six varieties for YSA and three varieties for thrips. The varieties N51, N52, N54, N58, N61 and N62 displayed significantly less YSA % damage with the application of Bandito®, when compared with the untreated controls. These varieties are generally more susceptible to YSA, indicating that Bandito® was able to provide intermediate or susceptible varieties protection against YSA when compared with more resistant varieties, in which the effects of the chemical may be masked by the endogenous resistance of the variety.

Even for varieties where the difference between Bandito® and control was not significant, damage was lower in all Bandito® treatments, except in N50. These consistent differences also indicate that the method used to measure % YSA damage is an appropriate one and is directly related to YSA infestation, which was reduced in the Bandito® treatment.

[9] The Department of Agriculture, Forestry and Fisheries (DAFF) was disestablished in June 2019. The agriculture function was incorporated into the new Department of Agriculture, Land Reform and Rural Development (DALRRD), while the forestry and fisheries functions were incorporated into the new Department of Environment, Forestry and Fisheries (DEFF).

[10] Established in 1984, the Insecticide Resistance Action Committee (IRAC) is an international association of crop protection companies. IRAC serves as the Specialist Technical Group within CropLife International focused on ensuring the long-term efficacy of insect, mite and tick control products through effective resistance management for sustainable agriculture and improved public health.

Varieties that were intermediate or susceptible to thrips were N52, N54, N61 and N62. These varieties all had significantly reduced damage in the Bandito® treatment and in most other varieties where differences were not significant, damage was slightly lower in the Bandito® treatment. This indicates that Bandito® is also effective against sugarcane thrips and that the method used to measure thrips % damage is appropriate.

Variety Evaluation: Diseases

Investigations are undertaken to:
(a) generate additional information on the reaction of late-stage and newly released varieties to diseases:
(b) confirm smut and mosaic ratings in commonly-grown varieties; and
(c) provide information on the effect of selected diseases, such as ratoon stunt, on cane yield and juice quality.

- In a trial conducted under irrigated conditions in Pongola, overall cane yield (t/ha) of a RSD-infected first ratoon crop was observed to be significantly lower than that of uninfected cane, while the RV% was higher.
- Consequently, no difference in overall RV yield (t/ha) due to RSD infection was observed in the first ratoon crop.
- However, it is important to note that the major negative effect of RSD on yield is exerted under water stress, to which the crop was not exposed in this field trial.

BIOLOGICAL, CULTURAL AND ENVIRONMENTAL CONTROL PRACTICES

Sterile Insect Technique Proof-of-Concept Study

An ongoing proof-of-concept is yielding promising preliminary results regarding the efficacy of the novel F1 sterile insect technique developed by SASRI in managing eldana damage to sugarcane grown within containment cages.

Despite unavoidable COVID-19 lockdown-related delays, progress was made in the sterile insect technique (SIT) proof-of-concept study. Preliminary evidence indicated that sugarcane grown in a containment cage into which F1 generation sterile moths were introduced, along with wild-type (non-irradiated) moths, supported a lower eldana population (1.3 e/100 stalks) when compared with the cage into which only wild-type moths were introduced (6.88 e/100stalks). The study is ongoing.

Eldana Control through Management of Endophytic Fusarium

Conazole fungicides (such as Prochloraz) can act synergistically with some insecticides and nematicides by inhibiting P450 mono-oxygenases in insects and nematodes. As well as being directly active against Fusarium, these fungicides may assist in limiting nematode damage to roots, a point of entry into the plant for Fusarium.

In Petri dish-based bioassays, exposure of *Meloidogyne* to Prochloraz appeared to significantly increase the activity of a combination of oxamyl and imidacloprid (simulating Bandito®) at 60 minutes in terms of recovery and mobility. This suggests that Prochloraz could be useful in limiting *Fusarium* entry into the plant via nematode damage.

Endophytic Beauveria for Pest Management

An isolate of the Gram-positive spore-forming bacterium Brevibacillus reuszeri shows potential for eldana and nematode control.

- Two isolates of the endophytic fungus, *Beauveria bassiana*, an entomopathogen, were tested for their effect on early growth of NovaCane® plantlets and for their ability to internally colonise plant tissues.
- An isolate of *Brevibacillus reuszeri* (8c leaf2) obtained in another project (Project Reference 16CP03: Eldana control through management of endophytic *Fusarium*) was also included in the experiment.
- Only the 8c leaf2 isolate of *B. reuszeri* significantly increased root length.
- In re-isolations, the 8c leaf2 isolate was obtained from all plant parts, while the *Beauveria* isolates could only be obtained from the roots.
- As well as its abilities to endophytically colonise sugarcane, promote sugarcane growth, inhibit the growth of *Fusarium*, tolerate fusaric acid (an antibiotic produced by *Fusarium*) and repel eldana, the 8c leaf2 isolate also appears to be nematicidal in Petri dish nematode dispersal assays.

Subject to further investigation, the 8c leaf2 isolate of *Brevibacillus reuszeri* may have potential for commercialisation as a bio-product for eldana and nematode control.

Crop Performance and Management Research

Dr Riekert van Heerden
(Programme Manager)

Research Focus Areas

SUGARCANE PHYSIOLOGY

Collecting and using crop physiological data in models that:

- assist sugarcane breeding for current and predicted future climates; and
- enable refined crop yield forecasting.

SUGARCANE NUTRITION AND SOIL HEALTH

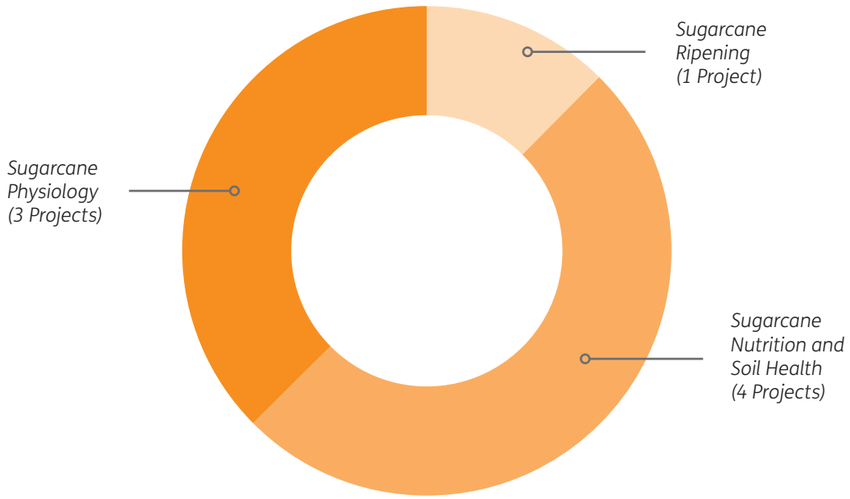
- Generating knowledge and developing technologies and resources that increase accuracy of fertiliser recommendations and enabling the maintenance of and where necessary, the restoration of soil health; and
- Testing of various sources of nutrients, fertiliser formulations and application rates that enhance the cost-effectiveness of recommendations.

SUGARCANE RIPENING

- Generating knowledge and developing technologies and resources that enable and demonstrate effective sugarcane chemical ripening practices in the industry.

CLIMATE CHANGE

- Predicting climate change impacts on crop water-use and yield for current and future potential agro-climatic situations;
- Developing appropriate resources to enable climate change adaptation and mitigation; and
- Developing best management practices to maximise yield under a predicted mid-century climate.



Research Highlights

- Indispensable knowledge generated to ultimately enable improved modelling of genotype performance in specific environments. Once refined, the improved models are to be applied to the identification of specific variety characteristics that result in improved performance and adaptability under specific circumstances, including in hot and dry environments.
- Infra-red spectroscopy shown to have potential to replace certain conventional, wet chemistry laboratory techniques for soil and leaf fertility testing with a rapid, low-cost diagnostic method.
- Results from participatory commercial ripener demonstration trials highlighted the potential for significant financial benefit from chemical ripening in longer-cycle rain-fed crops, provided care is taken in the identification of crops suitable for ripening.
- Hormonal mode-of-action ripeners, Ethephon® and Moddus® led to substantial increases in gross margins on five irrigated varieties tested, although the magnitude of response to the two ripeners differed between varieties.

New Research: Focus on Crop and Soil Health Management

Evaluating and demonstrating the value of best management practices for soil and crop health: Silicon as an indicator (Project Reference: 19CM02) (Project Manager: Dr Louis Titshall)

This research aims to evaluate and demonstrate the value of adopting best practices on improving crop performance, with a particular emphasis on silicon (Si) uptake. This multi-faceted research will build knowledge from:
(a) a quantitative review (meta-analysis) of pertinent scientific literature:
(b) cane grower source-data evaluation (grower survey); and
(c) a network of long-term best management practice (BMP) observation plots in collaboration with growers.

The research will examine the role of best management practices in promoting soil and root health and the impact of these improvements on silicon nutrition of the crop.

Outcomes from Completed Research

Modelling world-wide GXE interaction (International Consortium for Sugarcane Modelling project) (Project Reference: 10CM03) (Project Manager: Matthew Jones)

Indispensable knowledge was generated to ultimately enable improved modelling of genotype performance in specific environments. Once refined, the improved models will be applied to the identification of specific variety characteristics that result in improved performance and adaptability under specific circumstances, including in hot and dry environments.

Crop improvement could be enhanced if genotypes were to be screened early and easily for physiological traits that contribute to high yields for target environments. Theoretically, the breeding cycle can be shortened, and resources can be used more efficiently to accelerate breeding gains. However, identification of desirable traits is confounded by complex interactions between genetic traits and environmental factors. Process-based crop modelling can play a role in gaining a better understanding of these interactions, and can assist in identifying impactful traits and their ideal values for given environments (including future climates). Four research organisations, namely SASRI, Agricultural Research Centre for International Development (CIRAD) (France), Zimbabwe Sugar Association Experiment Station and Sugar Cane Growers' Co-operative (Florida, USA), collaborated, under the auspices of the International Consortium for Sugarcane Modelling, to explore this opportunity.

The project goal was to gain a better understanding of the physiological mechanisms underlying the genetic variation in crop response to environmental factors, by monitoring and modelling key plant processes contributing to yield in a common set of diverse cultivars grown in diverse environments, and by modelling genotype (G) by environment (E) interaction. This comprised growth analysis field experiments consisting of plant and first ratoon crops of several varieties (N41, R570 and CP88-1762 common to all sites) grown under irrigation, at four sites around the world (Pongola, South Africa; Chiredzi, Zimbabwe; La Mare, Réunion Island, France; and Belle Glade, Florida USA).

Significant GxE interaction effects on final harvest above-ground dry biomass yields were evident. For example, R570 produced the highest yield in La Mare (which was the warmest site on average), and the lowest yields in cool Pongola and Belle Glade. Canopy development rate and timing of stalk growth onset were affected by radiation intensity in addition to temperature. G-specific temperature responses in germination rate and canopy development rate were also evident. For example, it appears that CP88-1762 tolerates low temperatures better than R570.

Three leading sugarcane models (DSSAT-Canegro, APSIM-Sugar and Mosicas) were calibrated using G effect knowledge gleaned from the dataset analysis. Simulated G, E and GxE interaction effects were then evaluated. Models captured G and E effects on seasonal radiation interception and radiation use efficiency reasonably well, although the range of variation was underestimated. Models failed to capture GxE interaction effects on seasonal radiation interception, seasonal radiation use efficiency and biomass yield.

Results suggest that sugarcane models must accommodate G-specific base temperature model inputs for germination and canopy development processes, and that biomass accumulation and canopy development processes must be linked to allow source-sink control of crop development. These model interventions are anticipated to result in improved simulation of GxE interaction effects on growth and yield, and hence improve capability to identify desirable traits for target environments.

The knowledge generated in this project is indispensable for improving prediction capabilities of genotype performance in target environments. Sufficiently improved models can be applied to identify desirable traits for these environments. This information is required to design more efficient (less resource intensive and faster genetic gains) crop improvements programs to produce genotypes that exploit different environments optimally for high yields.

Highlights from Ongoing Research

CROP PHYSIOLOGY

Aerial Imagery for High-throughput Phenotyping in Breeding

In exploring the potential for breeding for stress tolerance, SASRI is currently investigating the feasibility of phenotyping sugarcane for photosynthetic capacity and drought tolerance using aerially-captured imagery data. Analysis of trial data from a plant crop of 54 genotypes grown under well-watered and water deficit conditions continues to deliver promising results.

The aim of this research is to assess the feasibility of phenotyping sugarcane for photosynthetic capacity and drought tolerance using aerially captured imagery. A large field experiment with 54 genotypes was conducted on the SASRI Komatipoort Research Station under well-watered and water-deficit conditions. Ground measurements included soil water content, canopy cover, leaf-level photosynthesis and stomatal conductance. Spectral data in the visual, near infrared and thermal bands were obtained using drones and related to ground measurements.

Results obtained from the plant crop data are promising, in that significant inverse correlations were observed between stalk dry mass (SDM) and remotely sensed canopy temperature (Tc) under conditions of high (R2 = 0.82), medium (R2 = 0.76) and low (R2 = 0.39) crop water stress. Seasonal average SDM and Tc were also strongly correlated across both water treatments (R2 = 0.83). The study also found a significant correlation between fractional interception of PAR (photosynthetically-active radiation), termed fractionally-intercepted photosynthetically-active radiation (FIPAR), and the remotely-sensed normalised difference vegetation index (NDVI) (R2 = 0.46) in well-watered treatments under medium (50-80%) canopy cover. The correlation between FIPAR and NDVI can be improved by phenotyping under conditions of low canopy cover, to reveal more about early vigour.

Exploring Aerial Imagery for High-throughput Phenotyping in Breeding. Spectral image obtained by UAV of the SASRI Komati Research Station showing thermal information for three trial replications, each with a well-watered (greenish) and moderately stressed (yellowish) block. Individual plot boundaries are overlaid.

Optimal Harvest Age for Different Production Regions

An analysis of the SASRI variety trial database was conducted as part of ongoing investigations into the optimal harvest age of cane in different regions of the industry. Average actual ERC yield (TERC/ha) and average annualised ERC yield (TERC/ha/annum) per harvest age category were determined for the irrigated, midlands, hinterland and coastal regions of the industry. The results of the analysis have highlighted the diversity and complexity of harvest-age issue in the industry. Further exploration of the data will continue ahead of an economic analysis of the data.

The aim of this research is to determine the optimal harvest age of cane in different regions of the industry. Three sources of data are used to analyse the effects of harvest age on yields:
(a) simulated crop model data;
(b) commercial production datasets; and
(c) trial data. The latest results from the analysis of the variety trial database conducted during the reporting period are presented.

The variety trial database, consisting of all plant breeding, variety evaluation, and other trials was categorised according to the age at which crops were harvested, in one month increments.

The average actual ERC yield (TERC/ha) against average annualised ERC yield (TERC/ha/annum) per harvest age categories for the individual regions (irrigated, midlands, hinterland and coastal) were examined. The data from all regions, except for the hinterland, had best fit trend lines with R2 values above 0.90 for actual ERC yields. Contrary to the actual ERC yields, fitted curves for the annualised ERC yields had R2 values above 0.90 in the irrigated and coastal regions and R2 values of 0.49 and 0.71 for the hinterland and midlands, respectively. In the irrigated region, a very pronounced increase in actual ERC yield was observed between 12 and 16 months, but with further ageing reducing ERC yields. Furthermore, annualised ERC yield peaked at 15 months, but beyond that harvest age crop productivity was reduced.

For the hinterland region, actual ERC yields only started to reach a peak at 24 months and annualised ERC yields remained stable across all harvest ages between 13 – 24 months. For the coastal region actual ERC yields were similar between 12 – 21 months and then declined sharply with further ageing. However, annualised ERC yields in the coastal region showed a linear decline with increase in harvest age, most likely in

response to eldana, which were not controlled in any of the trials. In the midlands region, actual ERC yields peaked at around 24 months followed by a sharp decline with further ageing. Annualised ERC yields in the midlands peaked at around 22 months, but then showed a decline with further ageing.

These trends highlight the diversity and complexity of harvest-age issue in the industry. Further exploration of the data will continue before a decision is made on the economic analyses component of the research.

CROP AND SOIL HEALTH

Near and Mid Infra-Red Spectrometry for Soil and Leaf Diagnostics

Infra-red spectroscopy offers the potential to replace certain conventional, wet chemistry laboratory techniques for soil and leaf fertility testing (which are costly, laborious and sometimes hazardous) with a rapid, low-cost diagnostic method. Research undertaken to-date has revealed that revision of the mid-infrared organic matter model currently used in the SASRI Fertiliser Advice Service may improve predictive accuracy of organic matter, which could enhance the accuracy of sample classification into N Category upon which nitrogen fertiliser recommendations are based.

Infra-red spectroscopy offers the potential to replace conventional, wet chemistry laboratory techniques for soil and leaf fertility testing (which are costly, laborious and sometimes hazardous) with a rapid, low-cost diagnostic method. The basic principle is that each soil has a unique infra-red spectral signature that relates to specific properties of the sample. With calibration, it is possible to simultaneously estimate these properties (e.g. texture, nutrient levels, carbon content) from sample spectra without the need to undertake conventional analysis.

This research aims to evaluate and refine spectral diagnostics for common soil fertility and leaf nutrient parameters to identify those properties that can be accurately estimated by infra-red scanning, with the goal of providing growers with a more cost effective and rapid soil fertility diagnostic service from the SASRI Fertiliser Advisory Service. Further development aims to enable the deployment of the technology at remote sites (e.g. Mpumalanga and out-of-country sites) to complement the existing diagnostic service provided centrally at Mount Edgecombe.

Research undertaken during the reporting period revealed that revision of the mid-infrared organic matter (OM) model currently used in FAS may improve predictive accuracy. Results indicate that the revised model more accurately predicts organic matter content (i.e. better prediction to actual value) and has fewer calibration and spectral outliers than when compared with the current model. The model error estimate is also considerably lower for the revised model. These observations also have implications for improving the accuracy of sample classification into N Category upon which nitrogen fertiliser recommendations are based.

Research is also underway to evaluate the quality of predictions for key soil nutrients (N, P, K, Ca, Mg) and properties (clay, organic matter, pH, CEC and salinity related parameters).

Comparing Long-term Effects of Fertilising, Burning and Mulching

An 80-year-old research trial that monitors the long-term benefits of green cane harvesting on soil health, crop nutrition and yield performance are located on the SASA/SASRI Mount Edgecombe site. Research conducted during the reporting period included the collection on 17 September 2019 of soil samples at depths of 0-5 cm and 0-20 cm. The soil samples were analysed for statistically-significant differences in crop residue and fertiliser effects on soil parameters. Noteworthy observations from this aspect of the study revealed the following: (a) Soil pH at the trial site was negatively affected by the application of fertiliser and further lowered by the retention of a residue blanket. Until about a decade ago, the effect of residue on soil pH in this long-term trial was noticeable but not significant. (b) Crops receiving fertiliser produced higher biomass, leading to accelerated depletion of total soil cations, especially in the 0-20 cm depth range. This depletion of cations might explain the significant lowering of the buffering capacity of the soil, resulting in the increased acidity where fertiliser was applied.

CANE QUALITY MANAGEMENT

Rain-fed Variety Responses to Ripeners

Nine ripener demonstration trials, located in the Dalton, Eston, Richmond, Jolivet and Park Rynie regions, were conducted in commercial fields with rainfed varieties harvested during April to July at harvest ages of 18 months or older. The results obtained from these participatory commercial ripener demonstration trials highlight the potential for significant financial benefit from chemical ripening in longer-cycle rainfed crops provided care is taken in the identification of crops suitable for ripening. Informed ripening decisions should be based on crop growth vigour and maturity status, which can greatly vary between seasons due to variable rainfall quantity and distribution.

A grower knowledge gap of the benefits of using chemical ripeners for cane quality management under commercial conditions in longer-cycle (18 – 24 months harvest age) rainfed crops has been identified. Consequently, nine ripener demonstration trials, situated in the Dalton, Eston, Richmond, Jolivet and Park Rynie regions, were conducted in commercial fields with rainfed varieties harvested during April to July at harvest ages of 18 months or older. Shortly before application of the ripener treatment, the suitability for spraying was established in each selected field through visual inspection in conjunction with whole-stalk juice purity estimation using a hand-held refractometer and the Pur*Est*® smartphone app.

Products containing the active ingredient fluazifop-p-butyl were applied in all trials, either by helicopter or crop-spraying drone, at intended spray-to-harvest intervals aligned with SASRI guidelines. Participating growers selected the spray and harvest dates and harvested the fields, although the cane consignments from the demonstration trials were sent separately to the mill where they were analysed by the relevant SASA Cane Testing Service laboratory. The RV% data and the individual cane consignment payloads were used to calculate the RV yield and the profitability of ripening, expressed as the gross margin difference in R/ha between the control (unripened) and ripened treatments, was established for each trial.

In all trials, the ripener treatment resulted in increases in cane quality (RV%). The effects of the ripener treatment on cane yield varied between trials. Analysis of rainfall data from nearby weather stations indicate that the growing conditions after spraying can influence the magnitude of the cane yield effect induced by the ripener. With the exception of one trial, the RV yields in the ripener treatments were higher than in the control treatments. The only exception was the trial at Jolivet. The lower RV yield in that ripener treatment was caused by an excessively long spray-to-harvest interval, which eroded cane yield amidst very good growing conditions. This emphasises the need for growers to take cognisance of the importance of appropriate spray-to-harvest intervals to strike a balance between RV% and cane yield responses for best RV yield outcomes.

Gross margin returns in all trials were favourably influenced by the ripener treatments and ranged between R541/ha – R8818/ha. The positive financial outcome in the trial at Jolivet, which was realised despite the lower RV yield, was brought about through savings in harvesting and high transport costs due to the long distance from the mill.

This set of participatory commercial ripener demonstration trials highlights the potential for significant financial benefit from chemical ripening in longer-cycle rainfed crops, provided care is taken in the identification of crops suitable for ripening. Informed ripening decisions should be based on crop growth vigour and maturity status, which may vary greatly between seasons due to variable rainfall quantity and distribution.

Irrigated Variety Responses to Ripeners

The efficacy and economics of the hormonal mode-of-action ripeners, Ethephon® and Moddus®, were compared on selected irrigated varieties. The study revealed that chemical ripening led to substantial increases in gross margins in all five irrigated varieties, but that the magnitude of response to these two ripeners differed between varieties. High levels of profitability in popular varieties such as N36, N49, N53, together with an observed stimulation of ratoon regeneration, are positive attributes which distinguish Moddus® from Ethephon®.

The research sought to compare the efficacy and economics of the hormonal mode-of-action ripeners Ethephon® and Moddus® in selected irrigated varieties. To this end, a completely randomised trial with six replicates was repeated over three ratoon crops at Pongola. The trial included three treatments: unsprayed control (Con), Ethephon® (Eth) and Moddus® (Mod) and five irrigated varieties: N36, N41, N49, N53 and N57. Plots consisted of six rows, 8 m long and spaced 1.4 m apart. The three ratoon crops were harvested in April of 2017, 2018 and 2019 at an age of 12 months. The Ethephon® and Moddus® were applied 12 and 10 weeks before harvest, respectively, with a hand-held spray boom fitted with two TK SS1 stainless steel flood-jet nozzles. A CO2 pressurised knapsack was used to apply the products at a rate of 1.5 l/ha (Ethephon®) and 1.0 l/ha (Moddus®) at 175 kPa and in a water volume of 57 l/ha. At product application, whole-stalk juice purity was estimated in variety control plots by means of a hand-held refractometer and the Pur*Est*® application.

At harvest, a 12-stalk sample was collected from rows two and five in each plot for determination of relative value percent (RV%). Rows three and four in each plot were harvested and weighed to determine cane yield (tc/ha). RV yield (tRV/ha) was calculated as the product of tc/ha and RV%. Stalk population counts (x1000 stalks/ha) were performed at intervals after the harvest of each crop to determine any residual effect of ripener treatments on ratoon regeneration. Data were statistically analysed using Genstat® (18th edition). Commercial ripening costs (R/ha) specific to Pongola, general industry harvesting costs (R/tc), standard and high cane haulage cost scenarios (40 and 100 R/tc, respectively), and the April 2019 RV price (R/tRV) were used to estimate gross margins (R/ha) for each treatment.

Since there was no statistically-significant year x treatment interaction, but a significant variety x treatment interaction, data obtained over the three ratoon crops were combined per variety. Due to vigorous growing conditions, estimated whole-stalk juice purity in all varieties at the time of Ethephon® and Moddus® application was <75% and <85%, respectively, which indicates suitability for chemical ripening with both products. All variety x ripener treatment combinations achieved statistically-significant increases in RV% over the controls.

For N36, N41 and N57, there were no statistically-significant differences between the RV% responses achieved by the two treatments. However, in N49 and N53 the RV% response in the Moddus® treatment was 0.9 and 1.1 percentage points, respectively, larger than in the Ethephon® treatment. Due to the large increases in RV%, in the absence of any statistically-significant effects on cane yield, all the variety x ripener treatment combinations achieved higher income from RV yield than the control treatments. Economic analysis revealed that all the variety x ripener treatment combinations were profitable with increases in gross margins ranging between R2,395 to R11,071 per hectare for the standard-haulage cost scenario and R2,927 to R10,954 per hectare for the high-haulage cost scenario.

For N36, N49 and N53, the Moddus® treatment was more profitable than the Ethephon® treatment under both haulage cost scenarios. This advantage was realised despite the much higher ripening cost, R1164/ha for Moddus® treatment versus R153/ha for Ethephon® treatment, brought about by differences in chemical cost and miller subsidy.

For N41 and N57, the Ethephon® treatment was more profitable than the Moddus® treatment under both haulage-cost scenarios, indicating the existence of varietal differences in relative economic response to these two products. Combined, across varieties, the Moddus® treatment was more profitable than the Ethephon® treatment by a margin of R432/ha and R627/ha under the standard- and high-haulage cost scenarios, respectively. Following harvesting, the Moddus® treatment resulted in temporary higher population counts (increased tillering) in the following ratoon in all varieties except N41. The Ethephon® treatment did not enhance tillering in any variety. These results indicate that Moddus® enhances ratoon regeneration, but that the presence and persistence of this effect depends on variety. These observations agree with reports from Brazil and Australia.

The results demonstrated that chemical ripening leads to substantial increases in gross margins in all five irrigated varieties tested, but that the magnitude of response to these two ripeners differs amongst varieties. High levels of profitability in popular varieties such as N36, N49, N53, and stimulation of ratoon regeneration, are positive attributes that distinguishes Moddus® from Ethephon®.

Systems Design and Optimisation Research

Dr Rian van Antwerpen
(Programme Manager)

Developing and sharing innovative systems that optimise industry agricultural performance.

Research Focus Areas

PRODUCTION SUSTAINABILITY

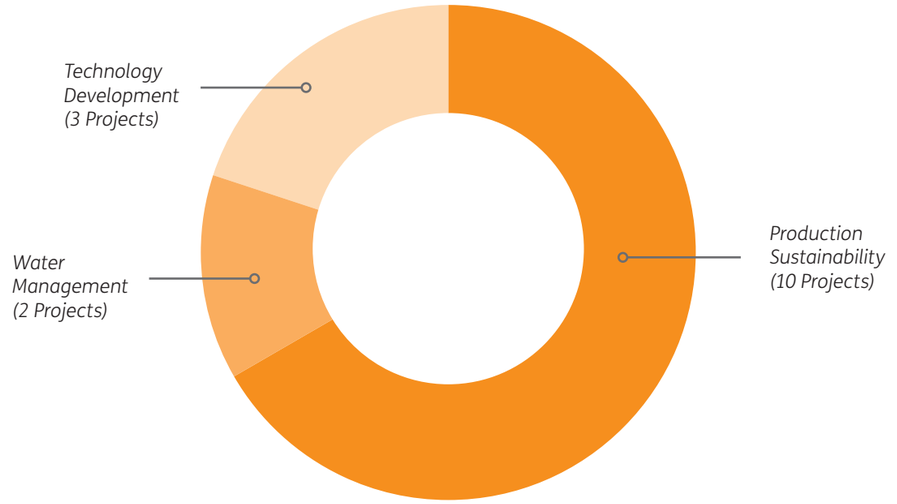
- Assessing the impacts of agronomic and mechanisation issues on production efficiencies and sustainability;
- Identifying opportunities for on-farm energy savings and reducing carbon dioxide emissions;
- Deploying novel technologies that improve operational efficiencies and service offerings; and
- Developing new and improvement of existing technologies and approaches that enhance alignment between research and industry requirements.

WATER MANAGEMENT

- Developing recommendations and advice that promote effective water management and technology deployment, both in terms of irrigation practices and surface water management;
- Developing guidelines to determine the footprint of water usage in irrigated regions; and
- Maintaining or improving soil quality in irrigated regions where the parent material is the source of salts.

TECHNOLOGY DEVELOPMENT

Developing, adapting and deploying technologies that focus on enhancing internal efficiencies and the quality of service provision, with a focus on small-scale growers.



Research Highlights

- Increased focus on developing technology suited to the needs and circumstances of small-scale growers:
  (a) three trial sites on the South Coast secured to demonstrate the possibilities for chemical ripening that crop-spraying drones have opened for small-scale growers; and
  (b) training of SASRI specialists in empowering participatory research methods undertaken with a view instituting community engagements aimed at increasing the self-sufficiency of small-scale growers in their management of varieties, pests, diseases and irrigation.

- A digital application developed to enable small-scale and large-scale growers to easily compare variety information as a means to facilitate their decision-making regarding variety choice.
- SASRI WeatherWeb online tool updated and an application to enable use of the site on smart-phones is to be released during 2021/2022.
- A customisable Excel-based tool developed to enable Extension Specialists to assist growers in calculating the effects of various lodging scenarios on their revenue.
- Tools and knowledge resources developed to assist growers in improving their awareness of the negative effects of salt build-up in soils under irrigated sugarcane production.
- A high-resolution spatial framework developed to improve the fidelity of monthly crop forecasts issued by the Canesim® Crop Forecasting System and other studies that require point-to-region upscaling.

New Research: Focus on Small-Scale Grower Production Sustainability

The need for small-scale grower support and mentorship of KZN DARD Agricultural Advisors includes practices relating to soil health and cane quality management as well as the management of varieties, pests, diseases and irrigation. It is within this context that SASRI implemented new projects to specifically target technology development for small-scale growers in these areas.

Soil conservation learning resources for small-scale extension (Project Reference: 19TD03) (Project Manager: Thulani Masondo)

Capacitating small-scale grower Extension Specialists and KZN DARD Agricultural Advisors in soil conservation theory and practice, thereby promoting small-scale grower learning.

The vision of this project is to:
(a) design and compile a set of demonstration tools, including for soil water infiltration, soil water-storage capacity and soil structure stability; and
(b) refine the soil modular course used by SASRI SSG Extension Specialists and KZN DARD Agricultural Advisors to empower SSGs in conserving and, where necessary, remediating the soils on which they cultivate their sugarcane crops. In addition to refining the soils modular course and developing complementary teaching and learning resources, the project also aims to upskill EVA DARD Agricultural Advisors in the contents of the soil modular course and the use of the new teaching aids to enhance SSG learning.

Advancing cane quality management in the small-scale grower sector (Project Reference: 19TD05) (Project Manager: Dr Riekert van Heerden)

Three trial sites on the South Coast were secured to demonstrate the possibilities for chemical ripening that crop-spraying drones have opened for small-scale growers. Engagement workshops were held during October 2020 to establish partnerships at each of the three locations and to introduce stakeholders to the potential economic benefits that crop spraying drones are making possible. The project team also introduced the demonstration trial concept and approach to the stakeholder participants and the way forward was mutually agreed.

In the large-scale grower chemical ripening has been a long-standing strategy to increase cane quality (RV%) in immature crops. In contrast, small-scale growers are generally not able to benefit from chemical ripening, largely because fields tend to be small, spatially fragmented and frequently surrounded by other forms of land-use, such as livestock or vegetable farming, which makes the deployment of fixed-wing aircraft or helicopter difficult. However, the recent entry of crop spraying drones into the industry provides chemical ripening opportunities due to the ability of these drones to operate effectively within fragmented small-field environments.

The objectives of this technology development are to:
(a) develop regional partnerships between all the relevant role players (SASRI ripener specialists, KZN DARD[11] Agricultural Advisors, SASRI Extension Specialists, SAFDA and SACGA representatives, regional mill/CTS representatives, the crop spraying drone contractor, harvesting/transport contractors, relevant government departments) needed to advance cane quality management in the small-scale grower sector;
(b) collaborate in developing an approach consisting of informed ripening decision-making, ripener application via drones and harvest scheduling;
(c) implement this approach on a pilot scale in selected small-scale grower communities, spanning the coastal and midlands regions and the Makhatini flats/Pongola (Northern Zululand) areas through a series of demonstration trials; and (d) quantify the economic benefit of the approach to small-scale grower communities.

In this new project, excellent progress was made in the South Coast region (SASRI Extension Specialist: Ms Bongiwe Chonco), in that the project team secured three demonstration trial site locations with varieties N39 (Umzimkhulu and Sezela) and N54 (Umbumbulu). Stakeholder engagement workshops to establish the regional partnerships at all three locations were held during October 2020.

Presentations and learning materials in isiZulu were used to introduce stakeholders to the exciting ripening possibilities and the potential economic benefits that crop spraying drones are making possible. The project team introduced the demonstration trial concept and approach to the stakeholder participants and mutual agreement on the way forward was established.

Small-scale growers within the community surrounding each trial location will be invited to attend the field days planned for 2021. At these first field days, growers will experience the process of determining suitability of the demonstration trial fields for ripening, a key step in the process of learning to identify ripening opportunities to avoid wasteful expenditure on crops that do not require ripening.

Once suitability for ripening has been established, the next field days will be demonstrations of drone application of ripeners to these fields. The final field days will be held just prior to harvesting to allow growers to experience the process of assessing ripener efficacy and determining suitability for harvesting. The trials will then be harvested in commercial fashion and the results used in economic analysis for sharing at small-scale grower days.

Stakeholder engagement workshop held in October 2020 in Umbumbulu to establish partnerships and to introduce stakeholders to the potential economic benefits that crop spraying drones are making possible for small-scale growers.

[11] KwaZulu-Natal Department of Agriculture and Rural Development

Empowering Participatory Research for Small-scale Grower Variety, Pest, Disease and Irrigation Management (Project References: 19TD07, 19TD09, 19TD10 and 19TD11) (Project Managers: Sbonelo Shezi, Nongcebo Memela, Khanyisile Buthelezi and Dr Ashiel Jumman)

The goal of this research is to use empowering participatory research methods to increase the self-sufficiency of small-scale growers in their management of varieties, pests, diseases and irrigation. During 2020/2021, three workshops were held to train project team members in: (a) participatory research methods and to consolidate stakeholder buy-in and participation in the project; and (b) community engagement skills.

Small-scale growers (SSGs) face enormous challenges with managing varieties, pests, diseases and irrigation, largely resulting from a lack of opportunities to develop technical knowledge and skills. To provide support to SSGs in the development of appropriate management skills, this project was initiated with the objectives of: (a) adapting and implementing the participatory observation trial method to enable SSG grower communities to observe successful approaches to variety, pest, disease and irrigation management under local conditions similar to their own; and (b) developing teaching resources and creating learning opportunities for small-scale growers and KZN DARD Agricultural Advisors in order to stimulate the implementation of SASRI preferred management practices and the realisation of the associated economic benefits.

Despite being a new project good progress was made, in that two workshops were hosted in January and February 2020, ahead of the start of the project in April. Workshop participants included discipline-specific SASRI project teams, SSG Extension Specialists and representatives from the SA Cane Growers Association (SACGA) and SA Farmers Development Association (SAFDA).

The first workshop was facilitated by an expert external consultant who used an interactive simulation-based format to familiarise participants with the different techniques and approaches available for conducting participatory research. Activities helped to establish a consensus that interactive, interdisciplinary, participatory research was necessary to engage, appreciate and address the complex array of problems faced by SSGs. Since SSG challenges extend beyond the agronomic-technological realm into socio-economic and socio-political spheres, strong partnership and involvement from the grower associations (SAFDA and SACGA) are essential. In addition, a consensus was reached that the participatory research with SSGs needs to adopt an empowerment paradigm. In addition to demonstrating the benefits of implementing preferred management practices or suggesting solutions, the project (and participatory methodology) needs to enable and empower SSGs to identify their own problems, seek out solutions and take their own decisions in order to become better farmers (calling on support and guidance from SASRI when necessary). With the above in mind, participants at the first workshop were placed into groups and asked to map out the discipline specific projects in order to explore which phases of the project were best suited for participatory methodology and which specific techniques/approaches could be applicable/useful in each phase. Finally, the importance of different roles and responsibilities of the multi-disciplinary team (social scientists, economists, agronomists/engineers, extension and knowledge management) were mapped out in order to secure commitment and willingness to participate in the project.

The second workshop was used to reaffirm and entrench the learning from the first workshop. Participants were required to reflect on how the empowerment paradigm and participatory techniques will change the way they conduct each discipline-specific SSG project. Responses from the participants indicated that a substantial shift had occurred in terms of the value of using participatory methodologies with an empowerment paradigm, relative to the way SSG-focused research was previously/historically conducted at SASRI. The two workshops succeeded in growing capacity, skill and willingness to make use of participatory methods in this project.

The third workshop, held in June 2020 and also led by an External Specialist consultant, increased the knowledge of the project team in social learning practice and introduced them to participatory research methodologies appropriate for SSG community engagements. The methods included transect walks, seasonal calendars, giving-and-taking diagrams, four-cell analysis and participatory budgets and workshop participants were required to reflect on how they could be applied effectively to the intended empowering participatory. Following these successful workshops, the project team developed a plan for initial community engagements and have prepared the required teaching and learning materials.

Initial engagements with selected SSG communities are to commence in 2021/2022, conditions permitting.

Outcomes from Completed Research

PRODUCTION SUSTAINABILITY

Interactive Variety Comparison Tool

A digital application was developed to enable advisors of small-scale and large-scale growers to easily compare variety information to facilitate their recommendations regarding variety choice.

- The objective of this technology development project was to create a web-based variety information resource encompassing all SASRI varieties. The intention was to create a resource that enables growers and Extension Specialists to extract selected information on specific varieties, in a format that allows for easier variety comparisons. The formats in which information was to be displayed needed to be aligned with the current variety information sheets and booklets as well as new formats that facilitate rapid comparisons for traits of interest.
- A web-based app, called the Variety Guide, has been successfully developed. The Variety Guide is a visually appealing, user friendly tool that facilitates the swift comparison of the characteristics of varieties that are suitable for the growing conditions on farms.
- The Variety Guide has also been designed to:
  (a) enable the SASRI Variety Scientist, Thobile Nxumalo, to regularly add information updates, traits and new varieties upon release; and
  (b) enable the tracking of the number of users and permit user feedback whilst using the tool.
- The Variety Guide draws on data captured in a centralised variety database that contains all currently available quantitative and qualitative variety information. This database was developed as part of this project and will become the source of all variety information going forward.
- Regular updating of the tool has been established as operational milestones within the SASRI breeding and variety evaluation projects.
- The app allows users to select their region, preferred cutting cycle and soil potential from drop-down lists. Varieties suitable for the selected scenario are presented in a user-friendly tabular format (using colours and words to show suitability or to highlight a limitation) to allow for quick and easy comparisons between varieties for a wide range of variety traits (best features, limiting features, RV yield, cane yield, RV content, range of management, range of agronomic traits, tolerance to pests and disease, ripener response and milling traits). The tool offers some flexibility, allowing the user to select a different number of varieties, different variety traits as well as their own varieties of interest. Users can export the output into MS Excel or print for easy future reference.
- Extension requested that the Variety Guide only be available to Extension initially to allow them some time to become familiar with the tool. Concern was raised that the recommendations from the tool were too broad in that it did not consider local conditions, specific soil types or individual management factors. These concerns were considered, and the tool will initially be made available to SASRI staff only to provide Extension with time to use the tool and to include local conditions in the tool where possible.

The project has been successful in delivering an app, the Variety Guide, that allows for quick, efficient and easy comparison of all available varieties and has the potential to improve the adoption of new varieties by Extension and growers. Early adoption of new and improved varieties will ultimately lead to increased profitability by growers and millers and a reduction in the current levels of pests and diseases.

Modernisation of the SASRI WeatherWeb

The SASRI WeatherWeb online tool was updated and an application to enable use of the site on smart-phones is to be released during 2021/2022.

The SASRI WeatherWeb site was designed over a decade ago (Project Reference: 06TT02). After the successful inclusion of real-time weather data on the site in 2015 (Project Reference: 12TD05), increased use of the decision support tool was noted, including by parties outside the South African sugar industry. The increased use of the SASRI WeatherWeb, while advantageous, created higher end-user expectations and exposed limitations of the site. One of the main limitations was poor compatibility with mobile devices with which users were more frequently attempting to access the WeatherWeb; a feature not considered during the original design of the site twelve years ago. Hence, this project aimed to establish the specific functional and technical requirements, potential service providers and actual cost of developing a new weather web application compatible with mobile devices.

An initial version of the app was developed for iOS and Android devices and is ready for registration and subsequent launch on the two respective app stores.

WATER MANAGEMENT

Reducing Salt Accumulation in Soils Under Irrigation

Tools and knowledge resources were developed to assist growers in improving their awareness of the negative effects of salt build-up in soils under irrigated sugarcane production.

Approximately 30 to 35% of the total annual sugarcane crop is produced under irrigation and estimates suggest that as much as 20% of the land on which production occurs is affected by water-logging or salinity. Water quality assessments conducted by the SASRI Fertiliser Advisory Service (FAS) are accurate but it is recognised that recommendations provided to growers based on these data require improvement. For instance, soils showing an increasing salt-load trend or those that are irrigated with sub-optimum quality water need to be accompanied by a warning that leaching of salts should be considered.

Recognition of the value of leaching salts is underestimated in SA sugarcane industry. The quality of irrigation water, especially in winter, is generally poor and the resulting application of salts to soils through irrigation leads to soil health deterioration and eventually to the development of saline or sodic soils. In some regions, the parent material is a source of salts, especially sodium, and suppression of salt levels to prevent it from reaching the surface is complicated and potentially expensive. Fields are not uniformly affected by salts, as they may accumulate in specific zones within a field depending on the topography, distribution of soil type and water tables. Hence, addressing the salt problem may be more cost-effective if the affected areas within a field can be easily identified and directly targeted.

This research provided proof-of-concept that electro-magnetic induction (EMI) scanning technology is suitable for the detection and mapping of the distribution of salt-affected areas within fields. The study further illustrated that EMI survey data may be regressed against a number of soil physical parameters affecting the hydraulics of soils and therefore the distribution and accumulation of salts. Combining data of this type with the outputs from a model such as the Soil Water Management Program (SWAMP) assists in formulating recommendations that will best improve the condition of salt-affected or salt-prone areas. Included in such recommendations is the geolocation of salt-affected areas, its depth, surface and subsurface drainage properties of the site, the type of salt present, the amount of salts to be removed and the amount of water required to remove the salt.

SASRI was contracted to conduct research in the selected areas of the irrigated sugarcane production regions as part of a national project funded by the Water Research Commission and administered by the University of the Free State. The broad aim of the project was to develop guidelines for improved diagnosis and management of salinity under irrigated conditions.

The specific objectives of the project were to:

- conduct a socio-economic survey to benchmark growers' knowledge, practices and perceptions of salt management;
- use case studies to demonstrate improved spatial diagnostic capabilities of the EMI technology; and
- evaluate the use of a decision support system for estimating salt dynamics in soils.

A significant outcome of this project was strong confirmation that alternatives to the conventional manner of conveying information to growers should be explored. SASRI has been aware of this for some time and has instituted steps to improve the effectiveness of knowledge exchange with growers. A recommendation from the project is that enhanced effectiveness of technology sharing may be accomplished through farm visits and associated situational analyses, demonstration plots, study group meetings, farmer-to-farmer contact and the publication of easy-to-follow literature tailored to each specific grower demographic.

From two field trials conducted, it was noted that, although the salt load in the surface soil layer is much lower than that deeper in the profile, it exerts a greater influence on yield loss. Based on this observation, it is recommended that growers should ensure that the rooting zone (top 600 mm soil) is ameliorated to a condition of pristine health if optimum yields are to be achieved. Quantification of the impact of sodium Na-affected soils on sugarcane production revealed for the first time that the maximum rate of yield loss is five times higher than the rate reported in world literature. This case-study is admittedly extreme, as it was the most severe of the two sites studied. Nevertheless, it serves to highlight the critical importance that growers be vigilant in their efforts to prevent their land from becoming sodic.

A further important outcome of the project is the awareness it created of the impact of salts on sugarcane production. Roadshow events, attended by 87 growers, resulted in the receipt of several requests from growers for assistance with salt problems. However, it is concern that many growers, who may be at risk of experiencing the yield losses due to salts did not attend the roadshow meetings. It is for this reason, and from the outcome of the questionnaire survey, that a knowledge exchange campaign is to be proposed.

TECHNOLOGY DEVELOPMENT

Point-to-region Upscaling for Simulation Modelling

A high-resolution spatial framework was developed for crop simulation modelling and other studies that require point-to-region upscaling. The development will lead to improved fidelity of the monthly crop forecast issued by the Canesim® Crop Forecasting System, as well as that of other decision-support tools, including the MyCanesim® real-time irrigation scheduling tool and the StalkGro growth increments tool.

A new, higher-resolution, spatial framework has been developed for crop simulation and other studies that require point-to-region upscaling. The new system is termed the Sugarcane Quinary Catchment (SQC) framework, and has a spatial resolution approximately ten times that of the system of Homogeneous Climate Zones (HCZs) currently in use. Daily weather data (rainfall, temperature, solar radiation, relative humidity and wind speed) for every SQC is available from 1 January 1950 until the present (two days to one month behind the current date, depending on availability of underlying weather station data).

The SASRI Meteorology database and WeatherWeb portal have been updated to generate SQC-level daily weather data interpolated from SASRI weather station data. Soil water holding capacity, age at harvest, irrigation status and water source, and mill supply contributions per SQC have been calculated from the HCZs in which they are located. These weather, soil, crop management, and mill supply area data allow for the Canesim® Crop Forecasting System to run simulations at the finer SQC spatial scale, which should improve the fidelity of the monthly crop forecast.

The SQC framework has the potential to improve the spatial fidelity of other decision-support tools (such as the MyCanesim® real-time irrigation scheduling tool and the StalkGro growth increments tool). Data resources have been made widely available to SASRI staff, and they have been empowered to adopt this new framework via an Integration Workshop.

A software specification has been prepared for the development of an Information System – internally named "ProFusion" – that links diverse source databases (such as the Meteorology database, the P&D surveys spreadsheet(s), Fertiliser Advisory Service (FAS) database, SUSFARMS® and potentially many others) in such a way that cross-database queries can be conducted easily and meaningfully. The ProFusion system would provide a systematic approach to addressing differences in the spatial and temporal scales of data from source databases recorded in their 'native' scales, as well as supporting diverse data formats/platforms.

Impacts of Lodging on Sugarcane Revenue

A customisable Excel-based tool has been developed to enable Extensions Specialists to assist growers in calculating the effects of various lodging scenarios on their revenue.

Besides the known negative impacts on crop productivity and ERC yield, the phenomenon of lodging also directly or indirectly affects the efficiency of harvest and transport, as well as other preceding management activities, including decisions to ripen or remove irrigation systems from lodged fields. Surprisingly, despite lodging being a relatively common occurrence in sugarcane production, little work has been done to assess the impact of lodging on revenue.

The objective of this research was to quantify the effect of lodging on grower revenue by assessing the increased costs in harvesting, loading and transporting the lodged cane and reduced income due to the reduction in ERC yield.

Based on data obtained from an extensive survey of published literature, various quantifiable effects of lodging on sugarcane operations have been incorporated into an Excel-based revenue loss calculator. The spreadsheet is tailored to include a range of scenarios, including those derived from either a crop estimate simulation or a more detailed desktop modelling simulator as the means to estimate crop productivity and rate of yield and sucrose accumulation at the time of lodging. The spreadsheet is fully customisable by region and crop cycle length or to the fields of individual growers based on current field performance estimates.

With this tool, Extension Specialists are now able to advise their growers on previously unaccounted lodging-associated losses in their estimates. With scenario-specific refinement, these models are anticipated to assist with on-farm variety selection decisions, harvest management decisions and due to the high costs associated with lodging, may also be used in plant breeding variety selection and variety release decisions for specific mill areas. The knowledge gained from this research may also lead to the promotion and the adoption of better management practices or adaptive practices to reduce the risks and severity of lodging events. The indirect benefit is that the awareness of the magnitude of lodging losses may help to guide various supply chain components from short-term on-farm cane harvesting, mill area cane supply prioritisation through to long term plant breeding strategies and holistic variety economic assessment comparisons.

Technology Development and Knowledge Exchange

Michelle Binedell
(Knowledge Manager)

Promoting adoption of sustainable best practice amongst growers remains an ongoing priority for SASRI. Key knowledge exchange activities include:

(a) empowering staff, though skills development, to plan and conduct effective knowledge with growers to promote adoption of best practice;

(b) maximising the accessibility and value of existing knowledge assets to promote implementation of best practice by growers.

Knowledge Exchange Focus Areas

BUILDING KNOWLEDGE-EXCHANGE TOOLS

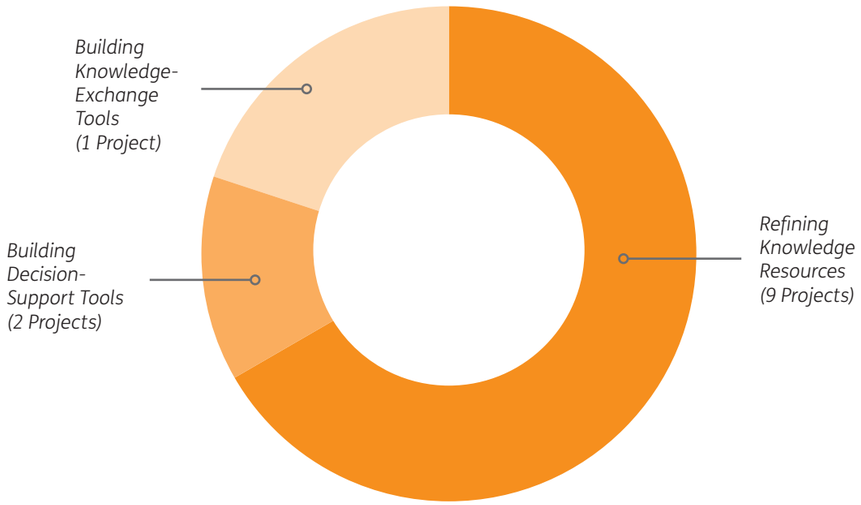
Developing and implementing knowledge exchange tools to assist researchers and Extension Specialists to more effectively plan and conduct knowledge exchange campaigns.

BUILDING DECISION-SUPPORT TOOLS

Developing tools, including online resources and smartphone apps, to ease grower decision-making.

REFINING KNOWLEDGE RESOURCES

Maximising the value of existing knowledge by consolidation of the suite of knowledge resources that contain SASRI recommendations, updating when required and ensuring coherence and easy access by growers.



New Projects

Revision of SASRI Publications Outlining Best Management Practices (seven projects)

Reviewing and developing the suite of knowledge resources that encapsulate SASRI recommendations within key areas crop management

A suite of seven projects was instituted to review and subsequently update, consolidate or develop, as necessary, new knowledge resources encapsulating SASRI recommendations within six key areas related to crop management:

(a) insect pests (Project Reference: 19KE01) (Project Manager: Dr Stuart Rutherford);
(b) diseases (Project Reference: 19KE02) (Project Manager: Sharon McFarlane);
(c) weeds (Project Reference: 19KE03) (Project Manager: Anushka Gokul);
(d) planting and harvesting (Project Reference: 19KE04) (Project Manager: Dr Peter Tweddle);
(e) irrigation (Project Reference: 19KE05) (Project Manager: Dr Ashiel Jumman);
(f) varieties (Project Reference: 19KE06) (Project Manager: Dr Marvellous Zhou); and
(g) cane quality management (Project Reference: 19KE07) (Project Manager: Dr Riekert van Heerden).

Outcomes from Completed Projects

Updating And Revision of Crop Nutrition and Soil Management Information Sheets

This project was undertaken to review and update all crop nutrient and soil health and conservation information sheets. In this regard, the key objectives were to:
(a) create a framework which could be used to guide these updates;
(b) review, revise and develop topic specific information sheets that provide the foundational information and guidance on best management practices on crop nutrition, soil health and conservation; and
(c) create awareness and disseminate the revised content.

Key products and outcomes of the project were as follows.

- A framework and guidelines associated with the process of updating the information sheets.
- Mapping and reorganisation of all crop nutrition and soils information sheets.
- Forty-eight information sheets were identified, with 25 crop nutrition twelve soil health and eleven conservation information sheets or guides identified as relevant. Of these, 23 were revised and updated, 16 were newly developed, four remained unchanged, four were identified for development once information becomes available and one was removed. In addition, nine FAS related sample submission guides and five FAS report guides were developed.
- A crop nutrition webpage was created to improve access to the revised content and several The Link articles were written in support of the revised content. A narrated PowerPoint video to introduce FAS soil fertility report was also created.

Regular reviewing of the content by subject specialists in the future will aim to keep the content current and relevant. Quarterly progress and annual reviews will be initiated by the SASRI Knowledge Management Unit and will be managed within SASRI project cycle processes through the establishment of a long-term project. Additional options to improve accessibility and ease of use have been proposed.

Guidelines for Optimising Root Development

Guidelines have been developed to serve as a knowledge resource for growers and their advisors on the management of fields to optimise root development.

A considerable body of information is available on field management practices that affect sugarcane root health but it is fragmented into different formats, which makes it difficult for growers and their advisors to prepare and implement recommendations that require a synthesis of the information. Hence, this project was undertaken to collate information on field management practices that promote a level of sugarcane root growth required for optimal crop production. To this end, the project team:
(a) reviewed background information on the growth dynamics and characteristics of sugarcane roots;
(b) conducted inter-disciplinary discussions of root health problems and associated ameliorative field management practices;
(c) in the absence of specific information on sugarcane roots, considered relevant information from other crops; and
(d) from these management practices, compiled a list of practical procedures to reduce root health problems.
The review also served to highlight gaps in knowledge regarding sugarcane root health.

Roots are sensitive to various growth-limiting factors and hence, will primarily extend into regions of the soil column that possess properties favourable to their growth and development. Hence, to promote crop production, growers should ensure that the soils on their farms are in a condition that favours root development into the largest possible volume of soil. Factors identified as negatively affecting root development and function include:

(a) soil physical properties (surface crusting, compaction, disturbance, anoxia from waterlogging):
(b) soil chemical properties (deficient and excess concentrations of specific nutrients, acidity, salinity, sodicity);
(c) soil biological properties (plant parasitic nematodes, white grubs, longhorn beetle); and
(d) potential negative and unintended collateral effects of other management practices (herbicide application).
In addition, other management practices that promote overall crop health, such as the effective integrated management of pest and diseases, are essential for healthy root development and functioning.

The guidelines emanating from the project focus on each of the factors identified as potentially exerting a negative effect on root health and provide recommendations on how these limitations may be overcome through effective management practices. It is anticipated that the guidelines will become a valuable resource to assist growers and their advisors in managing the root health of their sugarcane crops.

Highlights from Ongoing Projects

Refinement of the SASRI Knowledge Exchange Paradigm

During 2020/2021, emphasis was placed on the planning of a training programme to upskill and develop SASRI staff in the theory and practice of knowledge exchange. The programme was designed to promote learning and stimulate new practices based on cognitive principles. To this end, an external expert in behavioural science was engaged to design and facilitate a series of interactive simulation training events. During the skills training, participants were immersed in an interactive simulation scenario to enable engagement with the theory based on personal experiences. Together with the establishment of a community of practice, it is believed that the theory will become progressively entrenched within routine knowledge exchange practice at SASRI.

A SASTA international visitor grant was awarded to host Dr John Pickering, an expert behavioural change specialist from Australia. Dr Pickering achieved considerable success with the Cane Changer Project in Australia, in which Australian sugarcane farmers substantially increased their adoption of the Smart Cane Better Management Practices programme. Circumstances permitting, he is to engage with stakeholders at the 2020/2021 SASTA Congress and a satellite workshop with a view to assisting the industry in uncovering social solutions to intractable industry problems, particularly cane quality and burn-to-harvest-crush-delay challenges.

Contracted-out Research

On behalf of the industry, SASRI enters into contracts with specific research service providers for investigations for which the institute does not have the requisite skills or infrastructure.

Sugarcane sucrose enhancement by genetic modification (Institute for Plant Biotechnology, Stellenbosch University)

The Industry, through SASA/SASRI, entered into a series of research agreements with the Institute for Plant Biotechnology at Stellenbosch University spanning over two decades. The main goal of this contracted-out research was to investigate the feasibility of increasing the sugar content of sugarcane by genetic engineering, while a further goal was to assess whether the sugarcane plant could be used as a bio-factory for producing alternative high-value products through the expression of genes not native to sugarcane.

Modification through genetic engineering of the expression of genes coding enzymes involved in sugarcane primary carbon and energy metabolism in some instances resulted in enhanced sucrose concentrations in the stalk but these improvements did not persist over successive ratoons in the field. Consequently, research in this area was terminated in September 2020.

Biotechnological investigations to improve sugarcane drought tolerance (Institute for Plant Biotechnology, Stellenbosch University)

SASRI contracted the Institute of Plant Biotechnology at Stellenbosch University to conduct proof-of-concept research into enhancing sugarcane drought-stress tolerance using mutation breeding and genetic modification approaches. During the contract cycle from April 2017 to March 2021, several projects were undertaken by post-graduate students, A further three-year funding cycle from April 2021 to March 2024 was approved by SASA Council.

Some of the proof-of-concept studies have yielded promising preliminary results under glasshouse and poly-tunnel conditions, which will be continued in the further three-year funding cycle.

Investigation of genome structure, diversity and phylogenetic relationship of Saccharum species, and assessment of diversity incorporated into modern cultivars (Research Contract with CIRAD (France) under the auspices of the International Consortium for Sugarcane Biotechnology)

This research is being conducted by Dr Angélique D'Hont and her team at the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) in Montpellier, France. The project is co-funded by ten member countries and organisations of the International Consortium for Sugarcane Biotechnology, which includes SASRI. The investigation will generate new knowledge on the genome structure, origin and phylogenetic relationships of the *Saccharum* species involved in modern cultivars for introgression breeding applications and facilitating exploitation of available sugarcane genome sequence information for variety development purposes.

Research Grants

In 2020/2021, SASRI secured five grants from funding agencies to support research, technology development and knowledge exchange.

NATIONAL RESEARCH FOUNDATION

Three fellowships were sourced from the National Research Foundation to support doctoral and post-doctoral research in the development and application of breeding-enabling technologies and biotechnologies to variety improvement.

- NRF Professional Development Programme: One post-doctoral (Dr Motselisi Koetle) and one PhD placement (Ms Khethumusa Cele).
- NRF Post-doctoral Fellowship Programme: One post-doctoral fellowship (Dr Lucretia Ramnath).

INTERNATIONAL ATOMIC ENERGY AGENCY

A research grant was received from the International Atomic Energy Agency (Vienna, Austria) over a five-year period, with the last tranche paid in 2020/2021.

The grant supported investigation of insect-rearing and insect transport arrangements for off-site irradiation required to support proof-of-concept demonstration of the efficacy of a novel F1 sterile insect technique (SIT) for eldana population management.

WATER RESEARCH COMMISSION

SASRI collaborated in two research projects funded by the Water Research Commission.

Irrigation soil salinisation risk (Lead Organisation: University of the Free State; final year of five-year funding cycle)

The research resulted in the development of tools and knowledge resources that will assist growers in improving their awareness of the negative effects of salt build-up in soils under irrigated sugarcane production.

Water footprint of fuel and fibre crops (Lead Organisation: University of the Free State; final year of five-year funding cycle)

The research aims to quantify the water footprint of irrigated sugarcane at the farm level, with particular emphasis on the impact of irrigation systems and mulching practices on water footprint estimates.

BIOSAFETY SOUTH AFRICA (TECHNOLOGY INNOVATION AGENCY)

The investigations will develop new knowledge for use in the preparation of the regulatory dossier that will be required for the future potential release of Bt GM sugarcane. This multi-institutional partnership project is funded by Biosafety South Africa, which is a unit of the Technology Innovation Agency of the national Department of Science and Innovation

- Evaluation of the likelihood of gene flow from commercial sugarcane hybrids to compatible wild relatives (Principal Investigator: Dr S Joshi, SASRI).
- Refugia planning in a Bt GM sugarcane scenario in combination with sterile insect releases (Principal Investigator: Dr L Potgieter, Stellenbosch University).
- Development of an eldana risk index (Principal Investigator: M Jones, SASRI).
- Development of a communication strategy for GM cane (Principal Investigator: Prof J Limson, Rhodes University).

Research Stakeholders

NATIONAL GOVERNMENT DEPARTMENTS

- Department of Agriculture, Land Reform and Rural Development (including: Agriculture Products Input Directorate; Genetic Resources Directorate)
- Department of Science and Innovation (including: Technology Innovation Agency; Biosafety South Africa)

PROFESSIONAL ASSOCIATIONS

- Engineering Council of South Africa
- Entomological Society of South Africa
- National Science and Technology Forum
- Soil Science Society of South Africa
- South African Association of Botanists
- South African Council of Natural Scientific Professionals
- South African Genetics Society
- South African Institute of Agricultural Engineers
- South African Irrigation Institute
- South African National Committee on Irrigation and Drainage
- South African Society of Crop Production
- South African Sugar Industry Agronomists' Association
- South African Sugar Technologists' Association
- Southern African Plant Breeders' Association
- Southern African Society for Plant Pathology

NATIONAL & INTERNATIONAL UNIVERSITIES, COLLEGES & RESEARCH INSTITUTIONS

National Universities

- Rhodes University
- Durban University of Technology
- Stellenbosch University
- University of KwaZulu-Natal

- University of Pretoria (including: Forestry and Agricultural Biotechnology Institute; Bureau for Food and Agricultural Policy)
- University of the Free State

Research Institutions

- Council for Scientific and Industrial Research (Centre for High Performance Computing)
- National Research Foundation
- Water Research Commission

International Institutions

- French Agricultural Research Centre for International Development (CIRAD)
- International Atomic Energy Agency
- International Consortium for Sugarcane Biotechnology
- International Consortium for Sugarcane Modelling
- University of Illinois at Urbana-Champaign
- West Indies Central Sugar Cane Breeding Station

Awards and Achievements

SASRI researchers receive NRF Ratings and Incentive Funding

Drs Stuart Rutherford and Marvellous Zhou received both NRF rating and Incentive Funding for Rated Researchers for their new five-year rating cycles, which started on 1 January 2021.

Africa's 20 most influential plant breeders

SASRI's Senior Plant Breeder Marvellous Zhou was included on the list of Africa's 20 most influential plant breeders.

MSc Thesis Award

Tondani Mishasa (Assistant Research Officer: Plant Breeding) won the best MSc thesis award for the 2019 graduation class in the Faculty of Agriculture and Natural Sciences at the University of the Free State (UFS). Tondani's thesis *"Family evaluation for quality traits in sugarcane"* was supervised by SASRI's Dr Marvellous Zhou and Dr Rouxlene van der Merwe of UFS.

Technology Transfer

Michelle Binedell
(Knowledge Manager)

The provision of informative and appealing products is the responsibility of a small group of knowledge practitioners at SASRI. Together with research and Extension Specialists, we help transform scientific outcomes, technologies and practical recommendations into accessible, easy-to-use and appealing material.

The start of the 2020/21 year was particularly challenging with COVID-19 restrictions threatening to delay and even prevent the publication of our regular products. Fortunately, we were all able to adapt quickly to working remotely and managed to deliver all that was planned for the year.

Popular Publications

In the 2020/21 year, SASRI continued to produce *The Link* and *Ingede* magazines aimed at our English/ Afrikaans and isiZulu speaking growers respectively. These editions focussed on many of the issues pertinent to specific regions of the industry.

THE LINK

Three editions of *The Link* were published in 2020/21. May 2020 was a special edition, focussing on Organic Matter, with a series of informative content prepared by our Senior Soil Scientists, Drs Louis Titshall and Rian van Antwerpen. Topics included: managing residues, organic waste as alternative sources of nutrients, green manuring and minimum tillage.

The usual format was followed for the September 2020 and January 2021 editions, with a focus on pest and disease control, nutrient management, cane quality management in carry-over crops, ripener demonstration trials, and correct herbicide application.

THE INGEDE

The popular isiZulu publication, *Ingede* is distributed by hand to small-scale growers through Extension Specialists, Agricultural Advisors and other industry stakeholders. However, due to the restriction on travel due to COVID-19, it was evident that distribution of the magazine was going to be delayed. For this reason, an innovative solution was sought. In addition to the printed copy, narrated *Ingede* articles (voice notes) were recorded and sent out to growers via WhatsApp.

The May 2020 edition focussed on important aspects of sugarcane agriculture for the small-scale grower. These included Topical tips (a regular feature of each *Ingede*), appropriate for each month in the farming calendar, as well as topics such as sourcing seedcane, suitable varieties, ratoon management, chemical ripening and reducing the burn to crush delay.

The September 2020 and January 2021 editions contained eight articles of interest focussing on planting, training, diversified farming, a drone ripener trial, field water management, soil conservation, seedcane production and varieties.

Other Newsletters and Articles

Direct communication to growers in the numerous regions took place through the development of eleven *Extension newsletters*. These communicated upcoming events, alerts and latest trial results.

Four articles were produced for *Coastals News*, once again showcasing SASRI's achievements and promoting best practice, and a further article was published in the *South African Sugar Journal*.

BOOKLETS AND GUIDES

MECHANISATION REPORTS

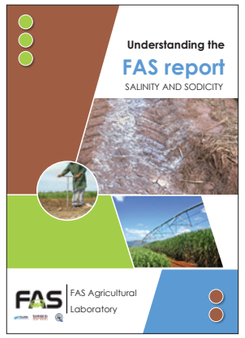
Annual updates of the Mechanisation Reports were completed and posted to the SASRI website.

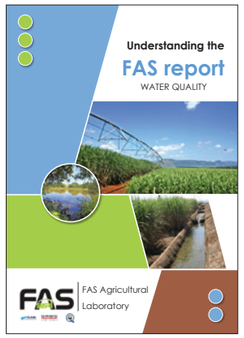
ELDANA BULLETIN

A 2020 update of the Eldana Bulleting was published in June. The bulletin contains a collection of pictures and identifiable traits enabling easy identification of all common pests and diseases found in the South African sugar industry. This pocket guide is useful for on-farm scouting teams, Biosecurity teams and growers who require a quick reference in the field. The updated version includes new information on pests such as yellow sugarcane aphid and nematodes.

FAS REPORT GUIDES

Regular sampling of soil, leaf, water sources and salinity status are recommended for cost-effective farm management. These measurements ensure soil health is maintained and adequate nutrients are applied. The Fertiliser Agricultural Laboratory offers this analysis service for a diverse range of crops at a competitive rate. To support these services, four guideline booklets were created to assist with understanding each of the packages that are on offer, and the results and recommendations that are provided for each test.





SEEDCANE GUIDES

Planting good quality seedcane, of an appropriate variety for your soils and climatic conditions, is the easiest step that can be taken towards improving and maintaining high productivity over many ratoons. For this reason, a *Guide to Buying Seedcane* was produced in English and isiZulu to offer advice on what to look out for when buying certified or approved seedcane. The guide provides a detailed outline of what a valid seedcane certificate should contain and what good quality, healthy seedcane should look like.

Tools

Pur*Est*®

A new update to the Pur*Est*® smartphone app was released in March 2021 to assist in ripener decision-making. This updated version includes a specific recommendation for crops sampled in the second half of July. In addition, the table of varietal responses to ripeners has been updated.

Information Sheets

Information Sheets provide a platform for the communication of research outcomes as well as guidelines and advice on the management of the sugarcane crop.

Nine information sheets were updated with latest information as well as three information sheets on the newly released varieties N73, N74 and N75.

A most notable development was the revamping of the Nutrition series of information sheets. This series contained advice on the easy identification of nutrient deficiencies in the field, adequate levels required for growth in plant and ratoon crops, and the most effective application guidelines for each nutrient. In addition, useful tables of suggested fertiliser sources for each nutrient have been provided. The Nutrition series also describes how to develop an effective nutrition plan, design strip plots and take soil and leaf samples as per FAS Agricultural Laboratory procedures.

Radio

During 2020/21, radio broadcasts continued to reach many of the rural communities in South Africa, even though live broadcasts were cancelled due to COVID-19 and pre-recorded broadcasts were encouraged. These focussed on important agronomic issues facing isiZulu speaking small-scale growers. The broadcasts were also used to advertise resources available to growers and encouraged growers to contact their nearest Agricultural Advisor for support.

Video Clips

During the time of social distancing, furthering extension support to small-scale growers through digital resources became more important than ever. SASRI and the KZN Department of Agriculture and Rural Development distributed short video clips to small-scale growers in their network through WhatsApp. The full list of topics is provided below. The videos are short, concise and practical and can be viewed on the SASRI YouTube channel or the SASRI website's eLibrary.

YouTube video clips available for download:

- How to conduct cane yield estimates
- The importance of yield estimates
- Damage caused by eldana
- Role of Pest and Disease Committees
- Controlling Weeds
- Influences of herbicide efficacy
- Fertiliser application
- Top-dressing
- Calibrating spraying equipment
- Seedcane
- Irrigating
- Erosion

Grower Interaction

Unfortunately, the COVID pandemic limited face-to-face interaction with industry stakeholders in 2020/21. However, the level of contact with industry stakeholders increased significantly through more frequent telephone calls, emails and online discussions. Extension Specialists and researchers conducted over 1 500 visits to growers, hosted 3 848 industry field visits and online communications, hosted 85 grower days and exhibitions, engaged in 309 conferences, workshops, refresher courses, seminars and demonstrations, as well as attended 250 Industry meetings.

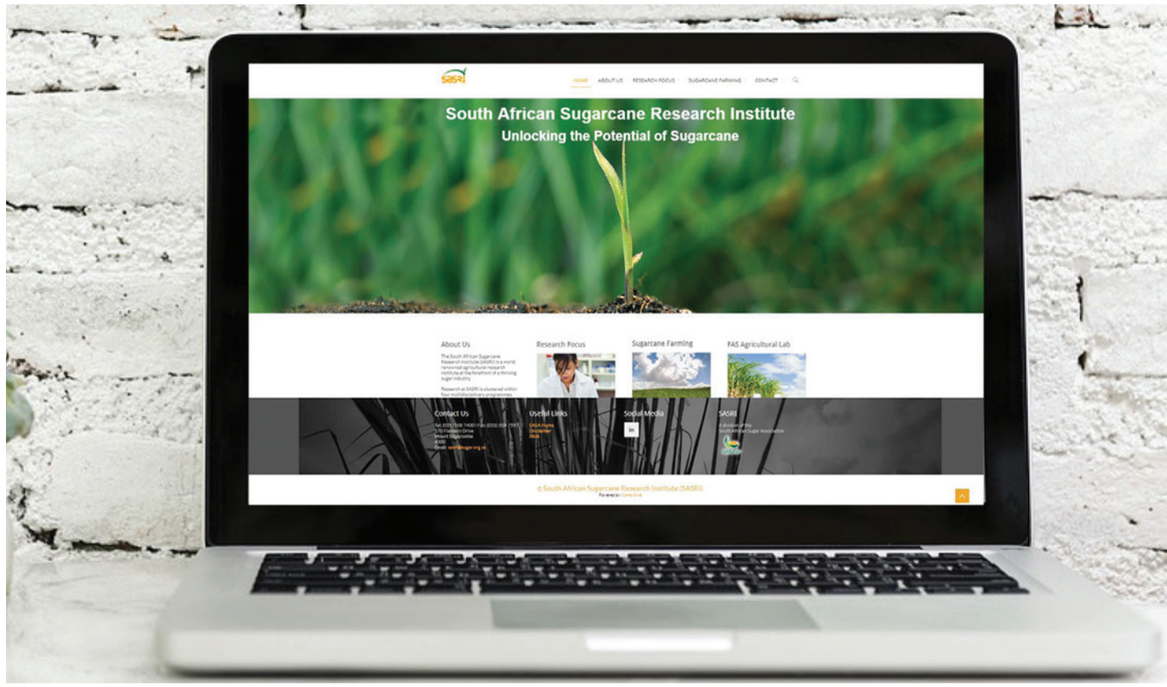
Certificate Courses

The COVID pandemic had a huge impact on SASRI's ability to conduct regular classroom-based Certificate Courses. Unfortunately, the lockdown prevented the start of the planned Junior Course in April 2020, and the subsequent Senior Course in June was also cancelled.

Fortunately, a small window between the first and second wave of the pandemic allowed a small class of 44 students to attend a Junior Course in November 2020. All but three of the students were from South Africa, and a pass rate of 82% was achieved.

SASRI Website

At the end of the 2017/18 financial year, a new website was released which contained more user-friendly features and content, with the addition of an eLibrary in the 2019/20 year. In the 2020/21 year, the website was continuously updated with new content and serves as a one-stop site for all SASRI publications, videos, decision-support-tools and services provided to the industry.



Extension

Rowan Stranack
(Extension and Biosecurity Manager)

Types of Extension Services Offered

LARGE-SCALE

SASRI provides a levy-funded extension service in ten of the twelve mill areas. This service consists of farm visits by the local SASRI Extension Specialist providing one-on-one advice on specific aspects of sugarcane agronomy, as well as group-learning activities in the form of grower days, study groups and written media such as newsletters.

Visits and group events often involve SASRI Specialists enabling growers to better understand and implement new technologies.

Valuable technical support is given to the many local grower structures operating in the industry, for example, Local Pest Disease and Variety Control Committees (LPD&VCCs), and local grower structures such as Mill Group Boards.

PRIVATE

The local milling companies in the UCL and Malelane cane supply areas deliver a private service to growers.

SMALL-SCALE

Extension is delivered to small-scale growers through a joint venture with the KZN Department of Agriculture and Rural Development (KZN DARD).

Under this Extension Venture Agreement (EVA), five SASRI Extension Specialists support 30 DARD Agricultural Advisors ensuring they are trained and equipped with all new SASRI research outcomes thereby enabling them to assist small-scale growers to farm more effectively and profitably.

A joint Monitoring Committee comprising DARD and SASRI oversees the work programme of the EVA through quarterly meetings.

DARD local managers are contacted regularly to ensure operational issues are addressed.

Research, Development and Extension (RD&E) Committees

A key function performed by Extension Specialists is to identify and gather specific research needs in their respective areas. This is enabled through locally elected RD&E Committees in each Extension area comprised of local growers and other role players. This link with the SASRI research programme provides a platform for growers to have their specific research issues addressed. In many instances, growers assist in this process by providing land to conduct trials. Growers also provide important local context to the research as well as advice on the practical implementation thereof. In addition, SASRI Extension Specialists are members of the project teams conducting research in their Extension areas and offer guidance in making these trials as relevant as possible.

Once new research outcomes are generated, RD&E Committees assist in facilitating the transfer of these technologies to growers, thereby completing the exchange of technology between grower and research. In addition to attending local meetings, RD&E committees gather annually to review research needs from the wider industry. These needs are prioritised and provide the foundation of the SASRI research programme of work for the coming year. These central workshops alternate between the irrigated and rainfed regions.

In March 2021, it was the turn of the rainfed regions to hold an RD&E workshop. Due to the COVID-19 pandemic, this event had to be cancelled. However, in its place a virtual workshop with Extension Specialists was arranged to discuss potential research issues for the following year. This proved to be very successful with several research priorities being identified.

The 2020/2021 Season

Although the final crop of 18.2 million tons was considerably lower than the previous season's 19.3 m tons, this was not a true reflection of yields during the season as there was a significant area of unplanned carryover cane at the end of the season, due to restrictions in milling capacity in the southern rainfed regions south of Umfolozi. This unplanned carryover made up much of the shortfall in tonnage between seasons. The 2019/20 summer rainfall season was generally good and gave good impetus to the crop coming out of a relatively dry winter and spring in 2019. This dry spell impacted the midlands areas where yields were lower due to the effects of the dry spell on the long cycle crop in that region. Apart from the Crocodile System in Mpumalanga where water resources were critically low, water supplies were adequate for irrigation in other irrigated areas. The dry winter of 2020 was ideal for natural ripening of the crop and some excellent cane quality was achieved. However, this was not always the case as sour rot, high eldana levels and flowered cane which had been carried over caused quality challenges for growers. Flowering in 2020 was not as widespread or as profuse as the previous season. In June and July there was severe frost in the Midland areas, with the July frost being particularly severe and extensive, similar to that experienced in the Lowveld and Pongola regions as well as many other higher altitude areas of the industry. Badly frosted cane had to be harvested as a matter of urgency. In the Midlands, some frosted cane was carried forward to the following season to stay in the planned harvest cycle. Unfortunately, this cane developed side-shoots, and was generally stressed, thereby attracting eldana and resulting ultimately in both poor yields and low quality at harvest.

Dealing with restricted milling capacity and a sizeable crop led milling groups to make efforts at promoting lower topping to reduce tonnage and improve quality. The UCL mill required a topping strategy from their growers which removed 20-30 centimeters below the growing point. Other mills promoted a similar strategy with varying success.

The dry winter also resulted in several runaway fires, with one at Eston running out of control for almost 20 kilometres. Unfortunately, unrest also took its toll, and on the South Coast, large areas were set alight, resulting in a considerable tonnage of cane having to be rejected and dumped.

Towards the end of the season, there was extreme pressure on the southern mills to attempt to get as much of the crop in as possible. Unfortunately, a considerable stand over tonnage was inevitable, forcing most mills to plan a March start to the 2021/2022 season. Extension was active in assisting growers with final decisions regarding fields suitable for carrying over. To further compound the problem, late emergence and aborted flowering was noted along the coastal belt, further affecting the growth of this cane during the off-season. In the irrigated North, the cold winter delayed the start to the crop for the following year, and lower than average yields were anticipated at the start of the 2021 season. On the positive side, the dry weather and adequate milling capacity helped enable the entire crop in the irrigated regions to be milled.

Yellow sugarcane aphid (YSA) had a significant impact on the crop in some parts of the Lowveld during the season. The variety N57 was severely affected with some significant yield losses being reported, despite efforts at control through the application of insecticides. Unfortunately, the effect of these applications was short-lived, and populations quickly re-established.

In late January and early February, the industry received widespread soaking rains due to the presence of a tropical cyclone which positioned itself over the northern parts of KwaZulu-Natal and Mpumalanga. Widespread flooding occurred and there was damage to fields and infrastructure. On The Umfolozi flats, cane lands on the lower parts of the Flats remained under water for some months into 2021. Rainfall over the southern parts of the industry was less than in the north, but very welcome, and rounded off another good summer rainfall season. The good rains immediately filled up all the storage dams in the Mpumalanga river systems and guaranteed water supplies for the coming season. Similarly at Pongola, the Bivane Dam overflowed and the Pongola River flooded, ultimately adding to the inflow to the Pongolapoort Dam which had been relatively low for some years.

The dry winter and spring also made conditions ideal for the spread of smut in the northern irrigated regions. At Pongola, controlling this disease continued to be a challenge and roguing and crop eradication orders had to be issued. In the Mpumalanga lowveld, the situation was better and only one eradication order was issued, a testimony to the continued efforts by the growers in these parts to keep the disease under control through regular roguing.

Varieties and Seedcane

The promotion of new SASRI varieties remained a high priority with Extension. A common question from growers is on choosing the correct varieties, as this becoming increasingly complex with a wider range of varieties available. In 2020, the varieties N70 and N71 were bulked up after release the previous year and N73 went into bulking plots. In the other areas, new varieties such as N66 and N69 (Midlands), N67 and N68 were released to South Coast growers, and N72 continued to be bulked up. Unfortunately, the new variety N64 did not perform well in many of the north and south coast post-release fields and showed symptoms of the fungal disease, pokkah boeng. The future of this variety in these areas is being considered. Whilst proving to be a most promising variety, N67 will need to be closely observed for eldana susceptibility. The varieties N54, N58, N59, N60, N61 and N62 continue to perform well under commercial conditions, with each slowly finding their niche on farms. Each has its own management requirements, and these are becoming evident as more experience with growing them is obtained.

SASRI variety trials are used extensively by Extension and researchers to promote the effective use of varieties. In addition to field days, the results of these trials are often publicised in Extension newsletters and other forums. Although COVID-19 placed severe restriction on this kind of activity, Extension kept their growers up-to-date once trials were harvested.

Ensuring adequate seedcane supply continued to be a major challenge for SASRI Extension and Biosecurity. Together with this effort is the requirement to comply with the 2023 deadline by which all commercial plantings need to be done using either Certified or Approved Seedcane. Areas where seedcane schemes are not operative have a particularly significant challenge in this regard. Encouragingly, a seedcane scheme has been established in Pongola where two hot water treatment tanks have been installed, and certified seedcane is being produced and planted both at a nursery site and on private co-operators lands. The local Cane Grower Association at Sezela established a formal seedcane scheme where growers are levied to receive certified seedcane in the form of transplants, produced locally in a nursery at Sezela. Only the uMzimkhulu, uMfolozi and Midlands South LPD&VCC control areas are without formal seedcane schemes, although certified seedcane is available in these areas. Considerable attention was paid to the need to facilitate access to seedcane by small-scale growers and this will become a key focus area going forward. Successful seedcane

schemes for small-scale grower communities were established using funds from both donor and local grower organisations, supplying valuable certified and approved seedcane to growers in their respective areas. A seedcane booklet for small-scale growers was produced to help these growers understand and appreciate the value of good seedcane and how it must be sourced and approved.

Extension Activities

The initial COVID-19 Level-5 lockdown reduced the number of farm visits, but with permits, and as restrictions were eased, on-farm contact with growers resumed to some level of normality. Grower days, study groups and grower meetings were held as and when restrictions allowed. Grower days are an excellent tool to communicate better management practices with all growers. However, only 30 - such events could be held compared with the previous season's total of 139 grower days. Often centered on SASRI trials, these gatherings encourage a less formal environment for growers to interact with Extension and specialist researchers. Study groups with smaller groups of growers, also sometimes involving specialists, are a means for deeper engagement with subjects and are highly effective.

The opportunity was taken to explore other means of contact and support for growers which did not require face-to-face contact. Email, telephonic and messaging systems such as WhatsApp have become more common, and Extension Specialists were asked to record these contacts in their monthly reports. During the lockdown extensive use was made of these alternative means of reaching growers and these communication channels will be extensively used in future because of their success. Not surprisingly, these forms of contacts were more than double the numbers of farm visits. However, this was possibly also a reflection of the situation before lockdown and raises the challenge as to how one could effectively capture all grower contacts. Doing so could enable a more comprehensive picture of the nature and subject of grower needs.

Extension also communicates with growers via newsletters and publications such as The Link and Ingede.

Education and grower interactions were also severely curtailed due to the COVID-19 pandemic. No SASRI Senior Courses could be held and only one Junior Certificate Course was possible and held with strict social distancing and other protocols. Extension usually contributes significantly to both Senior and Junior Courses in the form of lecturing.

The SASRI Knowledge Management Unit and EVA Extension also had an active and comprehensive community radio outreach programme that proved to be a highly effective means of interaction with growers and an opportunity to communicate new technology.

SUSFARMS® and Conservation

Growers in the Noodsberg, UCL and Eston mill supply areas continued their participation in the SUSFARMS® 2018 Collaboration. Extension has provided extensive support to the development and implementation of SUSFARMS® and the associated Progress Tracker as an environmental sustainability management tool. Growers in the South Coast submitted SUSFARMS® Progress Trackers during the coming season as part of their recent commitment to participation in this environmental management system. Extension also provided support to the co-ordinator of SUSFARMS® in her support of participating growers.

Extension continued to provide support to growers in soil conservation and land use planning. Although not offering a planning service, SASRI Extension assisted in implementing new field layouts and conservation structures. Whilst this work often is done in the context of a full Land Use Plan (LUP), significant ad hoc advice on field layout is given at individual field level.

Soil Health and Crop Nutrition

One of the main aims of Extension is to promote soil and leaf sampling. To this end, two Extension Specialists serve on the FAS Steering Committee to contribute their expertise and to represent the interests of their growers in the delivery of the service. There has been continued efforts to encourage growers from areas where previously few samples were received to send soil and leaf samples to FAS. The focus has been on the irrigated Northern regions not previously known as an area that sends many samples to FAS. Grower interactions, both personal and group activities, have been targeted towards these growers and some success has already been achieved. To further add value to FAS, Extension spends time on request from growers, customising recommendations to meet the grower's needs and objectives, such as adjusting lime recommendations to accommodate liming to lower acid saturation levels. Growers are also making extensive use of FAS for other crops. Here too, Extension has supported growers in the interpretation of results.

Promotion of sampling amongst the small-scale grower sector also remains a challenge, and a project was launched in the Midlands to attempt to focus on the identification of soils, their yield potential and critical management factors, specifically in these areas.

Other Crops

With growers increasingly diversifying into other crops there has been some demand upon Extension to assist with certain aspects of husbandry and nutrition related to these crops. The move into macadamia production has been widespread in almost all areas for some years. However, other sub-tropical crops have also enjoyed attention from growers. Nutrition recommendations and advice are being provided to sugarcane growers with other enterprises.

Pest and Disease Control

In their support to LPD&VCCs, Extension Specialists assist in guiding general pest and disease strategies in their areas. SASRI Extension Specialists also carry out certain line management responsibilities in the management of Biosecurity staff.

Yellow sugarcane aphid *(Sipha flava)* has developed as a major biosecurity threat to the industry. During 2020, after not being prevalent in the Lowveld for some time, the pest suddenly emerged as a significant problem. Developing initially mainly in areas where the cane was stressed due to erratic water supply, the pest has spread and established itself as a factor capable of causing significant yield reductions. This pest is notoriously difficult to control using chemicals alone and despite a careful strategy being followed, and with proactive spraying, the pest soon re-established itself after initial control. This pest remains a persistent problem in parts of the North Coast but tends to flare up dramatically and disappear equally rapidly in other parts of the coastal belt and Midlands.

Assisting growers with the management of eldana was a primary concern of Extension during the year particularly in those areas where significant carryover cane was present. The reasonably good summer rainfall and absence of water stress helped keep eldana low, generally, where a dry summer could have resulted in widespread damage to the crop. In instances where spray programmes were not completed or implemented or where flowered or frosted cane was carried over, fields recorded relatively high levels of the pest and required priority harvesting. Awareness and the implementation of remedial action such as preemptive harvesting and spraying insecticide are becoming the order of the day across all the southern regions. Managing varietal susceptibility to eldana is a major consideration for Extension and helping growers manage newer high-producing but sometimes eldana susceptible varieties, has required Extension to provide advice on a balanced approach to farm variety dispositions.

In the ongoing effort to contain an outbreak of the longhorn beetle *Cacosceles newmannii*, SASRI Extension continued to be closely involved in monitoring the area at Entumeni area where the outbreak occurred. The 1 130 hectares identified for eradication had been cleared of sugarcane and was under permanent pasture cover or fallow. Most of these fields were approaching the end of their mandatory two-year fallow. Unfortunately, in November 2020, longhorn beetle larvae were recovered from sugarcane fields in the Entumeni area not previously identified with the pest. This necessitated further eradication and long fallow, since increased from two years to three years compulsory fallow.

Smut continued to be a threat this year, made more problematic because of the dry winter and spring. A moratorium on the further planting of the variety N41 in the Pongola region was implemented where this popular variety N41 continued to record high levels of smut. In so doing, the intention was to encourage the planting of newer, more smut-resistant varieties thereby reducing the overall smut pressure in the area. The establishment in 2020 of a seedcane scheme in the area will help considerably in providing growers with alternative varieties to N41. Smut was also recorded at high levels in isolated fields in the Zululand area providing warning that this area is also vulnerable to smut outbreaks given favourable conditions.

The Extension Venture Agreement

SASRI and the Department of Agriculture and Rural Development have an Extension Venture Agreement (EVA) that has been in place since 1996. Over the years, this agreement has proved an excellent example of a private-public sector partnership, delivering value to both partners. The EVA model is widely held, both nationally and internationally, as a practical and workable framework for delivering Extension to a large number of recipient farmers. Currently, there are approximately 21 000 small-scale growers in the South African sugar industry making the delivery of individual Extension impractical. However, through group interactions, and with additional Extension staff accessed through the DARD, effective Extension is achieved.

Under EVA, SASRI employs five sugarcane Extension Specialists, jointly funded by SASRI and DARD, to provide support to DARD Extension staff working with small-scale and land reform sugarcane growers in KwaZulu-Natal. This support provides for assistance in planning of work programmes for sugarcane-related Extension, regular updates on new technology and better management practices for sugarcane. Specialist advice is also given to DARD Extension staff and, where necessary, SASRI subject specialists are engaged to help diagnose and remedy farm or area specific problems.

Increasingly, the EVA has become involved in delivering Extension to land reform grower beneficiaries. In this respect, regional levy-paid Extension also provides support under the broader SASRI umbrella. On the North Coast, a regional levy-funded extension specialist works specifically with land reform farmers, and in that region, Extension is managed and deployed regionally as a unified team. In so doing, the EVA has access to a wide range of advice and support.

To deliver an effective and relevant Extension service, the EVA team relies heavily on demonstration plots and the farming calendar to guide the timing of field events. Learning events with growers are timed strategically to coincide with activities in the cropping cycle (for example, crop estimating at the beginning of the season, and planting and weed control in springtime). Living field schools in excess of 100 hectares of demonstration plots have been established across KwaZulu-Natal. This provides instruction and learning on various farming operations. These plots are also sources of good quality seedcane for growers in the immediate area.

In addition to the above, in spring 2020, a SASA/KZN DARD seedcane project was launched using government funding whereby demonstration plots were planted in all small-scale grower areas in KZN. The EVA Extension team were closely involved in establishing these with suitable co-operators and with LPD&VCC certified seedcane so that, once again, these plots could double as field schools and seedcane sources.

Perhaps one of the standout successes of the 2020/2021 year in terms of grower interactions was the drone ripening project carried out on small scale grower farms on the South Coast, North Coast and Zululand. A structured approach was adopted. Grower days were held to introduce the concept, followed by others where the ripener was applied. There followed an evaluation of the effectiveness of the application which was being finalised after harvest around the beginning of the 2021/22 season.

The key role of the SASRI EVA sugarcane Extension Specialists is to equip and train DARD Extension staff to deliver advice to growers in their areas. Regular refresher courses with DARD Agricultural Advisors focused on the farming calendar are held, often with SASRI specialists present to facilitate this learning. However COVID-19 restrictions curtailed these events and only one such course was held. The EVA team also facilitated workshops with contractors and other stakeholders in the five regions of the industry at the end of the year when restrictions allowed. These were aimed mainly at emphasising and educating on the importance of cane quality management in the harvesting operation.

In March 2021 the Extension Venture Agreement with the KZN DARD was renewed for a further five years emphasising the department's faith in this unique public-private partnership.

Biosecurity

Rowan Stranack
(Extension and Biosecurity Manager)

The SASRI Biosecurity inspectorate comprises of 24 field inspection teams with attendant officers and technicians. The inspectorate operates in all regions of the industry but is managed centrally together with SASRI Extension, which provides management and technical support. The industry biosecurity function is driven by twelve Local Pest, Disease and Variety Control Committees (LPD&VCCs) situated across the industry having representation from both the milling and the two growing sectors, with SASRI staff providing technical and administrative support to the committees.

During the COVID-19 lockdown periods, regular meetings of LPD&VCCs were not possible. Some committees took to virtual platforms such as Zoom to hold meetings, and these were successful in many instances. However, in some areas, such as at Makhathini, such meetings were simply not possible, and growers and committee members relied on feedback from SASRI Biosecurity Officers to keep them informed of the pest and disease status in the areas. Due to the necessary safety protocols, the inspection team's daily operations were also affected. It was gratifying to note that a relatively low number of positive cases were recorded amongst biosecurity employees although frequent testing and isolation was necessary.

Committee Operation and Activities

Representation on LPD&VCCs includes members from the South African Farmers Development Association (SAFDA), SA Canegrowers Association and the South African Sugar Millers Association. SASRI Extension and Biosecurity staff are ex-officio members of LPD&VCCs and provide an administrative and technical advisory service to LPD&VCCs as well as managing the field survey programme.

Where necessary, LPD&VCCs liaise with other grower structures and industry bodies such as Mill Group Boards to fulfil their responsibilities.

Represented on LPD&VCCs are both small- and large-scale growers as well as the milling companies operating in the LPD&VCC control area. Wherever possible, representation from the various geographic areas or wards within the control area is also sought.

LPD&VCCs report to the Sugarcane Research and Sustainable Agriculture Committee (SRASA) who, in turn, report to the Council of the South African Sugar Association. The SRASA Committee has a Pest and Disease Working Group who meet to discuss and approve various issues such as changes to LPD&VCC Rules and standards as well as any other pressing matters relating to pest, disease and variety control. This Working Group provides recommendations to the SRASA Committee who then act upon the advice given. The Working Group met to discuss the pending replanting of sugarcane in the longhorn beetle containment area at Entumeni and approved a revised three-year compulsory fallow period, an increase from the two years initially agreed upon. The Working Group also approved the moratorium on the planting of N41 at Pongola.

The annual meeting of LPD&VCC Chairmen could not be held in July but committees were provided with the customary reports on the status of biosecurity in the industry.

Pest Occurrences in 2020/21

YELLOW SUGARCANE APHID *(Sipha flava)*

The focus changed to the irrigated Northern regions where severe outbreaks occurred in the Komatipoort area, particularly on variety N57, requiring intervention by SASRI Extension and Specialists in providing advice on control. The pest also emerged on the South Coast and Midlands areas as well as those areas on the North Coast where the pest has been present at damaging levels since 2017.

Scouting for the pest proved critical in efforts to control outbreaks and work continued in developing a suitable, practical method of monitoring fields for infestations. To aid this, the biosecurity field teams are recording observations of the pest during their other routine surveys.

Extension continues to co-operate with SASRI specialists undertaking trials and other research work on this pest. A pattern of varietal sensitivity to yellow sugarcane aphid is also emerging and considerable work has been carried out in assessing SASRI variety trials located in the various extension areas, emphasising once again the value of these regional trials to the industry.

LONGHORN BEETLE *(Cacosceles newmannii)*

The managed and co-ordinated approach to the longhorn beetle containment effort since 2017 has been largely successful. With very few larvae having been recovered since 2019, and no reported adult beetle emergence in the summers of 2020 and 2021, there was a setback in November when 26 larvae were recovered from a field on one of the originally infested farms. The field was close to other fields previously infested and subsequently eradicated so could not be considered a 'break-out' and, as such, urgent eradication orders were issued for the infested fields and others immediately adjacent. During 2020, it was considered appropriate to request an amendment to the Notice under clauses 77 and 78 in the gazette requiring newly infested fields to undergo a three-year fallow instead of two years as previously applied. It was found that for fields to be completely cleaned of new regrowth of cane, two years was in some instances too short a period. The views are optimistic that the incursion has largely been contained. This amendment was considered by the SRASA Committee and has been approved. Research into the pest has proved problematic in that adult female beetles have been scarce and are key to the development of a pheromone which could be used in a trap-and- kill strategy in the future. Monitoring for the pest in commercial sugarcane fields in the Entumeni area is ongoing.

ELDANA

The SASRI Biosecurity Inspectorate undertakes eldana surveys with three primary objectives in mind: monitoring the overall threat posed by the pest to the LPD&VCC control area; assisting growers with decisions relating to fields to carry over and, linked to that, determining the need for and success of spraying operations. During the reporting period, a total of 91 337 hectares was surveyed for eldana of which 3 127 (3.4%) were above the local hazard level requiring remedial action, either by harvesting or spraying of insecticide. The area of hazard cane remains encouragingly low and almost the same as the previous season. Despite the restrictions of the COVID-19 pandemic, biosecurity teams surveyed just over 4 000 hectares more than the previous season. This is both an indication of the inspectorate's commitment and the extent of the threat, particularly that resulting from the increased area of carryover cane.

Apart from the off-crop when it is important to prioritise fields for harvest at the start of the season, eldana surveys in the rest of the season are now focused largely on cane for harvest in the following year as this cane has potentially the highest risk for losses caused by eldana damage.

Further evidence of the importance LPD&VCCs place on managing eldana in their control areas is that the area surveyed for eldana in the 2020/2021 was approximately 40% above the minimum required.

Effectively managing eldana is complex, involving several factors, some of which, such as the weather, are beyond the control of growers. SASRI Extension Specialists and Biosecurity Officers play an important role in assisting with advice to LPD&VCCs and individual growers, balancing the influence of the weather, soils, the local environment, varietal susceptibility and the biology and ecology of the pest on management decisions.

There are success stories from both growers and regions in the effective control of eldana particularly following from the use of targeted applications of insecticide. In some cases, spraying is co-ordinated at regional level such as at uMzimkhulu. Currently, the area most under threat continues to be the Midlands North, although here too, strong efforts are in place to encourage effective scouting and appropriate control where required.

Attention has turned to eldana hazard levels in seedcane. As planting infested seedcane has been shown to spread the pest, it has been necessary to introduce hazard levels for seedcane, at a threshold which does not affect the availability of seedcane.

In most of the coastal regions where eldana had been problematic for many years, significant inroads were achieved in the control of the pest through targeted spraying of insecticide. Areas such as Zululand and North Coast recorded very low numbers of hazard fields, and the average age of cane at harvest has been extended somewhat due to the effectiveness of spraying.

Disease Occurrence in 2020/21

SMUT AND MOSAIC

These diseases continue to remain generally at low levels across the industry. The area of surveys in commercial fields was 70% of that required to obtain a fully representative sample. However, the areas where diseases, specifically smut, are a major threat, exceeded their targets. In the other areas the combined effect of the pandemic and the threat of eldana requiring additional surveys had a significant effect, limiting the time available for disease surveys. However, despite this, there was an encouraging increase in the area surveyed for diseases with a further approximately 5 000 hectares compared to the previous year, making a total of 39 831 hectares surveyed. Of this surveyed area, 298 hectares (approximately 1%) was above the local hazard level. Most of these problem fields had smut and were in the Pongola and Mpumalanga areas where roguing and eradication orders were issued.

Mosaic was mainly confined to the southern and high-altitude regions of the industry and on average at trace levels. High levels of off-types remained a problem in some commercial fields pointing to ineffective crop eradication and volunteer control.

RATOON STUNT (RSD)

Of the 4 830 commercial fields tested for RSD, only 3% were found to be infected. This was lower than the previous season 5% and lower than the 5-year average 4% samples infected. Of all the regions, Pongola remains the area recording the highest level of infection in commercial fields. However, an official seedcane scheme got off the ground in 2019 and with active heat-treatment of cane now under way, this situation should improve steadily. Of the 1 461 RSD samples taken in seedcane, less than 1% of these fields were found to be positive. Compulsory testing of all seedcane fields has largely prevented any infected seedcane being

planted out and this requirement should contribute to an overall reduction in RSD as seedcane sources are improved over time.

Sampling for RSD was one of the surveys which suffered because of the pandemic restrictions. The 4 830 samples extracted represents 83% of the samples which should be taken to provide a representative sample of the status of this disease in the industry.

Seedcane

CERTIFIED AND APPROVED SEEDCANE

All LPD&VCCs have been challenged in terms of the requirements of the industry LPD&VCC Rules to have in place adequate supplies of Certified and Approved Seedcane before March 2023. Most LPD&VCCs are now actively investigating the establishment of seedcane schemes to benefit all growers. Whilst in a few areas this objective has already been achieved, there are a significant number of other regions where only embryonic seedcane schemes are in operation. The provision of sufficient good quality seedcane, therefore, remains the most important challenge facing grower communities.

During the year, a decision was taken by the SRASA Committee to remove emergency planting material (EPM) as a category of seedcane. Although not eliminating this category of seedcane essential in the run-up to the 2023 deadline, it was agreed that only the categories of certified and approved seedcane should be recognised and, if other commercial cane was approved for planting in the interim, then it should be recorded as such i.e. commercial cane used for planting only in a specific instance and not for further propagation or sale.

STATUS OF SEEDCANE SCHEMES

2023 is the deadline by which time all commercial fields are to be planted using either LPD&VCC Certified or Approved Seedcane. There were several regional initiatives aimed at starting formal seedcane schemes. At Sezela, it was decided to implement a compulsory scheme, supporting both the transplant nursery and private co-operators, and at Pongola, certified seedcane nurseries were established. In Mpumalanga, the RCL mother blocks continue to generate certified seedcane for growers. The Felixton, Amatikulu and Entumeni areas still operate their long-standing seedcane schemes providing certified seedcane to plant farm nurseries. The North Coast has several producers of certified seedcane although changes in farm ownership and management are posing additional challenges in ensuring continuity of supplies. In the Midlands North, certified seedcane for the area is produced on a farm at Harden Heights but efforts are being made to develop satellite schemes as the area is large. The Umfolozi area has had a heat-treatment facility for many years and certified seedcane is produced, however, the area lacks any formal seedcane scheme. The areas of most concern are uMzimkhulu and Midlands South regions where there are no schemes and limited heat-treatment facilities available to start up a scheme.

During the 2020/21 planting season, a total of 4 224 hectares of certified and approved seedcane nurseries were approved for use. However, this is only approximately 50% of the area needed to meet the requirements of the 2023 deadline, and little progress was made relative to the previous season. The shortage of seedcane is made up by planting commercial cane which has been inspected by the Biosecurity Inspectorate, although seldom has this cane any history of heat-treatment or previous inspections. The industry therefore remains poorly prepared to meet the deadline and significant work will have to be carried out over the next two years for areas to be compliant.

Other Pests and Diseases

Both brown and tawny rust were recorded during 2020/21. The Biosecurity Inspectorate now routinely records the presence and severity of both types of rust, as well as damage caused by thrips and yellow sugarcane aphid. The high levels of humidity at the beginning of 2021 were a contributory factor to the occurrence of gumming disease, noted on the variety N59 in the Zululand region. A mild outbreak of eye spot also occurred in the same area also brought on by the humid conditions.

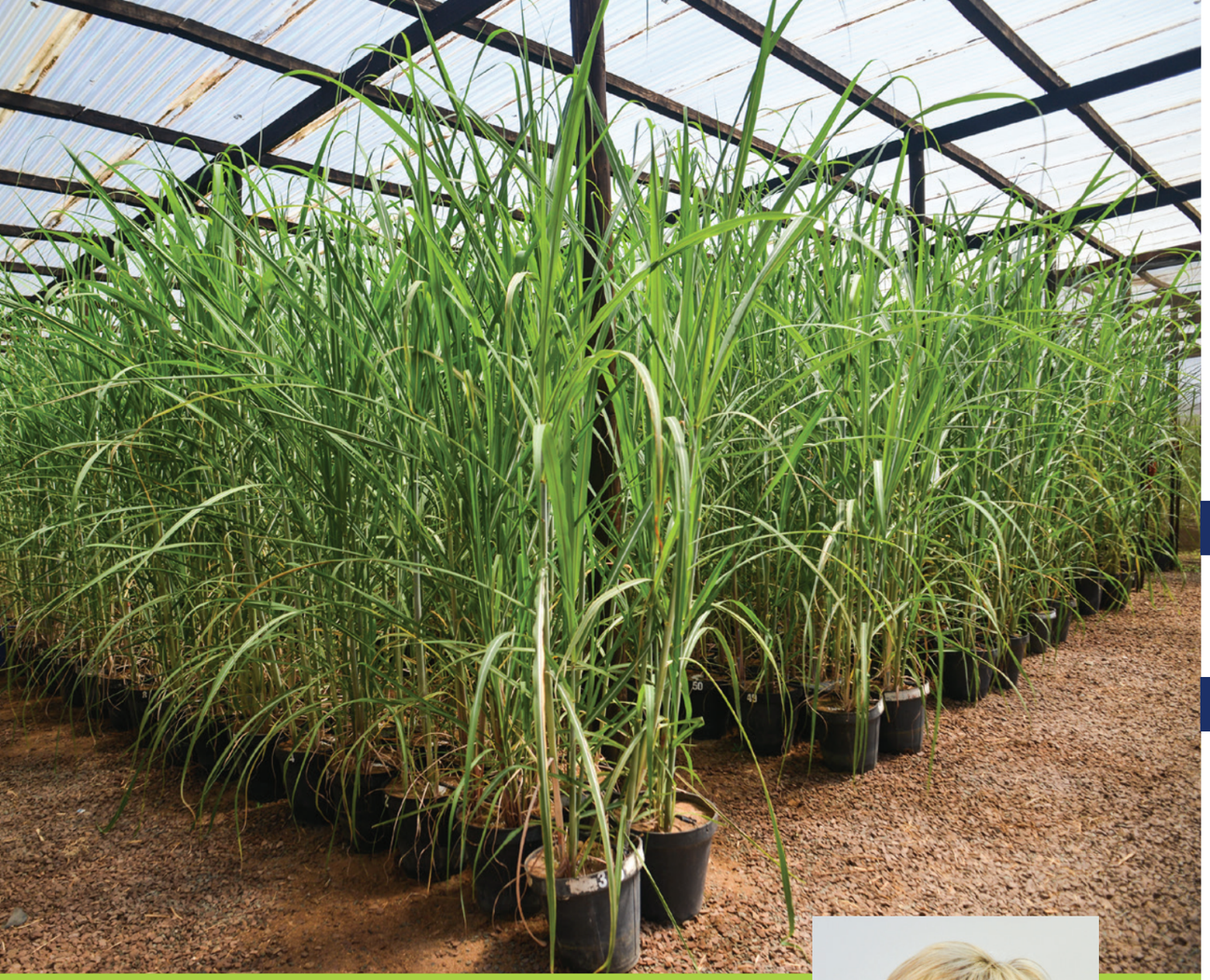
No further outbreaks of fall armyworm *(Spodoptera frugiperda)* have been recorded on sugarcane.

The stem borer *Chilo sacchariphagus* present in sugarcane in central Mozambique and a major threat to the sugar industry in South Africa, is monitored on behalf of SASA by Crop Watch Africa. Possible incursions are intercepted by means of several pheromone moth traps positioned along the KwaZulu-Natal and Mpumalanga borders with Mozambique. Fortunately, there have been no interceptions to date.

Orange rust *(Puccinea kuehnii)* continues to be monitored for in spore traps in the Mpumalanga. Despite positive identification of orange rust spores in the traps in some years previously, the disease has not been observed on sugarcane

Biosecurity Inspectorate

Employees of the Inspectorate are employed by SASRI and work on behalf of the LPDD&VCCs providing them with data which is used to make decisions regarding the control of various biosecurity threats. The COVID-19 pandemic initially impacted the work programme significantly when the hard lockdown was in force. However, with permits and appropriate personal protective equipment (PPE), work was able to resume with some normality. Isolation procedures and some positive cases resulted in frequent disruptions to the programme. PPE, sanitising, social distancing, and rapid response to instances of potentially infected employees possibly helped to ensure that relatively few of the inspectorate were diagnosed with COVID-19. Regular training of employees was a challenge during 2020/21 due to the pandemic and the focus had to revert to revision training within the regions and teams. Staff turnover is not high, and some long-serving and experienced employees have developed exceptional skills and knowledge in their work. There has been an on-going project to introduce electronic data capture in the field and this has progressed well enough using the Survey123 application to start a roll-out to the wider group. Vehicle and driver training was also undertaken at the beginning of 2021.



Advisory and Support Services

Kerry Redshaw
(Operations Manager)

Specialist Advisory Services

SASRI researchers and specialists provide essential sugarcane agriculture services and support to the local sugarcane industry as well as to several external customers (local and international). This expertise is offered as specialist advisory services to external clients for a consultancy fee when specialist capacity is available.

The income generated from the delivery of these services is used to offset operational expenses. These requests include specialist advice, technical support and training to Southern African Development Community (SADC) partners, SA agrochemical companies and other external clients. Specialist advice includes, but is not limited to, variety choice and evaluation, data analyses, crop nutrition, irrigation advice, pest and disease identification, control and management, crop forecasting, ripener advice and decision-making, soils management and crop performance and management.

Due to the COVID-19 pandemic the number of Specialist Advisory Requests (SARs) during 2020/2021 was lower than previous years. Ten SARs were completed during this reporting period. One of these SARs included an online cane quality training course provided to Compañía Agrícola Industrial Santa Ana, S.A. in August 2020.
The feedback from the customer was extremely positive and this has opened up potential possibilities for online training going forward for SASRI.

Extension Requests for Advice

SASRI received four requests for advice from Extension Specialists during 2020/2021. These services were provided to growers in addition to and as part of the ongoing service provision to the SA sugar industry.

Fertiliser Advisory Service

The Fertiliser Advisory Service (FAS) is a user-pays entity that uses state-of-the-art laboratory instrumentation and methods to provide growers with unbiased, customised advice based on their farm management practices and attainable yields. The FAS is SABS ISO 9001:2015 certified and provides accurate, sugarcane-specific fertiliser advice to ensure growers achieve sustainable and cost-effective returns from their input costs. FAS uses a Laboratory Information Management System to improve efficiencies in the delivery of accurate and reliable results and recommendations to customers.

The initial hard lockdown instituted by government, due to the COVID-19 pandemic, in March had a negative impact on FAS operations as the laboratory was forced to close for three weeks. With agriculture being classified as an essential service FAS was able to resume operations on 15 April 2021. FAS introduced a double shift system to assist with and increase the efficiency of processing samples and to ensure the recommended health and safety practices were followed.

The COVID-19 pandemic also had a negative impact on the samples received from countries outside of South Africa as foreign samples were withheld regularly for inspection by South African customs. This led to delays in delivery as well as additional costs as FAS had to pay the cost of inspection fees. Despite these problems, FAS received and analysed a slightly lower number of samples during 2020/2021 (33 006) compared to 2019/2020 (34 236).

A breakdown in sample numbers for 2020/2021 is provided here:

	2020/2021				2019/2020
	SA Growers	SASRI Research	Outside SA	Total	Total
Soil	22 249	929	3 818	26 996	27 268
Leaf	2 093	162	2 032	4 287	4 873
Fertiliser	1 471	1	163	1 635	1 973
Water	81	1	6	88	122
All				**33 006**	**34 236**

The continuing decline in leaf sample numbers remains a cause for concern due to the importance of growers being able to identify and adjust their management practices where necessary to prevent harmful soil conditions (e.g. acidity, salinity and nutrient imbalances) from developing. Soil testing forms an essential part of sustainable farming practice.

	2017/2018	2018/2019	2019/2020	2020/2021
SA Growers	23 987	20 288	19 603	22 249
SASRI Research	2 004	741	2 175	929
Outside SA	4 449	3 948	5 490	3 818
Total	**30 440**	**24 977**	**27 268**	**26 996**

There was an increase in the number of soil samples received from South African growers during 2020/2021 and these were able to fill the gap created by the reduced number of samples received by estates outside South Africa.

FAS attracted 417 new customers during 2020/2021. These new customers included small scale farmers, existing clients with new farms and customers outside of the sugarcane industry. It is believed that the increase in customers from outside the sugar industry indicated a positive response to the FAS marketing campaign, FAS web page (www.fasagrilab.co.za) and the use of social media to market FAS services to a wider farming community.

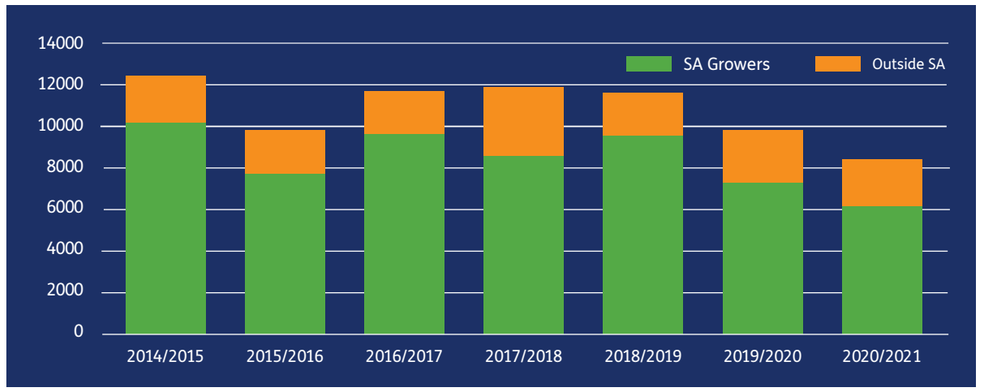
During 2020/2021, FAS implemented changes to the Reserve K rules for fertiliser recommendations.

FAS also embarked on an investigation into South African National Accreditation System (SANAS) (ISO17025) for leaf and fertiliser analysis as this accreditation is a requirement for many agricultural crops / products that are exported.

Disease Diagnostics

SASRI provides a disease diagnostics service for local and SADC growers to assist in mitigating risk and preventing yield loss associated with a range of diseases. The main focus areas of the disease diagnostic services are Ratoon Stunt Disease (RSD) and Yellow Leaf Virus (YLS). During 2020/2021, a total of 8 504 RSD samples were analysed with 6 131 of these samples coming from SA growers and 2 302 from other countries.

The graph shows the number of RSD samples analysed for South African growers and growers from outside of South Africa from 2014/2015 to 2020/2021.



SASRI was unable to conduct training outside of South Africa during 2020/2021 due to COVID-19 travel restrictions.

Quarantine

SASRI has a DAFF-approved, world class quarantine facility located at Mount Edgecombe for all sugarcane varieties imported into and exported from South Africa. Sugarcane varieties from foreign countries are imported into South Africa to broaden the genetic base of the parental breeding material. Imported varieties are also evaluated as potential commercial varieties. Through Variety Evaluation and Licence Agreements, SASRI controls the distribution of South African varieties into Africa in order to protect SASRI's Plant Breeders' Rights. SASRI is responsible for obtaining phytosanitary certificates from the Plant Health division of the Department of Agriculture, Forestry and Fisheries for the export of any sugarcane from South Africa.

During 2020/2021, disease-free varieties were exported to Barbados, Brazil, Ivory Coast, and Zambia. Du Roi Laboratory, Dube Agrilab and Visacane (France) supply SA varieties to countries where there are Variety Licence Agreements in place. Sugarcane fuzz was exported to Pakistan and Zimbabwe.

Weed Biocontrol

SASRI entered into a Memorandum of Agreement (1 April 2018 to 31 March 2021) with the Department of Environmental Affairs to mass-rear, supply and deliver specified biological control agents for a range of identified invasive alien plant species for the Natural Resource Management Programmes.

The facility being forced to close from 27 March to 1 May 2020, because it was not considered an essential service. The lockdown period had a negative impact on the overall quality of the host plants and on the insect populations. Despite these problems, SASRI was able to mass-rear and distribute 201 069 biological agents during 2020/2021. It is important to note that this number was in fact higher than the number of agents distributed during 2019/2020 (157 320).

The agents are effective for the control of *Pereskia aculeate* (Barbados Gooseberry), *Tecoma stans* (Yellow bells), *Parthenium hysterophorus* (Famine weed), *Salvinia molesta* (Kariba Weed), *Eichornia crassipes* (Water hyacinth), *Pistia stratiodes* (Water lettuce) and *Chromolaena odorata* (Triffid weed).

Genetic Analysis

SASRI provides a genetic analysis service to SASRI researchers for research projects, Quarantine, Biosecurity and to external clients as specialist advisory requests (SAR). This genetic analysis service includes DNA sequencing and DNA fragment analysis. During 2020/2021, a total of 640 DNA sequence and 1 608 DNA fragment analysis runs were conducted. It is standard procedure for all pre-release varieties being considered for bulking to be fingerprinted. All South African commercial varieties have been fingerprinted and this service is regularly used by researchers, Quarantine and Biosecurity for the accurate identification of varieties, pests and diseases.

Mechanisation and Advisory Service and Machinery Development

SASRI provides advice and recommendations on mechanisation alternatives on a request basis as well as costings and system optimisation. Annually, SASRI prepares two Mechanisation cost reports for the industry. The first report provides the costing of different equipment and machinery systems and the second report provides the costings of a range of system scenarios including land preparation, planting and ratoon management. These reports are made available on the SASRI Website.

Many stakeholders make use of these mechanisation reports. Growers use these reports for annual budget preparation while SA Canegrowers and SAFDA economists use the reports for updating the industry cane salvage rates and industry budgets. SASRI Specialists use these reports for the sugarcane certificate courses and for updating various Decision Support Tools.

When necessary, SASRI investigates the need for machinery development and, where appropriate, initiates and collaborates in the development of new machinery.

Policy Development and Implementation

SASRI offers specialist advice on policy development and implementation. In addition, SASRI provides specialist technical advice on specific requests pertaining to irrigation, transport, mechanisation and energy related issues and industry initiatives. Examples include:

- monitoring and providing comment on the development and implementation of the national government's water policy on behalf of the sugar industry;
- monitoring and providing comment on the development, amendment and implementation of transport related legislation such as: Haulage tractor; Consignee/consignor etc;
- transport related the sugar industry RTMS and Smart Trucks (PBS) meetings; and
- energy tariff changes and impacts thereof.

Weather Information

SASRI collects, collates and processes meteorological data continuously from a grid of automatic and manual weather stations distributed across the industry. This also involves the maintenance and calibration of the automatic weather station network and data processing system and the provision of summaries of meteorological data for comparative purposes. This data and related weather applications can be accessed via SASRI's WeatherWeb (www.sasri.org.za). It is possible to view and download all information in the form of maps, graphs or reports.

Users are able to view current weather information on the WeatherWeb from a range of weather stations. Rainfall and temperature figures are updated every five minutes, and the site also provides evapotranspiration values and a fire danger index. Real-time weather information is useful for decision-making regarding irrigation, chemical application and harvesting operations.

SASRI offers an Automatic Weather Station (AWS) installation and maintenance service both within and outside the borders of South Africa. SASRI provides support to Mondi for the installation and maintenance of 29 AWS weather stations. This AWS service was also provided to customers in eSwatini during 2019/2020. All installations are conducted according to established standards and include programming of data loggers to suit user needs and setting up automated data collection. All data from the AWS is processed to ensure integrity.

Maintenance routines include regular on-site calibration of sensors and equipment, any repairs or replacements required and general site maintenance. Calibration reports and certificates of compliance are issued with each visit.

Crop Forecasting

SASRI provides the industry with operational forecasts of the sugarcane crop, monthly from October of the preceding year to August of the current year, on a mill and industry level. Specialists make use of weather and irrigation water supply data, climate forecasts and the Canesim® crop model for these forecasts. Detailed cane yield forecast information are made available to registered users, while industry estimates of cane production are shared widely within the industry.

Information from Canesim® crop forecasts are also used by the SASA RV Forecast Committee to provide monthly forecasts from April onwards, of seasonal average RV content of cane for each mill area, to guide Mill Group Boards. These estimates are used to calculate growers' remuneration for cane deliveries.

Publications and Presentations

Scientific Journal Publications

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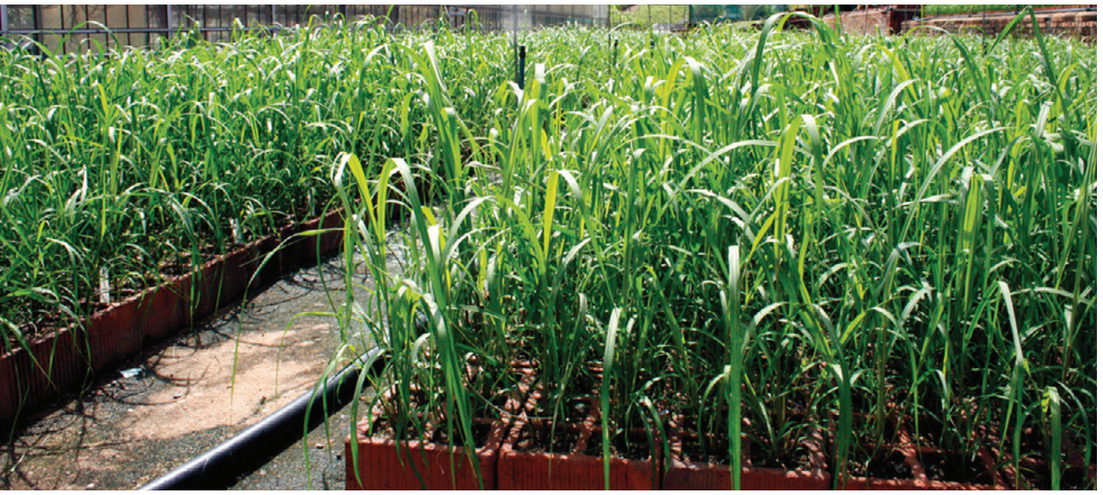

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