SOUTH AFRICAN SUGARCANE
RESEARCH INSTITUTE

Progress Report

2014/2015

Contents

SASRI Committee & Management

SASRI COMMITTEE 2014 - 15

(as at 31 March 2015)

Chairman PW Russell

Vice-Chairman ST Naidoo

GROWERS Representatives

KM Hurly, TJ Murray, F Potgieter, S Sharma,
GD Stainbank, R Talmage, GD Nelson,
TB Funke (alternative), D Littley (alternative),
A Russell (alternative)

MILLERS Representatives

EA Bruggemann, J Dewar,
JPM de Robillard (alternative),
SJ Saunders (alternative), D Sutherland (alternative),
TB Ngeleza (alternative), D van Rooy, DP Rossler,
PM Schorn

SASA Representatives

MK Trikam, CM Baker, DA Watt,
AJ van der Nest (Secretary)

MANAGEMENT TEAM 2014 - 15

(as at 31 March 2015)

Executive Committee

Director: CM Baker

Research Manager: DA Watt

Operations Manager: KA Redshaw

Finance and Admin Manager: AJ Van Der Nest

Human Resources Manager: C Botes

Programme Managers

Variety Improvement: SJ Snyman

Crop Protection: RS Rutherford

Crop Performance and Management: R van Heerden

Systems Design and Optimisation: R van Antwerpen

Resource Managers

Crop Biology Resource Centre: S Buthelezi

Plant and Environment Resource Centre: B Naidoo

Diagnostic and Analytical Resource Unit: KA Collings

Breeding and Field Resource Unit: S Ramgareeb

Extension: GW Maher

Knowledge Management: ML Binedell

Biorisk Management: RA Stranack

Chairman's Report

"A world class sugarcane research institute delivering relevant technology and facilitating implementation of innovative solutions for a sustainable industry" is the proposed new vision for the South African Sugarcane Research Institute as it strives to meet the requirements of its customers in the face of challenging times. This vision, developed by the SASRI committee members working together with SASRI management and scientists, reflects on the recent past and describes the role of the institute as it celebrates its ninetieth year of existence.

The year under review has come with its challenges, specifically the dry conditions which have been experienced across the bulk of the sugarcane growing regions. The industry mean annual rainfall was 64% of the long-term mean measured from May 2014 to April 2015 with some regions, notably Zululand, being particularly negatively impacted. Here, rainfall measured as little as 439 mm, down from a long-term mean of 920 mm. These climatic conditions, together with external pressures on the industry, certainly challenge SASRI to respond to the changing needs of the industry and to adapt its research approach to meet these challenges.

SASRI is a world class establishment, well placed to meet the challenges ahead. Its influence throughout the African continent is notable with technology and variety sales making up a significant revenue source. Varieties propagated at the institute are in high demand and SASRI has variety licence agreements and variety evaluation agreements with the SADC and further afield to countries such as Cameroon, Congo, Sudan, Senegal and Nigeria. SASRI's scientists are highly regarded with Drs Rutherford, Zhou and Ramburan being awarded National Research Foundation ratings over the past 12 months, joining a long list of SASRI scientists who received this award in previous years. Dr Sandy Snyman and Dr Ruth Rhodes also received recognition for their respective industry leading contributions to the Public Understanding of Biotechnology and Crop and Soil Science.

In an effort to improve plant breeding and promote the planting of disease-

Paul Russell
(Chairman - SASRI Committee)

> SASRI is a world class establishment, well placed to meet the challenges ahead. Its influence throughout the African Continent is notable.

free seedcane, the industry has embraced NovaCane® technology. This has resulted in plans being approved to construct a NovaCane® facility that significantly enhances the existing plant breeding facility and its capability to produce true to type seedcane. Maintaining varietal purity in the plant breeding function through tissue culture and the control of plant germplasm are key components of the NovaCane® process and are best managed "in house" by experienced SASRI scientists and programme managers. The strategic objective to develop and release varieties with improved genetic traits acceptable to both growers and millers in order to enhance sucrose yield, increase resistance to pest and diseases and improve milling characteristics remains the primary focus of this programme. Its ultimate success will be dependent on the rate of adoption of these varieties by the industry. This objective is supported by a number of research areas including integrated pest management, crop protection and systems design and optimisation. The integration of these initiatives has established a sound launching pad for accelerated, albeit long-term, research into genetically modified sugarcane that could well result in a step change in sugarcane yield with improved traits such as pest resistance, enhanced nitrogen utilisation and herbicide resistance.

As the sugar industry expands in Africa, the risk of pest and disease incursions increase, requiring the South African sugar industry to maintain and build on its defence capabilities. Since 2000, the various growing regions within South Africa have experienced outbreaks of new pests and diseases including brown rust, maize streak virus, thrips, yellow sugarcane aphid and tawny rust. Chilo borer, not yet encountered within South African borders remains a significant threat to the industry and will require extensive collaboration with our SADC partners if the pest is to be controlled. With this in mind, it has been encouraging to witness the support that the South African Sugar Association at large has given to SASRI in its successful drive to incorporate the entire pest, disease and variety control programme into the SASRI function. Adherence to industry rules and regulations, and improved hazard identification and risk assessment will better position the industry to respond to pest and disease incursions in an integrated fashion, limiting the potential negative impact of incursions.

Sustainable agriculture within the sugar industry remains a key focus area with all SASRI programmes supporting the SUSFARMS® management system. The system is designed to reduce the negative impacts of sugarcane farming on the environment whilst ensuring economic sustainability and social upliftment through the implementation of better management practices. All growers should be encouraged to adopt the system, and in partnership with their milling colleagues, work towards an integrated industry outcome where best practice becomes the new norm.

I would like to acknowledge the commitment and expertise of the SASRI Director, the functional managers and the resource and research programme managers as well as the efforts of the extension specialists. I would also like to thank all the SASRI, Grower and Miller representatives on the committee for their considerable input and support. The next twelve months will pose a number of challenges I am sure.... bring it on!

Director's Report

> The prevailing conditions highlighted the relevance of resilient varieties and the urgent need for a secure and robust biosecurity system.

Founded in 1925, SASRI celebrates its 90th year in 2015. Throughout this time the primary mandate of the institution associated with research and extension has remained unaltered. What has changed, however, is the specific focus of these two main functions, which are influenced by the prevailing industry conditions and its requirements for sustainability - and hence the specific focus constantly shifts. Regardless, the unique challenges associated with growing sugarcane in South Africa have successfully stimulated the development of innovative research and resulted in delivery of valuable outcomes that are tailor-made for the sugar industry.

Work in this past year was conducted within the context of a looming drought that influenced the approach adopted in developing the programme of work. The prevailing conditions highlighted the relevance of resilient varieties and the urgent need for a secure and robust biosecurity system. The importance and value of engaging with growers to share knowledge on practices geared towards ensuring sustainability was highlighted and through this process the 'lived' experiences of growers enabled others to more fully appreciate the importance of adhering to good management principles based on sound research.

Sugarcane varieties

Two new varieties were released: N58, with its superior RV and cane yields and good general disease and eldana resistance was geared for the coastal long-cycle conditions; while N59 with similar characteristics was targeted for the hinterland. Further efforts to improve the plant breeding programme culminated in approval for the development of a tissue culture facility at SASRI that is directed towards production of NovaCane® for the final stages of the programme. This facility, with a targeted capacity for development of 300 000 plants, will be built during the course of 2015 for use in the 2016 season.

Significant debate on the value of developing and deploying a GM variety was held, following delivery of a business case for insect resistance. The specific approaches that should be adopted in embarking on such a programme in conjunction with their associated risks will form the basis of further discussions in the coming year.

Carolyn Baker
(Director)

Biosecurity

Recognising the considerable yield losses that eldana continues to incur in the industry, an effort to refocus the work conducted on this pest was initiated within the context of an integrated pest management approach. This resulted in the development of an eldana research framework to enable a more directed

approach towards achievement of the outstanding work that is required to provide the additional tools required to complete the 'tool-kit'. Of the six focal areas that included crop stress management, plant resistance, habitat management, chemical control, monitoring, and implementation, gaps were identified in several key areas associated with habitat management and chemical ecology that relate to biological control of the pest. The effective implementation of sterile insect technology (SIT) to control false coddling moth in the citrus industry encouraged an investigation into the suitability of this method of population control for the eldana moth. Following a fascinating visit to the Western Cape to view the facilities and infrastructure required to successfully mount a sterile moth release programme, details regarding the pilot project to establish proof of concept for the technique were finalised and presented to the SASRI Committee. Fundamental to the success of the project is construction of an irradiator for sterilisation of moths, and support for fully scoping this facility was granted.

Following the incursion of yellow sugarcane aphid, a LINK article alerting the industry to the new pest appeared in May 2014. While considerable information regarding this pest was available in the literature, evidence for its role in transmitting SCMV was lacking, leading to the initiation of a research project in this regard. Further work on establishing the response of commercial varieties to the pest as well as the likely yield loss from this pest was also initiated, but hampered by the ephemeral nature of the pest.

Closely associated with pest and disease research at SASRI, are the surveys conducted by the industry's local pest and disease structures to monitor the industry pest and disease status. Arguably, one of the most significant changes to the SASRI complement took effect at the end of March 2015, when the pest and disease (P&D) operations (and 164 new employees) were assumed into SASRI. In preparation for the new function, some re-arrangements were made to the Extension structure to accommodate the new function in recognition of their close alignment. This culminated in the development of a combined Extension/ Biosecurity function.

The research programme

The extent and scope of SASRI's research programme forms the bulk of this progress report, and reflects on the range of innovations and achievements accomplished by our team. The drive to improve the genetic base of South African sugarcane varieties through introgression breeding continued, with some progress being made in understanding the relationship between DNA content and chromosome number, designed to enable prediction in the chromosome numbers of progeny from crosses. Further understanding of the performance of released varieties was achieved in an investigation into the genetic traits that are associated with good ratooning ability as well as the emergence, growth and yield responses of varieties grown and cut under either burnt or green-cane harvested conditions.

Emphasis continues to be placed on determining efficiencies associated with nitrogen fertiliser usage. At the molecular level early results from genetically engineered NCo376 to enhance nitrogen use efficiency enabled a 36% reduction in nitrogen applications, while in the field specific placement of fertilisers and also crop rotation research have generated some good results. The importance of soil health and its impact on the sugarcane plant root system prompted investigations into top- and sub-soil acidity studies, and the focus on soils was further highlighted by the distribution of the new soils book, *Understanding and Managing Soils in the South African Sugar Industry*.

Good progress was made in the development of a range of diagnostic and predictive tools: the molecular

tool for detecting sugarcane mosaic virus and sugarcane yellow leaf virus will be used in the Quarantine facility to assist in mitigating the biosecurity risk posed by the pathogens; the new assay for RSD detection enables near-field analysis of sugarcane; the stalk juice purity calculator that relies on simple in-field brix measurements will assist in decision-making associated with ripening; and a model to assess costs associated with crop residue recovery for electricity co-generation demonstrated economic viability.

Continued investigations into suitable chemistries for combating pathogens and pests resulted in identification of two new products suitable for eldana control, and one other for thrips control. Further work on the efficacy of a range of products aimed towards yellow sugarcane aphid control was initiated. In an effort to achieve environmentally sensitive ways to control pests, investigations into appropriate bio-pesticides for the control of white grubs and stalk borers were ongoing.

Service delivery

Strides in delivering a cost effective, consistent and reliable Fertiliser Advisory Service (FAS) were evident in its achievement of SABS accreditation and also its ISO 9001:2008 quality management system certification. Further, refinements in recommendations emanating from analysis of soils and leaves were realised through development of improved methods and also acquisition of several new instruments including the mid-infrared spectroscope (MIR) that has enabled faster sample-throughput and an expanded range of determinations.

Promoting the adoption of SUSFARMS®, a sustainable sugarcane farm management system, remained a key focus in Extension, with several study groups and grower events structured to elaborate on the specific value that the management tool would deliver. The Progress Tracker tool served as a valuable aid that enabled growers to discuss their own practices with their Extension Specialist in order to monitor their management improvement. Notably in two mill areas, 100% submission of Progress Trackers was achieved. Benchmarking SUSFARMS® against an international standard facilitated identification of any gaps in the system and provided valuable guidance in developing the updated version.

SASRI's reputation for delivery of high quality education was evident in the demand for enrolment in the certificate courses in sugarcane agriculture. A total of 326 students attended the Junior and Senior courses, 70% of which emanate from South Africa.

Ensuring that all new research outcomes are made available in an appropriate format for our stakeholders remains a key purpose for the Knowledge Management Unit at SASRI, and production of technical publications to meet the requirements of a range of stakeholders is required. Apart from the Link, the Ingede, Information Sheets and Mechanisation Reports, a host of more specialised guides were produced including the pocket-sized *Pest and Disease Guide*, the *Manual for Successful Implementation of Small-scale Grower Projects,* the updated *Sugarcane Diseases in South Africa* booklet, and the *P&D Operations Manual.*

Developing new expertise and assuring quality

To develop future scientific expertise, SASRI remains committed to developing young scientists and accomplishes this through their research internship programme and also through postgraduate development. While the intern group remains fluid, since their employability and prospects are greatly enhanced through their association with SASRI and during the course of the year several replacements are made, the postgraduate group is more stable and is associated with completion of degrees usually over two or three years. In the past period six MSc students and one PhD student graduated.

As a way of determining the extent to which the research programmes meet industry requirements and also compare with international standards, a review of one of the four research programmes by an expert panel is conducted annually. In 2014, the Systems Design and Optimisation programme was the subject of review by three specialists: one from the USA; the second from Australia; and the third from South Africa. In their report, the reviewers articulated their "commendations", "affirmations" and "recommendations", providing clear comment on where, in their collective view, SASRI was making excellent headway, and those areas where some attention was required. The value in conducting such reviews is patent.

Benchmarking SASRI scientists' performance against national and international standards is another important gauge of scientific excellence, and during the past year three researchers were awarded National Research Foundation scientific ratings, bringing the SASRI total to nine rated scientists. Such ratings not only signal the stature of our scientists but also enables access to external incentive funds designed to augment research activities and facilitate research delivery.

In a year filled with a number of significant advancements and achievements it is with sadness that we remember the loss of several of our staff members including one of our senior Plant Breeders in a tragic road accident. Our commitment to the industry and delivery against stated objectives remains unabated however, and it is a tribute to the collective effort of all SASRI staff that we are able to meet our mandate and conduct our research, development and knowledge exchange activities within budget.

Overview of SASRI Research

Goals

To develop and deliver new sugarcane varieties providing increased economic returns for all sectors of the industry.

To undertake research and provide services that advance nutritional, agronomic and engineering practices and pest and disease control measures.

To generate new ideas with the potential to enlarge the scope of sugarcane agriculture and sustain the industry into the future.

RESEARCH PROGRAMMES AND KEY RESEARCH AREAS

CROP PERFORMANCE AND MANAGEMENT

Key Research Areas:

- Crop Nutrition (7 projects)
- Soil Health (3 projects)
- Crop Ripening (2 projects)
- Crop Physiology (4 projects)
- Crop Residue Management (2 projects)
- Water Management (1 project)
- Climate Change (2 projects)

CROP PROTECTION

Key Research Areas:

- Biosecurity (5 projects)
- Crop Resistance (3 projects)
- Agro-ecology of Pathogens and Pests (4 projects)
- Biological Control, Cultural and Environmental Practices (3 projects)
- Agrochemicals (6 projects)

SYSTEMS DESIGN AND OPTIMISATION

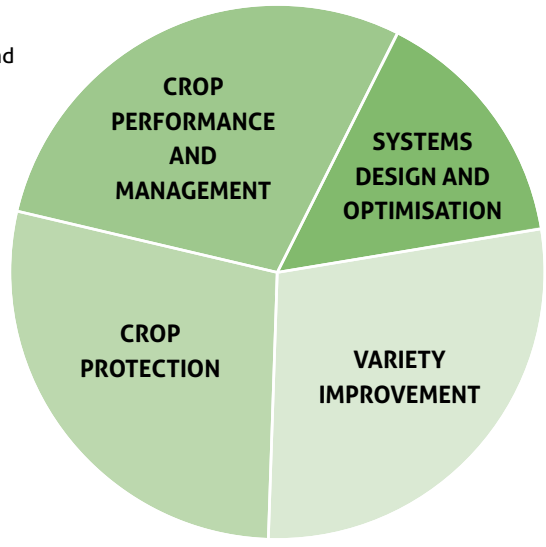
Key Research Areas:

- Production Sustainability (3 projects)
- Water Management (3 projects)
- Technology Development (5 projects)

VARIETY IMPROVEMENT

Key Research Areas:

- Breeding and Selection (7 projects)
- Variety Characterisation (3 projects)
- Novel and Improved Traits (9 projects)
- Genomics and Bioinformatics (1 project)
- Sucrose Metabolism (1 project)



Derek Watt
(Research Manager)

RESEARCH OBJECTIVES

Variety improvement

To conduct research and implement strategies for the continual release of new varieties that add value and enhance productivity.

Crop protection

To minimise the effects of disease, weeds, nematodes and insect pests on crop production in a sustainable manner.

Crop performance and Management

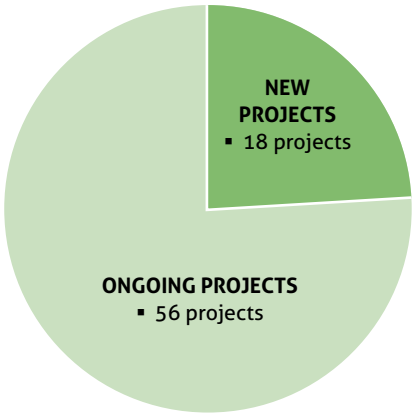
To develop new and fine-tune existing crop management practices to enhance the economic and environmental sustainability of sugarcane production.

Optimisation

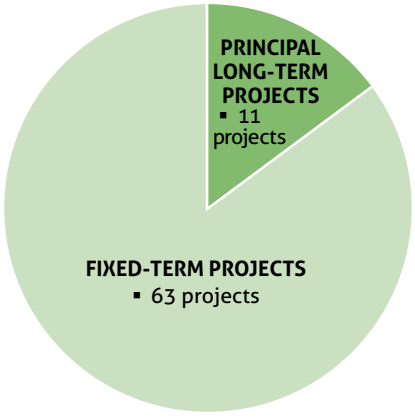
To design and improve farming systems that account for the economic, social and environmental issues that impact on the sustainability of sugarcane production.

PROJECT PORFOLIO OVERVIEW

Project Disposition



Project Type



RESEARCH FOR SUSTAINABLILITY: ELDANA MANAGEMENT

Nature of Eldana

The African sugarcane stalk Borer, *Eldana saccharina*, remains an ongoing and severe constraining factor on industry production. After being first observed on the Umfolozi flats in 1939, this highly damaging insect pest is now ubiquitous throughout the South African sugar belt, from the lower South Coast of KwaZulu-Natal through to the Mpumalanga Lowveld. The impact of this pest on the industry is estimated to be in the region of R 0.9 billion of lost revenue per annum, both as direct sucrose yield loss due to infestation damage, as well as the cost incurred by growers to implement the agronomic and pest management practices required to constrain the population size of the pest.

Several characteristics of eldana make the design and implementation of effective and sustainable management practices particularly challenging.

Pest characteristic

- Eldana is an indigenous lepidopteran insect that is native to African wetlands and resident primarily in sedges (members of the *Cyperaceae*).
- Eldana displays cryptic behaviours: (a) female moths lay most eggs in concealed locations (e.g. in dry leaf material); (b) larvae initially scavenge externally on the stalk protected by the leaf sheaths; (c) surviving larvae bore into the stalk where they spend the remainder of the larval stage feeding on the internal tissues; and (d) pupation occurs internally in the excavated stalk or when externally, frequently behind a leaf sheath.
- Eldana reproduction is continuous, apart from two peaks in moth numbers around April and October.
- When compared to the vast majority of moth species, eldana has a highly unusual reproductive biology: (a) it is the male eldana moth that calls female moths for mating; (b) after dusk, eldana male moths emit a complex cocktail of pheromones from both wing and abdominal glands that is thought to attract females over long distances; (c) three to six males aggregate during calling to amplify the pheromone signal; and (d) eldana is a 'hearing' moth, emitting acoustic cues that are believed to orientate females at close range.

Eldana saccharina larva

Managment implications

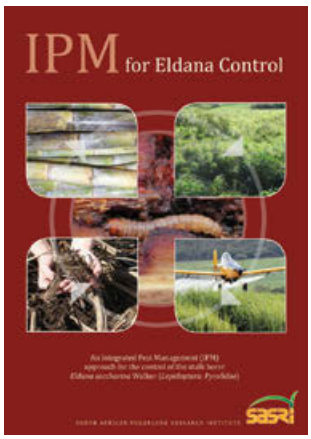
The original eldana host switch from sedges to sugarcane in Umfolozi was likely due to widespread habitat disturbance. However, the maintenance of wetland habitats under intensive sugarcane monoculture is an important component of eldana IPM. These wetland areas serve as an important sink for eldana, in which populations are maintained at low levels by natural enemies.

- Eldana eradication from sugarcane is not attainable due to the widespread ocurrence of natural host plant species and continuous population replenishment from other locales.
- The cryptic nature of eldana in sugarcane renders the insect largely inaccessible to biocontrol agents and agrochemicals during the majority of the life cycle.
- Continous reproduction makes targeted eldana management through biocontrol agent releases or agrochemical applications only partially effective.
- The complexity of the eldana mating process requires the development of a fully customised management strategy, as those applied successfully to other lepidoteran pests are not effective against this unique pest.

Eldana IPM principles

Knowledge gained from years of research into the biology and agro-ecology of eldana has formed the foundation of an area-wide Integrated Pest Management (IPM) approach that will ultimately facilitate the sustainable management of the pest.

In 2014, SASRI published a book describing the precepts of Eldana IPM and which is intended to provide growers and other industry stakeholders and roleplayers with insights into the requirements for effective eldana management. The book is available from the SASRI Knowledge Management Unit and interested parties are invited to contact the SASRI library for further details (library@sasa.org.za).

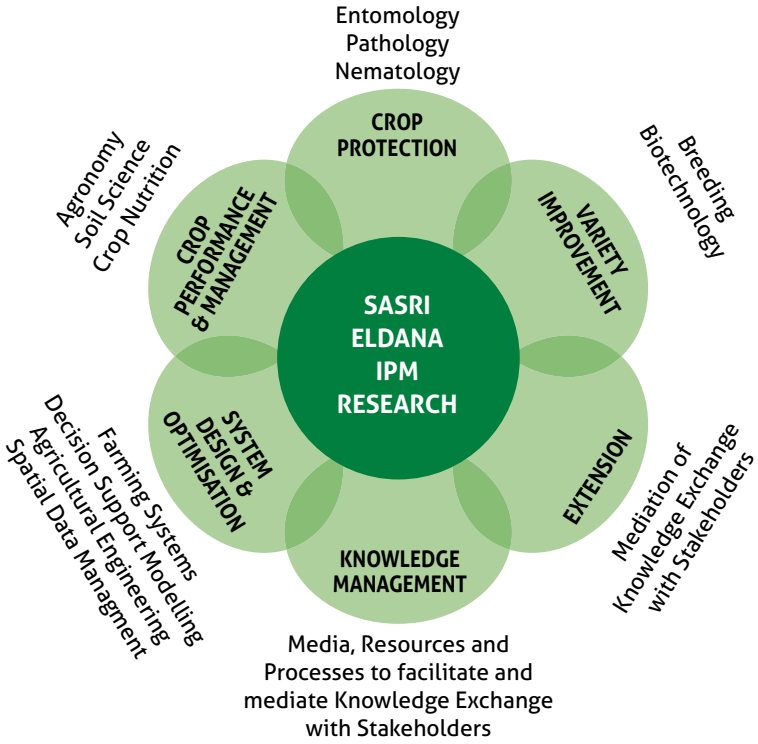


SASRI Eldana IPM Book

Eldana IPM research

Research and technology development to provide growers with the necessary repertoire of tools for effective Eldana IPM is multi-disciplinary and is conducted across the four research programmes (Variety Improvement, Crop Protection, Crop Performance and Management and Systems Design and Optimisation) and encompasses the activities of the Knowledge Management Unit and Extension Services.

SASRI Eldana IPM Research occurs in six Focus Areas corresponding to the required technology components of the Eldana IPM toolkit (right).



1. Crop stress management

To develop technologies that enable the reduction, avoidance or priming of plant stress such that plant innate resistance to eldana is not compromised or is potentially enhanced.

2. Plant resistance

To harness native and foreign genetic sources of resistance to eldana and implement technologies to increase the efficiency of eldana resistance breeding.

3. Habitat managment

To develop cost-effective technologies that permit the establishment of agro-ecological environments in which eldana populations are suppressed to low levels by benign biological means.

4. Chemical control

To develop a suite of effective insecticidal eldana control agents and responsible application tactics that are agriculturally, environmentally, ecologically and economically sustainable.

5. Spatial planning and monitoring

To implement digital spatial mapping (GIS) that facilitates the collation and interpretation of environmental and biological data that are central to effective and proactive eldana management.

6. Implementation

To enhance adoption of eldana IPM through practical demonstration of efficacy and promote the approach as an integral component of sustainable sugarcane farming practice.

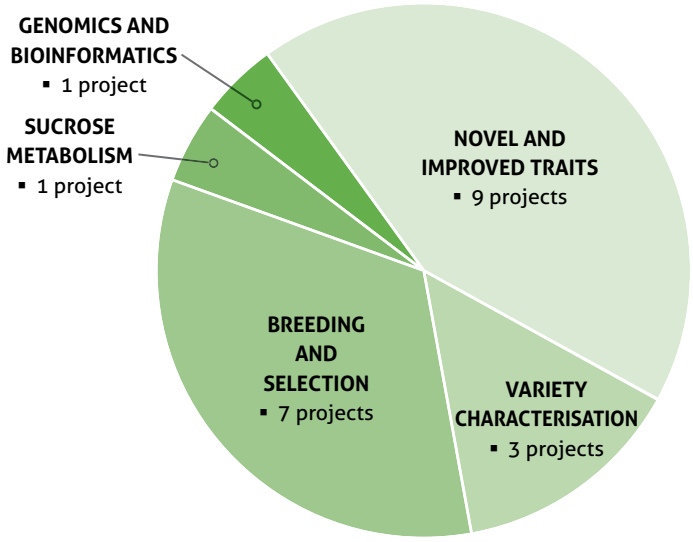
VARIETY IMPROVEMENT PROGRAMME

Goal

Conduct research and implement strategies for the continual release of high sugar yielding (biomass and sugar content), adaptable, pest and disease resistant varieties that add value and enhance Industry productivity.

Dr Sandy Snyman
(Programme Manager)

Key research areas



Breeding and selection

The principal, long-term Plant Breeding Project lies at the core of the Variety Improvement Programme.

- The project consists of five primary areas of research and operations, *viz.* crossing, selection, genotype testing, bulking and release.
- The project facilitates the development and release of varieties with high sugar yield (both sucrose and cane yield), pest and disease resistance, adaptability, ratooning ability and agronomic and milling characteristics that are desirable to both millers and growers.
- The Plant Breeding Project is complemented by a cluster of research projects that aim to improve the efficiency of sugarcane breeding for the industry through innovation, including:
  - expansion of the genetic base of germplasm used as parents for crossing through introgression breeding; and
  - development of resources to facilitate the use of genetic markers for the selection of parents for crossing.

This research is strongly complemented by investigations conducted in the Resistance Key Research Area of the Crop Protection Research Programme.

Variety Characterisation

Running in parallel to the Plant Breeding Project is the principal, long-term Variety Evaluation Project, which aims to provide comprehensive information on the performance of new varieties under different management practices and agro-climatic zones upon, or soon after, their release to the industry.

As for the Plant Breeding Project, the Variety Evaluation Project is complemented by a series of research projects that are instituted to address specific issues, for example variety ratoon longevity and the performance of varieties derived from the NovaCane® technology.

Novel and Improved Traits

This Key Research Area is strongly focused on the development of innovations of strategic importance to the future delivery to, and sustainable maintenance of, varieties with novel traits (characteristics) to the industry, for example enhanced nitrogen-use efficiency and herbicide tolerance. Research projects in this area develop technologies and resources required for genetic engineering, mutagenic breeding and preservation of valuable germplasm, as well as demonstrate proof-of-concept regarding the performance of the novel lines produced.

Genomics and Bioinformatics

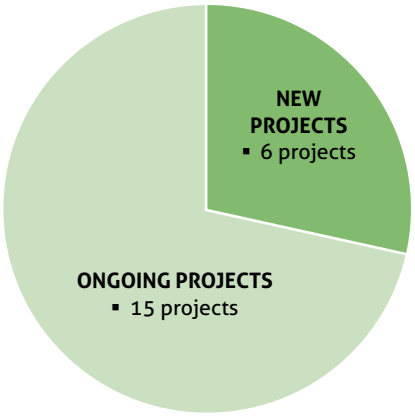
Projects in this Key Research Area focus on unravelling the extremely complex sugarcane genome with a view to the development of genetic markers linked to important sugarcane traits, for example pest and disease resistance. Knowledge and resources generated in this area feed into the Breeding and Selection Key Research Area.

STRATEGIC OBJECTIVES

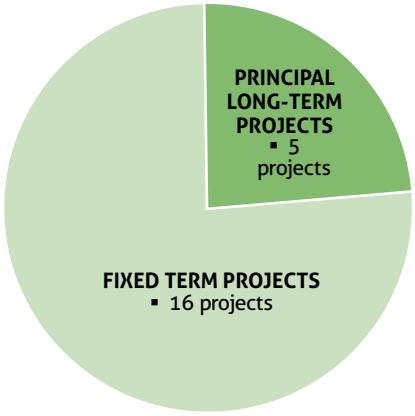
- To develop and release varieties with sucrose, yield, pest and disease, agronomic and milling characteristics desirable to both millers and growers.
- To provide comprehensive variety information to assist the industry in making optimal variety choices.
- To diversify breeding strategies to exploit the full genetic potential of sugarcane.
- To implement molecular breeding and crop modelling strategies to improve variety delivery.
- To conduct basic research to develop new genetic resources for variety improvement through commercial breeding, genetic engineering and mutagenic breeding.

PROJECT PORTFOLIO OVERVIEW

Project Disposition



Project Type



New Projects

Introgression Breeding

Need Statement:	▪ The international sugarcane breeding community is in general agreement that the intensive selection for high sucrose over the past several decades has resulted in a narrowing of the sugarcane genetic base, which is arguably the primary factor responsible for the apparent lack of significant gains in sugarcane breeding. ▪ Evidence suggests that chromosome loss with each successive generation, particularly of the *Saccharum spontaneum* component of the sugarcane inter-specific genome, has eroded this genetic diversity. ▪ Effects of the postulated erosion of genetic diversity has become noticeable at a time when new challenges for sugarcane agriculture are emerging: in biosecurity (more pest and disease incursions); in climate change (longer dry periods, higher temperatures) and from increasing input costs. ▪ Among established pests and diseases, eldana and sugarcane smut are likely to become more prominent, as both are favoured by warmer and dryer winters. ▪ Within the current breeding material at SASRI, there is an inverse relationship between resistance to the stalk borer and resistance to smut, making breeding for resistance to both problematic. ▪ To address these challenges, greater genetic diversity will be needed and introgression breeding has been identified as a way to achieve this. ▪ The goal of the introgression research is to provide the Plant Breeding Project with superior parental material from which to develop commercial sugarcane varieties with an expanded genetic base.
Project Objectives:	▪ To increase genetic diversity of parental populations through introduction of new traits, *viz.* high cane yield and high levels of eldana and smut resistance, from wild ancestral and closely related species.

Project Objectives:	▪ To characterise wild and related germplasm and assess levels of genetic diversity in the *Saccharum* germplasm collection at SASRI to aid selection of a core set of clones for introgression. ▪ To optimise all parameters relevant to the success of creating intergeneric hybrids, viz. synchronised flowering, pollen fertility and molecular techniques (flow cytometry and genomic *in situ* hybridisation). ▪ To generate knowledge about the breeding systems of wild and related sugarcane species. ▪ To generate breeding values for identification of superior parents to include in mating designs.
Anticipated Outcomes:	An expanded set of genotypes, with novel sources of pest and disease resistance, for use as parents in breeding superior sugarcane varieties into the future.
Technology and/ or Knowledge Exchange Plan:	(a) Hybrids obtained from introgression breeding will revert to commercial breeding for use in the crossing programme; (b) results from the studies will be communicated in The Link, Proceedings of the South African Sugar Technologists' Association and articles in science journals.
Value to Industry:	The sustainability of the South African sugar industry is linked to the ongoing release of superior and adaptable varieties that can withstand prevailing climatic conditions and pests and disease pressures.

Agronomic performance under rainfed conditions of NovaCane® plantlets compared with plantlets derived from conventional seedcane

Need Statement:	▪ New varieties are to be routinely released to the industry as NovaCane® plantlets for bulking and subsequent distribution for planting in regional seedcane programmes. Consequently, the performance of NovaCane®-derived seedcane requires thorough characterisation.
Project Objectives:	(a) To compare the yield and agronomic performance of crops derived from NovaCane® plants with those from conventional seedcane sources in the first, second, and third propagation stages across several ratoons under rainfed conditions; and (b) to evaluate plant spacing and planting density to optimise performance of NovaCane® plantlets and NovaCane®-derived seedcane.
Approach to be Adopted:	The investigation, which is to be conducted on the SASRI Mount Edgecombe Research Station, will be based on fully replicated field trials specifically designed to compare the performance of crops derived from the NovaCane® technology with those derived from transplants (plantlets derived from single-bud setts). The trial will be continued over three crop cycles to further examine the performance of NovaCane®-derived crops across ratoons. In addition, the stalks from NovaCane®-derived crops will be used as planting material for subsequent trials to examine subsequent crop performance over several ratoons.
Anticipated Outcomes:	▪ Comprehensively characterised performance of planting material derived from the NovaCane® technology, facilitating better advice to bulking co-operators and growers. ▪ Evaluation of whether plant spacing and planting density influence the performance of NovaCane®-derived crops.
Technology and/ or Knowledge Exchange Plan:	The results of the study are to be communicated through the publication of articles in The Link and the hosting of grower events.
Value to Industry:	The information generated will allow SASRI to provide recommendations to bulking co-operators and growers regarding the agronomic performance of NovaCane® plantlets and NovaCane®-derived commercial sugarcane crops. The information generated on the effects of plant spacing and planting density will assist both seedcane producers and growers in optimising the performance of NovaCane®-derived crops.

Agronomic evaluation of several imazapyr tolerant lines and characterisation of resistance

Need Statement:	Previous research (Projects 07VI03 and 11VI01) resulted in the development of three mutant lines of N12 that show increased tolerance of the herbicide, imazapyr (active ingredient of Arsenal®). When compared to non-mutant N12 controls, improved herbicide tolerance of the mutants may be ascribed to either: (a) greater expression of the gene encoding the enzyme acetolactate synthase (ALS); (b) alteration of the DNA sequence of the ALS gene which prevents the inhibitory binding of imazapyr to the ALS enzyme; or (b) higher capacity for imazapyr detoxification.
Project Objectives:	(a) To evaluate and compare the agronomic characteristics of three imazapyr-tolerant mutant N12 lines to a standard N12 control; (b) to determine the mode of tolerance of the mutant lines to imazapyr; and (c) to sequence the ALS genes of the three mutant lines to determine whether any of the mutated ALS genes might be useful in the development of a selectable marker system for the genetic engineering of sugarcane.
Approach to be Adopted:	The three lines with enhanced imazapyr tolerance will be subjected to field screening to confirm their tolerance under standard weed control regimes. A concurrent phenotypic assessment (stalk height, stalk diameter, number of tillers, sucrose and fibre content) of the lines relative to standard N12 will be conducted in replicated field trials to assess whether unintended somaclonal variation effects have occurred during the mutation breeding process. In addition, the mechanism leading to the enhanced tolerance to imazapyr will be investigated through the genotypic characterisation of the mutant lines, which will include the analysis of ALS activity, examination of ALS gene copy number and determination of the ALS gene sequence.
Anticipated Outcomes:	(a) Agronomic performance assessments for three mutant lines of N12 displaying improved tolerance to imazapyr; (b) comprehensive information regarding the mechanisms underlying the increased imazapyr tolerance of the three mutant lines; and (c) ALS gene sequence data that will enable the development of a selection marker technology for future genetic engineering of sugarcane.
Value to Industry:	Upon the introduction of a herbicide tolerant N12-based variety, it is envisaged that the cost of *Cynodon* control (per ha) under certain circumstances could potentially be reduced by almost 50%. Early spraying would reduce the *Cynodon* population thus also reducing the total number of herbicide applications required to control this weed. Similar cost reductions are envisaged for the control of other problematic weeds.

Protocol optimisation for genetic modification of sugarcane

Need Statement:	For commercial release in South Africa, genetically modified (GM) crops must satisfy the regulatory requirements established by the Department of Agriculture, Forestry and Fisheries (GMO Act 17 of 1997). One of the features of a GM crop considered by the regulators is the number of copies of the transgene and associated selectable marker gene inserted into the genome of the host plant, with single copies of each being viewed most favourably. Furthermore, a practical requirement in the production of the GM plants is that the genetic transformation protocol must generate a sufficient number of plants to enable the selection of the best candidates to satisfy potential commercialisation requirements.
Project Objectives:	(a) To develop a sugarcane transformation protocol that yields high numbers of GM plants containing single copies of both the gene of interest and selection marker gene; and (b) to evaluate the size of the genetic construct that can be successfully delivered into sugarcane plants using micro-projectile bombardment (biolistics).
Approach to be Adopted:	Varying concentrations and sizes of linearised genetic constructs containing a transgene of interest and associated selection marker genes will be introduced into sugarcane callus (undifferentiated cell masses produced through tissue culture) by biolistics. The targeted plant callus will be subjected to various post-bombardment and selection treatments, after which the cells surviving selection will be regenerated to form plantlets. The resulting plants will be subjected to a series of DNA analytical tests that will enable the determination of the number of copies of the transgene and selection marker gene inserted into the genome of each GM plant.

Anticipated Outcomes:	A sustainable, high-throughput genetic engineering protocol optimised to produce high numbers of GM plants containing single copies of both the gene of interest and the selectable marker gene.
Technology and/ or Knowledge Exchange Plan:	The optimised protocol will be included in the SASRI Biotechnology Laboratory Protocol Manual and become standard laboratory practice. The results will also be presented for peer evaluation and scrutiny at a science congress.
Value to Industry:	The protocol will reduce the manpower requirements and costs associated with transgenic plant production and ease aspects of the regulatory approval process.

Tissue-specific transgene expression in the SA sugarcane germplasm: Do we have functional promoters?

Need Statement:	Foreign genes introduced into sugarcane for the purposes of genetic engineering are frequently silenced, which is an unwelcome phenomenon experienced by sugarcane biotechnology laboratories across the globe. For several years, SASRI has worked towards the development of gene promoters to enable targeted transgene expression in specific regions of the sugarcane plant (e.g. insect resistance gene expression in the mature regions of the stalk) but these too have been silenced. Evidence now suggests that: (a) the characteristics of the reporter gene encoding the enzyme b-glucuronidase, which SASRI uses routinely to test the expression level and specificity of gene promoters, may trigger silencing; and (b) the specific complex, polyploid genetic background of the N series of varieties may somehow render tissue-specific promoters particularly susceptible to silencing.
Project Objectives:	To determine whether: (a) specific characteristics of the foreign genes (e.g. b-glucuronidase reporter gene) used in the genetic engineering of sugarcane trigger the silencing phenomenon; and (b) the genetic environment of the N varieties triggers endogenous gene silencing mechanisms.
Approach to be Adopted:	Propensity for silencing will be tested through the genetic engineering of: (a) an N variety with genetic constructs in which a root-specific promoter has been fused to a reporter gene other than b-glucuronidase (e.g. bovine lysozyme); and (b) the genetic engineering of varieties from Australia (e.g. Q117) and the United States (e.g. CP72-1210) with a root-specific promoter developed by SASRI.
Anticipated Outcomes:	Confirmation of the root-specificity of a gene promoter previously isolated by SASRI and an indication of whether promoter silencing is particularly problematic in the N varieties, which will enable the design and testing of appropriate strategies to overcome this limitation. If successful, the approach will be used to validate the specificity of other tissue-specific promoters (e.g. stem specific) previously isolated by SASRI.
Technology and/ or Knowledge Exchange Plan:	The information will be communicated through the publication of an article in a science journal.
Value to Industry:	The knowledge will strengthen the SASRI GM technology platform and the capacity of the institute to support the production of GM varieties for potential commercialisation into the future.

Development of a semi-automated AFLP technique (one-year project)

Need Statement:	At SASRI, the analysis of genetic relationships amongst sugarcane varieties for certain breeding, genetic engineering and mutagenic breeding applications relies on an expensive, complex and labour-intensive laboratory technique that uses a radioactive isotope of phosphorus (^{33}P). Due to the potentially hazardous nature of the isotope and the development of alternative non-radioactive technologies internationally, ^{33}P has become difficult and costly to source (many nuclear facilities throughout the world have ceased or down-scaled production).
Project Objectives:	To develop a semi-automated method for certain types of genetic analysis that increases analytical throughput, improves efficiency and removes the reliance on costly and increasingly difficult to source radioactive P-isotopes.
Approach to be Adopted:	Several duplicate blind analyses will be conducted to compare the results obtained using the currently established protocol with those generated by means of semi-automated capillary electrophoresis optimised for the SASRI ABI3500 Genetic Analyser.
Anticipated Outcomes:	A semi-automated method for certain types of genetic analysis that permits increased sample throughput and improved efficiency and which does not depend upon costly and difficult to source radioactive P-isotopes.
Technology and/ or Knowledge Exchange Plan:	The optimised protocol will be included in the SASRI Biotechnology Laboratory Protocol Manual and become part of standard laboratory practice.
Value to Industry:	The semi-automated technology for the determination of sugarcane genetic relationships will enable improved research and operational efficiencies.

OUTCOMES FROM ONGING RESEARCH

Advances Made:	Value Derived:
Breeding of new and improved varieties	
Genotypes 01G1662 and 02K0663 were approved for release to the Industry as varieties N58 and N59, respectively.	▪ N58 has superior RV and cane yields with good general disease and eldana resistance under Coastal long-cycle (18-month cycle) conditions, relative to varieties established in the region. ▪ N59 has superior RV and cane yields with good general disease and eldana resistance under Hinterland conditions, relative to varieties established in the region.
Breeding and selection	
Selection tactics have been revised to improve pest and disease resistance breeding efficiencies: (a) pest and disease screening trials are to be conducted simultaneously to advanced variety trials to enable enhanced statistical analysis of pest and disease resistance data for decision-making; and (b) resistance traits are to be screened in the early stage of breeding, particularly at the first stage of selection in which families of plantlets from specific parental crosses are evaluated.	Enhanced pest and disease resistance breeding efficiencies, particularly with regard to eldana resistance.
Introgression (Diversification) Breeding	
Analysis of the genetics of ancestral noble canes (*Saccharum officinarum*), ancestral wild canes (*S. spontaneum*), modern cultivars (inter-specific *S.* spp hybrids) and the complex hybrid progenies produced by crossing noble and wild canes with the modern hybrid cultivars, revealed that: (a) increases in genome size in the progenies were generally accompanied by increases in chromosome numbers; (b) chromosome transmission from the parents was n+n for all the progeny; and (c) some progeny experienced chromosomal loss or gain.	Application of the technologies developed in 2014/2015 provides a foundation for the implementation and analysis of introgression breeding strategies that aim to enhance sugarcane vigour and stress tolerance.
Variety evaluation	
In instances where the direct assessment of damage caused by frost events are not feasible, a general rule-of-thumb has been developed which indicates that growers should target the mid-May to mid-June period for the harvesting of cane cultivated in frost-prone areas.	A feasible harvesting strategy to maximise ERC yields in frost-prone areas, in instances where actual assessments of frost damage are not possible.
NUE genetic modification	
The nitrogen-use efficiencies (NUE) of two genetically-modified NCo376 lines were significantly higher than the untransformed controls in a four month pot trial assessment.	GM technology enables the improvement of sugarcane NUE.
Overcoming transgene silencing in GM sugarcane	
Gene promoters (the on-off switches) in which key sequences have been mutated to prevent transgene silencing were identified, synthesised and re-introduced into sugarcane for functional testing.	Overcoming transgene silencing removes a significant impediment to GM technology deployment.

Advances Made:	Value Derived:
Preserving valuable germplasm	
Progress was made towards the development of a method for the storage of encapsulated sugarcane meristems (excised growth points) at ultra-low temperatures.	Cryo-preservation of valuable sugarcane germplasm reduces the costs and risks associated with maintenance of collections under natural field (*ex-vitro*) conditions.
Genomics and bioinformatics	
Further significant progress was made in fulfilling the South African sugar industry contribution to the international effort to sequence the gene-rich portions of the sugarcane genome.	Availability of a partial sequence of the sugarcane monoploid genome will provide significant impetus to development of sugarcane marker-assisted breeding, as has occurred with other important crop species (e.g. rice, wheat).

OUTCOMES FROM CLOSED PROJECTS

Specific observations:	Essential outcomes:
Sugar sensing and signalling-mediated regulation of photosynthesis in sugarcane	
▪ The rate of sucrose production by sugarcane leaves (via photosynthesis) declines as the leaves age and the plant (stool) matures. ▪ This research sought to characterise the negative feedback system which modulates the rate of leaf photosynthesis according to the amount of sucrose in the stalk, particularly the molecule which transmits the message from stalk to leaf and its site of action on leaf photosynthesis. ▪ The investigations were undertaken with a view to identifying targets for the future genetic engineering of higher stalk sucrose content. ▪ Glucose was identified as a candidate molecule for signalling the stalk sucrose status (sucrose demand) to the leaf photosynthetic machinery and two potential signalling cascades in the leaf were identified as recipients and amplifiers of the signal. ▪ In the leaf, the amplified signal was observed to modulate the expression of numerous genes associated with several important functions, including photosynthesis, starch metabolism and cell wall biosynthesis.	▪ A potential molecular mechanism mediating the relationship between the rate of sucrose biosynthesis in the leaf and the sucrose storage demand of the stalk has been described. ▪ Uncoupling of this mechanism may serve as a viable means to increase sucrose content per unit biomass through genetic engineering. ▪ This work is not being pursued further at this time due to shifts in resource allocations and research priorities.
Overcoming transgene silencing in sugarcane	
▪ The hypothesis underlying this research is that the silencing in sugarcane of foreign genes (transgenes) inserted during genetic engineering is a result of a process called 'methylation'. ▪ Methylation is one of the processes occurring in plants (and animals) through which gene expression is naturally regulated and involves the addition, at multiple locations in a gene, of a chemical group (methyl group; — CH_3) to a particular type of DNA molecule, which stops expression. ▪ Observations made in this study indicate that silenced transgenes in GM sugarcane are heavily methylated, although the genetic complexity of sugarcane does not permit unequivocal interpretation of the data.	▪ Specific regions of genetic constructs used in genetic engineering that appear to trigger the silencing of foreign genes have been identified and mutated experimentally to reduce their propensity for silencing. ▪ Examination of the expression in GM sugarcane of the mutated foreign gene sequences is currently under way in a related project (13VI01: Tissue-specific transgene expression in the SA sugarcane germplasm: do we have functional promoters?). ▪ Should the mutation approach developed in this study proof successful, new avenues for the targeted, tissue-specific expression of transgenes in SA sugarcane varieties will become available.

- The regions of transgenes that were identified as being heavily methylated have been mutated to reduce their propensity for methylation and reintroduced into sugarcane by genetic engineering for testing.

Specific observations:

Essential outcomes:

Unlocking genetic variation in sugarcane for disease resistance

- Strains of the fungus, *Fusarium*, occur naturally within sugarcane (endophytically) without causing negative effects but, when the plant is damaged or stressed, they frequently secrete chemicals that are toxic to the plant (phytotoxic) causing stem rot.
- In addition to causing stem rot, some of these phytotoxins (e.g. beauvericin) are also harmful to insects that infest sugarcane (e.g. eldana).
- The hypothesis tested in this research was that overcoming the negative effects of beauvericin on the sugarcane plant would increase eldana resistance without any compromise to plant health.
- Through targeted mutation breeding and selection, *Fusarium*-tolerant lines of N41 and NCo376 were produced that were resistant to stem rot and which had improved eldana resistance.

- *Fusarium*-tolerant lines of N41 and NCo376 were: (a) produced by targeted mutation breeding and selection; and (b) demonstrated to be resistant to stem rot and have improved eldana resistance.
- Selected lines are currently undergoing field experimentation and analysis of mode of resistance in a follow-on project (14VI03: Mutation breeding for eldana resistance).
- Project 14VI03 also explores whether the mutation breeding approach could be applied to produce other types of eldana resistance.

Genomics of quantitative disease resistance in sugarcane

- Breeding for sugarcane disease resistance is difficult, frequently leading to high-yielding genotypes not being released due to susceptibility to a particular pathogen.
- This project sought to: (a) develop a deeper understanding of the genetic basis of sugarcane disease resistance, using brown rust resistance as a model; and (b) assess the potential of rapid screening methods (e.g. chlorophyll fluorescence and near infra-red spectroscopy [NIRS]) as means to detect resistance or susceptibility to brown rust.
- Results obtained indicated that: (a) the major brown rust resistance gene, *Bru1*, contributes to the resistance of SA varieties to brown rust; (b) the occurrence of the *Bru1* gene has increased in the N varieties from 46% (1975-1985) to 68% (2001-2005), with 75% of all recent releases containing the gene; (c) this prevalence exceeds that observed in USA-bred varieties: 15% (1975-1985) to 47% (in the current decade); (d) in some instances, other sources of resistance to brown rust appear to underlie the effect of the *Bru1* gene in the N varieties; and (e) rapid screening methods show potential for detecting a resistant reaction of sugarcane to rust infection and distinguishing between constitutive resistance and the physiological response of the sugarcane plant to infection.

- The project has demonstrated that the potential exists for: (a) the development of DNA markers for brown rust resistance that are complementary to the current marker of the major rust resistance gene, *Bru1*; and (b) the use of rapid screening methods to establish variety resistance or susceptibility to brown rust resistance.
- Both (a) and (b) above are being pursued and applied to additional pathogens and pests in a current project (14CP07: Prediction of quantitative resistance to eldana, smut, rusts, YSA and thrips using NIRS).

Specific observations:	Essential outcomes:

Re-breeding sugarcane for the future: Innovations through plant genome sequence mining and sugarcane genome sequencing

- The availability of the genome [1] sequence [2] of a number of crop species, together with detailed phenotype [3] information, has provided a powerful and rapid means to identify the genetic basis of important agricultural traits and predict the breeding values of individuals in plant breeding populations.
- In this way, genomics [4] has greatly assisted in improving crop trait performance and increasing breeding efficiencies for a number of important crops, including rice, sorghum, soybean and chickpea.
- Similarly, sugarcane genome sequence information and relevant phenotype information would greatly enhance sugarcane breeding efficiencies and accelerate breeding for specific traits of agricultural importance.
- This project formed the basis of participation in an international collaborative effort to sequence important regions of the dauntingly complex sugarcane genome (commercial sugarcane varieties are inter-specific polyploidy hybrids and are reputed to have the most complex genome of all commodity crop species).
- In partnership with Australian (Sugar Research Australia [SRA] and the CSIRO) and French (CIRAD) research institutions and, more recently, under the auspices of the International Consortium for Sugarcane Biotechnology (ICSB), this project has made a substantial contribution to the sequencing of regions of the sugarcane genome containing genes of importance to the industry.

- Through SASRI, the SA industry has played a key leading role in sequencing important parts of the sugarcane genome, along with France (CIRAD) and Australia (SRA and CSIRO) and, more recently, member countries of the ICSB.
- To-date, the sequencing effort has focused on the Réunion Island cultivar, R570, due to the availability of extensive phenotype and other essential genetic information for that sugarcane variety.
- Although R570 genome sequencing remains ongoing, sequencing of SA varieties could commence in the near future using the R570 data as an essential sequence template.

Development of an AFLP method that is optimised for use on a semi-automated genetic analyser

- At SASRI, certain types of sugarcane genetic analysis have, in the past, relied on an expensive, complex and labour-intensive laboratory technique that uses a radioactive isotope of phosphorus (^{33}P).
- Recent research outcomes indicate that a transition away from the use of ^{33}P and the implementation of a semi-automated technology are feasible.
- Before full implementation, additional research will be required to maximise the amount of genetic information that the technology provides.

- A safe and cost-effective genetic analysis technology has been developed for use in sugarcane breeding research.
- Further optimisation will occur ahead of implementation in routine research operations.

[1] The 'genome' is all the genetic information possessed by any organism.

[2] The 'genome sequence' is the complete DNA sequence of an organism's genome at a single point in time that is determined by a laboratory process.

[3] The 'phenotype' is the observable physical or biochemical characteristics of an organism, as determined by both genetic makeup and environmental influences.

[4] Genomics is an area within genetics that concerns the sequencing and analysis of an organism's genome.

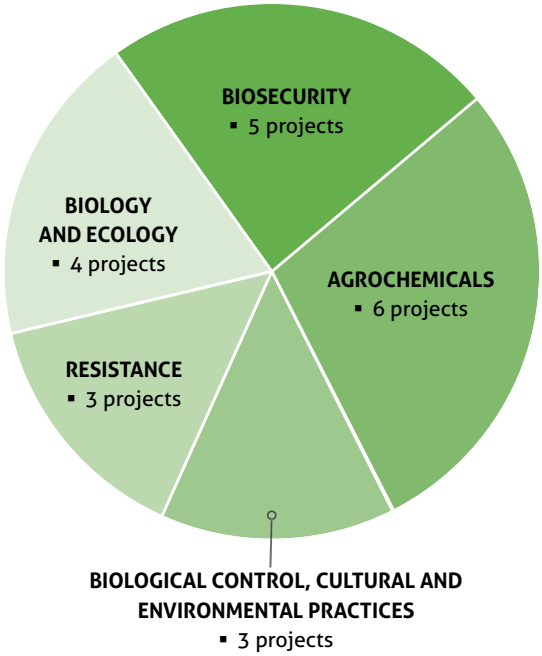
CROP PROTECTION PROGRAMME

Goal

To develop Integrated Management Strategies that minimise the effects of pests, diseases and weeds on crop production in a sustainable manner.

Dr Stuart Rutherford
(Programme Manager)

Key research areas



Biosecurity

Research in this Key Area focuses on:

- development of proactive threat-specific counter-measures and biosecurity incursions plans;
- generation of knowledge of the biology, pathogenicity and epidemiology of pathogens posing a potential incursion threat to the industry, as well as the agro-ecology, behaviour and reproductive biology of new potential pests; and
- development of improved procedures and diagnostic technologies to ensure that varieties released or propagated into the industry, or imported into the Industry Quarantine Facility, are free of pathogens and pests.

The information and knowledge gained in this Key Research Area are applied towards the development of Integrated Management tactics for potential new pathogen and pest incursions into the industry.

Biology and Ecology

Research in this Key Area focuses on:

- investigation of the biology and ecology of the primary pathogens, pests (including nematodes) and weeds of the industry with a view to the development of integrated management tactics and knowledge exchange with the grower community; and
- assessment of the impact on crop yield of the primary and emerging pathogens, pests (including nematodes) and weeds in the industry to facilitate grower decision-making with regard to the implementation of management tactics.

The information and knowledge gained in this Key Performance Area are applied to the development of Integrated Management tactics for the major pathogens, pests (including nematodes) and weeds in the industry.

Resistance

Research in this Key Area seeks to develop knowledge regarding the biological basis of sugarcane resistance to pathogens and pests (including nematodes) in order to develop approaches, resources and technologies to enhance resistance breeding in the Plant Breeding Project (see 'Breeding and Selection' Key Research Area of the Variety Improvement Research).

The information, resources and technologies developed in this Key Research Area are applied to the development of Integrated Management tactics for the major pathogens, pests (including nematodes) and weeds in the industry.

Biological Control, Cultural and Environmental Practices

Research in this Key Area seeks to develop cost-effective technologies that permit the establishment

of sugarcane agro-ecological environments in which pathogens, pests (including nematodes) are suppressed to low levels by benign biological or ecological means.

Several complementary habitat management technologies are investigated, including:

- push-pull technology;
- biodiversity management, namely wetland, riparian zone and vegetation corridor restoration;
- crop husbandry, including crop rotation, use of fallow crops and crop residue management (see 'Crop Husbandry' Key Research Area of the Crop Performance and Management Research Programme);
- Sterile Insect Technique; and
- parasitoid and entomopathogen release.

Agrochemicals

Investigations in this Key Research Area focus on the development of a suite of effective pathogen, pest (including nematodes) and weed control agents that are agriculturally, environmentally, ecologically and economically sustainable.

Research focuses on a series of technologies, including:

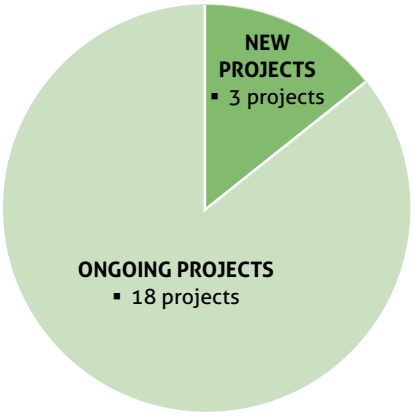
- development of pheromones to enable monitoring and agrochemical application programmes, primarily for eldana;
- the search for more benign alternative chemistries; and
- development of superior application tactics and product formulations.

STRATEGIC OBJECTIVES

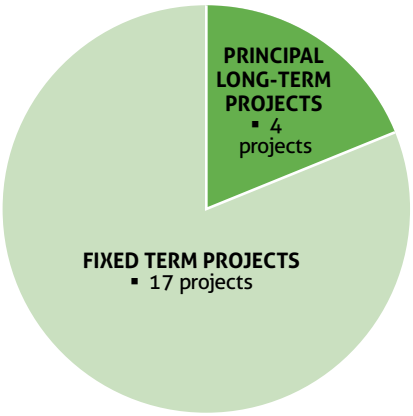
- To promote biosecurity by conducting research resulting in improved procedures that ensure varieties released or propagated into the industry, or imported through quarantine are free of disease; and (b) to conduct research leading to the development of proactive threat-specific countermeasures and biosecurity incursion plans.
- To generate knowledge on the biology and ecology of pests, diseases, nematodes and weeds and to facilitate knowledge transfer.
- To gain understanding of the biological basis of resistance to pests, diseases and nematodes and to develop improved resistance screening techniques for the plant breeding project.
- To develop effective integrated management strategies and models combining varieties, agrochemicals, biological control agents and nutrition with beneficial cultural and environmental management practices.

PROJECT PORTFOLIO OVERVIEW

Project Disposition



Project Type



Improving translocation of herbicides in problematic weeds

Need Statement:	*Cyperus rotundus* and *Rottboellia cochinchinesis* are problematic weeds within the industry and considerable effort and cost are associated with their effective management. Information on the best timing of herbicide application is required, as poor translocation between leaves and tillers in *C. rotundus* and leaves and tubers in *R. cochinchinesis* may result in inefficient control.
Project Objectives:	(a) To determine the timing of application and dosages of herbicides that promote optimum translocation of active ingredients between leaves and tillers of *C. rotundus* and leaves and tubers of *R. cochinchinesis*; and (b) to assess whether adjuvants may promote translocation through improved herbicide spreading, cuticle-cutting, penetration and salt binding.
Approach to be Adopted:	*C. rotundus* seeds and *R. cochinchinesis* tubers will be collected from the field, planted into pots, with subsequent cultivation under controlled conditions. Herbicides will be applied to the plants at different times and dosages in combination with various adjuvants. To enable comparison, the herbicides will also be applied according to current standard recommendations to determine whether any of the novel practices under investigation result in improved translocation and herbicide efficacy.
Anticipated Outcomes:	Should the practices under investigation (novel spraying regimes and dosages, new adjuvant mixtures) prove effective in enhancing active ingredient translocation and efficacy, opportunities for registration will be explored in conjunction with the relevant agro-chemical company.
Technology and/ or Knowledge Exchange Plan:	Should the amended protocols be registered, the SASRI Herbicide Guide will be updated accordingly and the results communicated through the The Link, Proceedings of the South African Sugar Technologists' Association and an article in a science journal.
Value to Industry:	Revised herbicide application protocols for *C. rotundus* and *R. cochinchinesis* have the potential to increase management efficiencies by up to 50% and 35%, respectively.

Investigation of the possible interaction between nematicides and conazole fungicides

Need Statement:	Previous studies have shown that fungicides with triazole or imidazole active ingredients (conazole fungicides), when applied in combination with insecticides, improve the efficacy of the insecticide. The improvement results from a decrease in the dosage of the insecticide required to achieve 50% mortality of the target insect pest.
Project Objectives:	To assess whether the demonstrated synergistic effect exerted by conazole fungicides on insecticide efficacy can be extended to selected nematicides.
Approach to be Adopted:	(a) To develop a laboratory bioassay based on a nematode dispersion index that permits the identification of interactive effects between conazole fungicides and selected nematicides on nematode mortality; (b) to deploy the bioassay to investigate synergistic effects amongst fungicidal conazole active ingredients (difenoconazole, carbendazim, iprodione) and nematicidal compounds (abamectin, thiamethoxam) that are currently registered or under investigation for use in the industry; and (c) to conduct trials with potted sugarcane plants to further test promising conazole fungicide and nematicide combinations.
Anticipated Outcomes:	(a) A laboratory bioassay methodology that permits the effective screening of nematicidal compound efficacy; and (b) identification of promising combinations of conazole fungicides and nematicides for field testing. Should the field trials yield promising results, the agrochemical companies owning the chemistries will be encouraged to pursue registration.

Investigation of the possible interaction between nematicides and conazole fungicides

Technology and/ or Knowledge Exchange Plan:	The results of the investigations will be conveyed in the Proceedings of the South African Sugar Technologists' Association. In addition, the data will be communicated to the relevant agrochemical companies to encourage the pursuit of registration.
Value to Industry:	If synergies occur between conazole fungicides and nematicides, the efficacy of nematicide applications could be enhanced thereby enhancing nematode control and decreasing associated costs.

Development of a Crop Protection Database (one-year project: 1 April 2014 – 31 March 2015)

Need Statement:	SASRI conducts on-going investigations throughout the industry to identify insects and pathogens that represent risks to biosecurity or might potentially be used as the basis of biocontrol tactics. The resulting collections and data are extensive and require careful curation and management to ensure integrity and accessibility into the future.
Project Objectives:	To develop an integrated data repository that incorporates all currently available insect and pathogen identification data in a user-friendly searchable database. Data incorporated will include images, taxonomic data, morphological descriptions, distribution maps (including GIS co-ordinates, where available), DNA sequences and phylogenetic data.
Approach to be Adopted:	The format of the database will be determined by extensive consultation with potential end-users. As a test case, the database will be initially populated with data on eldana, thrips, species of chilo and tawny rust.
Anticipated Outcomes:	An easily searchable database containing important information on pests and pathogens readily available on-line to SASRI researchers and extension and biosecurity specialists through a wiki-type portal.
Technology and/ or Knowledge Exchange Plan:	Training workshops will be hosted to familiarise SASRI specialists with all aspects of the use of the database, both as a source of information and as a repository for data,
Value to Industry:	A centralised database of important information on sugarcane pests and pathogens will enable the activities of SASRI researchers and extension and biosecurity specialists.

OUTCOMES FROM ONGOING RESEARCH

Advances made:	Value derived:
New chemistries for pest, disease and weed control	
Nematicides: Strip trials conducted in the Midlands have identified a nematicidal compound that has the potential to serve as an effective alternative to Temik®.	Data obtained will serve to encourage the manufacturer of the compound to pursue registration of the product for use on sugarcane in South Africa.
Insecticides: Investigation of alternatives to Fastac® for eldana control have identified four potential treatments that are at least as effective as the current industry standard in significantly reducing the negative impact of eldana on carry-over crops (up to a 60% increase in sucrose yield per hectare relative to the untreated controls).	The availability of alternatives to Fastac® for eldana management in carry-over crops will contribute substantially to improved agro-chemical stewardship within the industry.
Fungicides: An alternative treatment to the industry standard (Bayleton®, active ingredient: triadimefon) was demonstrated to show promise for smut control, provided that the compound was applied to setts without a hot-water treatment before planting.	The treatment applied to the setts before planting provides systemic protection to young plants and an alternative to the standard treatment will contribute to improved agrochemical stewardship.

Advances made:	Value derived:

Biosecurity: Tawny Rust

Molecular diagnostic assays revealed the newly emerged rust as a new fungal species, which has been assigned the scientific name of *Puccinia fulva* (common name: tawny rust). Abacus® has been registered for use against tawny rust in the industry.	Identification of the rust was essential to ongoing development of risk assessment and disease management strategies.

Biology and ecology of pests and diseases: Sugar Cane Yellow Leaf Virus (SCYLV)

▪ Reaction of varieties to infection by the SCYLV is variable. In plant crops: (a) significant cane yield penalties are likely in NCo376 (35 - 43% loss), N39 (18% loss) and N12 (8% loss); and (b) cane yield gains are apparent in response to infection of N31 (12% increase) and N33 (15% increase). ▪ SCYLV infection results in a significant increase in the root biomass of N32. ▪ Differences in variety resistance to SCYLV are evident: N33 more resistant and NCo376 more susceptible. ▪ A significant increase in juice colour of NCo376 occurs in response SCLYV infection but not in N12 or N31.	▪ While yield losses of up to 43% can occur in SCYLV susceptible varieties, some varieties are tolerant and may even show improved yields when infected. ▪ Varietal SCYLV resistance or tolerance is critical to the management of yellow leaf syndrome. ▪ Establishment of seedcane nurseries with virus-free NovaCane® plantlets is likely to be effective in reducing SCYLV levels over time.

Biology and ecology of pests and diseases: Maize Streak Virus (MSV)

▪ The Maize Streak viral pathogen was identified as the most virulent strain in maize. ▪ A new species of mastrevirus, Saccharum Streak Virus, was discovered as a co-infection. ▪ MSV was shown to be transmitted from grasses and maize in the vicinity of sugarcane fields by the leafhoppers, *Cicadulina mbila* and *C. anestae*. ▪ Trials conducted with potted sugarcane plants grown under secure quarantine conditions indicated that MSV reduces N44 cane yield by an average of 44%. ▪ Growers have been informed that eradication of N44 from their fields is required by June 2015.	▪ This investigation lead to N44 being degazetted in 2009 based on: (1) the extreme susceptibility of the variety to the MSV-A4 virus strain; (2) the severity of the effects of MSV on yield; (3) the high inoculum of MSV in natural vegetation; and (4) the widespread distribution of the leafhopper vectors.

Biological control: Cultural and environmental practices

▪ Two isolates of the sugarcane endophytic fungus species, *Fusarium*, produce an insecticidal compound, beauvericin, which is antagonistic to eldana larvae. ▪ An endophytic strain of the fungus *Beauveria bassiana*, isolated from *Typha latifolia* (bulrush), is highly pathogenic to eldana larvae. ▪ An isolate of the fungal epizootic, *Beauveria brongniartii*, was found to have good host specificity, dispersal ability and environmental persistence against white grubs (endemic scarabaeids) in the Midlands. ▪ An entomopathogenic nematode (EPN) has been isolated which shows promise as a predator of all the immature life stages of eldana (larvae and pupae).	▪ Manipulation of the endophytic fungal community in sugarcane stalks, through sett inoculation or hot-water treatment, is a potentially viable component of the technology tool-kit recommended for eldana Integrated Pest Management. ▪ Potential exists for the development of a commercial myco-insecticide (a biological agent) against eldana. ▪ Potential exists for the development of a commercial myco-insecticide (a biological agent) against white grubs. ▪ Potential exists for the development of a commercial EPN (a biological agent) against eldana.

- Cultivation of a mixture of selected varieties within individual sugarcane fields does not significantly or consistently alter nematode communities, eldana population size or crop yield
- Preliminary evidence from potted sugarcane trials of the efficacy of eleven different sources of Si, indicated that: (a) pre-treatment with lime over a period of 30 days prior to Si source application significantly increased leaf Si values; and (b) Calmasil® remains a promising source of Si and, because it is also a slag, it assists in further reducing the Al saturation of a very acid soil.

- Cultivation of variety mixtures within individual fields is not a feasible means to control pests and diseases or improve sugarcane yields.
- Once validated under field conditions (studies currently in progress), the improved crop Si nutrition facilitated by this knowledge will serve to enhance sugarcane resistance to eldana, particularly of more susceptible varieties and under mild water stress conditions.

OUTCOMES FROM ONGOING RESEARCH

Specific observations:

Essential outcomes:

Development of methodology for the control of eldana based on its interaction with *Fusarium* species (Part III)

- Beneficial and antagonistic relationships between species of *Fusarium* isolated from sugarcane and eldana were demonstrated.
- The strain of *Fusarium* most antagonistic to eldana was found to produce beauvericin, an insecticidal toxin. This strain was *F. sacchari* isolate PNG40b (PNG40b).
- Lower levels of beauvericin were produced by the strain ZN12 (*F. pseudonygamai*), which had a less adverse effect on eldana.
- No beauvericin was detected in the *Fusarium* strain that was beneficial to eldana. This strain was SC17 (*F. pseudonygamai*).
- The *Fusarium* strains were observed to influence the behaviour of both eldana neonate larvae and mated female moths.
- A range of volatiles were identified in sugarcane tissue inoculated with the three isolates.
- In the beneficial *Fusarium* strain (SC17), the volatiles demonstrated to be attractive to eldana neonate larvae included phenyl ethanol alcohol, 4-ethylguaiacol, nerolidol/farnesol and benzaldehyde (salicylaldehyde).
- Among the volatiles produced by PNG40b (repellent isolate), 2-tridecanone, nonanoic acid and Kaur-15-ene have known insecticidal properties.
- None of the isolates found to influence the behaviour and development of eldana in vitro were capable of stably colonising sugarcane endophytically (all caused some stalk reddening and most negatively affected germination).
- The selected isolates PNG40b, SC17 and ZN12 were successfully inoculated into NovaCane® plantlets but persistence varied.
- Expected trends in eldana damage and larval numbers were observed in pot and field-grown cane inoculated with the different isolates but no statistically significant differences between treatments were obtained.

- The research demonstrated the existence of both antagonistic and mutually beneficial relationships amongst *F. sacchari*, *F. pseudonygamai* and eldana, which have the potential for exploitation in eldana control.
- None of the *Fusarium* isolates that effectively influence eldana behaviour (either attracting or repelling the insect) were able to adequately colonise sugarcane without causing damage to the plant.
- For the *Fusarium* isolates to be used as part of eldana IPM, it is apparent that sugarcane resistance to the negative effects will have to be established, e.g. through directed mutagenic breeding (see report on Project 09VI09: Unlocking genetic variation in sugarcane for disease resistance).

Specific observations:	Essential outcomes:

Towards a crop nutritional IPM method to reduce the impact of pests and diseases on plant cane

- Seventeen silicon (Si) sources and eight different amendments were tested across a series of 13 pot trials.
- Si reduced promotional effects of N on eldana in susceptible varieties.
- Si had no effect on thrips but N increased their numbers.
- Si uptake was significantly enhanced with N in ammonium form compared with nitrate (low pH from ammonium solubilises Calmasil® and releases Si).
- Organic matter amendments (chicken litter, compost, humate, biochar) had no effect on Si availability and uptake.
- Phosphate and gypsum had no effects on Si availability and uptake.
- Lime, when incubated with an acid soil (≥40% acid saturation) for 1 or 3 months, had no effect on Si uptake from Calmasil® (Calmasil® is an effective liming agent).
- Lime significantly increased Si uptake from non-liming Si sources (however, such non-liming Si sources are not viable for sugarcane agriculture).
- Calmasil® and Calsimag-P® are the best Si sources as they provide ample available Si, Ca and Mg (and P if Calsimag-P® is applied).

- Desilicated (weathered) soils are usually acid (with associated Al^{3+} phytotoxicity) and require liming
- Subject to resolution of issues around affordability, it is recommended that growers apply Calmasil®, as this will also provide Si, Ca and Mg (soils in the rain-fed regions of the industry are most in need of Si supplementation).
- Calmasil® can be applied at FAS-recommended liming rate (Calmasil® is as effective as dolomitic lime) to reduce acid saturation to at least 20%; nitrification over time will increase soil acidity and solubilise applied silicate.
- Calmasil® is a registered agricultural lime that is locally available and subject to quality control to remove contaminants.
- Calsimag-P® ('thermophosphate') is also a readily available, slow-release source of Si, with liming capability.
- Growers are cautioned against investing in foliar Si sprays (e.g. silicic acid), diatomaceous earths, potassium silicate, Mg silicate, bagasse flyash, or crushed volcanic rock (in these instances, the Si either not available and/or the product is too expensive).
- It is of note that the application of lime will not increase Si uptake from native or applied sources; instead, the resultant increase in pH decreases available Si in soil solution.
- Ammoniacal fertilisers (e.g. urea) can be applied with Calmasil® to solubilise Si and increase uptake.
- Growers are urged to ensure that applied Calmasil® or Calsimag-P® is thoroughly incorporated.
- Evidence obtained indicates that Si uptake remains problematic under field circumstances and potential reasons for this remain under investigation.

Optimisation and extensive validation of the brown rust risk model

- Brown rust is an important sugarcane disease in SA as it can result in yield losses of up to 26%.
- Infection is favoured by relatively cool, humid conditions and young cane of between three to six months in age is particularly vulnerable to infection.
- Varietal resistance is the most powerful control measure, although fungicides also play an important role in limiting losses caused by the disease.
- Fungicides for brown rust control are best applied before symptoms appear and, consequently, prediction of when and where the disease is likely to emerge is important to effective management.

- Two beta-versions of the rust risk model are in the process of being posted on the SASRI WeatherWeb site: one which uses leaf wetness and temperature to predict rust risk and another which substitutes leaf wetness with relative humidity.
- These models will continue to be tested for accuracy and refined accordingly.
- It is envisaged that the models will be most useful in predicting the early onset of the disease (primary infections) e.g. after winter.
- Sentinel plots of varieties susceptible to tawny rust are in the process of being established in several regions of the industry to serve as an additional component of the rust infection warning system.

Specific observations:	Essential outcomes:
▪ The objectives of this study were to: (a) refine and validate a rust risk model; (b) to establish the model on the SASRI WeatherWeb to enable growers to maximise the efficacy fungicide treatments; and (c) to gather data on fungicide efficacy to facilitate registration of suitable products.	▪ As a result of this research, combined with the outcomes of additional investigations conducted under contract for a major agrochemical company, Abacus® was registered for use in brown rust management (the product has also been observed to be effective against tawny rust).

Trash Moth Control in Swaziland (Conducted in association with Swaziland Sugar Association Technical Services)

▪ The objectives of this research were to: (a) determine the crop loss attributable to trash moth infestations; (b) identify and test insecticides/biocides for control of the pest; and (c) establish moth population monitoring. ▪ The trials established were subject to low feral trash moth infestations and consequent crop damage was negligible ▪ No consistent trends were observed to demonstrate the efficacy of insecticide treatments, primarily due to the low infestation levels.	The research was unable to provide reliable information on the effect of trash moths on yield or develop management options due to the low level of feral trash moths that occurred during the study period. This further highlights the fact that trash moth infestations are sporadic and unpredictable. In addition it should be noted that, by the time damage becomes noticeable, the pest is already in the process of coming under natural biological control by parasitoids.

Yield loss due to sugarcane thrips in annual drip irrigated sugarcane crop

▪ Trials were undertaken in Pongola to determine yield loss caused by thrips infestations under irrigated conditions (drip irrigation). ▪ The growth stimulation effect caused by the insecticide (active ingredient: imidacloprid) was indirectly accounted for in the yield loss assessments, although the data obtained are not unequivocal.	Yield loss due to thrips infestations in annual drip-irrigated crops was estimated to be: (a) 9.6% TCH, ranging between 5.7% and 11.9%; and (b) 8.6% TSH, ranging between 5.8% and 12.8%. The growth stimulating effects of imidacloprid on yield have been loosely accounted for but the data are not unequivocal.

Rapid means of mass screening for pest and disease resistance

▪ Determination of sugarcane resistance to pests and diseases during the breeding process is difficult and costly. ▪ In this project, the potential of near infra-red spectroscopy (NIRS) as a means to determine the degree of pest and disease resistance of the industry's sugarcane breeding population was investigated. ▪ In addition, the feasibility of *Chilo partellus*, which occurs within the industry, serving as a research surrogate for the major biosecurity threat, *Chilo sacchariphagus*, was demonstrated.	▪ Performance of the NIRS calibration models developed for eldana, smut and brown rust is promising, although, disappointingly, the thrips model did not perform well. ▪ The investigations have demonstrated the potential value of the NIRS technology as a high throughput method to screen sugarcane genotypes for pest and disease in the breeding programme. ▪ NIRS may be used as an additional screening method in the early stages of selection which will result in a higher proportion of resistant genotypes being progressed through to the later stages of selection. ▪ Additional research into developing the NIRS technology for deployment in breeding for pest and disease resistance is continued in Project 14CP04 (Prediction of quantitative resistance to pests and diseases using NIR).

Specific observations:	Essential outcomes:

Investigation into options for the suppression of grasshopper infestations

- Severe outbreaks of grasshoppers during 2011/2012 in the Zululand region of the industry prompted this research, which aimed at providing the basic information of grasshopper community structure and population dynamics required for the formulation of management options.
- In conjunction with growers in the region, various management options were explored, including: (a) the destruction of egg batches through the shallow ploughing or ripping of the inter-rows of affected fields; and (b) the application of selected insecticides to control adult grasshoppers.
- No conclusive evidence was found to support the efficacy of shallow inter-row ripping/ploughing nor for insecticidal treatments targeting adult insects.

- A targeted approach is necessary for effective grasshopper management, which relies on the ongoing scouting of potential outbreak fields between October and February.
- Fields to be targeted are those with old ratoons and sub-optimal weed control or which have a history of grasshopper infestations.
- Once detected, it is the hopper stage that must be treated with insecticide (SumiAlpha® is now registered for use against hoppers in sugarcane fields).
- It is advisable to maintain reduced weed pressure in all fields but particularly in older ratoons, as evidence suggests that these are likely to be most prone to grasshopper outbreaks.

Development of quantitative real-time PCR diagnostic tests

- The real-time reverse-transcription polymerase chain reaction (qRT-PCR) technology was successfully optimised for the detection of sugarcane yellow leaf virus (SCYLV) and sugarcane mosaic virus (SCMV).
- The newly developed qRT-PCR diagnostic tests for SCYLV and SCMV are more sensitive that the tests previously used.

- New tests for the diagnosis of SCYLV and SCMV have been developed and will be implemented into quarantine procedures after further refinement and optimisation.
- Development of the technology to detect systemic smut infections and maize streak virus (MSV) are in progress.

An alternative method for diagnosing ratoon stunt (RSD)

- The suitability of a novel molecular biotechnology called LAMP (loop-mediated isotherm amplification) as an alternative to currently-used laboratory methods for RSD diagnosis has been investigated.
- The LAMP technology offers several advantages over the current methods of RSD diagnosis, including higher sensitivity (100 times more) and the potential for use at near-to-field locations (e.g. regional Biosecurity Offices).
- For potential use of the LAMP technology by Biosecurity Officers or Technicians, a detection system using a lateral flow device has been developed (these devices are commonly used in home diagnostic kits e.g. pregnancy tests).

- A LAMP-based molecular technology with a lateral-flow device detection system has been developed to provide sensitive and accurate detection of the bacterium that causes RSD.
- The extremely high sensitivity of the developed diagnostic test suggests a high probability of cross-contamination amongst samples if deployed at near-to-field locations.
- The development of a method for reducing the risk of false positive results from sample cross-contamination is nearing completion in collaboration with the University of KwaZulu-Natal.

Development of Incursion Management Plans

Four response or action plans were developed:

a) **The South African Sugar Industry Pest and Disease Emergency Response Plan**
A generic response plan including all necessary action to enable effective early warning and preparedness for an incursion as well as an emergency plan in the event of an incursion.

The incursion plans can be rapidly and effectively implemented in the event of incursions either of *Chilo sacchariphagus* or orange rust. In addition, a generic emergency response plan is available to guide the development of further pest specific incursion plans as required.

Specific observations:

b) ***Chilo sacchariphagus* Response Plan**

A specific plan to prevent and counter a possible incursion of the sugarcane stem borer *Chilo sacchariphagus*.

c) **Orange rust Response Plan**

A specific plan to prevent and counter a possible incursion of the sugarcane leaf fungus disease, orange rust (*Puccinia kuehnii*).

d) **Local Pest Disease and Variety Control Committee pest incursion plan action plan**

Drawing upon the generic and specific incursion plans, a local checklist of necessary actions and procedures to be followed before and in the event of an incursion.

Essential outcomes:

Important note: the effective implementation of these plans can only take place once the Pest Disease and Variety Steering Committee has agreed and allocated the necessary funding, resources and responsibilities as proposed in the plans. At the time of finalisation of this report agreement had not yet been reached and only once this has been concluded can the proposals be fully implemented.

Development of a Crop Protection Database (one-year project: 1 April 2014 – 31 March 2015)

SASRI conducts on-going collections and identifies insects and pathogens found within the sugar industry. Currently, records are kept in various forms by different researchers. The objective of this project was to develop an integrated data repository that incorporates all currently available insect and pathogen identification data in a user-friendly searchable database.

- A draft database template is available on Saziswa in a 'Wiki-pedia' format.
- Once database is fully functional and fully populated with pest and pathogen information, it will provide a useful resource that can be accessed remotely by SASRI Researchers and Extension and Biosecurity Specialists.
- Database development will continue until the desired functionality is achieved.
- Updates to and maintenance of the database will be an on-going activity as new information is obtained from the field and the laboratory.

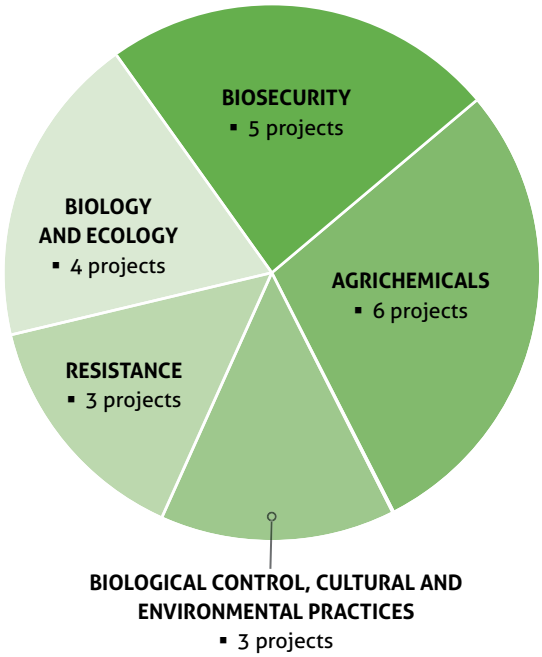
CROP PERFORMANCE AND MANAGEMENT PROGRAMME

Goal

To develop models and better management practices to sustain and enhance sugarcane production.

Dr Riekert van Heerden
(Programme Manager)

Key research areas



Crop Physiology

Research in this Key Area focuses on the gathering of crop physiological data and the use thereof to facilitate modelling, with a view to:

- assessing the potential resource requirements (water and nitrogen) for high biomass cultivars with potential future bioenergy applications;
- developing tools to assist sugarcane breeding under current and predicted future climatic conditions; and
- refining the accuracy of crop yield forecasting.

The resources and technologies developed will ultimately enhance the quest for improved efficiencies in the Plant Breeding Project (see 'Breeding and Selection' Key Research Area of the Variety Improvement Programme).

Crop Nutrition

Research in this Key Area focuses on the development of knowledge, technologies and resources to enable the:

- accurate quantification of soil and leaf nutrient concentrations and the determination of improved leaf nutrient threshold values to further enhance the accuracy of fertiliser recommendations to the grower community;
- assessment of potential differences in variety nutrient requirements to further enhance the provision of cost-effective fertiliser recommendations to the grower community;
- assessment of the efficacy of various sources of nutrients, fertiliser formulations and application rates to further enhance the provision of cost-effective fertiliser recommendations to the grower community; and
- development of soil sampling guidelines and protocols to further enhance the accuracy of fertiliser recommendations to the grower community.

Crop Ripening

Research in this Key Area focuses on the development of knowledge, technologies and resources to enable and demonstrate effective sugarcane chemical ripening practices in the industry. Under development are technologies and models that will assist the grower community with chemical ripening decision-making.

Crop Residue Management

Research projects in this Key Performance Area focus on the development of knowledge, technologies and resources to enable effective and beneficial crop residue management practices in the industry. Particular emphasis is placed on the determination of

variety responses to the retention of a crop residue blanket, so that specific recommendations to growers may be formulated.

Soil Health

Research in this Key Area focuses on the development of knowledge, technologies and resources to enable the maintenance of, and where necessary, the restoration of soil health.

In progress are studies to develop:

- a Soil Health Index that will facilitate grower decision-making regarding the potential requirement for ameliorative measures or alternative practices;
- guidelines for the amelioration of top and sub-surface soil acidity, which is complemented by a series of trials to demonstrate the efficacy and practicality of recommendations; and
- an understanding of the factors that may contribute to the low level of root development and soil penetration that has been observed in various areas of the industry.

Water Management

Research in this Key Area focuses on co-ordinated knowledge generation and model development to enable efficient irrigation and the optimal use of available water. In progress is the development of a model (decision support tool) that will facilitate grower decision-making with regard to irrigation scheduling during periods of heightened water scarcity.

The resources and technologies developed in this Key Area strongly complement the research outcomes in the 'Water Use' Key Area of the Systems Design and Optimisation Programme.

Climate Change

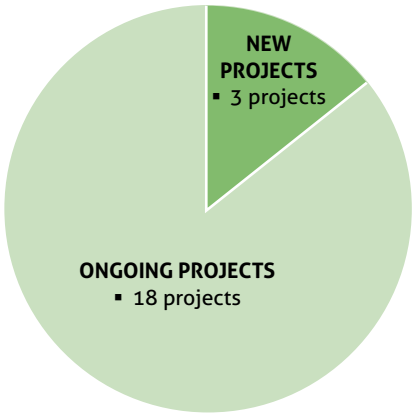
Research in this Key Area focuses on the assessment of potential impacts of climate change on the industry and exploration of ways in which field management might be modified to adapt to the projected changed climate.

STRATEGIC OBJECTIVES

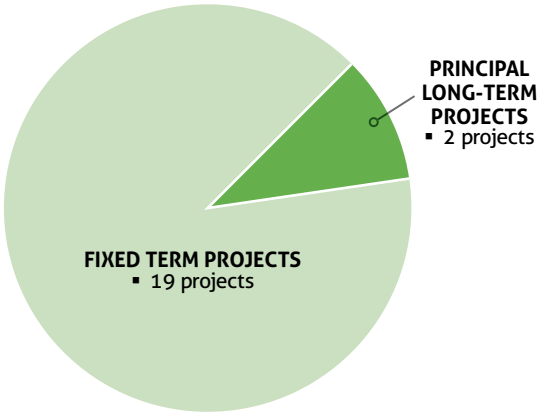
- To develop new, and fine-tune existing, crop management practices to enhance the economic and environmental sustainability of sugarcane production.
- Through adaptive, exploratory and strategic applied research, to improve our understanding of how climate, soil, nutrient and crop management factors affect sugarcane productivity (growth, yield and quality); and the extent to which these effects are genotype specific.
- In combination with economic analyses and the outcomes of the other SASRI research programmes, to develop and refine models that predict crop performance and inform crop management practices.

PROJECT PORTFOLIO OVERVIEW

Project Disposition



Project Type



Development of whole-stalk juice purity calculator to simplify chemical ripener decision-making

Need Statement:	Growers ideally base their decision to apply chemical ripeners on the results of stalk juice purity analyses conducted on their behalf by the SASA Cane Testing Service or the SASRI Pongola or Mount Edgecombe mill rooms. While this approach is successful, it is not feasible during the off-season when mills are closed. Consequently, a method to determine stalk juice purities based on brix readings made in-field with a hand-held refractometer would provide growers with a more consistently accessible tool to guide their ripening decision-making processes.
Project Objectives:	(a) To determine whether a correlation exists between easily-measured brix% differentials and juice purity; and (b) if a robust correlation is demonstrated, to develop a juice purity calculator for use by growers and SASRI Extension Specialists in ripening decision-making.
Approach to be Adopted:	Sub-samples of cane consignments delivered to the SASRI Pongola and Mount Edgecombe mill rooms falling into the juice purity categories of 70, 75, 80, 85 and 90% will be selected for study. Brix% differentials amongst the upper, middle and lower portions of the stalks of a range of varieties falling into these purity classes will be determined. The brix% differentials measured in all samples for each variety will then be correlated against juice purity and other cane quality parameters. If robust correlations are observed, statistical analyses will be conducted to determine if varieties differ from each other in terms of the relationship between brix% differential and juice purity. This information will then be used to either generate a variety-specific or generic juice purity calculator in Excel format initially and later as a smartphone and tablet app.
Anticipated Outcomes:	A calculator to enable the rapid estimation of juice purity based on brix values determined with a hand-held refractometer.
Technology and/ or Knowledge Exhange Plan:	The juice purity calculator will be distributed to growers in electronic format along with guidelines for use. In addition, the results of the study will be communicated via articles in The Link and the Proceedings of the South African Sugar Technologists' Association.
Value to Industry:	Rapid estimation of juice purity will significantly promote effective chemical ripener use, a practice with a proven track record of substantially increasing profitability.

Regional monthly growth increments

Need Statement:	Data regarding monthly crop growth increments could potentially inform several important grower management-related decisions, including ripener application, field carryover determinations, harvest scheduling and crop cycle length assessments. Although physical measurement is not feasible, the potential exists that such growth increments may be effectively simulated by means of an appropriate crop growth model.
Project Objectives:	(a) To determine long-term mean monthly average potential growth rates for sugarcane grown over a range of plant / harvest dates and harvest ages, for a range of soil water holding capacities, across the South African industry, using a crop growth simulation model and historical observed weather data; and (b) to develop a web-based decision support program (DSP) and information sheet(s) to provide users with easy access to this information.
Approach to be Adopted:	A SASRI sugarcane growth model (DSSAT-Canegro or Canesim) will be run for a range of combinations of inputs (start date, harvest age and soil-water holding capacity) in each region (homogenous climate zone) of the industry, over ten or more seasons of historical weather data. Average simulated monthly growth increments will be calculated and made available via a web-based DSP. An information sheet will be prepared that contains lookup tables for a subset of this information.
Anticipated Outcomes:	A web-based DSP that will: (a) permit the choice of simple parameters (region/coordinates, start/harvest month, soil water holding capacity, climate status (wet/normal/dry); and (b) simulate and display results corresponding with the selected input parameters.

Technology and/ or Knowledge Exchange Plan:	(a) The DSP will be demonstrated to SASRI Extension Specialists at an appropriate forum; (b) an information sheet will be published on monthly growth increments to complement the DSP; and (c) the DSP will be publicised by means of an article in The Link.
Value to Industry:	Monthly crop growth increment data will enhance grower decision-making with regard to ripener application, field carryover determinations, harvest scheduling and crop cycle length assessments.

Development of a system to quantify soil variability (one-year project: 1 April 2014 – 31 March 2015)

Need Statement:	Soil heterogeneity within fields demands consideration during the design of research and plant breeding trials to ensure the veracity of results. Currently, such variation is accounted for by intensive soil sampling and costly soil analysis by the SASRI Fertiliser Advisory Service. Recently, reports have appeared in the literature indicating that commercially-available electromagnetic-induction meters have the capacity to rapidly, reliably and cost-effectively map soil spatial heterogeneity. Outputs from such meters can be related to several soil properties of which salinity, clay, bulk density, soil water and carbon are examples.
Project Objectives:	(a) To evaluate the applicability (sensitivity, accuracy and stability) of a selected electromagnetic-induction meter to measure (derive) the permanent and variable soil properties of selected experimental sites spatially and temporally; and (b) to evaluate the sensitivity of the instrument to detect depth limiting layers from electro-conductivity (ECa) data, including duplex soils, shallow soils on hard rock, compacted layers and high water tables.
Approach to be Adopted:	The study site selected will be highly variable, particularly with regard to clay content (ideally from 5 to 50% in the top soil). A 4 m by 10 m grid layout consisting of nine rows spaced 4 m apart will be used. Soil samples will be collected at eleven positions per row at depths of 15 to 30 cm, 55 to 70 cm and 115 to 130 cm and analysed for clay content, organic carbon and salinity. The electromagnetic conductance instrument (Geonics EM38-MK2®), linked to a hand held computer equipped with a GPS unit, will be used to compile delineation maps. Two subsequent surveys will be conducted seven weeks apart, with scanning in both the vertical and horizontal dipole orientations to cover depths of 38, 75 and 150 cm.
Anticipated Outcomes:	Documented evidence that an electromagnetic induction meter can be used with confidence to reliably map the variability in clay content of a field.
Technology and/ or Knowledge Exhange Plan:	(a) An operating manual will be developed to guide users of the electromagnetic induction meter; and (b) user training workshops will be conducted.
Value to Industry:	Improved knowledge of soil variability will result in the improved design of research and plant breeding field trials, thereby improving SASRI operational and research efficiencies.

OUTCOMES FROM ONGOING RESEARCH

Advances made:	Value derived:
Chemical ripening	
▪ Ripener recommendations have been updated or developed for several varieties, including those newly released to the industry. ▪ Several grower days held throughout the industry have promoted and increased the adoption of chemical ripening recommendations and buy-in into ripener schemes subsidised by milling companies. ▪ Ethephon®, Fusilade Forte® and Moddus® do not have negative residual effects on regrowth of the next ratoon, while Moddus® stimulates initial tillering.	▪ Variety-specific recommendations assist grower decision-making regarding ripener application. ▪ Adoption of chemical ripening recommendations promotes grower and miller profitability. ▪ Chemical ripener application has no deleterious consequences on the regrowth of subsequent ratoon crops.
Burning crop residues versus maintenance of a residue blanket	
Evidence indicates that more soil N is mineralised in the presence of a crop residue blanket in the long-term, compared to the absence of a blanket.	Quantification of long-term soil N mineralisation under a residue blanket will permit refined N fertilisation, resulting in savings for growers.
Variety and crop residue blanket interactions	
Amongst varieties studied, N47 produces the highest leaf residue yields in ratoon crops, while N45 produces lower leaf residue yields in general. Under rainfed conditions, leaf residue yields range from approximately 7 to 20 tons/ha depending on variety and production season.	Varietal differences in leaf residue yields occur, although seasonal effects are generally of greater consequence. Residue yield information is vital for the planning of brown-leaf harvesting initiatives by both milling companies and growers.
Resource-use efficiency	
Compared to erianthus (cv. IK76-63), Napier grass, sweet sorghum (cv. Big Kahuna) and sugar beet (cv. Python), selected commercial sugarcane cultivars (N19, N31) are more desirable as feedstocks for second-generation bioethanol production.	Compared to several other crops, sugarcane is a preferable feedstock for second-generation bioethanol production, due to the comparative ease of cultivation and processing versatility.
Crop Nutrition	
A variety of commercial N-source fertiliser products have been categorised according to suitability for application to soils prone to high N volatilisation.	Matching N fertilisers to soil N volatilisation risk will improve grower profitability by reducing N volatilisation losses from applied N fertilisers.
Irrigation decision support	
Cane and sucrose yields are relatively insensitive to deficit irrigation during the tillering phase of crop development.	This information is being used to develop a management tool to assist growers with farm-level irrigation scheduling decisions when water supply is scarce.
Crop modelling	
A new version of the DSSAT Canegro model has been developed to encompass current knowledge of sugarcane biophysical characteristics: germination and emergence, primary shoot development, tillering, tiller senescence, leaf appearance, leaf and stalk elongation and a source-sink partitioning algorithm.	With further ongoing validation, the new Canegro edition will enable prediction of the performance of individual varieties under different environmental conditions, which will ultimately enhance crop modelling capacity and associated forecasting precision within the industry.

Advances made:	Value derived:

Climate change

DSSAT Canegro simulation results suggest that future cane yields under rainfed conditions in the industry, as exemplified by a site at La Mercy, may increase by approximately 20%. The prediction is based on future climate scenarios from three Global Circulation Models set at a future atmospheric carbon dioxide concentration of 734 ppm. The prediction has a high degree of uncertainty due to assumptions of no change in rainfall distribution, solar radiation and relative humidity between the present and future scenarios.	Potential exists of using an ensemble of Global Circulation Models together with DSSAT Canegro to assess potential impacts of climate change scenarios on cane yield. Further refinements (in progress) of the crop model to improve simulations of: (a) elevated carbon dioxide concentration on crop photosynthesis and transpiration; and (b) high temperature effects on crop development, photosynthesis and respiration.

OUTCOMES FROM CLOSED PROJECTS

Potassium in sugarcane production: requirements and interactions with nitrogen and silicon

Specific observations:	Essential outcomes:

The goals of this investigation were to: (a) refine K recommendations of the SASRI Fertiliser Advisory Service (FAS) for rain-fed plant and ratoon crops on low- to medium-base status soils; (b) determine K balance in terms of K inputs and outputs, including assessment of subsoil K use; (c) determine N, K and Si interactions in terms of yield, quality and nutrient uptake; and (d) determine the effects of N, K and Si and their interactions on pests (eldana and thrips) and diseases (rust, smut and mosaic).

Yield Responses

Potassium Nutrition

- Higher K levels significantly increased sucrose yields on both Inanda (41% clay) and Glenrosa (24% clay) soils.
- Responses support current FAS K recommendations.
- The muted K responses observed under certain circumstances suggest utilisation of subsoil and/or 'slowly-available' K.

Nitrogen Nutrition

- A lack of response in sucrose yields to N was observed in plant crops.
- The data suggest that current N recommendations are justified for ratoon crops but not for plant crops.

Silicon Effects

- No yield response to Si amendments was observed on the Inanda soil, although a significant response occurred on the Glenrosa soil.

Interaction Amongst Nutrients

- Interactive effects amongst the nutrients were not consistent across soils or in successive crops on the same soil.

- This comprehensive investigation provided essential information regarding sugarcane K, N and Si nutrition.
- Based on the observations made, it is clear that:
  - FAS recommendations for K, N and Si are accurate and broadly appropriate; and
  - sub-soil and/or 'slowly-available' K levels are to be considered in the formulation of FAS recommendations under specific circumstances.
- Additional investigations are required to:
  - enable the required adjustment of N recommendations for plant crops;
  - clarify the effects of high soil K levels on crop Ca and Mg nutrition; and
  - understand the unexpectedly low level of Si uptake observed during the study (refer to outcomes of Project 08CP02: *Towards a crop nutritional IPM method to reduce the impact of pests and diseases on plant cane).*

Crop Nutrition Status

- Relationships between leaf nutrient concentrations and crop yields were poorly defined, potentially due to intermittent moisture stress experienced throughout the study.
- Silicon treatments resulted in only limited improvements in crop Si uptake and did not raise Si above the 0.75% threshold.

Interaction between Crop Nutrition and Pest and Disease Status

- Treatments (N, K and Si) generally had little or no effect on eldana, rust or thrips.
- Only at one harvest (out of five where measurements were taken) were higher levels of eldana damage observed with increasing N rate.

Development of a system to quantify soil variability (one-year project: 1 April 2014 – 31 March 2015)

Specific observations:

- Soil characteristics often vary quite considerably over short distances within fields, which presents a major challenge for the effective design of research trials, including plant breeding selection trials.
- This variation has previously been accounted for by extensive soil sampling and analysis of the selected site prior to trial establishment.
- The intensity of soil analysis required to fully characterise a trial site is costly, labour-intensive and time-consuming.
- Consequently, the potential of a commercially-available electromagnetic-induction meter (EM-38) to rapidly, reliably and cost-effectively map soil spatial heterogeneity was investigated.
- The outputs from the EM-38 can be related to several soil properties of which salinity, clay, bulk density, soil water and carbon are examples.
- The results of this study revealed that the EM-38 can be used with confidence to: (a) demonstrate variation in clay distribution per depth interval of a land area to be surveyed; and (b) detect the depth interval at which abrupt changes in clay content occur.
- The investigations further revealed that: measurements made with the EM-38 are reliable (repeatable); (b) trends in measurements are consistent between different EM-38 instruments; and (c) the GPS unit supplied with the EM38 instrument is accurate, with a deviation of less than 0.5 m.

Essential outcomes:

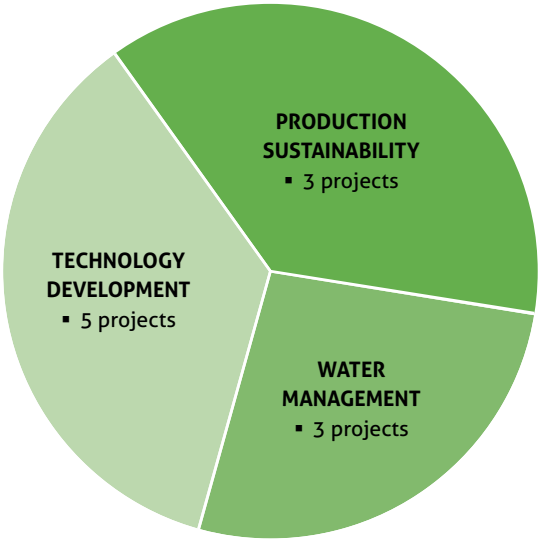
The electromagnetic-induction meter, EM-38, may be used to rapidly, reliably and cost-effectively map certain soil characteristics within a field. If a particular parameter is to be quantified, then attention to instrument calibration is required at each new site. However, if the user is only interested in relative differences, then no calibration is required but ground truthing should be considered.

SYSTEM DESIGN AND OPTIMISATION PROGRAMME

Goal

To investigate, develop and transfer innovative systems that optimise industry performance.

Key research areas



Dr Rian van Antwerpen (Programme Manager)

Production Sustainability

Research in this Key Area focuses on topical issues pertaining to production sustainability, including:

- assessment of the impacts of agronomic and mechanisation issues on production efficiencies and sustainability;
- determination of opportunities for on-farm energy savings and reduction of carbon dioxide emissions;
- deployment of novel technologies to improve operational efficiencies and services to the industry; and
- development of new and improvement of existing technologies and approaches to further promote alignment between research and development and industry requirements.

Water Management

Research in this Key Area focuses on the:

- development of recommendations and advice to promote effective water management and technology deployment, both in terms of irrigation practices and surface water management; and
- analysis of the socio-technical drivers of adoption of technology, recommendations and best practice advice, with specific reference to irrigation scheduling.

Technology Development

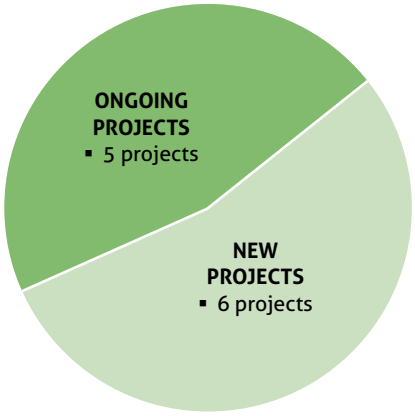
This Key Area encompasses the adaptation, development and deployment of technologies that focus on enhancing internal efficiencies and the quality of service provision to the industry.

STRATEGIC OBJECTIVES

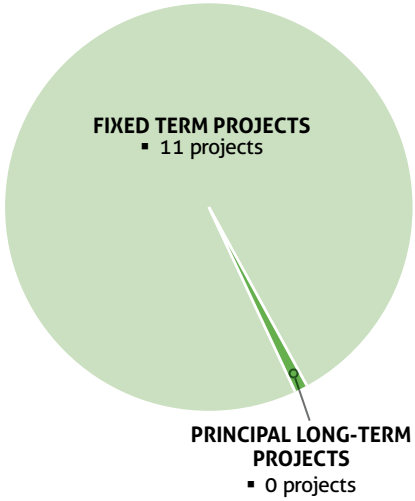
- To design and improve farming systems that account for the economic, social and environmental issues which impact on the sustainability of sugarcane production.
- To design and optimise effective and sustainable mechanisation, water management and supply chain systems for sugarcane production.
- To investigate the economic and social issues that impact on sugarcane farming in order to better understand BMP adoption patterns.
- To facilitate knowledge exchange with growers through appropriate media and contact events in conjunction with the SASRI Knowledge Management Unit and Extension Services.

PROJECT PORTFOLIO OVERVIEW

Project Disposition



Project Type



The impact of lodging on sugarcane revenue (On hold in 2014)

Need Statement:	Lodging may directly or indirectly affect the efficiency of cane harvesting, loading and transport, as well as other management practices, including crop residue management. Although common in the South African sugarcane industry, little research has been conducted to quantify the impact of lodging on revenue.
Project Objectives:	To develop a user-friendly calculator that enables quantification of the impact of lodging on on-farm revenue.
Approach to be Adopted:	Existing local and international literature will be mined to extract qualitative and quantitative information regarding yield penalties associated with lodging and the increased costs associated with lodged cane management. The information will be used to create a comprehensive database on lodging and its effects on harvesting and transport efficiencies. This will be compared with the performances associated with the management and harvesting fields with erect cane. A spreadsheet-based model will be created to indicate the potential cumulative loss in revenue (R/tcane) associated with the lodging and the management of lodged cane.
Anticipated Outcomes:	Increased awareness of yield penalties and increased management costs associated with lodging enabling informed grower decision-making.
Technology and/ or Knowledge Exchange Plan:	The calculator will be made available to Extension Specialists and interested growers in electronic format, while communications regarding the calculator will be presented in The Link, the Proceedings of the South African Sugar Technologists' Association and an appropriate science or agricultural economics/engineering journal.
Value to Industry:	Growers will be able to assess the impact of lodged cane on their revenue and adopt cost-effective practices and systems that might enable improved management and amelioration of the impact of lodging.

Best management practice guidelines for low flow sub-surface drip irrigation systems

Need Statement:	Increasing mechanisation, higher labour costs and smaller profit margins have led to low-flow (0.4 to 0.7 litres per hour) sub-surface drip irrigation (SDI) systems gaining popularity in the industry as a means to supply irrigation water and fertilisers more efficiently. However, poor crop growth (germination and ratoon establishment) and system performance (occasional clogging of emitters) are often reported and ascribed to a lack of proper design and management information pertinent to site-specific conditions.
Project Objectives:	(a) To assess the performance of established low-flow SDI systems under local field conditions in order to develop rules-of-thumb regarding the correct design (installation depth, emitter discharge rate and spacing within the lateral) and management strategy (frequency and duration of irrigation) for a given soil type; and (b) to estimate running costs for low flow SDI systems to quantify potential economic advantage (water saving, reduction in labour requirements, higher yields).
Approach to be Adopted:	(a) The literature will be reviewed to determine how factors such as system design, soil properties and day-to-day management affect the wetting patterns of low-flow SDI systems in different soils. The study will also provide information on appropriate assessment techniques and factors to consider when quantifying economic issues. (b) An extensive industry survey will be conducted (all irrigated areas including Swaziland) to determine the extent of poor performance/constraints of SDI systems, if any, and whether this results from poor design and/or management. (c) A number of existing commercial on-farm SDI systems (with different design and management specifications) on different soil types will be monitored to determine typical wetting patterns, develop rules-of-thumb and gather information on running costs.

Anticipated Outcomes:	The new knowledge and expertise generated by this study will enable confident and unambiguous site-specific recommendations regarding the design and management of low-flow SDI systems. Uptake of the SDI system by growers could further enhance water-use efficiency and has the potential to contribute towards improving profit margins of growers.
Technology and/ or Knowledge Exchange Plan:	The knowledge generated by this study will inform the development of: (a) a guidelines document for the optimal deployment of SDI systems; (b) articles in The Link, the Proceedings of the South African Sugar Technologists' Association and an appropriate science or agricultural engineering journal; and (c) grower days on the farms of growers who have successfully implemented low-flow SDI systems.
Value to Industry:	The envisaged increase in the uptake and effective deployment and management of low-flow SDI systems in irrigated regions of the industry will enhance water-use efficiency in already over-subscribed water catchments and potentially contribute towards improving profit margins of growers.

An economic conversion tool for research results

Need Statement:	When considering whether to adopt a particular technology, recommendation or practice, economics feature prominently in grower thinking and decision-making. Consequently, it is imperative that, wherever possible, SASRI specialists communicate to growers the financial implications of the technologies or practices that they recommend. A particularly important requirement in this regard is that the economic information conveyed is accurate, current and consistent.
Project Objectives:	To develop an economic conversion tool to calculate profitability associated with various agronomic treatments.
Approach to be Adopted:	The envisaged tool will be used in calculating (at the individual trial level) the cost-to-benefit ratio of one treatment relative to another. The tool will calculate "profitability", which can then be treated as any other variable that is routinely measured in field trials. The idea is not to simulate or predict the profitability of a crop for the grower but to create a platform from which "relative" profitability of treatments can be estimated. Given the wide range of agronomic treatments routinely tested at SASRI, the tool will be designed with different treatment categories/templates e.g. varieties, foliar sprays, nutritional treatments. The tool will be designed in user-friendly software like MS Excel, with separate worksheets for different user inputs. A coding sheet will be defined for each trial, linking plot numbers to treatments. A user should be able to copy and paste the cane and RV% of plots from a trial, define certain key costs associated with different treatments, and receive an output of profitability at the plot level.
Anticipated Outcomes:	An Excel-based calculator that will enable SASRI specialists to express the benefits of the technology products and services that are recommending to growers in economic terms, thereby promoting adoption.
Technology and/ or Knowledge Exchange Plan:	The economic conversion tool will made available to all SASRI researchers and release of the calculator will be accompanied by a training workshop. The approach will be communicated to the industry more broadly in the Proceedings of the South African Sugar Technologists' Association.
Value to Industry:	Improved economic reporting will promote the adoption of SASRI technologies and recommendations. The tool will also permit: (a) the retrospective analyses of past research outcomes to establish whether previous recommendations remain viable in changed economic contexts; (b) scenario testing to assess the impacts of input cost increases on the viability of recommendations; and (c) potential assessment of the value brought to the industry by individual SASRI products and services.

Revamping MyCanesim®

Need Statement:	MyCanesim® is a web-based sugarcane crop simulation system designed to assist sugarcane researchers, extension specialists and growers who do not have access to Canepro. The model has been used operationally for yield benchmarking and irrigation scheduling, as well as in many research projects. The crop model component is written in PL/SQL and the supporting algorithms in C# and Java®, while input and output data are stored in Oracle®. The user-interface was developed in Oracle® Portal, which will soon be phased out. The re-creation of Portal user-interfaces of several applications (e.g. WeatherWeb) using the Oracle® Application Development Framework (ADF) is soon to be undertaken by SASRI (see 'Migration of Oracle Forms and Reports to Oracle ADF' on page 42). A number of shortcomings as well as possible new features and improvements to the MyCanesim® model have been identified since the last major revision, which will enhance the usefulness of MyCanesim® as a decision support and research tool for the industry.
Project Objectives:	(a) To add new functionality and improve the MyCanesim® crop model and its user-interface; (b) to update the system documentation; (c) to evaluate the new system to ensure more reliable estimates of crop growth, water use and yield, as well as better quality irrigation scheduling advice; and (d) to market the new system to potential users.
Approach to be Adopted:	The approach comprises several stages, including: (a) expansion of the genetic trait parameter database; (b) improvement and testing of MyCanesim® algorithms; (c) restructuring of system code to allow more effective maintenance and documentation; (d) improvement of the MyCanesim® user interface; (e) addition of a spatial component in ADF to enable mapping of field outlines using Google Maps; (f) addition of an ADF web-interface for smart phones and tablets; (g) preparation of MyCanesim® system documentation; and (h) marketing and training, including the registration of the domain name (MyCanesim.com) and launch of a MyCanesim® blog for user/developer communications and trouble shooting.
Anticipated Outcomes:	An enhanced version of MyCanesim® with greater functionality, enhanced forecasting capacity and an improved user-interface with maps that is accessible by means of tablets and smartphones
Technology and/ or Knowledge Exchange Plan:	The release of the improved MyCanesim® DSP will be accompanied by a series of training workshops for end-users. Communication regarding the upgrades will occur in The Link, The Sugar Journal, the Proceedings of the South African Sugar Technologists' Association and appropriate science journals.
Value to Industry:	The improved MyCanesim® will facilitate: (a) improved irrigation scheduling; (b) calculation of production potential and risk; (c) increased support for agronomic decision-making, including cultivar choice, dryland ripener use, crop residue management and harvest scheduling; (d) exploration of the impacts of climate change on water use and yield; and (e) more efficient and cost-effective system maintenance.

Migration of Oracle® Forms and Reports to Oracle® ADF

Need Statement:	The current SASA Oracle® Application Server is now defunct, as no further patches or product updates are available. This is of significance as most SASRI applications have been built using Oracle® Forms and Reports 10g, Oracle® Forms and Reports 6i and Oracle® Portal 10g and require an application server to allow users to access them via a browser like Internet Explorer. The applications affected include the database serving Breeding, Research and the Fertiliser Advisory Service, as well as MyCanesim® and WeatherWeb. In the short-term, the applications will remain functional, although this will only persist if: (a) the Windows operating system continues to support older versions of Java® Client, which is required to run these applications via the browser; and (b) Java® Client is not upgraded past version 1.6. Consequently, SASRI is currently at risk of applications failure.

Project Objectives:	To rewrite key SASRI Applications (database serving Breeding, Research and the Fertiliser Advisory Service, as well as MyCanesim® and WeatherWeb) on the Oracle® Application Development Framework technology.
Approach to be Adopted:	An agile programming methodology will be implemented to assist the product owners (the specialists who developed the applications) in creating visions for each application. The vision will be reviewed at least annually to validate the overall purpose for the application. The product owners will determine the features that are necessary for the application to accomplish this vision. The feature set will be prioritised and a minimum viable product will be identified. This will form an important deadline as it is at this point that the end users should be able to cross over and use this application in place of the one that currently serves the purpose
Anticipated Outcomes:	A modern and stable technology platform with enhanced functionality for key SASRI applications.
Technology and/ or Knowledge Exchange Plan:	A user manual will be made widely available through a posting on Saziswa in wiki-format.
Value to Industry:	The new technology platform will provide functionalities to ultimately enable grower access to SASRI applications in modern formats, accessible via smartphones and tablets. In illustration, refer to 'Revamping MyCanesim®' above.

OUTCOMES FROM ONGOING RESEARCH

Advances made:	Value derived:
Energy use and carbon footprints	
▪ A tool has been created to enable calculation of on-farm direct energy use and associated greenhouse gas emissions. ▪ A Pump Evaluation Kit has been developed to enable assessment of the efficiency of electrical irrigation pumps.	The tools can be used in life cycle assessments and will enable growers to identify and evaluate opportunities for on-farm energy savings and estimate greenhouse gas emissions.
Drying-off decision support	
Several tools were developed or updated to assist grower decision-making regarding drying-off: (a) a new versatile and flexible database of recommendations; (b) a MyCanesim® optimisation routine and algorithms for calculation of drying-off regimes for new sites; (c) an improved internet drying-off Decision Support Program; (d) simplified drying-off and Total Available Moisture tables based on soil depth and clay percentage; and (e) drying-off calculators or wheels to simplify recommendations to growers.	The variety of updated and new tools available to facilitate drying-off decision-making will serve to promote improved cane quality at harvest in the irrigated regions of the industry.
Water management	
Yield predictions based on crop simulations are enhanced when the model is driven by remotely-sensed crop status information, as compared to simulations based on weather and soil water data alone.	Commercial application of the technology, which facilitates the incorporation of remote-sensing derived data into crop management models, is being pursued by industry stakeholders

Specific observations:

Essential outcomes:

Sugarcane trash recovery for co-generation

- The typical potential energy content of crop residues (brown leaves and tops) from a cane field yielding 100 tons/ha is about 167 GJ/ha, equivalent to 4 639 litres of diesel/ha.
- At a diesel price of R 12.50/litre, the diesel-equivalent value of crop residues is approximately R 58,000/hectare.
- A total of 29 residue recovery routes were considered (14 manually and 15 via chopper harvester) and two case studies were used to evaluate the cost effectiveness of these options.
- In a case study of a Midlands farm 25 km from a mill, the most cost-effective residue recovery route is: (a) manual harvesting with tops removed; (b) transport of cane and residue together; and (c) separation of the residue from the cane at the mill. The cost of this route is R 497.69/ton of residue, or R 29.80/GJ.
- In a case study in the northern irrigated region for a farm located 153 km from a mill, the most cost-effective residue recovery route is:
  a) cane harvest by means of a chopper harvester with the extraction fans running; (b) raking of in-field residue with collection by means of a forage harvester; (c) transport of residue to a processing plant established 5 km away to increase feedstock bulk density; and (d) transport of densified residue to the mill separately to cane. The cost of this route is R 424.77/ton of residue, or R 25.44/GJ.
- The cost of both these least-cost residue recovery routes proved to be less than that of the coal equivalent cost (R 600/ton, calculated by multiplying the coal cost in energy terms of R 36.18/GJ by the energy in cane residue of 16.7 GJ/ton) and both are thus economically feasible.
- For the Midlands case study, four residue recovery routes (one manual and three mechanical harvested) were economically feasible, while for the Irrigated North case study, three options were economically viable (all mechanically harvested with various residue densification options). The other residue recovery routes investigated were not economically feasible.

- Economically-viable crop residue harvesting and transport options have been identified.
- As part of the study, the Econocane costing model was elaborated to assist in estimating the costs associated with residue recovery and costing.
- As yet, the model does not take into account the storage of sugarcane residue which might be required for the off-season.
- Improved model precision has the following requirements: (a) improved capital cost values for pelleting/torrefaction/TOP (combined torrefaction and pelletisation) processing plants; and (b) a more comprehensive cost system for residue separation at the mill.
- Further case studies (both from South African and international trials) are required to validate the model. Those data would help ensure that the model calculates realistic current real-world costs.

Optimisation of in-field mechanisation during harvesting operations

- Sugarcane crop extraction from the field is typically associated with heavy in-field traffic, which leads to considerable yield losses.
- An exhaustive meta-analysis of data derived from trials conducted both locally and abroad revealed that traffic in the inter-row or on the row resulted in an average yield loss penalty of 5% (n=40) and 24% (n=26), respectively, relative to no-traffic control treatments.

- The study has provided estimated yield losses associated with the in-field movement of equipment comprising popular harvesting systems.
- Such economic assessments will facilitate:
  - more informed decision-making regarding equipment selection and the design and implementation of field operations or field practices.
  - advanced planning and optimisation of existing in-field harvesting operations and management.

- To determine how in-field traffic might be currently impacting on yield in the SA industry, the in-field movement of equipment associated with popular harvesting systems was tracked and the data visualised by means of GIS.
- Using the benchmark data from the meta-analyses and GIS maps of typical in-field traffic patterns, yield losses were assigned to different levels of traffic intensity, which were estimated for individual items of equipment accounting for axle loads and tyre pressure.

HARVESTING SYSTEM AND IMPACT RATING *The subjective Impact Rating is presented in parentheses, where: L = low impact; M = moderate impact; and H = high impact.*	Estimated field production yield loss (%)
Single-stack self-loading trailers (L/M)	1.0
Double-stack self-loading trailers (L/M)	1.2
Non-slewing loader, 1 windrow (L/M), box trailers (L /M)	4.7
Non-slewing loader, 2 windrows (L/M), box trailers (L/M)	6.0
Non-slewing loader, 3 windrows (L/M), tri-axle trailer (H)	9.2
Slewing loader (L/M), 2 x tandem-axle trailers (H)	3.2

WeatherWeb Real-Time Weather Data

Specific observations:

- A system was implemented to enable low-cost frequent (near continuous) automatic weather station (AWS) data downloads by replacing airtime-based Global System for Mobile (GSM) modems with internet/data-based general packet radio service (GPRS) modems.
- The Real Time Monitor and Control software package was used to design a screen display of real-time AWS weather data and related variables, updated every five minutes and with options to save the data tables to one's computer.
- A website was created to enable accessibility of the real time AWS data on the internet.
- Eighteen AWS (14 owned by SASRI and another four owned by private growers/estates) are on the system and a plan has been devised to gradually and systematically upgrade the remaining 15 AWS on the SASRI network to the system.

Essential outcomes:

Real-time weather data and associated derived data from a network of 18 automatic weather stations throughout the industry are now available via the SASRI weather website, http://portal.sasa.org.za/weatherweb/, where it can be accessed by all industry stakeholders.

Developing a system for electronic data capturing at SASRI (one-year project: 1 April 2014 – 31 March 2015)

- The feasibility of tablet technology for capturing data in the field was demonstrated.
- However, several issues where identified that require resolution before electronic data capture could be fully integrated into operations, including: (a) expanded testing to encompass more users and applications; (b) optimisation of the data capture process; and (c) fostering increased buy-in of potential users of the technology.

- This project has demonstrated that electronic tablets can indeed be used to capture data efficiently in the field.
- SASRI will benefit significantly from capturing field data electronically through a more efficient and streamlined data flow process from field to final analysis.
- The transition to infield electronic data capture should therefore be seen as a critical next step as it will allow SASRI to take advantage of the advances in information technology, as well as improve the validation, use and protection of arguably the most valuable asset of SASRI – the data from many of its research projects.

Research Contracts

INTERNATIONAL CONSORTIUM FOR SUGARCANE BIOTECHNOLOGY

Towards a "mosaic" monoploid sequence of the gene-rich part of the sugarcane genome

RESEARCH TEAM:
Dr Angélique D'Hont (CIRAD, Montpellier),
Dr Karen Aitken (CSIRO, Brisbane),
Dr Bernard Potier (SASRI)

DURATION:
1 Year (April 2014 – March 2015)

PROGESS:
A significant section of the sugarcane genome that contains important genes was sequenced, with SASRI playing an important role alongside the CSIRO (Australia), Queensland Alliance for Agriculture and Food Innovation (Australia), CIRAD (France) and the University of São Paulo (Brazil).

- Research has clearly demonstrated the success of the strategy developed for sequencing strategically important parts of the large and complex sugarcane genome.
- Availability of the partial genome sequence will inevitably lead to innovations in sugarcane breeding, as has occurred in other important commodity crops with sequenced genomes.

NORTH-WEST UNIVERSITY

Effects of elevated CO_2 concentration on local sugarcane varieties

RESEARCH TEAM:
Professor Gert Krüger,
Dr Jacques Berner,
Dr Misha de Beer-Venter,
Ms Charné Malan (MSc Student) (School of Biological Sciences),
Dr Alana Eksteen,
Dr Riekert van Heerden (SASRI)

DURATION:
4 Years (April 2014 – March 2018)

PROGESS:
The collaborative research commenced on 1 April 2014 and good progress has been made:

- a post-graduate (MSc) student was recruited;
- sugarcane varieties (NCo376 and N31) selected for study were established in the open-top high CO_2 incubators on the NWU Potchefstroom Campus.
- In 2015, the effect of elevated CO_2 on the growth and physiology of the sugarcane will be monitored over the year (early Spring to late Autumn).

UNIVERSITY OF KWAZULU-NATAL

Profiling, issue identification and comparing different sugar milling areas in South Africa

RESEARCH TEAM:
Professor Carel Bezuidenhout, Professor Peter Lyne (School of Engineering) and Professor Gerald Ortmann (School of Agricultural, Earth and Environmental Sciences)

DURATION:
3 Years (April 2013 – March 2016)

PROGESS:
Five post-graduate students were recruited and the following accomplished:

- review of the international literature on stochastic seasonal rainfall generators, sugarcane deterioration under different conditions and sugar quality;
- participation of six South African mills was secured.
- The study will deliver mill-specific models to facilitate stakeholder decision-making regarding system efficiency improvements.

STELLENBOSCH UNIVERSITY

Integration of area-wide pest management methods for arthropod pests in South Africa, with special reference to the Eldana Sterile Insect Technique

RESEARCH TEAM:
Dr Pia Addison, Professor John Terblanche (Department of Conservation Ecology and Entomology), Dr Des Conlong (SASRI)

DURATION:
3 Years (April 2013 – March 2016)

PROGESS:

- A pilot project to establish proof-of-concept regarding the efficacy of the sterile insect technique (SIT) to suppress Eldana population size was placed on hold due to insurmountable technical issues related to the unavailability of a moth irradiation facility in KZN.
- Options for establishing the Eldana moth irradiation facility in KZN that is required for establishing SIT proof-of-concept are to be pursued in 2015/2016.

Modelling to Aid Release Strategy and Cost Benefit Decisions for Sterile Insect Technique (SIT)

RESEARCH TEAM:
Professor Jan van Vuuren, Dr Linke Potgieter, (Department of Logistics), Dr Des Conlong (SASRI)

DURATION:
3 Years (April 2013 – March 2016)

PROGESS:

- The population dynamics of Eldana in differently configured sugarcane habitats were investigated by means of the mathematical simulation modelling of Eldana population growth and dispersal. A primary objective of the research was to establish which field structure layouts perform best in terms of average infestation over time. It was found that more diversified field configurations (in terms of crop age) yield lower infestation levels.
- The models developed will ultimately inform the release strategies to be adopted during the potential future deployment of the Sterile Insect Technique.

Genetic engineering of sugarcane to enhance sucrose accumulation and to improve the fermentability of remaining biomass

RESEARCH TEAM:
Professor Jens Kossmann, Dr Christell van der Vyver (Institute for Plant Biotechnology)

DURATION:
3 Years (October 2014 – September 2017)

PROGESS:

- Several transgenic sugarcane lines were produced to: (1) enhance sucrose concentration (separate over-expression of glucoronokinase, uracil monophosphate synthase and adenylate kinase).
- Preliminary proof-of-concept demonstration obtained of potential of GM technologies to increase sugarcane sucrose content (sugar yield).
- Inclusion of GM research to enhance sugarcane drought tolerance is to be pursued in 2015/2016.

Achievements and Awards

Value derived:

International standing

- Eighteen peer-reviewed publications were published in internationally-accredited scientific journals.
- Six chapters were published in books with wide international recognition and distribution.
- Thirteen Honorary University appointments were sustained by staff members.
- NRF rating was awarded to a further three SASRI scientists in addition to the ratings currently held by six scientists.
- Four SASRI scientists achieved professional registration in terms of Section 20(3)(a) of the Natural Scientific Professions Act, 2003 (Act No 27 of 2003).
- Several international collaborations were sustained (SRA, CIRAD, CSIRO, ICIPE, ICSB, ICSM, IRD, MSIRI).
- Thirteen post-graduate students and four post-doctoral researchers were based full-time at SASRI.
- Degrees were conferred on one PhD and six MSc post-graduate students.
- Research of eight SASRI staff was undertaken towards post-graduate qualifications (4 PhD, 4 MSc)
- Six staff obtained MSc or MSc (Engineering) degrees.
- The contribution of one staff member to the development of plant biotechnology in SA was officially recognised by SAASTA.

Quality assurance and bench-marking research excellence against best in the world thereby ensuring innovative and advanced technology development.

Increased research capacity provided through collaborations and post-graduate research programme thereby providing more value to our stakeholders.

Strategic R&D Partnerships

SASRI maintained formal research partnerships or collaborations as follows:

- School of Engineering (UKZN): Research project and Senior Research Fellow position at UKZN.
- Institute for Plant Biotechnology (SU): Research project.
- Department of Entomology and Conservation Ecology (SU): Research project.
- Department of Logistics (SU): Research project.
- ICSB: Research project.
- ICSM: Research project.
- WRC: Research project.
- WESSA: Research project.

SASRI seeks out new and fosters established partnerships to enhance its research and development capacity for the benefit of the industry.

Funding Awards

	Value derived:
▪ Funding for three projects conducted in conjunction with SU and UKZN was leveraged from THRIP of the DTI (managed by the NRF). ▪ SASRI Researchers were awarded grants from the NRF's Thuthuka Programme and the DST's Bioinformatics and Functional Genomics Programme. ▪ Research excellence at SASRI was recognised by the award of NRF Incentive funding to eight SASRI scientists and project co-funding from the WRC, WWF, DAFF and NRF.	Increased leveraging of funds achieved, contributing to research efforts.

Acronyms

CIRAD - Centre de coopération internationale en recherche agronomique pour le développement (France)

CSIRO - Commonwealth Scientific and Industrial Research Organisation (Australia)

DAFF - Department of Agriculture, Forestry and Fisheries

DST - Department of Science and Technology

DTI - Department of Trade and Industry

ICIPE - International Centre of Insect Physiology and Ecology (Kenya)

ICSB - International Consortium for Sugarcane Biotechnology

ICSM - International Consortium for Sugarcane Modelling

IRD - Institut de recherche pour le développement (France)

MSIRI - Mauritius Sugar Industry Research Institute (Mauritius)

NRF - National Research Foundation

SAASTA - South African Agency for Science and Technology Advancement

SRA - Sugar Research Australia (Australia)

SU - Stellenbosch University

THRIP - Technology and Human Resources for Industry Programme

UKZN - University of KwaZulu-Natal

WESSA - Wildlife and Environment Society of South Africa

WRC - Water Research Commission

WWF - World Wildlife Fund

Awards

▪ SASRI Soil Scientist, Ruth Rhodes, was awarded the prize for 'best paper in the soil sciences' at the 2014 Combined Crops, Soils, Horticulture and Weeds Congress that took place at Rhodes University (20 - 23 January). Ruth's award was for her paper entitled "Crop nutrition and soil textural effects on *Eldana saccharina* damage in sugarcane" which she co-authored with Drs Neil Miles and Malcolm Keeping.

▪ Tendekai Mahlanza was awarded the sole 2014 PhD international travel grant offered by UKZN's College of Agriculture, Engineering and Science. Tendekai submitted an abstract for the joint Society for In Vitro Biology (SIVB) and Cryobiology meeting '2014 World Forum on Biology' meeting in June in Savannah, Georgia USA.

▪ In December 2014, Drs Stuart Rutherford, Marvellous Zhou and Sanesh Ramburan were awarded National Research Foundation (NRF) ratings. Stuart Rutherford and Marvellous Zhou were categorised as Established Researchers who have, over an eight year period, produced a sustained, cohesive body of original, high quality knowledge that has been communicated in relevant, internationally-accredited discipline journals. Dr Sanesh Ramburan was recognised by the NRF as a highly Promising Young Researcher who is on-track to become an Established Researcher within five years. This category applies to researchers who are younger than forty years-of-age and who have been in possession of a PhD for less than five years.

▪ At the annual Combined Congress that was held in George from 19 to 22 January 2015, Ruth Rhodes, Francois Olivier and Drs Rianto van Antwerpen and Alana Eksteen were awarded prestigious titles. Rianto van Antwerpen was elected President of the Soil Science Society of South Africa (SSSSA) and will serve in this position for 2015 and 2016. Ruth Rhodes was elected to serve on the SSSSA Council and Alana Eksteen was elected onto the Council of the South African Society of Crop Production.

▪ Francois Olivier won the Best Poster in Agronomy prize at the Combined Congress for the poster "Monitoring soil water content for drip irrigated sugarcane with capacitance probes" that he co-authored with Dr Abraham Singels and Aresti Paraskevopoulos.

▪ Prabashnie Ramouthar was elected onto the Nematological Society of Southern Africa as the 2017 symposium organiser.

Extension

The SASRI Extension Service plays an integral role in facilitating the production of sugarcane in a profitable, sustainable and environmentally responsible manner. This is achieved by communicating stakeholder needs to SASRI so that an appropriate Programme of Work can be developed, by facilitating effective technology exchange with relevant stakeholders, participating in Research Projects, communicating outcomes from research to the industry and facilitating access to a wide range of relevant support services.

In the 2014/15 season, with the exception of the Mpumalanga region, rainfall was generally very poor across the industry, with half of the industry receiving less than 60% of the Long Term Mean (LTM) by the end of March 2015. This comes on the back of the previous season's low rainfall and highlighted a number of crop-stress issues which Extension had to deal with.

NORTHERN IRRIGATED REGION

MPUMALANGA

With the decent summer rains during late 2013 and early 2014, lodging was an issue in those fields exceeding 100 tons/ha. Ripening of cane has become a common practice in the region. Generally this was a good season for both large and small-scale growers (SSGs). Yields were above normal and the quality figures satisfactory. There was some carry-over cane, which reflected positively on the tons cane per hectare figures going into the 2015/16 season.

There were several instances of cane producing side-shoots after being sprayed with the ripener Ethephon™. SASRI specialists are currently investigating this issue as side-shooting is not normally associated with this chemical.

There were increasing instances of heavy infestations of eldana in young ratooning cane. Growers used chemical control over large areas where infestations were found, predominantly in the Komati area. There was a noticeable decline in cane quality with the flowering-prone varieties, especially N14 and N23.

The annual grower award ceremony was held at the end of March 2015. This is where TSB recognises the best performance by growers in the area during the previous season. The top spot this year went to TSB Libuyile - Bien Donne farm with a relative tons RV/ha/annum of 16.09 followed by UVS at 15.94 and TSB Libuyile Voorspoed at 15.40. Among the SSG, 14 growers performed exceptionally well with relative tons RV/Ha/annum values in excess of 16.

PONGOLA

Lodging was a problem, which was caused by a number of factors such as the large area of carry-over, high yields and strong winds.

Geoff Maher
(Extension Manager)

The application of ripeners was adopted by more growers and spray programmes were all on track.

With the large carry-over area, cane was diverted to the Felixton mill. The level of eldana damage was higher than usual on a number of these carry-over fields, especially on N46

with two fields of N46 being rejected due to eldana damage. Growers were advised to take care in the selection of future carry-over fields and to take special steps to control eldana in these fields. A strategy is being prepared to prevent the increase in eldana numbers due to the large size of the carry-over crop of the past three years and the years to come.

The adoption of new varieties is progressing well with more than 200 ha having been planted to N57 and with a good uptake of N53.

A hail storm damaged about 700 ha of cane, about 400 ha of which was severely damaged. This resulted in about 60 ha of young cane having to be slashed back to regrow, and a large area of immature cane being harvested early to limit losses. A substantial portion of the young hail damaged cane was also affected by an outbreak of armyworm three weeks after the hail storm.

Even with the continued dry spell there was still sufficient irrigation water available throughout the season, however, the level of the Bivane dam decreased dramatically.

ZULULAND

UMFOLOZI

April to June 2014 was an exceptionally dry period resulting in the Umfolozi River drying up significantly toward the end of June, triggering restrictions on growers' water abstraction. However, the March 2015 rainfall brought some welcome relief with the rains falling at strategic times. Water restrictions on the Umfolozi were lifted later in the month after some good rainfall in the catchment.

Road haulage was an issue and this put the tramline system under pressure. The Umfolozi Sugar Mill (USM) requires both tramline and road haulage to keep the mill running economically. Due to poor estimating, some growers found themselves with more cane than the mill was able to crush at the end of the season.

Of serious concern was the RSD prevalence in the area. Growers were encouraged to improve planting and harvesting practices to control the problem.

The Umfolozi Cane Growers offices burnt down on the night of the 13 September 2014 due to an electrical fault. This building housed the Mill Group Board, SASRI Extension and SA Canegrowers. The staff were re-located to the Old UCOSP offices which USM kindly made available.

Several sugarcane farmers from Zambia who were on a visit to the South African sugar industry stopped over at Umfolozi on 20 March 2015. There were valuable discussions and exchange of ideas between the two grower groups.

There is a likelihood of future visits to the area by Zambian farmers and the possibility of a reciprocal tour by Umfolozi growers to Zambia.

FELIXTON

Rainfall in all the areas supplying the Felixton Mill remained below the LTM for most of the season. This shortage of rainfall had a severe effect on irrigation due to the level of the Goedertrouw Dam being only 51%. Water restrictions were imposed with the water allocation for agricultural use being cut by 50%, effective from 1 February 2015. This water restriction was to be reviewed in May 2015. Crop growth suffered greatly with very little cane growth being observed.

There were reported cases of heavy trash worm infestations in some fields in the area. Monitoring of red locusts commenced in October 2014, with large swarms of red locust being observed on several farms. Of concern was the eldana infestations on new shoots, which caused considerable damage with many shoots dying-off.

'Best Sugarcane Management Practices' study groups were introduced in Felixton during the year. These study groups focus on local area issues and have been well attended and well received by many growers.

The Felixton Local Environment Committee (LEC) was disbanded, with environmental issues now falling under the ambit of the Felixton Cane Growers Association. The monitoring function of the LEC will be carried out by the Department of Agriculture.

There was a poor record of SUSFARMS® Progress Tracker submissions with the lack of land use plans being raised as a huge concern in this regard.

AMATIKULU

Rainfall during the 2014 calendar year has proven to be the worst on record for the whole of the Amatikulu supply region with 419.6 mm being recorded at the Amatikulu mill - the lowest annual rainfall recorded since 1913. The crop suffered tremendously from the prolonged dry and hot weather conditions which also resulted in numerous fires. In the new development areas within the SSG sector, fires have resulted in thousands of tons being burnt, with consequent delays in the burn to crush period.

Poor milling performance led to growers maintaining an inflated estimate in the hopes of increasing their daily allocation. Overall reduction in yield potential for the supply area was about 15%, but in excess of 20% for the coastal region. Ratoon failure was fairly widespread and a large proportion of fields suffered from a reduction in plant population, which will result in yield reduction during the next season. The economic ramifications are extreme and the consequences will be dire for a number of growers.

While the hinterland growers generally managed to control eldana through the use of Fastac®, there were a few isolated outbreaks. One field of N35 that was unintentionally carried over and not sprayed was severely infested (recording 115e/100 in March) and proved to be a source of infestation for neighbouring fields.

Lack of fire control within the Land Reform and SSG sectors is one of the biggest obstacles to sustainable cane farming. Most vegetation is extremely dry and this has led to numerous devastating fires, particularly in the Melmoth and Eshowe/Entumeni areas. At one stage during July, there were approximately seventy thousand tons of burnt cane in the supply chain. Unfortunately, this coincided with a period of particularly poor milling performance and some of this cane took almost three weeks to be milled.

Given the drought, fires, mill strikes and poor milling performance, 2014 rates as one of the worst years ever experienced in the Amatikulu region.

NORTH COAST

DARNALL, MAIDSTONE, GLEDHOW

The continuing dry spell during the season resulted in very dusty conditions being experienced, especially in the Darnall area, where soils hardly had any moisture available for plant growth. The hot and extremely dry conditions contributed to the occurrence of a number of runaway fires. Low rainfall throughout the season caused the crop to experience drought conditions, especially in the Darnall area where the fields were severely affected. Many growers were forced to harvest immature cane due to the constant arson fires burning many hectares of young cane and even seedcane.

Yellow Sugarcane Aphid seemed to have had a bigger impact on fields than originally thought. Serious damage to both old and young cane was observed with some reports of almost complete crop devastation.

A successful SUSFARMS® workshop held with Tongaat Hulett Sugar managers resulted in almost all of the Maidstone growers returning their Progress Tracker reports. Analysis of these has shown that the biggest problem seems to be the lack of Land Use Plans.

A workshop was held in conjunction with CANEGROWERS to address the issue of Burning Codes of Practice for

the North Coast. The outcome of the workshop was the recommendation to draft a document that will be used as a standard burning code of practice for all three mill groups on the North Coast.

Investigations into implementing a full Fastac® spray programme for eldana starting at the end of August and continuing through to December resulted in a favourable return on investment and very low eldana counts going into the new season.

Analyses of SASRI's Fertiliser Advisory Service (FAS) results have shown that many growers are over-applying fertiliser at huge expense due to fertiliser applications being based on over-inflated yield expectations and old soil analyses. Growers were encouraged to undertake regular sampling.

MIDLANDS

NOODSBERG

Severe frost events early in July 2014 unfortunately caused widespread damage to both the 2014 and 2015 crop. There were reports of temperatures as low as -10°C. The frost damage was exacerbated by a crop already stressed as a result of the very dry conditions. The frost events which took place were worse in extent and severity than previous years, with some growers reporting that it was the worst in 35 years. About 50–60% of area under cane in the Midlands North area was affected.

Extremely dry conditions prevailed during the season. Daytime temperatures approached 30°C, with some days experiencing hot, windy conditions, which caused most cane in the area to exhibit severe moisture stress symptoms. The burning of cane for harvesting also became very dangerous, with reports of runaway fires. Good rainfall was recorded during January and February 2015, which brought some relief and the cane responded well.

WWF has been assisting SASRI Extension with the investigation of

an "Environmental layer" to be added to a conventional Land Use Plan. This was in response to the SUSFARMS® Progress Tracker requirements related to the open areas on the farm such as wetlands, grasslands and natural forests. Such a layer enables the identification, mapping and classification of these areas on the farm. WWF also offered assistance in the development of education interventions with growers regarding the environmental aspects contained within the SUSFARMS® Progress Tracker. These interactions were in the form of grower days or study groups.

A meeting was held with representatives of both UKZN and Monash South Africa to discuss an international water security research programme. The study involves the Umgeni River basin, which is being used as a case study to assess sector-based self-governance and self-regulatory systems with a focus on water security. The sectors being looked at are timber, cane and dairy. SUSFARMS® was used to gain a better understanding of the sugarcane sector and to share lessons learnt.

ESTON

Very little rain fell during the season resulting in the district experiencing the driest period in the last 50 years. Heavy frost was also experienced throughout the whole area with 20% of the 2014 crop being affected. The widespread frost also had a negative effect on the 2015 crop with almost 20% of the crop being damaged. With the season's very low rainfall, several growers experienced stool deaths. The combination of poor growing conditions and widespread frost resulted in a lack of seedcane for planting.

With the eldana numbers increasing in the area, the consensus was that next year's crop will have to be treated with chemicals where eldana numbers are high. Eldana is becoming a concern in young 10-14 month old ratoon cane. In cases where eldana-affected cane was not treated, eldana counts were as high as 40e/100.

An investigation into some very poor cane quality results at the mill revealed that Sour Rot was the cause. Five farms reported seeing Sour Rot in their cane.

Seedcane was very scarce, which caused a number of the larger growers to long-fallow some of their replant fields due to the unavailability of seedcane.

Some growers have set new records with very high RVs, with several growers achieving 20 t RV/ha.

SOUTH COAST

SEZELA

The rainfall received during the season was well below the LTM with severe frost being recorded at the beginning of July 2014 in the inland ward areas. Some of the inland growers who underestimated the severity of the frost experienced extensive damage, which could affect next year's crop as there were fields that had to be harvested earlier than normal.

About 5 000 tons of cane were lost due to the frost.

The dry conditions seriously stunted the crop's development particularly with regards to the coastal cane. A positive aspect of the dry conditions was the favourable RVs attained by some growers with the RV for the month of June 2014 reaching 13.79%.

The mill strike that occurred in June 2014 saw no deliveries been accepted by the mill. Unfortunately, due to logistical constraints, about 7000 tons were not delivered to the mill before the strike commenced. This problem was further compounded by an additional 6 000 tons being affected by arson fires.

The second half of the ripening strip trial that is being conducted on Kembali farm (Hibberdene area) was harvested with very favourable results. The trial consisted of 17 month old N39 that was piggy-back ripened with Ethephon™ and Fusilade® Forte. The difference in RV results between the treated area and the control was 1.6% proving that coastal ripening provides an excellent return on investment.

UMZIMKULU

Severe frost was recorded at the beginning of July 2014, affecting the inland ward areas. This widespread frost provided the lowest temperatures experienced in the inland areas. Poor rainfall continued from April until August 2014 and the dry weather continued to be a challenge as drought stress became more evident. Fires posed a challenge due to the dry weather, resulting in some growers delivering immature cane to the mill.

The rainfall in December 2014 was slightly higher than that of November 2014 and was also very well spread over the month. Although the LTM was not reached, the rainfall was sufficient and effective. The rainfall continued to arrive in small amounts at regular intervals. The region also experienced a large storm event, which brought strong winds and hail. These strong winds caused lodging of cane in certain areas of Harding.

In general, the southern coastal cane looked healthy with no obvious effects from the dry conditions. However, the northern coastal cane received less rain, and there were some areas with gaps, especially on hilltops and on very steep slopes. Inland, the cane looked very healthy and green. With the Department of Transport clamping down on overloading and requiring mass measurements on each axle, growers were concerned about the future cost implications as a large number of the hauliers do not have load cells on each axle.

SMALL-SCALE GROWERS AND LAND REFORM BENEFICIARIES

Much time was spent on compiling Agronomic Assessment Reports for the Department of Land Affairs and Rural Development as well as the Agribusiness Development Agency (ADA). The purpose of these agronomic assessment reports was to secure finances from government. A special Land Affairs and Rural Development meeting was held at the government offices in Richards

Bay to discuss the interventions required to rescue land reform farms from being repossessed by the Land Bank. Agreements were reached for government to recapitalise these farms.

The 5-year renewable Extension Venture Agreement (EVA) between SASRI and the Department of Agriculture and Rural Development (DARD) ended on 31 March 2015.

The new EVA agreement was drafted with both SASRI and DARD expressing support for the terms of the new agreement and a continued partnership through the EVA Monitoring Committee.

The following advances were made in the year:

- Inclusion of land reform extension support in the new EVA agreement, and a further two SASRI Extension staff members' costs to be subsidised by DARD.
- Additional DARD extension staff for the South Coast and Zululand regions in order to increase capacity.
- Improved understanding of weed control and adoption of a simplified calibration method by small-scale growers using the drum method, which was the theme for the 2014 Annual SSG Modular courses.

The successful EVA Annual Refresher Training programme co-ordinated by SASRI for DARD extension staff led to further requests to develop a customised training programme for all DARD Extension staff operating in sugarcane regions.

SUSFARMS®

Sustainable farming is high on the agenda of SASRI Extension and in the 2014 year, much emphasis was placed on encouraging the adoption of the Sustainable Sugarcane Farm Management System, SUSFARMS®.

In the Midlands region, the Midlands Sustainable Sugar Supply Chain Collaboration known as 'SUSFARMS 2018' was launched in June 2014 and includes Noodsberg Canegrowers, Illovo Planters Group, Illovo Group, UCL, SASRI, WWF, SAB Miller and Solidaridad southern Africa. This collaboration promotes sustainable sugarcane supply chains and supports the implementation of SUSFARMS®.

The collaboration seeks to support their major customers of sugar in reaching their 2020 vision of sustainably sourced sugar from South Africa. SUSFARMS® will further be used as the vehicle to achieve the implementation of sustainable sugarcane farming practices in the Midlands region.

Technology Transfer & Knowledge Exchange

Much emphasis was placed in 2014 not only on ensuring that our stakeholders were *informed* of new research outcomes, but also on *learning* from them – focussing on knowledge *exchange* rather than only on knowledge *transfer.*

Popular Articles

In the 2014/15 reporting period, four editions of *The Link* and *Ingede* magazines, aimed at our English and isiZulu speaking growers, were published. These focussed on many of the issues that were raised by the industry during our annual Research, Development and Extension workshop, along with issues that were pertinent to specific regions. Other media included articles in the South African Sugar Journal, Coastal News and popular agriculture magazines.

The Link Newsletter

Out of the forty-one articles published in *The Link*, two of the main subjects that were addressed were soil sustainability and pest control.

The Ingede Newsletter

The *Ingede* focussed on important aspects of sugarcane agriculture for the small-scale grower. Topical tips (a regular feature of each *Ingede*) are appropriate for each month in the farming calendar and provided clear guidance on management interventions and necessary activities to ensure a good crop.

eNewsletters

Monthly electronic newsletters are regular outputs from many Extension offices. These newsletters contain information and advice specific to the region and are an important communication tool for Extension Specialists.

In January 2014, SASRI launched a new bilingual eNewsletter for the Lowveld region called *The Lowveld Insight* or *Laeveld Insig*. These contained specific information for Mpumalanga growers and focussed on irrigation, weed control and mechanisation issues.

Michelle Binedell
(Knowledge Manager)

"Publications have effectively communicated existing and new best practice to industry stakeholders in an effort to support their uptake.

LINK ARTICLES PUBLISHED IN 2014/2015

Regular features
- Topical Tips
- Weather
- Messages from the Director

Weed control
- Famine weed (Parthenium): A deadly invasive
- Cynodon control

Stewardship and sustainability
- Agrochemical stewardship
- Driving a community toward sustainability
- Evaluating sugarcane biomass for energy production
- SUSFARMS®: Supporting sustainable farming into 2015

Pest and disease control
- Improve Your profits!
- Chemical roguing for smut
- Smut control in Mpumalanga
- A new nematicide for the sugar industry
- New Pest Alert: Yellow Sugarcane Aphid
- What to look for when identifying rust
- Biosecurity Hotline – New Number
- Nitrogen and Eldana
- Trash caterpillars in sugarcane

Cane quality
- Harvest to Crush: Don't Delay!
- Dealing with accidental cane fires

Mechanisation
- Mechanical sugarcane harvesting

Ripening
- Chemical ripener responses in varieties grown under coastal production conditions

Soil sustainability
- Understanding your Soil Test Report
- Soil Health in Perspective
- Keeping track: The importance of keeping FAS records
- Soil Health: Farming with nature – Keeping soils covered
- Mind your language: Stop talking trash
- Turn over a new leaf: Take regular leaf samples
- Why should I consider controlled traffic?
- Fertiliser Advisory Service: SABS ISO 9001:2008 Certification
- Soil Health: Earthworms : Soil Doctors!
- Soil Health: Unpacking soil organic matter

Varieties
- The never-ending quest for better sugarcane varieties
- Optimising age at harvest
- Flowering: What does pithiness have to do with it?
- Ratooning-ability of newer varieties
- N41: A widely adapted variety with limitations
- N41 Smut Alert

Irrigation and climate
- Matching sprinkler irrigation application to soil water holding capacity
- SASRI weather products ... for better decision making!
- Climate change impact on sugarcane agriculture

INGEDE ARTICLES PUBLISHED IN 2014/2015

January 2014
- Field measuring and job tasking
- Demonstration plots
- The importance of cane estimates
- Topical Tips
- Radio broadcasts

May 2014
- Yellow Sugarcane Aphid
- The seven secrets of soil
- Parthenium weed
- Topical Tips
- Obrico field day

September 2014
- Burnt cane not harvested
- Soil potential
- Planting depth
- Control of Parthenium weeds
- Topical Tips

January 2015
- Recent weed control modular courses
- More demonstration plots requested
- Sugarcane estimates
- Contractors and sugarcane harvesting
- Year planner programme
- Changes within Extension at SASRI

Over the year, SASRI published twenty-three articles in the *South African Sugar Journal* and ten articles to *Coastal News*, once again show-casing SASRI's achievements and promoting best practice.

Technical Publications

Information Sheets provide a platform for the communication of research outcomes as well as guidelines and advice on the management of the sugarcane crop. A total of sixteen information sheets were published containing new and updated information on varieties, pests, diseases and good production practices.

Annual updates of the Herbicide Guide, Mechanisation Reports and Rates for SASRI Services were completed providing recommendations, new products and prices relevant for the new year.

Two technical booklets *Sugarcane Diseases in southern Africa* and *Seedcane Production* were updated with latest information pertinent to the management of diseases and the production of good quality seedcane.

Since one of the most important activities of a grower is related to the identification and management of sugarcane pests and diseases, a technical pocketsized *Pest & Disease Guide* was produced. This small, colourful, robust booklet is an invaluable tool for both growers and biosecurity staff.

ARTICLES PUBLISHED IN THE SOUTH AFRICAN SUGAR JOURNAL-2014/15

- Agrochemicals in the sugar industry
- Encouraging sustainability: SASRI student field day
- Unlocking the potential of sugarcane
- The SASRI Herbicide Guide
- Irrigation management – Getting the balance right
- Donovale Farm – Picture perfect
- Factors affecting the selection of an effective irrigation system
- Make more money by cutting costs
- SASRI's Mechanisation reports
- Controlled traffic systems
- Mechanisation systems
- Crop protection
- Biosecurity in the SADC region
- All about agrochemicals
- The search for alternative chemical remedies

- The new era of nematicides
- Improving quality cane through chemical ripening
- Highlights of the 2014 SASTA congress
- Midlands sustainable sugar supply chain collaboration
- SUSFARMS®: The Sugar Industry's Sustainability Compass

INFORMATION SHEETS PUBLISHED IN 2014/15

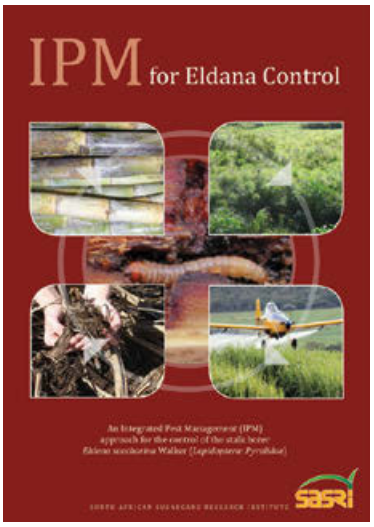
Updated Information Sheets

4.1 Management of fire cane, 10.1 Watergrass control, 10.6 Understanding the label on herbicide containers 14.4 Infield traffic management, 13.3 Variety N12 13.5 Variety N16, 12.11 Variety N25, 13.22 Variety N36, 13.23 Variety N37, 13.24 Variety N39, 13.26 Variety N41, 13.27 Variety N42, 13.33 Variety N48, 13.34 Variety N49

New Information Sheets

8.7 Thrips, 11.5 Flowering and pithing in sugarcane

With the management of eldana being a critical subject, a comprehensive book on *Integrated Pest Management for Eldana Control* was finalised and published. This book was written for those who wish to get a deeper insight into the mechanisms that govern the interactions between eldana, the sugarcane crop and the various practices recommended for control of this pest.



Career Days

Since the promotion of agriculture amongst our youth is a key priority of our Institute, SASRI attended the UKZN Career Day in August 2014. Hundreds of university undergraduates from a number of faculties attended and were exposed to the post-graduate and internship opportunities available at SASRI. They were also made aware of the vast contributions that they could play in the future of the industry through their studies in science and agriculture.

Radio

During 2014, over 50 radio programmes were broadcast over 10 radio stations within KwaZulu-Natal. The radio broadcasts which take place every month have become an effective medium used successfully to transfer agronomic advice to isiZulu speaking growers. The radio programme is co-ordinated through a Radio forum which is formed by different sectors that meet quarterly to discuss topics that are relevant to the audience, and aims at providing a platform to educate and inform the community. The partnership SASRI has with the Department of Agriculture and Rural Development (DARD) via the Extension Venture Agreement (EVA) has proved to be very fruitful over the years with more sugarcane growers showing interest and participating by calling during broadcasts.

Stakeholder Interaction

Significant face-to-face interaction with industry stakeholders in 2014 served to transfer best practice, research outcomes and technical know-how effectively, thereby informing the industry of new advancements. Extension Specialists and researchers conducted over 1500 visits to growers, hosted 154 grower days and exhibitions and were involved in 276 conferences, workshops, refresher courses, seminars and demonstrations. SASRI also hosted 1160 visitors in 2014.

Significant face-to-face interaction with industry stakeholders served to transfer best practice, research outcomes and technical know-how effectively, thereby informing the industry of new advancements.

Certificate Courses

The demand for skills development and training in sugarcane agriculture continued to increase in the 2014/15 season. Since there was a greater demand for attendance of the Senior Course, a decision was made to conduct three Senior Courses rather than the two that are normally hosted. A total of 215 students from 7 different countries attended these three Senior Certificate Courses and one Junior Certificate Course.

Certificate Courses have served to build the competence and capacity of the industry, equipping new emerging farmers and new generation farmers with the knowledge to farm more effectively and sustainably.

Infopack CD

One of the most valuable resources produced by SASRI is the newly updated 2015 InfoPack CD which contains a historical collection of nearly all SASRI publication resources. This resource can be used to rapidly locate previously published articles, information sheets, books, manuals or posters.

The 2015 version of the InfoPack has a number of new additions. These included:

- The manual, *Sugarcane Diseases in southern Africa* was updated with information related to Tawny Rust and Maize Streak.
- A booklet, *Feedback to RD&E Committees: 2014 Stakeholder Issues*. This contained SASRI's responses to 72 industry issues raised at the RD&E AGM of 2014.
- A new video in isiZulu: *Harvesting*.
- A newly published book written by SASRI scientists for the management of the sugarcane pest, Eldana: *IPM for eldana control*.
- Pocket sized *Pest & Disease Guide*.

Knowledge Exchange Projects

A knowledge exchange project determined the effects of climatic factors on the extent of flowering and pithing in southern Africa. A knowledge exchange project investigated the use of audio clips to share information with small-scale growers.

These two knowledge exchange projects have resulted in new recommendations for the control of flowering and pithing in sugarcane varieties; and have resulted in guidelines for the development and sharing of audio clips amongst SSGs.

Throughout 2014, staff at SASRI have been committed to transferring both new research outcomes as well as established, "back-to-basics" practices that have been shown to benefit the industry. Relevant and appropriate technology transfer mechanisms have been chosen to achieve this. Throughout the coming year, SASRI will continue to explore new tools and new communication technologies that will be effective in addressing a diversity of stakeholders and their needs.

Publications & Presentations

Peer reviewed articles

Benjamin Y, Görgens JF and Joshi SV (2014). Comparison of chemical composition and calculated ethanol yields of sugarcane varieties harvested for two growing seasons. *Industrial Crops and Products* 58: 133-141.

Coutinho TA, van der Westhuizen L, Roux J, McFarlane SA and Venter SN (2014). Significant host jump of Xanthomonas vasicola from sugarcane to a Eucalyptus grandis clone in South Africa. *Plant Pathology* doi: 10.1111/ppa.12298 (online).

Conlong DE, Barnes BN, Hofmeyr JH, Groenewald S and Wohlfarter M (2014). The sterile insect technique in agricultural crops in South Africa: A metamorphosis but will it fly? *African Entomology* 23(2): 1-18.

Eksteen AB, Singels A and Ngxaliwe S (2014). Water relations of two contrasting sugarcane genotypes. *Field Crops Research* 168: 86-100.

Ghai M, Singh V, Martin LA, McFarlane SA, van Antwerpen T and Rutherford RS (2014). A rapid and visual loop-mediated isothermal amplification assay to detect *Leifsonia xyli* subsp.*xyli* targeting a transposase gene. *Letters in Applied Microbiology*. doi:10.1111/lam.12327.

Hajari E, Snyman SJ and Watt MP (2014). Inorganic nitrogen uptake kinetics of sugarcane (*Saccharum spp.*) varieties under in vitro conditions and with varying N supply. *Plant Cell Tissue*[1] *and Organ Culture: Journal of Plant Biotechnology*[2] 117: 361-371.

Horsley TN and Zhou MM (2014). Potential gains from introgression breeding based on analysis of three breeding populations. *Proceedings of the South African Sugar Technologists Association* 87: 438-446.

Joshi SV, Zhou MM, Leslie GW, Way MJ and Keeping MG (2014). Comparison of methods for determining thrips (*Fulmekiola serrata*) damage and implications for resistance screening. *International Sugar Journal* 114-116.

Kleynhans E, Conlong DE and Terblanche JS (2014). Host plant-related variation in thermal tolerance of *Eldana saccharina*. *Entomologia Experimentalis et Applicata* 150: 113–122.

Kleynhans E, Mitchell KA, Conlong DE and Terblanche JS (2014). Evolved variation in cold tolerance among populations of *Eldana saccharina* (Lepidoptera: Pyralidae) in South Africa. *Journal of Evolutionary Biology* 27: 1149-1159.

Keeping MG, Miles N and Sewpersad C (2014). Silicon reduces impact of plant nitrogen in promoting stalk borer (*Eldana saccharina*) but not sugarcane thrips (*Fulmekiola serrata*) infestations in sugarcane. *Frontiers in Plant Science* 5: 289 doi: 10.3389/fpls.2014.00289 (online).

Keeping MG, Rutherford RS, Sewpersad C and Miles N (2014). Provision of nitrogen as ammonium rather than nitrate increases silicon uptake in sugarcane. *AoB PLANTS* 7: plu080; doi:10.1093/aobpla/plu080 (online).

Krüger GHJ, De Villiers MF, Strauss AJ, de Beer M, van Heerden PDR, Maldonado R, Strasser RJ (2014). Inhibition of photosystem II activities in soybean (Glycine max) genotypes differing in chilling sensitivity. *South African Journal of Botany* 95: 85-96

Maher GW (2014). Developing a strong Research - Extension - Grower linkage to ensure adoption of new sugarcane technology in South Africa. *Proceedings of the South African Sugar Technologists Association* 87: 362-371.

Mahlanza T, Rutherford RS, Snyman SJ and Watt, MP (2014). *Eldana saccharina* (Lepidoptera: Pyralidae) resistance in sugarcane (*Saccharum* sp.): Effects of *Fusarium spp.*, stalk rind, fibre and nitrogen content. *African Entomology* 22(4):810-822.

Mahlanza T, Rutherford RS, Snyman SJ and Watt MP (2015). Potential of *Fusarium sacchari*-tolerant mutants in controlling *Eldana saccharina* and borer-associated *Fusarium* stem rot in sugarcane. *European Journal of Plant Pathology* 141:825–837.

Miles N, Manson AD, Rhodes R, van Antwerpen R & Weigel A. (2014). Extractable silicon in soils of the South African sugar industry and relationships with crop uptake. *Communications in Soil Science and Plant Analysis* 45:2949-2958.

McElligott DM, van Antwerpen R and Ducasse G (2014). An Extension specialist's yield and gross revenue database used to guide recommendations and improve grower profitability. *Proceedings of the South African Sugar Technologists Association* 87: 372-393.

Olivier FC and Singels A (2015). Increasing water use efficiency of irrigated sugarcane production in South Africa through better

agronomic practices. *Field Crops Research* 176: 87-98.

Paraskevopoulos AL and Singels A (2014). Integrating weather based crop modelling and soil water monitoring technologies to provide improved decision support for sugarcane irrigation management. *Computers and Electronics in Agriculture* 105: 44-53.

Ramburan S (2014). A multivariate illustration and interpretation of non-repeatable genotype x environment interactions in sugarcane. *Field Crops Research* 157: 57-64.

Ramburan S (2014). Optimising sugarcane cultivar choice and time of harvest for frost-prone environments in South Africa. *Agronomy Journal*. doi:10.2134/agronj14.0159 (online).

Ramouthar PV, Rhodes R, Wettergreen T, Pillay U, Jones MR, van Antwerpen R and Berry SD (2014). Intercropping in sugarcane: A practice worth pursuing? *International Sugar Journal*, XVI (1381): 46-53.

Rhodes R, Berry SD, Ramouthar PV and Rutherford RS (2014). Evaluation of *Desmodium uncinatum, Fagopyrum esculentum* and *Brachiaria humidicola* as potential green manure crops for nematode management in sugarcane. *South African Journal of Plant and Soil* 31: 25–33.

Rutherford RS, Snyman SJ and Watt MP (2014). *In vitro* studies on somaclonal variation and induced mutagenesis: progress and prospects in sugarcane (*Saccharum* spp.) – A review. *Journal of Horticultural Science and Biotechnology* 89:1-16.

Singels A, Jones M, Marin F, Ruane AC and Thorburn P (2014). Predicting climate change impacts on sugarcane production at sites in Australia, Brazil and South Africa using the Canegro model. Sugar Tech 16(4): 347-355.

Singels A, Leslie GW, McFarlane SA, Schoeman J and Gabriel A (2014). South African sugarcane production in 2013/2014: A record breaking season. *Proceedings of the South African Sugar Technologists Association* 87: 1-22.

Singels A, Jarmain C, Bastidas-Obando E, Olivier FC and Paraskevopoulos AL (2014). Validating sugarcane water use and yield estimates derived from remote sensing and crop modelling for irrigated sugarcane in Mpumalanga, South Africa. *Proceedings of the Australian Society of Sugarcane Technologists 36*.

Snyman SJ, Hajari E, Watt MP, Lu Y and Kridl J (2015). Improved nitrogen use efficiency in transgenic sugarcane: Phenotypic assessment in a pot trial under low nitrogen conditions. *Plant Cell Reports* 34: 667-669. doi: 10.1007/s00299-015-1768-y (online).

van Heerden PDR (2014). Differential acclimation capacity to frost in sugarcane varieties grown under field conditions. *Plant Growth Regulation* 72: 181-187.

van Heerden PDR (2014). Evaluation of Trinexapac-ethyl (Moddus®) as a new chemical ripener for the South African sugarcane industry. *Sugar Tech* 16(3): 295-299.

van Heerden PDR, Adendorff MW, Lagerwall G, Botha P, Cronjé CPR, van der Merwe J, Nel N, Smith P, Höll E, Hyslop G, Smith V, Harris A, Harris W, Mhlongo JB, Harris DM, Dheopursad J, Matthews T and Naidoo P (2014). Grower-Extensionist-Researcher partnerships: On-farm demonstration trials to facilitate adoption of chemical ripening. *Proceedings of the South African Sugar Technologists Association* 87: 77-90.

Zhou MM (2014). Cultivar genetic gains for sugarcane yield, sucrose content and sugar yield in the Midlands region breeding programme. *Proceedings of the South African Sugar Technologists Association* 87: 419-431.

Zhou MM (2014). Family evaluation for sugarcane yield using data estimated from stalk number, stalk height and stalk diameter. *Journal of Crop Improvement* 28(3): 406-417.

Zhou MM, Kimbeng CA, Tew TL, Gravois KA, Pontif M and Bischoff KP (2014). Logistic regression models to aid selection in early stages of sugarcane breeding. *Sugar Tech*: 16: 150-156.

Non-peer reviewed papers (short communications)

Boote DN, Smithers JC and Lyne PWL (2014). The development and application of an energy calculator for sugarcane production in South Africa. *Proceedings of the South African Sugar Technologists Association* 87: 459-463.

Eksteen A, Halse E, Simwinga E and Sutherland D (2014). An investigation into factors influencing flowering and pithing of sugarcane in Southern Africa. *Proceedings of the South African Sugar Technologists Association* 87: 493-496.

Jenkins EPG and Bezuidenhout CN (2014). The development and evaluation of a predictive mill-scale sugarcane quality model. *Proceedings of the South African Sugar Technologists Association* 87: 464-468.

Jugurnauth M, Bezuidenhout CN and RamasawmyH(2014). The development of a strategic sugarcane vehicle optimisation tool. *Proceedings of the South African Sugar Technologists Association* 87: 469-473.

Jones MR and Singels A (2014). A preliminary assessment of mid-century climate change impacts on sugarcane production in South Africa. *Proceedings of the South African Sugar Technologists Association* 87: 290-297(Also published in International Sugar Journal Vol. CXVII No. 1394:114-121).

Jones MR, Singels A, Thorburn P, Marin FR, Martine J-F, Chinorumba S, Viator R and Nunez O (2014). Evaluation of the DSSAT-CANEGRO model for simulating climate change impacts at sites in seven countries. *Proceedings of the South African Sugar Technologists Association* 87: 323-329.

Kadwa M, Bezuidenhout CN and Ortmann GF (2014). Quantifying and modelling disruptions in the Eston sugarcane supply chain. *Proceedings of the South African Sugar Technologists Association* 87: 474-477.

Leslie GW and Moodley S (2014). A preliminary assessment of new insecticides for the control of the sugarcane borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae). *Proceedings of the South African Sugar Technologists Association* 87: 455-458.

Lichakane ML and Zhou MM (2014). The influence of genotype by environment interaction on yield, quality and agronomic traits for the coastal short cycle breeding programme. *Proceedings of the South African Sugar Technologists Association* 87: 432-437.

Makoro P, van Antwerpen R, de Jager C and Miles N (2014). Impact of CMS on soil acidity and aluminium toxicity in the sugarcane industry. *Proceedings of the South African Sugar Technologists Association* 87: 345-348.

Miles N and Farina MPW (2014). Towards the more efficient use of fertiliser potassium: prediction of 'slowly-available' potassium reserves in soils. *Proceedings of the South African Sugar Technologists Association* 87: 330-333.

Ngxaliwe S, Eksteen AB, Singels A and Pammenter NW (2014). Resource capture and conversion efficiency of two contrasting sugarcane genotypes under water stress. *Proceedings of the South African Sugar Technologists Association* 87: 358-361.

Poswa LZ, Miles N, Manson A and Roberts V (2014). Prediction of fertiliser phosphorus requirement factors for soils of the southern African sugar industry. *Proceedings of the South African Sugar Technologists Association* 87: 349-352.

Searle A (2014). The Umfolozi flats: Opportunities and challenges in a niche sugarcane production area. *Proceedings of the South African Sugar Technologists Association* 87: 72-76.

Sibomana MS, Sobratee N, Workneh TS and Bezuidenhout CN (2014). Attempts to detect the degree of deterioration in commercial sugarcane: lessons learnt. *Proceedings of the South African Sugar Technologists Association* 87: 482-485.

Ramouthar PV (2014). Abundance and diversity of nematode genera present in South African sugar industry. *Proceedings of the South African Sugar Technologists Association* 87: 451-454.

Rhodes R, Jones MR, Edmonds A, Gillitt CG and Wilkinson D (2014). Potential economic impact of a long fallow and changing plough-out dates in the KwaZulu-Natal Midlands. *Proceedings of the South African Sugar Technologists Association* 87: 486-492.

Thorburn P, Biggs J, Jones MR, Singels A, Marin F, Martine J-F, Chinorumba S, Viator R and Nunez O (2014). Evaluation of the APSIM-Sugar Model for simulating sugarcane yield at sites in seven countries: Initial results. *Proceedings of the South African Sugar Technologists' Association* 87: 318-322.

Weigel A, Miles N, Nyandeni B, Naidoo G and Wettergreen T (2014). Ammonia volatilization losses from Nitrogen fertilisers: Laboratory studies. *Proceedings of the South African Sugar Technologists' Association* 87: 353-357.

Way MJ, Conlong DE, Martin LA, McFarlane SA, Stranack R, Keeping MG and Rutherford RS (2014). First record of yellow sugarcane aphid, *Sipha flava* (Homoptera: Aphididae) in the South African sugarcane industry. *Proceedings of the South African Sugar Technologists Association* 87: 53-57.

Book Chapters

Conlong DE and Way MJ (2015). Sugarcane. 156-176. In: Prinsloo GL and Uys VM (Eds). Insects of cultivated plants and natural pastures in southern Africa. Entomological Society of Southern Africa.

Rutherford RS (2014). Mechanisms of resistance to pests and pathogens in sugarcane and related species. In: Botha FC and Moore PH (Eds.). Sugarcane physiology, biochemistry, and functional biology. Wiley-Blackwell. ISBN: 978-0-8138-2121-4.

Singels A (2014). Crop Models. 541 – 578. In: Botha FC and Moore PH (Eds.). Sugarcane physiology, biochemistry, and functional biology. Wiley-Blackwell. ISBN: 978-0-8138-2121-4.

van Heerden PDR, Eggleston G and Donaldson RA (2014). Ripening and Post-harvest deterioration. 55 – 84. In: Botha FC and Moore PH (Eds.). Sugarcane physiology, biochemistry, and functional biology. Wiley-Blackwell, USA, ISBN: 978-0-8138-2121-4.

Watt D, McCormick AJ and Cramer MD (2014). Source and sink physiology. In Botha, FC and Moore PH (Eds.). 483 – 520. Sugarcane physiology, biochemistry, and functional biology. Wiley-Blackwell, USA, ISBN: 978-0-8138-2121-4.

Zhang J, Zhou M, Walsh J, Zhu L, Chen Y and Ming R (2014). Sugarcane genetics and genomics. 623 – 644. In: Botha FC and Moore PH (Eds.). Sugarcane physiology, biochemistry, and functional biology. Wiley-Blackwell, USA, ISBN: 978-0-8138-2121-4.

Theses and Dissertations

Bam AJ (2014). Acridid identification keys for species in Zululand sugarcane. MSc Dissertation: Stellenbosch University. (Supervisors: Dr Conlong DE (SASRI) and Addison P (Stellenbosch University)).

Boote D (2014). The development and assessment of an energy calculator for use in sugarcane production. MSc Eng Dissertation. University of KwaZulu-Natal (Supervisors: Dr van Antwerpen R (SASRI) and Prof Smithers J (UKZN)).

Edmonds GJ (2014). Investigating induced resistance in sugarcane. MSc Dissertation. University of KwaZulu-Natal (Supervisors: Dr Rutherford RS (SASRI) and Caldwell P (University of KwaZulu-Natal)).

Huripurshad S (2014). Imazapyr-potential herbicide for the control and management of creeping grass, *Cynodon dactylon* (L.) Pers. (Cynodon). MSc Dissertation. University of KwaZulu-Natal (Supervisors: Dr Campbell PL (SASRI) and Beckett R (UKZN)).

Jacob R (2015). De novo assembly and transcriptome analysis of subtracted cDNA libraries: Towards the regulation of photosynthesis through sugar signalling in sugarcane. MSc Dissertation. University of Manchester (Supervisors: Drs Brass A (University of Manchester) and Sweby DL (SASRI)).

Mahlanza T (2015). The interaction between endophytic *Fusarium* species and *Eldana saccharina* (Lepidoptera) following in vitro mutagenesis for *F. sacchari* tolerance to control the borer in sugarcane. PhD Dissertation. University of KwaZulu-Natal. (Supervisors: Drs Rutherford RS (SASRI), Snyman SJ (SASRI) and Prof Watt MP (UKZN)).

Memela N (2014). Isolation of *Beauveria bassiana* strains from KwaZulu-Natal as biocontrol agents against the African sugarcane stemborer *Eldana saccharina*. MSc Dissertation. University of KwaZulu-Natal (Supervisors: Prof Schmidt S (UKZN) and Dr Rutherford RS (SASRI)).

Mkhize ND (2014). Investigating crop rotational benefits of a soybean and sugarcane cropping system in South Africa. MSc Dissertation. University of KwaZulu-Natal (Supervisors: Prof Modi A (UKZN) and Dr Berry S (SASRI/ BASF)).

Mkize L (2015). Rapid and sensitive detection of *Leifsonia xyli* subsp. xyli by Loop-mediated Isothermal Amplification combined with Lateral Flow Devices'. BSc Honours Project Report. University of KwaZulu-Natal (Supervisors: Drs Ghai M (UKZN) and Rutherford RS (SASRI)).

Moon C (2014). Rapid means of screening for resistance to pests in a sugarcane plant breeding selection programme. MSc Dissertation. University of KwaZulu-Natal (Supervisors: Prof Laing MD (UKZN) and Dr Rutherford RS (SASRI)).

Ngxaliwe S (2014). Water stress effects on growth, development, resource capture and resource use efficiency of two contrasting sugarcane genotypes. MSc Dissertation. University of KwaZulu-Natal (Supervisors: Dr Eksteen A (SASRI), Prof Singels A (SASRI/UKZN) and Pammenter NW (UKZN)).

Rossler R (2014). Water stress effects on the growth, development and yield of sugarcane. MSc Dissertation. University of Pretoria. (Supervisors: Prof Singels A (SASRI/UKZN), Prof M Steyn (UP), Olivier FC (SASRI)).

Rees B (2014). Evaluation of systems to harvest, process and transport sugarcane biomass. MSc Eng Dissertation. University of KwaZulu-Natal (Supervisors: Prof Smithers J (UKZN), Prof Lyne P (UKZN) and Dr Van Antwerpen R (SASRI)).

Published Research Reports

Jarmain C, Singels A, Bastidas-Obando E, Paraskevopoulos A, Olivier FC, van der Laan M, Taverna-Turisan D, Dlamini M, Munch Z, Bastiaanssen W, Annandale J, Everson C, Savage M and Walker S (2014). Water use efficiency of selected irrigated crops determined with satellite imagery. WRC Report No. TT 602/14, ISBN 978-1-4312-0573-8.

Presentations and posters at congresses or symposia

Campbell P and Thwala S (2014). Propagation of *Melinis minutiflora* to improve push-pull technology adoption by sugarcane growers. *Combined Congress of the Crop Science, Soil Science, Horticulture and Weed Science Societies of South Africa*. Rhodes University, Grahamstown, 20 – 23 January.

Eksteen AB. (2014) An investigation into flowering and pithing in the southern African sugarcane industry. *Combined Congress of the Crop Science, Soil Science, Horticulture and Weed Science Societies of South Africa*. Rhodes University, Grahamstown, 21–24 January.

Eksteen AB, Ngxaliwe SN and van Heerden PDR (2014). Growth and photosynthetic response of different sugarcane varieties to chemical ripening. *Combined Congress of the Crop Science, Soil Science, Horticulture and Weed Science Societies of South Africa*. George, 20 – 23 January.

Evans D and Joshi S (2014). Indels: Crucial informative characters in phylogenomic analyses. *South African Genetics Society and South African Society for Bioinformatics, Joint Congress*. Kwalata Game Ranch, Gauteng, 23 - 26 September.

Garsmeur O, Potier BM, Aitken K, Berkman P, Droc G, Charron C, Martin G, Harrison B, van der Vossen E, Henry R and D'Hont A (2015). Toward a reference sequence of the gene-rich part of the highly polyploidy sugarcane genome. *Plant and Animal Genome XXIII Conference*. San Diego, USA, January.

Garsmeur O, Potier BM, Aitken K, Berkman P, Droc G, Charron C, Martin G, Harrison B, van der Vossen E, Henry R and D'Hont A (2014). Toward a reference sequence of the gene-rich part of the sugarcane genome Green technologies for sustainable growth of sugar and integrated industries in developing countries. *Proceedings of the 5th IAPSIT International Sugar Conference IS-2014*. Nanning, China, November.

Gillespie WA, Mitchell FJ and Way MJ (2014). Successful and sustainable technology transfer for profitable small-scale sugarcane agriculture: A case study. *48th Annual Conference of the South African Society for Agricultural Extension*. Tramonto, George, Western Cape Province, 10 – 12 June.

Huripurshad S, Beckett RP, Rutherford RS, and Campbell P (2014). Seasonal translocation of imazapyr- in *Cynodon dactylon* (L.) Pers. (Cynodon). *Annual Congress of the South African Association of Botanists*. Stellenbosch University at SAAB, 13 – 17 January.

Horsley T and Zhou M (2014). Trends in quality traits for F1, BC1 and commercial crosses among South African sugarcane breeding populations and implications for introgression breeding. *10th Annual Symposium of the Southern African Plant Breeders' Association*. Thaba 'Nchu, Free State, 10 – 12 March.

Horsley TN (2014). Use of introgression breeding to enhance genetic potential of sugarcane germplasm in South Africa. *Annual Congress of the Australian Society of Sugarcane Technologists*. Queensland, Australia, 29 April – 1 May.

Joshi SV and Evans D (2015). Stable chloroplast: myth or reality? *Plant and Animal Genome* XXIII Conference. San Diego, USA, January.

Joshi S and Evans D (2014). Re-annotation of chloroplast genomes in sugarcane: Lessons for whole genome analysis. *South African Genetics Society and South African Society for Bioinformatics*. Joint Congress. Kwalata Game Ranch, Gauteng, 23 - 26 September.

Joshi SV, Zhou M and Oosthuizen N (2014). Suitability of bagasse chemical composition variables for biomass breeding in sugarcane. *10th Annual Symposium of the Southern African Plant Breeders' Association*. Thaba 'Nchu, Free State, 10 – 12 March.

Jumman A, Bezuidenhout CN and Dent M (2014). Conceptualising the process for adoption of scientific irrigation scheduling: A system dynamics approach. *2nd Annual ESKOM System Dynamics Conference*. Midrand, Johannesburg, 12 November.

Keeping MG, Rutherford RS and Sewpersad C (2014). Provision of nitrogen as ammonium rather than nitrate increases silicon uptake in sugarcane. *Proceedings of the Sixth International Conference on Silicon in Agriculture*. Stockholm University, Sweden, 26 – 30 August.

Lichakane M and Zhou M (2014). Variance components and broad sense heritabilities for *Eldana saccharina* borer damage among coastal long cycle sugarcane populations. *10th Annual Symposium of the Southern African Plant Breeders' Association*. Thaba 'Nchu, Free State, 10 – 12 March.

Martin LA, Lloyd Evans D, Castlebury LA, Sifundza JT, Comstock JC, Rutherford RS, McFarlane SA (2015). A new species of rust infecting sugarcane in southern Africa. *49th Congress of the Southern African Society for Plant Pathology*, Bloemfontein, 19 – 21 January.

McFarlane SA, Martin LA, Wilkinson D, Koch AC, van Antwerpen T, Pillay N and Rutherford RS (2014). Effect of mulches and chemical treatments on virus spread in NovaCane® plantlets. *Proceedings of the South African Sugar Technologists Association* 87: 77–90 (poster).

McFarlane SA, Rutherford RS and Stranack RA (2015). Monitoring diseases in the South African sugarcane industry. *49th Congress of the Southern African Society for Plant Pathology*. Bloemfontein, 19 – 21 January.

Mthembu IB, Collings KA and Maher GW (2014). Review of the SASRI geographic information systems service. *Proceedings of the South African Sugar Technologists Association* 87: 77–90 (poster).

Olivier FC (2014). Crop productivity and evapotranspiration in the sugar industry. *Omnia Agronomists Conferenc*e. Mount Amanzi, Hartebeespoortdam, Gauteng, 4 - 6 June.

Olivier FC (2014). Optimising agronomic aspects of water management to increase water use efficiency. *SA Sugar Industry Annual Agronomists Association Symposium*. SASA, Mt Edgecombe, 28 October.

Olivier FC and Singels A (2014). Better agronomy can improve water use efficiency of irrigated sugarcane production. *South African National Council on Irrigation and Drainage Symposium.* Glenburn Lodge, Gauteng, 18 - 20 November.

Olivier F, Singels A, Van Heerden R and Jumman A (2014). Simplified tools to aid sugarcane water management. *Combined congress of the South African Society of Crop Production, Soil Science Society of South Africa, Southern African Weed Science Society and Southern African Society for Horticultural Sciences.* Grahamstown. 20 – 23 January (poster).

Olivier FC, Singels A and Paraskevopoulos A (2015). Monitoring soil water content for drip irrigated sugarcane with capacitance probes. *Combined congress of the South African Society of Crop Production, Soil Science Society of South Africa, Southern African Weed Science Society and Southern African Society for Horticultural Sciences.* Tramonto, George, 19 - 22 January (poster).

Paraskevopoulos AL and Singels A (2014). Optimising sugarcane irrigation scheduling with limited water: A simulation study. *South African National Council on Irrigation and Drainage Symposium,* Glenburn Lodge, Gauteng, 18 - 20 November.

Pillay U and Ramouthar PV (2014). Results of a nematode survey conducted in the Midlands North growing region. *Proceedings of the South African Sugar Technologists Association* 87: 77–90 (poster).

Ramburan S (2013). Optimising sugarcane cultivar selection for frost-prone environments in South Africa. *American Society of Agronomy, Crop Science Society of America and Soil Science Society of America*. Tampa, Florida, 3 – 6 November.

Ramburan S, Jones M, Tweddle P (2015). An economic conversion tool for sugarcane research results: Preliminary evaluations. *Combined Congress of the Crop Science, Soil Science, Horticulture and Weed Science Societies of South Africa.* George, 20 – 23 January.

Ramouthar PV, Ntshobeni N, Pillay U and Berry SD (2014). Testing of new nematicides for use in the South African Sugar Industry. *6th International Congress of Nematology*. Cape Town, 4 - 9 May (poster).

Singels A (2014). Modelling and monitoring water use efficiency. *Omnia Agronomy Conference*. Hartebeespoort, 4 - 5 June.

Singels A, Paraskevopoulos AL, Olivier FC, Jarmain C and Bastidas-Obanda E (2014). Monitoring water use efficiency of irrigated sugarcane production. *SA Sugar Industry Annual Agronomists Association Symposium*. SASA, Mt Edgecombe, 27 October.

Singels A, Jarmain C, Bastidas-Obando E, Olivier FC and Paraskevopoulos AL (2014). Monitoring water use efficiency of irrigated sugarcane production in Mpumalanga using SEBAL. *South African National Council on Irrigation and Drainage Symposium.* Glenburn Lodge, Gauteng, 18 - 20 November.

Snyman SJ (2014). Genetically modified sugarcane – the who, why, what, when and how much. *87th Congress of the South African Sugar Technologists Association.* Pietermaritzburg, August.

Snyman SJ (2014). In vitro manipulations and strategies for the improvement of sugarcane cultivars in South Africa. *10th Regional Plant Biotechnology Forum: Crop improvement and Genetic Transformation.* University of the Witwatersrand, Johannesburg, October.

Snyman SJ, Redshaw KA and Stranack R (2014). NovaCane® - A boost for seedcane schemes. *Proceedings of the South African Sugar Technologists Association* 87: 124 (poster).

Snyman SJ and Banasiak M (2014). In vitro germplasm conservation for sugarcane in South Africa. *2014 World Forum on Biology*. Georgia USA, 31 May - 4 June (poster).

van Antwerpen R and Kanamugire A (2014). Estimation of critical soil water values from soil texture data. *Proceedings of the South African Sugar Technologists Association* 87: 77–90 (poster).

van Antwerpen R and Tweddle P (2014). Controlled Traffic within the South African Sugar Industry. *Combined Congress of the Crop Science, Soil Science, Horticulture and Weed Science Societies of South Africa*. Rhodes University, Grahamstown, 21 – 23 January.

Weepener HL, Singels A, Jones MR, Engelbrecht CJ and Carstens JP (2015). Potential positive effect of climate change on the production of sugarcane in South Africa. *Combined Congress of the Crop Science, Soil Science, Horticulture and Weed Science Societies of South Africa.* George, 20 - 22 January.

Zhou M and Mokwele A (2014). Analysis of family selection data using best linear unbiased prediction (BLUP) to evaluate *Eldana saccharina* borer resistance breeding in sugarcane. *10th Annual Symposium of the Southern African Plant Breeders' Association.* Thaba 'Nchu, Free State, 10 – 12 March.

Statistical Snapshot

Reporting period: 01 January 2014 – 31 March 2015

Research projects as at 31 March 2015

Closed:	23
Ongoing:	52
New:	7

Staff complement - (excluding contract staff)

Crop Biology	45
Plant and Environment	21
Breeding and Field	248
Diagnostic and Analytical	32
Extension	27
Knowledge Management	7
Human Resources	6
Administration and Management	7
Management	4
TOTAL	**397**

Number of Honorary appointments at tertiary institutions:	9
Number of post-doctoral researchers associated with SASRI:	4
Number of post-doctoral researchers based at SASRI:	2
Number of postgraduate students associated with SASRI:	15
Number of postgraduate students based at SASRI:	21

South African Sugarcane Research Institute

170 Flanders Drive, Mount Edgecombe, 4300

Private Bag X02, Mount Edgecombe, 4300

Tel: (031) 508 7400 Fax: (031) 508 7597

Website: www.sugar.org.za/sasri