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2016 RDE COMMUNIQUÉS

FEEDBACK TO REGIONAL

RDE COMMITTEES

South African Sugarcane Research Institute

Mount Edgecombe

UNLOCKING THE POTENTIAL OF SUGARCANE

Website: http://www.sugar.org.za

PREFACE

Contained within these pages are informative communiqués from SASRI specialists on the issues raised in 2016 by representatives of the ten regional RDE Committees. In instances where essential knowledge is lacking, certain issues have led to proposals for new research projects, which are to be implemented in 2017/2018, subject to funding approval by the Industry leadership.

For the first time, the annual RDE Committees Workshop in 2016 was held in the northern irrigated region of the Industry (Malelane) and hence, issues relevant to sugarcane cultivation under irrigation predominate in this document. As agreed by the RDE Committees, the annual workshops will alternate between the irrigated and rain-fed regions, with the next workshop planned for Mount Edgecombe in March 2017.

ACKNOWLEDGEMENT

SASRI would like to thank the representatives of the grower and miller communities who give of their time to serve on regional RDE Committees. Without this commitment and generosity, SASRI's delivery of meaningful research outcomes to the industry would be severely compromised.

SASRI would also like to thank Malelane CANEGROWERS for kindly allowing SASRI to host the 2016 workshop in their excellent meeting facilities. Particular thanks go to Alwyn van Graan (Chairman of the Malelane RDE Committee), as well as to Jacques Schoeman and Colette Coetzee of CANEGROWERS.

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AMATIKULU RDE COMMITTEE

NUTRITION - INCREASING SILICON UPTAKE BY CANE (SASRI REF: ISSUE 38)

Grower Issue Description

Although a few promising Si carriers have been researched by SASRI, plant uptake remains poor. Growers are thus unable to fully enjoy the many benefits of adequate Si nutrition. This remains a big concern, considering the ravaging effects of eldana in times of drought (and otherwise), both in the dryland and the irrigated areas. Numerous trials have highlighted the problem of poor Si uptake. Why?! With the wealth of expertise available at SASRI – including physiologists and molecular biologists – we should be able to solve this problem. If Si is effective in reducing Eldana – which most studies report that it does - surely this must be an absolute priority.

SASRI Response

SASRI has tested the efficacy of 17 different silicon (Si) sources in providing plant-available soil Si and its subsequent uptake from these sources. Calmasil® (calcium silicate slag) remains the most effective in terms of Si provision and uptake, product cost, and very importantly in its ability to correct soil acidity. Soil acidity is important because acid, sandy, low organic matter soils in the rain-fed areas of the industry are also those that are depleted of natural reserves of plant-available Si (i.e. desilicated).

The exact causes of poor Si uptake even where Calmasil has been applied remains a knowledge gap. However, aluminium (Al) appears to be the most likely culprit, given the very strong association between low soil Si concentrations and high levels of exchangeable Al. In humic soils, the huge reserves of Al bound to organic matter may be reacting with and removing available Si from soil solution and thereby making it unavailable for plant uptake. Responses to Calmasil application on such soils have been very poor. In contrast, treatment of acid, sandy, low organic matter soils, or even straight (Umgeni) sand, with Calmasil has produced significant increases in leaf and stalk Si content. This indicates that Calmasil is likely to be most effective in sandy, acid soils with low organic matter, and growers would be advised to restrict Calmasil use to these soils until further research has been completed. However, organic matter amendments and retention of crop residues (trash may contain up to 3% Si) can also serve to bind exchangeable Al and may therefore reduce its reaction with soluble Si (native and applied). This possibility will be explored in current SASRI field-based research.

In the interim, good soil management practices that include trashing, avoidance of soil compaction, and application of lime and gypsum where recommended, will improve soil health and moisture and therefore root growth. The latter will inevitably also improve Si uptake. Calmasil can correct soil acidity and reduce Al saturation as effectively, and frequently more effectively, than dolomitic lime when both are applied at the same rate to an acid soil. Therefore, for the purposes of correcting soil acidity and reducing Al toxicity, Calmasil can safely and confidently be applied at the same rates recommended for lime applications by FAS. Silicate slags, such as Calmasil, are almost seven times more soluble than calcium carbonate (lime) and can therefore correct acidity to a greater depth than lime. Calmasil will also provide ample supplies of available Ca and Mg.

Other Si sources tested, including potassium silicate, thermophosphate (fused Ca-Mg-Si-P) and liquid silicic acid, had no, or much reduced, liming capacity, even where they did provide adequate Si, so would be of no value in addressing soil acidity. Many of these products are also prohibitively expensive.

While desilicated acid soils dominate in the rain-fed parts of the industry, the irrigated northern regions have clays that are replete in native, more available forms of Si. Silicon deficiencies (i.e. leaf Si values <0.75%) are therefore not of concern in these regions and application of Si fertilizers, whether for growth promotion or protection against stresses such as eldana, is unwarranted. Hence, it is essential that appropriate soils are targeted for application of silicate slag, as benefits of supplied Si will not be seen where native soil Si is already abundant. Furthermore, it is well established that Si benefits will generally only be evident under circumstances where the crop is subjected to some form of biotic (e.g. pest or disease) or abiotic (e.g. drought, metal toxicity, salinity) stress. With respect to management of eldana, Si should be viewed as only one component of an overall IPM strategy and will provide little if any benefit in varieties that are already resistant to eldana. Significant enhancements in resistance due to Si are generally only evident in susceptible or intermediate resistance varieties, and in particular when these are under drought stress.

Mention in the issue description of molecular biology and biotechnology in relation to Si uptake by sugarcane is highly pertinent. Research conducted at SASRI in 2007 and 2008 identified the presence in sugarcane roots of a Si transporter gene similar to one found in rice, which is a high Si accumulator species. The ultimate goal of that investigation was to assess whether the expression by genetic engineering of this gene at high levels in sugarcane roots would enhance Si uptake. However, the project was terminated because: (1) the uptake and transport of Si within a plant was revealed to rely on the expression of several Si transporter genes, not just on the root transporter; and (2) conversations with the Industry leadership revealed that the Industry had the appetite for the potential future commercialisation of only one GM sugarcane event, with resistance to lepidopteran insect pests (eldana, chilo, sesamia) being the most valuable trait. Hence, although a biotechnological solution to the problem is not currently feasible, SASRI is confident that the soil health amelioration research described above will ultimately provide recommendations that will enable improved Si uptake by sugarcane.

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PRECISION AGRICULTURE (SASRI REF: ISSUE 39)

Grower Issue Description

The SA sugar industry has for many years lagged behind other agricultural industries in terms of GIS mapping of the industry and precision farming methodologies. This gap needs to be closed – in the interests of improved industry efficiencies. The visible variability in growth in many fields is evidence of soil-related issues impacting productivity. Working on a 'field average' soil sample is fraught with inefficiency and error. A move of the industry from this outdated approach is overdue. With the above in mind, SASRI needs to give attention to the following aspects: 1. A more cost-effective analytical package to minimize analytical costs, and thereby allow for intensive (grid) sampling of fields.2. To develop a protocol for a grid sampling approach, as well as for the reporting of results where gps co-ordinates are recorded (FAS and/or extension to generate shape files?). 3. Yield-mapping of hand harvested cane. This would represent a quantum leap for the industry.

SASRI Communication

FAS's development of a rapid and less costly analytical option for testing soils is at an advanced stage. This package will be ideally suited for the high analytical demands of precision nutrient management based on grid sampling of fields. It is anticipated that this option will become available to growers within the next 12 months.

Importantly, FAS is currently working on ensuring that analytical data are presented in a format that is compatible with software packages widely used in sugar industries and which cater for precision agriculture, such as CanePro (SQR Software [Pty] Ltd) and Plan Ahead (Plan-A-Head Management Software).

A project proposal for the 2017/18 program of work has been submitted with regards to the development of yield maps. It is envisaged that remote sensing and pre-and post-harvest yield mapping techniques will be investigated in the study.

NEW PROJECT PROPOSED

SASRI is initiate a research project in 2017/2018 that will investigate various practical approaches to yield mapping (subject to funding approval by the grower and miller leadership serving on SASA Council)

NEW INTERNATIONAL COLLABORATIVE PROJECT PROPOSED

In an exciting development, the University of Edinburgh, in collaboration with SASRI, is to submit a funding application on 26 September 2016 to the UK's Biotechnology and Biological Sciences Research Council for a project entitled "*Sustaining African sugarcane production using precision agriculture technologies*". The aim of the three-year research project is to develop remote sensing technology to facilitate: (a) more accurate monthly estimates of crop production in the SA sugar industry; and (b) the calculation of an industry-wide monthly crop stress index which will be invaluable to eldana and irrigation management.

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LAND USE PLANNING (SASRI REF: ISSUE 40)

Grower issue description

Growers are well aware of the history of, and reasons behind, the closure of the Land Use Planning Department, and that it is unlikely to be reinstated. One of the prime tenets of SUSFARMS®, however, is that growers have, and make use of, a land use plan. Without this, many of the other management activities on the farm are hollow. Large areas of land are being planted (or replanted) to cane with no land use plan. This is deplorable! We therefore submit this 'Research request' in order to support any efforts by SASRI to assist with the production of land use plans. We are aware of the GIS technicians who have provided such plans in the past; in our experience, those plans which were completed were fairly well executed, but most of the plans requested were never produced. This indicates insufficient staff capacity. We therefore request the continued, and hopefully increased, allocation of staff to this very important function.

SASRI Communication

The Amatikulu RD&E Committee's support for the creation of capacity at SASRI to complete Land Use Plans as a requirement of SUSFARMS® is greatly appreciated. At present there is some limited capacity within SASRI Extension and the SASRI GIS Unit to undertake Land Use Plans. In addition, funding support for the Midlands 2018 Collaboration has enabled the engagement of a full-time technician, whose sole task it is to draw LUPs and this is helping to eliminate the backlog of plans amongst Midlands' growers. Private agricultural consultancies, such as Bosch are also offering this service, but obviously at a cost. However, as has been pointed out, overall capacity for Land Use Planning falls far short of that required should SUSFARMS® ever become a requirement in the Industry. If this were to become a reality, then further discussion and action will be required. A further aspect to be considered is that the low income environment within the Industry, resulting primarily from the ongoing drought conditions and drop in production, has placed a significant constraint on SASRI's ability to fill vacant positions, some of which are within the GIS Unit. Hopefully, this constraint will gradually abate of the next few seasons as more favourable rainfall patterns return.

FELIXTON RDE COMMITTEE

HIGH NON-SUCROSE PROBLEM (SARI REF: ISSUE 37)

Grower Issue Description

The Felixton Mill production area (which includes Empangeni, Felixton, Mposa, Nkwalini, Mtunzini and Heatonville) has historically had a problem with high non-sucrose due to factors occurring on farm. This must not be confused with the problems encountered in the mill where there is an allegation of the question of non-sucrose (Brix – Pol) in the milling process. The Felixton RD & E Committee has requested a study into the reason for the occurrence of the high non-sucrose experienced by its growers. As a general rule, Felixton growers farming practices do not materially differ from the growers at Amatikulu or Umfolozi, yet the non-sucrose percentage at Felixton historically differs markedly from the non-sucrose percentage experienced at Amatikulu or Umfolozi. What is the reason for the difference?

SASRI Communication

This issue would undoubtedly be best addressed by a project led locally. Extension specialists have local knowledge of growing conditions, as well as of historical and current agronomic and harvesting practices. As such, it is imperative that the local extension specialist formulates and leads this project, while drawing on additional specialist advice from SASRI scientists as necessary. As a first step, it will be necessary to confirm the nature and extent of the problem and to identify all possible factors which could contribute to high non-sucrose levels. This is an essential step, as the Felixton mill supply area is diverse in many respects and it is possible that high non-sucrose levels could be linked to certain homogenous areas or practices. Linked to this is the fact that a significant tonnage of cane delivered to the mill is from areas considerable distances away, which carries associated challenges in the management of post-burn cane deterioration. As part of the greater investigation, Drs Sanesh Ramburan and Shailesh Joshi will undertake an analysis of data from Felixton to identify potential trends that might underlie this issue (further information may be obtained by e-mailing Sanesh.Ramburan@sugar.org.za). At the same time, the extension specialists should conduct a full situation survey to gather all relevant local data on cane quality by region. Factors such as soil type, climatic conditions harvest cycles, irrigation, varieties, harvest practices and any other possible relevant factor should all be documented by region in preparation for analysis by SASRI specialists. Ideally this data should date back as far as possible so that changes in practices may potentially be matched to changes in quality data. Changes in deliveries to Felixton mill must also be highlighted in respect of new areas which have been added to the cane supply area, as well as areas that no longer supply Felixton. Once all the data has been collated, an Extension Request for Advice (ERA) should be submitted to SASRI for analysis.

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IRRIGATED NORTHERN REGIONAL RDE COMMITTEES

SNAKE OILS (SASRI REF: ISSUE 16)

Grower Issue Description

Describe the issue: Is there a way which we (Growers) can deal with this? Past: SASRI referred to – gave approval. Many products are proposed – too many to evaluate all of them. **Background:** SASRI can be approached. Promising chemistries are evaluated. Need to apply 'checklist' to products (need to circulate to Growers). Strip trials can confirm company claims. **Desired End Result:** Clear guidelines. They can ask SASRI. Point of contact (RAS). Publish registered product list.

SASRI Communication

SASRI is aware of the large range of agricultural products that continually enter the market because sales representatives of the companies that market such products frequently ask SASRI to conduct efficacy assessments and provide a seal of approval. SASRI simply cannot provide such commercial endorsements. In many instances, these agents directly approach growers with the intention of convincing them of the product's worth. Many of these products have not been scientifically tested in pot or field trials, and their mode of action has not been established, despite the claims made by the vendors in their advertising and brochures. Furthermore, it is illegal to use any product not registered for use in sugarcane or to use a registered product but not according to the label (i.e. "off-label"). Growers are therefore strongly cautioned against wasting a considerable amount of money and effort in purchasing and applying new "wonder" products without being able to objectively assess their true effects (if any) on soil health, cane growth, yield etc., as well as the legal implications of misuse of products.

SASRI does not have the capacity to test all these products and will in any event only test products that have clear scientific and economic potential for use in the sugar industry, and preferably that have already been registered for use in other crops (in the case of agrochemicals such as herbicides and pesticides). One of the conditions attached to such testing is that SASRI's name will not be used in product marketing. All such requests are channelled through SASRI's SAR (Specialist Advisory Request) Panel, who make an assessment of the scientific credibility of the product, its likely benefits to the industry, and whether there is capacity among SASRI specialists and technicians to take on the work of testing it in sugarcane. Two articles detailing SASRI's role in this process and the legal aspects of the use of new products in sugarcane have been published in *The Link* (Redshaw, 2011; 2016).

However, in light of these issues raised by growers, the SAR Panel will also produce a document that will serve as a guide for growers and Extension Specialists to use for their own initial assessment of whether to give any such products consideration in the first place. The document will provide a series of questions that need to be answered to satisfy growers or their Extension Specialists that the product either is, or is not, worthy of further consideration for use on their farms or in their region, and possibly for testing by SASRI. Should growers, based on this initial assessment, decide that they wish to pursue their own testing of a product on their farm, then they are advised to perform an observational trial with the guidance of their Extension Specialist. Guidelines for the establishment and conduct of such trials have been provided in an article in The Link (Berry, 2007).

Growers and Extension Specialists are also alerted to several other previously published articles, which explain the SAR process and may serve as a guide in the interim (Anon, 2009; Berry, 2011; Botha, 2007; Miles and van Antwerpen, 2009).

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ARABLE ROTATION (SASRI REF: ISSUE 17)

Grower Issue Description

Research into arable rotation – holistic approach. **Describe the issue:** Rotation + diversity contribute to reduced P&D and improved soil health. Cost-benefit analysis essential. Benefits in times of drought. Cane / other crop mix + economics. **Background:** To keep Growers viable. Alternatives available for SSG. Mike Parsons study. Economics. BFAP (UP + US) – Outlook forecast on commodities. **Desired End Result:** Evaluate a holistic approach to sugarcane production (economics of diversification). Balance "collective" production package e.g. Pannar.

SASRI Communication

Over the years, SASRI has investigated and communicated the advantages that crop rotation may hold for sugarcane production, particularly for the soil health improvements that result from a break in sugarcane mono-cropping (e.g. Berry *et al*., 2005; 2009). The economic and other benefits that small-scale growers could potentially gain from inter-cropping and crop rotation with cash crops has been a particular focus of attention (e.g. Parsons, 1999; 2003; Ramouthar *et al*., 2013; Cockburn *et al*., 2014), as it has been in other parts of the world (e.g. Pillay and Mamet, 1978; Govinden *et al*., 1984; Leclezio *et al*., 1985; Govinden, 1990).

The issue on arable rotation raised and discussed during the 2016 RDE Committees' Workshop in Malelane, however, speaks to crop rotation on a scale completely different to that previously considered by SASRI. From this issue, it is clear that growers are seeking tools to guide their decision-making around the diversification of their sugarcane farming enterprises. This need is compatible with an increasing recognition of the need to support growers in endeavours that ensure the sustainability of cane supply in the medium- to long-term.

To address this RDE Issue, agreement has been reached between SASRI and CANEGROWERS as follows:

- The work is to be conducted as a collaborative project between CANEGROWERS (Jacques Schoeman, Theuns Theunissen, Christopher Gemmel) and SASRI (Rowan Stranack, Marius Adendorff, Prabashnie Ramouthar, Derek Watt.
- The work to be undertaken falls within the mandate of both parties, in that focus is on promoting sugarcane grower sustainability through diversification.
- CANEGROWERS will provide economics modelling expertise, while SASRI will provide input on agronomic issues and manage the project.
- Economics of diversification falls within the specific job scope of Theuns Theunissen (CANEGROWERS Area Manager: Regional Services Pongola).
- The envisaged solution comprises a tool, based on economic models, which will facilitate grower decision-making regarding improved profits that might be achieved through enterprise diversification into other crops as part of a crop rotation strategy with sugarcane.
- The tool will focus on irrigated cultivation of four to five annual crops and will specifically target commercial-scale end-users.

NEW PROJECT PROPOSED

In 2017/2018, SASRI is to implement a collaborative project with SA CANEGROWERS to develop an on-line tool that will assist grower decision-making around diversification of their farming enterprises.

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RIPENING (SASRI REF: ISSUE 18)

Grower Issue Description

Describe the issue: Subsidies / when to ripen, etc? Who makes the call if and when to ripen? **Background:** Farmers' responsibility to communicate with those who can advise. Work has been done – info needs to be packaged. **Desired End Result:** More direct (specific) recommendation for ripening (PurEst). Alternative methods of applying ripening.

SASRI Communication

In this issue stakeholders raised two areas of attention: a) More direct (specific) recommendations for ripening (e.g. PurEst™); and b) alternative methods of applying ripening.

a) A ripener efficacy index (REI) is under development for implementation in WeatherWeb. This tool will allow the Extension Specialist, or individual growers, in a region to assess the suitability of crops on an area-wide basis for ripening. Together with PurEst™, which allows estimation of juice purity (with hand-held refractometers) on a field-by-field basis, this empowers extension specialists, growers and millers in ripening decision-making. SASRI can supply the technology to enable grower and miller decision-making but cannot adjudicate miller-grower decision-making with regard to ripener application.

b) Chemical ripening is a very well-established BMP within the South African sugarcane industry with a highly favorable cost-benefit ratio. Aerial application of a single ripener product can cost in the region of R730/ha of which ~R505/ha can be the actual application cost. On the other hand, RV yield benefits of between R3600 to R7200/ha are often realized under commercial conditions, provided ripeners are applied correctly to sufficiently immature crops. Hence, chemical ripening is a lucrative and widely-adopted BMP.

On an industry-wide scale, over 60 000 ha of sugarcane are ripened in a season with normal rainfall. At the current maximum application cost of ~R505/ha ripener application could cost the industry up to R30 million per season. Milling companies often subsidize this cost therefore resulting in an even more favorable cost-benefit ratio to growers. In the subsidizing of ripening within a mill supply area, the miller therefore spend substantial amounts of money per season. More cost-effective alternatives to apply ripeners could reduce these subsidy costs. Besides the fact that growers share in these costs to a lesser or larger extent (in some mill supply areas the full cost), they often also struggle to secure the services of crop spraying pilots at the right times within their harvesting schedules, especially in remote areas (e.g. Pongola), or during years where the majority of crops are not suitable for ripening and pilot visits to these areas are infrequent. Smaller, or irregular shaped, fields on both large-scale and small-scale grower farms are also often not suitable for aerial ripener application. This often results in very poor quality results in fields that needed ripening. In light of this, three RDE requests (miller, grower and extension-driven) have been received during 2016 requesting SASRI to investigate more cost-effective ripener application methods (issues no. 6, 18 and 26).

In terms of more cost-effective aerial application of ripeners it is recognized that unmanned aerial vehicles (UAVs) might potentially be the method-of-choice in future. However, UAV technology is not yet suitable for commercial implementation partially because of the current 18 kg payload limit for most UAVs. There are also other limitations such as the requirement that UAVs fly very low during ripener application and still lack sufficiently sensitive surveillance technology to detect all types of physical obstacles (power lines etc.). It is estimated that UAV technology is at least five years away from overcoming these and other limitations. SASRI will remain abreast of developments and collaborate with potential service providers to test the efficacy of UAVs for purposes of ripening when such opportunities arise.

There are other potential methods of applying ripeners on the ground such as through irrigation systems (center pivot, Venturi in overhead sprinkler system, sub-surface drip) and by other means (hand-held spray boom, tractor-mounted spray boom, high-rise tractor with spray boom, and mist-blowers).

The current reality is that, for purposes of applying ripeners, the system (hardware) and operating specifications and thresholds, user protocols and efficacy results (i.e. suitability for ripener application) are not readily available for many of these potential alternatives. Growers are therefore unsure which alternatives would be the most effective from a ripening and cost perspective, and also how to ripen crops with these methods.

With this in mind, a technology development project, has been developed for inclusion in the 2017/2018 SASRI Programme of Work. Implementation of the project is subject to funding approval from the grower and miller leadership serving on SASA Council.

The objective of the work is as follows.

Evaluate the suitability of the above-mentioned alternative ground-application methods for chemical ripening purposes, specifically to:

a) define for each suitable alternative the hardware and operating costs, hardware and operating specifications

NEW PROJECT

SASRI is to initiate a project in 2017/2018 to investigate technologies for ground-based ripener application (subject to funding approval by the grower and miller leadership serving on SASA Council).

and thresholds, and protocols for use; and

b) evaluate the in-field efficacy of suitable alternative methods in collaboration with extension and growers in the form of commercial demonstration trials.

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HARVEST AGE (SASRI REF: ISSUE19)

Grower Issue Description

Variety released in Autumn? – NovaCane will solve? Ageing cane? Eradicate Nov- fallow summer. Optimum age of cane. Accurate testing of varieties for recovery. **Background**: After drought + wet feet tolerance of. Desired **End Result**: Economic analysis of optimum age of cane. Drought tolerance of varieties evaluated.

SASRI Communication

There is current uncertainty around the optimal harvest age of cane, not just in the irrigated region, but in all regions of the industry. In the irrigated region, spring plant crops are sometimes carried over and harvested at 17 months of age, with good RV yields. It must be noted that these good RV yields are linked to the fact that these are plant crops with slower growth and development. Ratoon crops, on the other hand, should certainly not be harvested at 17 months of age due to the high risks associated with lodging, flowering and eldana damage. There is also a perception that harvesting ratoon crops at 14 to 15 months may be more economical in irrigated areas. Although this is a theory that is yet to be confirmed with actual production or experimental data. While older harvesting may lead to higher RV yields per crop, the long term effects of this strategy are still unknown, particularly when considering the agronomic limitations of lodging, flowering and eldana damage. Furthermore, varietal suitability to time of harvest is a factor that complicates the staggering of subsequent ratoon crops further into the milling season.

Given the above considerations, it is clear that the issue is not simple. An extensive evaluation of the yield potentials, risks, and economic impacts of older harvesting in irrigated areas is needed. Consequently, SASRI is to initiate a project in 2017/2018 (subject to funding approval from the grower and miller leadership serving on SASA Council) to evaluate these issues and provide guidance to growers on the optimal harvest age of cane over a full cropping cycle in the different regions of the industry.

NEW PROJECT

SASRI is to initiate a research project in 2017/2018 that will provide information to guide growers on optimal harvest ages for their regions (subject to funding approval by the grower and miller leadership serving on SASA Council).

For now, however, growers in irrigated areas are still encouraged to maintain the 12-month harvest cycle and focus on varietal adaptability to harvest time (early, mid, or late season).

For additional information, refer to Drought Tolerance of Varieties (SASRI Reference: Issue 4)

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MECHANICAL HARVESTING (SASRI REF: ISSUE 20)

Grower Issue Description

Describe the issue: RCL – doing trials on range of aspects related to mechanical harvesting – not sharing. Also controlled traffic at Pongola. SASRI needs to verify results. **Background:** Loss of jobs? Impact on social issues Spread **Desired End Result:** Quantification + verification of trials + studies (SASRI). Mechanical harvesting, loading, controlled traffic. Quantify impact of RSD and impact of social issues.

SASRI communication

In preparation for moving to a semi- or fully-mechanised operation, there are a number of considerations that need to be taken into account. These are comprehensively detailed in the paper by Meyer (1997). In summary, a move to mechanical harvesting requires assessment of the following:

- *labour* - availability, productivity, health and safety, cost and management, training, legislation;
- *mechanical system considerations* - capital, cash flow, tax, choice and serviceability, replacement, risk, machine operations, operator proficiency, scale of operations and utilization, after sales service, transport systems to suit, DRD, payload density, road and zone infrastructure requirements;
- *crop presentation* - condition, row shapes, row spacing, row lengths, field layout, stalk thickness, hardness, brittleness, trash levels, lodging, P&D, field conditions, slopes, headlands, rocks, drainage, soil compaction;
- *crop management* - cane quality implications of the system, losses, extraneous matter, post-harvest deterioration, environmental considerations; and
- *management* - preferences, skills, facilities, security.

These crop, machine and management inter-dependencies and interactions need to be carefully considered when comparing systems. Such a change would require dramatic organizational changes, stringent field preparation, agronomic and integrated harvesting system considerations and an entirely different transport system (Meyer *et al*., 2005).

A spreadsheet model to estimate mechanical harvesting costs was developed by Meyer (1998) to enable the cost implications to be better understood when considering such a move. As per the above list, this is only a small component that needs to be taken into account. Any limitations impacting on harvester performance would need to be included in the cost analysis. Meyer's paper (Meyer, 1998) covers some of these aspects by looking at the impact of row length, cane yield, harvester speeds, operating hours, ancillary equipment requirements and similar parameters impacting on harvester output.

In South Africa, Meyer (1996) showed a decrease in productivity of manual cutters from burnt to green cane in the order of 10% for windrow operations from 8.2 to 7.5 t/man-day. If stacking was required, then the production decrease was in the order of 40% from 5.5 to 3.3 t/man-day. In reviewing the work of de Beer and Boevey (1979), Meyer (1996) noted that row length and lack of ancillary trailers had a marked impact on harvester performance. Meyer and Fenwick (2003) investigated cutter performance and showed a reduction in productivity of 15% (6.6 to 5.6 t/day) for cut and bundling green cane and 28% (4.2 to 3.5 t/day) when stacking was compared to burnt cane.

In the 1970s, trials on chopper harvester performance and cane loss were conducted by the SA sugar industry in Swaziland (de Beer, 1980). In those trials, manual cutting had the greatest field recovery of cane (2.1% loss) compared to that of two mechanical harvesters (6.8% and 15.3% loss respectively), the latter showing the impact of poor harvester maintenance compared to the first. The hand cut cane had less extraneous matter at 3.1% compared to the mechanical (4.5% and 12.5%, respectively). Extraneous matter (EM) was reported to have a detrimental impact on transport, milling performance (crushing rate reduced by 2.2 to 3% per % EM) and sugar recoveries (1.5-2% loss per % EM).

Such trials were repeated using more modern harvesters over three seasons ending 2001 in Swaziland by Meyer and co-workers (2002). Those trials showed that infield losses were significantly lower using manual harvesting compared to mechanical chopper harvesting, ranging between 1.5-3.9% (manual) versus 3.7-5.6% (chopper). Quality measurements were not statistically different. Quantity of cane delivered varied considerably between trials but for two of the three trials there was a greater recovery of millable cane for the chopper harvester compared to the manual cut cane. Subsequent growth measurements did not show statistical differences, but this was not carried through to subsequent harvest or ratoons to test long term longevity and ratoonability related to varieties or to treatments.

During the 1970s, the Australian industry transitioned from whole stalk to chopper harvesting. Substantial losses for chopper harvested cane in the gathering process (0 to 10% losses) and the cleaning process (2-10% in burnt cane and 3-15% in green cane) were measured from the 1970s to the 1990s (Anon, 1992). Factors associated with chopper harvested cane losses were reported as:

- *poor field preparation or operating conditions* - unsuitable row profiles, poor topping, harvesting during adverse field conditions;
- *harvester design and operating settings* - cleaning systems, fan speeds, air velocities, speed of operations, cane presentation;
- *varietal traits and condition at harvesting* – lodging, thin stalk, high trash levels, low stalk population densities, green cane harvesting (when harvesters set to remove EM); and
- *EM levels* - dirt levels increased during the early stages of mechanical harvesting.

Other concerns raised were: (a) field compaction effects; (b) cane stubble damage (worse when base cutting above ground level and at higher speeds); and (c) subsequent ratoonablity.

Reducing losses and EM levels are a trade-off.

In Brazil, with the move towards integrated cogeneration-ethanol-sugar milling plants, combined with a prohibition of burning practices, there has been a shift away from manual burnt cane harvesting (40% of production) to mechanical harvesting (60% of production) (Anon, 2012). Drivers for this were noted as:

- *social and environmental impacts* - negative impacts of cane burning on workers, surrounding communities and on the environment;
- *labour productivity* - manual green cane harvesting results in productivity decreases of around 50% from 12 t/d to 6 t/d (Anon, 2012);
- *biomass demand for cogeneration* – ideally with high efficiency high pressure steam boilers and turbines to generate energy surplus for exporting to the national energy grid;
- *efficient water use* - reduced water use associated with green cane processing versus burnt cane processing; and
- *legislative pressure* - legislation to phase out pre-harvest burning practices entirely by 2017.

In Brazil, a significant major disadvantage of mechanisation was the loss of jobs, estimated to be about 100 jobs per chopper harvester (operating 24 hours per day).

In Sudan, Ahmed and Alam-Eldin (2015) reported the shift to mechanical harvesting as being a cost effective change. Severe labour shortages and rising labour costs promoted the adoption of mechanical harvesting to 40% of the area harvested in Sudan since 2000. A study of manual versus mechanical harvesting was conducted. The local industry typically achieves yields of approximately 100 t/ha. Manual harvesting under these conditions achieves rates of approximately 4.5 t/man-day. Cost comparisons were given in Sudanese pounds (SDG) with a currency conversion of 1 SDG = 0.486 US$. Labour costs in Sudan were 18.47 SDG per man-day for the 2006/07 season with 13.7 SDG (74%) attributed to cutter wages. The costs attributed to chopper harvester (4.95 SDG/t) were found to be much lower than manual cutting (5.58 SDG/t) and loading operations (3.4 SDG/t) combined and, thus, was given as a motivation for further adoption of mechanical harvesting. Losses were found to be marginally higher for the mechanical harvesting operation. Extraneous matter levels were much higher for the mechanically harvested cane compared to manually harvested (10% versus 3.7%). Trailer payloads were found to be approximately 40% higher for the billeted chopper harvested cane compared to manual harvested cane.

Meyer *et al.* (2005) reported on the impact of harvester pour rates, comparing green and burnt cane in relation to cane yield. A rough guide is approximately 25% reduction in pour rates and about 13 % increase in fuel consumption (1.04 to 1.18 L/ton) associated with mechanised green-cane harvesting. There appears to be a consistent view indicating that the losses due to green cane harvesting (EM removal) is comparable to the losses through accelerated deterioration and longer BHTC delays for burnt cane. Load densities comparing whole stalk and billeted cane range from 160 kg/m³ for whole stalk loosely packed cane to 400 kg/m³ for neatly bundled straight cane. Billeted cane under various EM% and billet lengths range from 320 kg/m³ for 350 mm billets (15% EM) to 430 kg/m³ for 200 mm billets (0% EM). Various specific management considerations when moving to a green cane system are:

- *harvesting system* - harvesting system change implications as described previously;

- *residue management issues* - mulch levels, residue treatment, partial or full removal and subsequent considerations…
- *crop nutrition* - fertilizer choice and placement under residue; and
- *weed control* - weed spectrum changes, selective herbicide and application strategies, savings.

Norris *et al.* (2015) provided an overview of chopper harvesting experiences. Worldwide trends show an increase in mechanical harvesting particularly towards green cane harvesting. When widely adopted and poorly managed, the result was typically a destruction of value with reduced crop cycles and accelerated yield declines, gross yield loss and value loss across industries. The Australian yield plateau was given as a reference and experiences and development made providing important areas in order to prevent similar experiences being repeated. The focus areas include:

- *basecutter blade maintenance* – length, numbers, blade speeds, sharpness and profiles, blade angles;
- *harvester setup* - fan speeds vs EM levels, billet lengths (15 to 40 cm) vs load densities, harvester speed vs basecutter speed, extractor system;
- *harvester type* - number of blades on drum vs losses, larger bin diameters, aggressive fan blades and thus higher airflow;
- *field conditions* - rocky, uneven profiles etc.;
- *crop characteristics affecting EM levels* - lodged vs erect, thin vs thick stalks;
- *compaction and stool damage* - compaction and stool damage resulting from uncontrolled traffic and row spacing mismatching;
- *EM levels* - transport density, mill performance (crush rates, sugar extraction, sugar quality) LOMS increases,
- *divergent goals* - harvester output (speed and pour rates), transport (billet length) and milling (EM - extractor speeds); and
- *best management practices* - best harvesting practices target minimal losses and higher recoveries and can be comparable with hand cut operations

Results from recent trials conducted in Mpumalanga indicated that, when operated under best practices, mechanical harvesting indicated:

- higher cane delivery from for machine harvested plots compared with harvested by hand;
- higher RV% for green hand cut (trashed) and burned hand cut plots;
- highest RV (t/ha) for green cane machine harvested operations; and
- lowest harvest to crush delays for machine harvested plots.

Synopsis

Reasons necessitating a move to mechanical harvesting operations, include:

- lack of labour / unwillingness to harvest the crop; and
- rising labour costs and lower productivity

a) Manual harvesting operations (burnt cane)

Advantages	Disadvantages
• Harvesting costs are a known variable cost (R/ton)	• Health and safety and environmental issues (burning)
• Flexible – can alter systems relatively easily	• High social skills/people management requirement
• Suited for smaller operations	• Higher dirt/ash levels typically (depends on systems)
• Can harvest on slopes	

b) Manual harvesting operations (green cane)

Advantages	Disadvantages
• Environmentally more sustainable, residue blanket pro's	• Loss of worker productivity
• Reduced deterioration rates for green cane	• High social skills/people management requirement
• Savings in weed control, water and soil conservation with residue blanket	• Loss of available payload

c) Mechanical harvesting operations (green)

Advantages	Disadvantages
• Can operate in green and bunt cane	• Loss of jobs
• Possible Tax incentives	• High initial capital costs require high utilization of equipment to reduce fixed cost component
• If well managed and operated CH: cane recovery can be higher than manual cane harvesting	• Higher skilled operations, higher technical and management requirements
• Payloads improved with billeted cane vs whole-stick green	• High losses if not managed well- visibility, billet lengths, speed, fan speeds, cane presentation, cane stalk thickness, cane trash levels
• Can use residues as a cogeneration opportunity and increase revenue streams	• Higher levels of EM – impacts on crushing rate and sugar recovery
• Harvest to crush delays typically lower than manual systems	• Field compaction and high traffic levels
• Reduced deterioration rates for green cane	• Operations subject to terrain and slope limitations
• Reduced water use for milling processes compared to burnt	• Risk of rapid disease spread (eg. RSD)
• Can operate on a 24 hour basis for continuous mill throughput	• 24 hour operations required for utilization benefits
• Savings in weed control, water and soil conservation with residue blanket	• Cane stubble damage and poor ratoonability may occur
• Green leaves can be left in field and brown leaves extracted	• High infield residue levels may lead to other issues
	• Operator visibility can be limited/base cutter sensors

- Higher dirt/ash levels typically (depends on systems)- floating base cutter is better at not cutting roots and stools
- Residue blanket: Pests and diseases eg. trash worm, eldana, RSD

Resources available

The Sugar Research Australia (SRA) harvester best management practices (BMP) manual provides information on mechanical harvesting issues such as base cutting management, fan speed settings, extraneous matter levels and how to minimise cane losses from mechanical harvesting systems (general principles).

http://www.sugarresearch.com.au/page/Growing_cane/Resource_library/Publications/Harvesting/

The Harvester BMP manual from SRA (www.sugarresearch.com.au) describes a number of guidelines to produce quality cane economically. Listed below is a summary of considerations.

- Cane harvested green produces higher quality raw sugar (ash content and dextran levels) than burnt cane.
- Clean cane, lower losses, less soil and less stool damage improves at lower harvester pour rates which are achieved by slowing down the harvester – all at the expense of higher harvesting costs.
- Optimum topping height should be set.
- Gathering spirals are optimised for speeds of 6-8 km/h.
- The type (profile) and setup of floating shoes can be adjusted in order to best gather stalks.
- Height control settings of the gathering fronts is essential to pick-up all the crop.
- Forward feed controllers regulate the supply of cane evenly and consistently into the base cutters and can cause stool damage if not setup correctly.
- Knockdown roller assists primarily in non-erect cane to position the cane away from the harvester for butt first feeding. Setup is important to minimise stool damage, soil in cane, extractor losses etc.
- Finned rollers help moderate the cane supply across the basecutters. Their speed of rotation is important.
- Basecutters cut the cane at ground level and feed the cane into the feed train and are also the source for stool damage and soil ingress. Setup considerations include: number of blades, sharpness, angle of leading edge, blade length, blade speed (rpm), surface profile, blade thickness, blade design, hardness and soil surface characteristics encountered.
- The butt lifter roller is used to guide cane into the feed-train butt-first. Roller tip speed of the butt roller needs to be considered.
- The roller train accepts and conveys cane to the chopper box evenly. Speed adjustment will affect the feed roller speeds and harvester feed through the machine. Critical ratios of relative speeds of the sets of rollers is essential to ensure good billet quality and minimum deterioration.
- Rubber coated rollers are required for quality seedcane billets with minimum damage. Ratios of roller to chopper speeds are essential.
- Rotary chopper systems- factors affecting losses include: roller speed ratios; pour rate; blade sharpness and variety and crop condition.

- Primary extraction chamber is where the cane is cleaned via extractor fan. Correct setup is essential.
- The deflector plate controls the trajectory of the cane from the chopper.
- Elevator conveyor is the next phase of getting the cane to the haul out equipment.
- The secondary extractor is located on top of the elevator for final clean-up of extraneous matter from the cane. Balancing of the primary and secondary extractor workload is required by the operator.
- Cane losses are an inevitable part of the process of separating trash from cane on the harvester. Cane losses through the extractor are essentially invisible with typically less than 20% cane loss as visible cane stalks. For each ton of trash not extracted, an additional 2 to 5 tons of cane is recovered compared to normal harvesting operations.

The full manual on harvester best practices is available on the SRA website:
http://www.sugarresearch.com.au/page/Growing_cane/Harvesting/Publications/

Weblink address:
http://www.sugarresearch.com.au/content/FlippingBooks/Harvesting%20Best%20Practice%20Manual/ Accessed 24/06/2015.

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OPTIMAL WATER USE (SASRI REFERENCE: ISSUE 21)

Grower Issue Description

Describe the issue: More crop per drop. As per Pongola issue list. Linked to holistic approach. **Background: Desired End Result:** Minimum water to sustain / keep crop alive for commercial and SSGs. Set of recommendations. Water use guidelines – crop response to water stress, what to do with limited water?

SASRI Communication

Irrigation is essential for successful sugarcane production in the hot and dry regions of northern KwaZulu-Natal, Swaziland and the Mpumalanga lowveld due to insufficient rainfall. For maximum growth, the supply of water to the plant from the soil must equal the demand of water from the atmosphere. Irrigation scheduling is the practice of deciding when and how much water to apply. Poor irrigation scheduling can result in either under-irrigation, leading to water stress and reduced yields, or over-irrigation which leads to misuse of water and electricity resources, leaching of expensive fertilisers, erosion of topsoil and anaerobic soil conditions resulting in yield reductions and consequent negative return on investment. Several tools are available to assist growers with accurate scheduling of irrigation.

During times of limited water supply, normal irrigation scheduling practices will initially help to limit the effect of drought and increase the efficiency of water use (more crop per drop), but as water supplies dwindle, alternative irrigation strategies are required. These strategies may include reducing the total area under cane (abandoning fields) or spreading the limited amount of water over the total area. In order to do this correctly, prior knowledge is required with regards to the sensitive growth stages of sugarcane. To aid growers in this decision making process on how to manage limited water supplies, work is underway (SASRI project 09CM06) to develop a whole-farm water allocation decision support program (DSP). The development of the DSP is at an advanced stage and further information may be obtained directly from Dr Abraham Singels (SASRI Principal Agronomist) (Abraham.Singels@sugar.org.za) or via the local extension specialist.

Irrigation booklet development

SASRI has recently begun to update and expand the information sheet series on irrigation. Completed information sheets to date are listed in Table 1. Of specific interest is the information sheets on available irrigation scheduling tools (Info sheet 5.4: Irrigation scheduling toolbox) and strategies during times of drought (Info sheet 5.2: Water management strategies during water limiting periods). Once all the planned topics are covered it is envisaged that all the information will be combined into a small irrigation booklet.

Table 1. Available information sheets on the topic of irrigation

Information sheet	Contents
• Fundamentals of irrigation (Information Sheet 5.1)	• Soil water balance, irrigation efficiency
• Water management strategies during water limiting periods (Information Sheet 5.2)	• Management strategies, sensitive growth stages
• Basics of irrigation scheduling (Information Sheet 5.3)	• Soil water content limits, evapotranspiration, atmospheric demand
• Irrigation scheduling toolbox (Information Sheet 5.4)	• Available irrigation scheduling tools
• Chemigation – Principles and fundamental equipment (Information Sheet 5.5)	• Equipment, application methods
• Chemigation – Guidelines for choosing chemicals (Information Sheet 5.6)	• Fertilisers, herbicides, fungicides, insecticides and growth regulators
• Introduction to irrigation systems (Information Sheet 5.7)	• List of different irrigation systems
• Energy inputs and electricity saving (Information Sheet 5.10)	• Energy tariff structures, irrigation design and management factors

Irrigation scheduling tools

Knowing when to irrigate and how much to apply with each irrigation requires knowledge of the amount of water in the soil and/or the crop water status. Knowledge can be gained either through direct measurement or by means of estimation. Direct measurement of soil water content is preferable to weather-based model calculations. Various irrigation scheduling tools are available in each of the above categories. A decision tree, such as the example shown in Figure 1, can be used to choose the most appropriate tool for your specific situation. Information sheet 5.4 provides basic information on the advantages and disadvantages of each. Of special note is the capacitance probes which have gained tremendous popularity in the past few years due to user-friendly software, easy access to near real-time data. As a result this service is advertised by a large number of companies. SASRI has compiled a checklist to aid growers in selecting an appropriate service provider.

Further details may be found in Development – how to manage water optimally (SASRI Reference: Issue 23).

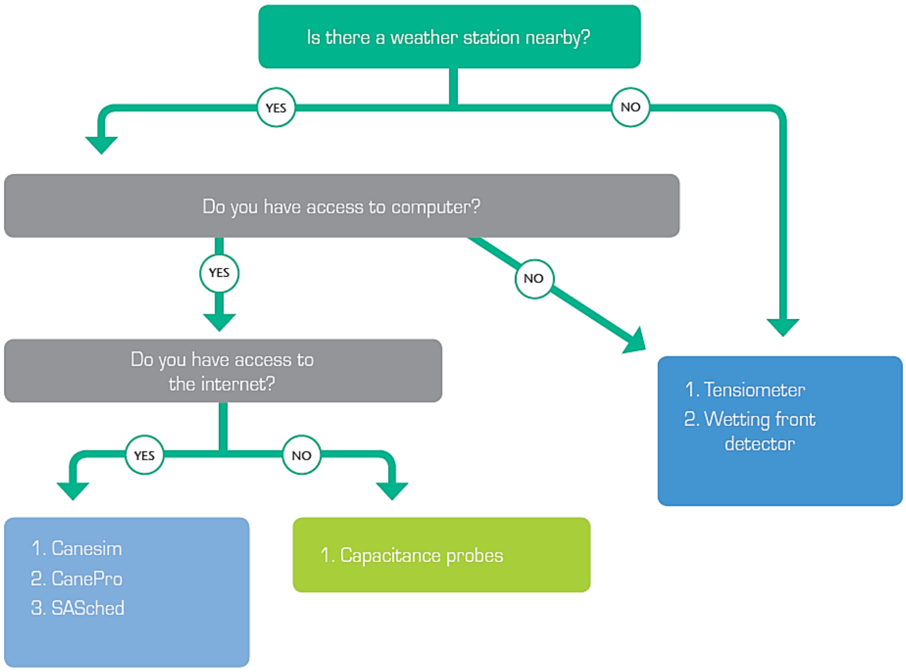

Figure 1. Decision tree for selection of the most appropriate irrigation scheduling tool

In many instances, growers only consider the capital cost of the scheduling tool and/or software (Table 1) to make the decision whether to schedule or not, without taking into account the cost savings in reduced water application and electricity (less pumping hours). Issue 23 (*Development – How to Manage Water Optimally*), which is discussed further on in this document, elaborates further on this by means of an example and shows clearly that the advantages of scheduling far outweighs the cost and that the investment in an irrigation service provider can be paid off within the first year.

Table 1. Most widely used irrigation scheduling tools in the sugar industry.

IRRIGATION SCHEDULING TOOL	COST
Direct measurement of soil water content	
• Capacitance probes	R7000 to R10 000 (incl. automatic rain gauge)
• Tensiometers	Irrometer (R1450 for 300 mm, R1550 for 600 mm and R1600 for 900 mm)
• Wetting front detector	R482 for set of two (600mm and 900 mm) from AgriPlas
Indirect estimation of soil water content	
• Soil water budgeting spreadsheets (SASched)	No cost

• Crop models Canesim and CanePro	MyCanesim: www.sugar.org.za/sasri (look under the Crop Resources tab) Weather web: http://portal.sasa.org.za/weatherweb/

Irrigation strategy during water limiting periods

Droughts are an inherent part of the South African climate. An important strategic decision to be made during a drought or water-scarce period is whether to reduce the area irrigated or to spread the limited water over the whole area.

Reduction in irrigated area - Reducing the area irrigated by abandoning fields is a drastic step which should only be considered as a last resort. The long-term consequences can be very costly due to the high costs associated with replanting. This may be the ideal time to eradicate poor yielding and old ratoons as well as diseased fields.

Spreading limited water - There is good evidence that spreading limited water over a relatively larger area results in optimal overall returns due to gains in irrigation and rainfall use efficiency, as well as reductions in variable production costs. Sugarcane is a hardy crop and mild water stress towards the end of the crop often results in increased sucrose content. Overall, a flexible approach is best, where some fields may not receive their full water requirement, but can be brought back into production when the water situation improves, rather than being completely abandoned.

Critical stages of crop water requirement

Not all sugarcane growth phases are equally sensitive to water stress and considerable water savings can be made if the irrigation strategy is adapted accordingly:

- *Shortly after harvest* - Restore the soil to field capacity (FC) or as close as possible to FC depending on water availability.

- *Post-harvest or tillering phase* (less sensitive) – Mild water stress in this period has minimal impact on yield, provided the stress does not affect final tiller numbers. Reduce irrigation amounts and extending irrigation intervals Considerable water can be saved.

- *Rapid growth or stalk elongation phase* (which stretches from just before the establishment of a full crop canopy to just before the drying-off phase) – Most sensitive stage which requires adequate irrigation to limit impact on yield.

- *Prior to harvesting or drying off phase* (less sensitive) - Water stress is beneficial enhancing sucrose yields. Considerable water savings can be made here.

Other considerations include:

- Available water should rather be used for refilling the soil profile on recently harvested fields than for irrigating old and maturing crops.

- If necessary, give preference to fields that have had only a few ratoons, rather than fields which have had many ratoons and are due to be replanted soon.

Water allocation DSP

SASRI is developing a computer tool to help farmers allocate limited water optimally to the various fields on the farm during times of drought. It will take into account current crop and soil water status, and expected climate and irrigation water supplies to work out how to allocate available water on the farm for the rest of the season. This will assist in maximizing whole farm profit, and minimizing the damage to long term production potential. The DSP will be rolled out on selected farms early in 2017. Further information is available from Dr Abraham Singels (SASRI Principal Agronomist) (Abraham.Singels@sugar.org.za) or the local extension services.

INNOVATION

Development of a decision support tool is nearing completion. The tool will assist growers in decision-making regarding the best use of limited irrigation water.

Further information on the DSP is available from Dr Abraham Singels (SASRI Principal Agronomist) (Abraham.Singels@sugar.org.za) or the local extension services

Further details may be found in How to manage water optimally (SASRI Reference: Issue 23).

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IN SITU RSD TESTING (SASRI REF: ISSUE 22)

Grower Issue Description

Describe the issue: Local RSD testing (by whatever method). **Background: Desired End Result:** To be able to test more for RSD – on the 'to do' list.

SASRI Communication

A previous SASRI technology development project aimed to develop a new molecular technique, known as Loop-mediated isothermal amplification (LAMP), to diagnose ratoon stunt (RSD). The first objective of the project was to develop the LAMP method, which involved the design of specific primers, optimisation of the protocol, and specificity and sensitivity studies to ensure the assay was reliable, rapid and robust. The assay was developed successfully and allows detection of *Leifsonia xyli* subsp. *xyli* (Lxx) (the bacterium that causes RSD) in 30 min at 65°C using xylem sap as the template. This is then followed by visualization of the amplified bacterial DNA product using a disposable lateral flow device (LFD) which gives a negative or positive RSD result.

The second objective of the project was to investigate the feasibility of using this assay in a near-to-field situation. It became evident that the LAMP assay was prone to contamination due to its sensitivity which increased the likelihood of false positives. For this reason the LAMP-

LFD method needed to be refined further before testing in outlying areas. The optimisation of the LAMP-LFD method was carried out by Dr Meenu Ghai at UKZN with the help of an honours student. This work included the successful testing and incorporation of an enzyme known as uracil-DNA-glycosylase (UDG), which was shown to reduce the risk of contamination when the assay was conducted in a well-equipped laboratory by someone with experience in molecular biology.

Current work

- Testing the storage capacity of the reagents when they are combined in a cocktail for the LAMP assay. Due to the sensitivity of the assay, the LAMP cocktail would ideally be made up in batches in a sterile environment before being sent to the outlying areas. It has been confirmed that the LAMP cocktail can be stored in the freezer for a period of two months without any deterioration. The three month storage test will be completed in July 2016.
- The LAMP assay is being tested in the RSD laboratory by staff who have laboratory experience but are not as skilled as molecular biologists in performing highly sensitive assays. Cross-contamination is still a concern but further training is underway.
- The increased sensitivity of LAMP means that alternative sampling methods can be investigated. Instead of extracting xylem sap from bulky stalk samples, small disks are excised from the leaf sheaths of standing stalks as described by Young et al. (2014). The leaf sheaths are combined in a tube with water which is later tested for the presence of RSD. This new method is non-destructive and sample collection is quicker and easier to perform. This allows for additional samples to be collected from a field, increasing the likelihood of detecting RSD in fields with low levels of infection.

Conclusion

The reason for considering LAMP as a suitable near-to-field RSD diagnostic assay was that it was reported to be a simple, quick and robust method. However, we have found it to be highly sensitive and prone to cross-contamination if adequate care is not taken when preparing the samples. For this reason someone with technical expertise, preferably with an understanding of and practical experience in molecular biology should ideally perform the assays. If the LAMP assay works well in the RSD laboratory at SASRI the method can then be tested further in the outlying areas. A 'laboratory' with a small bench-top microcentrifuge, water bath, micropipettes and a kettle would be required.

A new project aimed at developing a lateral flow device (LFD) that could be used at the field edge by relatively unskilled staff to quickly and reliably diagnose RSD is to be implemented in 2017/2018.

Reference

Young AJ, Nock CJ, Martin A and Ensbey M (2014). Novel diagnostic method for ratoon stunting disease: development and implications for RSD management.

NEW PROJECT

SASRI is to implement a technology development project in 2017/2018 to develop a robust near-to-field RSD diagnostic test kit (subject to funding approval by the grower and miller leadership serving on SASA Council).

The potential to share the high development costs of the test kit amongst multiple international sugarcane industries

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is to be explored at the annual business meeting of the International Consortium for Sugarcane Biotechnology to be held in San Diego during January 2017.

Further details may be found in Mechanical Harvesting: RSD and Cost Benefit Analysis (SASRI Reference: Issue 25) and Test for RSD (SASRI Reference: Issue 27).

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HOW TO MANAGE WATER OPTIMALLY (SASRI REF: ISSUE 23)

Grower Issue Description

Describe the issue: Cost benefit analysis of systems (measurements – soil moisture thresholds). Determining soil moisture thresholds. Which tools to use (tested by SASRI). **Background:** Information is available but compilation is needed. **Desired End Result:** Needs evaluation of the systems. Compilation of available information. Cost benefit.

SASRI Communication

The recent drought in northern KwaZulu-Natal and Mpumalanga lowveld has again emphasised the importance of accurate irrigation scheduling. Irrigation scheduling is the practice of deciding when and how much water to apply. Sub-optimal irrigation scheduling can result in either under-irrigation, leading to water stress and reduced yields, or over-irrigation which leads to misuse of water and electricity resources, leaching of expensive fertilisers, erosion of topsoil and anaerobic soil conditions resulting in yield reductions. A number of irrigation scheduling tools (please also refer to the SASRI communications on the issues Optimal Water Use [SASRI Reference: Issue 21]) are available to growers in the sugar industry that provides the user with advice in different forms. These tools include:

- suggestions to apply specified amounts on specified dates;
- measured or simulated estimates of soil water status which help the user to calculate how much to apply and when; and
- recent evapotranspiration estimates from weather data, which allow the user to calculate the soil water status and water requirement of the crop.

There are many service providers of irrigation scheduling advice in these various types. One specific method of measuring soil water content that has gained popularity in recent years, is the continuous logging capacitance probes. User-friendly software and ease of access to near real-time data has helped with the fast uptake of these probes.

With all this information at hand, growers are faced with a myriad of questions such as:

- How shall I go about choosing a service provider?
- How do the costs of the various service providers compare to each other?

- How much can I save by scheduling my irrigation?
- How long will it take me to cover the cost of the irrigation scheduling equipment?

Choosing an appropriate service provider

Choosing a service provider can be a daunting task. The following checklist outline provides some guidelines as to the key questions to ask before deciding on a specific provider.

1. *What does the product/service entail?*

- Data/ advice conveyance:

  - Is the data available via direct download to local PC, via web interface on central server, or delivered on PC or smart phone, via web or radio signal?

- Level of involvement:

  - Can the irrigation advice be applied immediately (when, how much and where to irrigate) or is additional post processing required (soil water deficit calculation)?

- Format and frequency of advice:

  - Is soil water status reported in index values (not calibrated) or in volumetric units (calibrated)?
  - Is advice provided on hourly, daily or weekly basis?
  - Is weather data also used in the advice to make a forecast?

2. *What is the quality of the equipment and software?*

- Durability:

  - What is the typical life span?
  - Is there some kind of guarantee?
  - How much of it is exposed above the ground?
  - What is expected from the user regarding maintenance and care?

- Sensors:

  - What kind of soil moisture sensor is used and can rainfall/ irrigation also be measured?
  - Sensor specifications, number of sensors, sensor depths, accuracy and precision?

- Battery:

  - What type?
  - How long does battery last and what is the cost of replacement?
  - Who replaces it?

- Data logger and transmission:
  - Data logging frequency and data transmission frequency?
  - Data transmission/download method (cell, local radio, Bluetooth/wireless)?

- How easy is the software package to use?

- What are the initial and annual cost of package?

3. *Installation and after sales service*

- How are the probes installed (placement in relation to cane row, irrigation applicators, soil variation, depth, angle)?

- What quality control criteria is used?

- After sale service:
  - What after calibration procedures are done, when and how often?
  - What is the agreement regarding maintenance and repairs?
  - How long to respond to a query and what are the call out fees involved?

- Cost:
  - How much is the initial cost of equipment, software, transmission costs (air time or radio licence), cost of repairs, maintenance costs, data costs, annual licence fee, etc.

4. *Is the company reputable?*

- Local or International:
  - Who and where is the owner/manufacturer of the company, probes, data transmitters, software?

- Do they have a web presence?
- How long have they been in existence?
- Do they have local representatives?
- Are they registered with SABI?

- References from other users:
  - Any feedback from current users?

- Are there local consultants for the company or does someone have to travel far from head office?

- What is the training and knowledge (ET and its factors (weather and canopy), soil water relations, irrigation systems, agronomy and crops, probe principles) of the local rep/agent and company staff?
- How easily contactable are they?
- Sugarcane knowledge:

  − Does the company have knowledge/ done previous work in sugarcane?

5. *Other considerations*

- Theft or vandalism:

  − How conspicuous is equipment (poles, solar panels, rain gauges etc.) in the field?

- Protection during burning and harvesting:

  − What measures are taken to protect the probes from damage during cane burning and harvesting operations?

- Is there good coverage by one or more cell phone provider across the farm?

- Are there any obstructions such as small hills or large trees between fields and the office that could limit telemetry based systems?

Cost comparison amongst different service providers

There are three major companies that are active in the sugar industry that make use of capacitance probes as part of their irrigation service to growers. These have been named company A, B and C (Table 1). Costs of company A and B are structured fairly similar, but company C is slightly more expensive due to the fact that they also make use of a crop model in addition to probe data to provide scheduling advice.

Of utmost importance in selecting a service provider is not to only look at the costs involved, but to also do some homework on the quality of the after-sales support. It will make a world difference if a service provider/ representative in your specific area is willing to walk the extra mile and address queries in a timeous and professional manner. Therefore growers must also be willing to pay a little extra to get the full benefit from their investment in the equipment and peace of mind.

Table 1. List of the major irrigation service providers which make use of capacitance probes. Company C also applies a crop model in addition to probe data to generate scheduling advice.

Company	Estimated cost of service Dated: June 2016	Comment
Company A	Probe = R6785 includes rain gauge Sim fee = R540 /probe/annum Data fee = R0	Replacement battery R100

Probes only	Software = R3815 Call out fee = R450/hour Initial cost = R11 590 Running cost = R1090 [R450 +R640/probe/annum]	
Company B Probes only	Probe = R7410 (R3300+R4110 Logger) Rain gauge = R2595 Sim fee = R150/probe/annum Client licence = R 2500 /annum Data fee = R95/probe/annum Installation fee = R350/probe Travelling fee = R4.80/km from Malalane (100km) Initial cost = R13 580 Running cost = R 3645 (R2980 + R665/probe/annum)	Replacement battery R420 Re-installation and removal = R175+R175
Company C Crop model **plus** probes	Probe = R7490 includes rain gauge Sim fee = R 0 Software = R6720 /annum Data fee = R1440/probe/annum Initiation fee = R3750 Initial cost = R19 400 Running cost = R8 260 (R6720 + R1540/ probe/annum)	Including installation cost Battery and sim included Replacement battery R100 No call out fees

Cost savings associated with accurate irrigation scheduling

An irrigation scheduling demonstration trial is currently being conducted in Pongola to evaluate scheduling methods of varying sophistication and to demonstrate the advantages associated with accurate scheduling. In this trial, surface drip irrigation is scheduled using a continuous logging soil water capacitance probe, the weather based Canesim® crop model and a combination treatment, namely Canesim® crop model plus capacitance probe. Standard farm practice (fixed irrigation cycles) served as the control treatment. Performance was evaluated in terms of cane yield and quality, amount of irrigation applied and financial benefits (Table 2).

Table 2. Final cane and RV yield, water use and cost of water and electricity obtained in the Pongola irrigation demonstration trial (plant crop).

Treatment	Cane yield (t/ha)	RV* yield (t/ha)	Water use (mm)	Water cost	Electricity cost	Total cost	Saving due to scheduling	RV gain
Control	118.3	14.5	1,350	R 1,485	R 3,771	R 5,256	-	-
Canesim	129.8	17.1	820	R 902	R 2,460	R 3,362	R 1,894	R11,439
Capacitance probe	120.8	15.8	950	R 1,045	R 2,782	R 3,827	R 1,429	R5,720

Canesim + capacitance probe	119.7	15.7	650	R 715	R 2,040	R 2,755	R 2,501	R5,280
						Average	R 1,941	R 7,480

*Current RV price = R4399.75/ton

* Please note. The trial is ongoing and the results above are preliminary (from the first harvest only).

In summary the main findings were:

- Substantially less water was applied where irrigation was scheduled compared to standard farm practices, without negatively affecting the cane yield or quality. Irrigation savings of 30% (400 mm), 39% (530 mm) and 52% (700 mm) were achieved for the treatments scheduled with the capacitance probe, Canesim® model and combination method, respectively.
- The combination method had the highest cost (water and electricity) saving (R2 501/ha) followed by the Canesim® (R1 894/ ha) and capacitance probe (R1 429/ha) methods.
- Profit margins increased due to higher RV yields as a result of irrigation scheduling, the highest was achieved by Canesim (R11 439), followed by capacitance probe (R5 720) and combination (R5 280) methods.
- Increases in irrigation water use efficiency (IWUE) were observed in all irrigation scheduling methods, the highest being 19.9 tc/100 mm irrigation for the combination method compared with 9.5 tc/100 mm irrigation for the control (standard farm practice).

How long will it take me to cover the cost of the irrigation scheduling equipment?

If the assumption is made that one capacitance probe covers an area of approximately 10ha (Table 3), it is quite clear that just the savings in water and electricity alone is sufficient enough to cover the cost of the investment in the scheduling equipment/ service within the first year. If the potential increase in income associated with higher cane and RV yield is also taken into account, there should no doubt whatsoever as to the benefits of accurate irrigation scheduling. The costs are thus relatively small in relation to the benefits that there are to be gained.

Table 3. Scaled up values of the savings in water plus electricity costs and increase in income.

Treatment	Saving due to scheduling (Water plus electricity) per 10 ha	RV gain per 10 ha
Control	-	-
Canesim	R 18 940	R 114 394
Capacitance probe	R 14 290	R 57 197
Canesim + Capacitance probe	R 25 010	R 52 797
Average	R 19 413	R 74 796

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VARIETY DEVELOPMENT FOR LONGEVITY AND RELATIVE DROUGHT TOLERANCE (SASRI REF: ISSUE 24)

Grower Issue Description

Describe the issue: Ensure we have information on longevity. ± 5 seasons = return on investment. **Background:** Concerned about longevity of varieties on the long run. We are not getting the 'legs' out of varieties. Need to grow varieties for 10 years. **Desired End Result:** Plant breeders to link up with commercial grower data to assist longevity of varieties. What is in the pipeline?

SASRI Communication

For information regarding variety drought tolerance, please refer to Drought tolerance of SASRI varieties (SASRI Reference: Issue 4).

Growers remain concerned about the longevity of the more recent sugarcane varieties released for cultivation, despite previous attempts by SASRI to demonstrate that management and environment play far greater roles i the longevity of these varieties greater relative effects of on ratoon longevity. Additionally, traditionally in South Africa, sugarcane production aims to maximise the number of harvestable crops from single plantings.

Generally, the relative profitability associated with quicker replanting has not been a major focus for many growers nor considered formally in the past. It appears that growers might value tools to assist with ratoon cycle decisions based on their individual production conditions. Consequently, SASRI is to implement a technology development project in 2017/2018 which will aim to provide growers with tools to support their decision making.

The objectives of the project are:

- to evaluate ratoon decline trends in different sugarcane varieties, with focus on a comparison of new with old varieties;
- to determine the relative contribution to ratoon decline of management and environmental factors compared with variety;
- to develop generic ratoon decline trends for different production conditions for incorporation into a decision-support system; and
- to evaluate the long-term profitability of different ratoon cycle strategies in different regions of the industry.

To accomplish these objectives, commercial production datasets from sugarcane estates will be mined to derive examples of ratoon decline trends associated with different management practices. The datasets will be used to illustrate the relative effects of variety versus management and environment on ratoon decline. Examples of ratoon decline associated with new compared to old varieties will also be extracted from the datasets and complemented with variety trial data. These examples will be used in various forums (including grower days and articles in *The Link*) to illustrate various concepts associated with ratoon decline under different conditions. The ratoon decline trends will also be incorporated into an existing decision-support system (Replant) to make it more representative of commercial conditions. At the same time, Replant will be updated to enable additional functionalities to assist growers with ratoon cycle decisions. Finally, an economic appraisal of different ratoon cycle strategies will be conducted for short, medium or long ratoon cycles using the SASRI CaneTEC economic conversion tool and the revamped Replant tool.

It is believed that the outcomes for the project will: (a) provide growers with comfort regarding his ratooning performance of new varieties; (b) demonstrate the effects of management on ratoon decline; (c) illustrate potential economic benefits associated with quicker replanting; and (d) provide a tool to assist growers with replanting decisions. It is envisaged that these approaches will encourage growers to consider ratoon cycle strategies that may be more profitable compared with conventional strategies.

NEW PROJECT

SASRI is to implement a technology development project in 2017/2018 that will advance knowledge of variety ratoon longevity based on both commercial and field trial data (subject to funding approval by the grower and miller leadership serving on SASA Council). The project will also develop a decision-support system that will assist growers in planning their replant programmes.

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MECHANICAL HARVESTING: RSD AND COST BENEFIT ANALYSIS (SASRI REF: ISSUE 25)

Grower issue description

Describe the issue: What is the cost benefit of the mechanical harvesting system – want SASRI involvement. Trials for RSD control with mechanical harvesting. **Background:** ± 5 year window before mechanical harvesting will happen on big scale à RCL trials will end by end of 2017. **Desired End Result:** RCL / SASRI – collaboration on mechanical harvest trials in the area à evaluating cost benefits and clear recommendations on RSD control (recommendations).

SASRI Communication

RSD is considered to be a manageable disease provided the recommended IPM strategy is followed, which primarily comprises planting healthy seedcane, decontaminating farm implements and fallowing. Unlike diseases such as smut and mosaic, RSD is not spread by wind and rain or insect vectors and should therefore not be a risk to neighbouring farms when levels are high. Once a field has been planted, the main risk of spread is at harvest - the disease can be spread from one field to another on contaminated cane knives and the use of cane cutters through contractors increases the risk of farm-to-farm spread. However, cane knives can be easily and effectively decontaminated before entering another field or farm and, provided the recommendations are followed, the risk of spread is low.

Researchers in Australia showed that RSD is spread rapidly by mechanical harvesters - in one trial, up to 70% of the stools in the harvested rows tested positive in the following crop. The researchers demonstrated that RSD spread could be prevented by cleaning all parts of the harvester that came into contact with cut cane using a high pressure washer before spraying with a decontaminant.

Although RSD incidence has traditionally been high in the Lowveld, efforts to reduce levels through grower awareness campaigns and improvements in seedcane health are beginning to pay off. It is anticipated that mechanical harvesting will be practiced on an increasingly large scale in the area over the next few years which is likely to result in an increase in RSD levels through field-to-field spread on growers' farms. Of more concern however, is the increased risk of spread into seedcane nurseries (including the Malelane motherblock) as well as farm-to-farm spread if harvesters are not properly cleaned and decontaminated before entering farms.

A trial is to be conducted at the SASRI Komati Research Station to demonstrate the spread of RSD by mechanical harvester and the effect of cleaning and decontaminating the harvester on RSD spread. The time taken to complete the decontamination procedure will be recorded and the economics of implementing the procedure will be determined. The possibility of using alternative decontamination methods that are more practical and less time-consuming will be investigated.

NEW PROJECT

A technology development project is to be implemented in 2017/2018 to assess various methods for the decontamination of mechanical harvesters (subject to project funding approval by the grower and miller leadership serving on SASA Council). The yield losses associated with RSD infection are well known and, once a practical-as-possible harvester decontamination protocol have been assessed, growers will have sufficient information to conduct economic assessments.

Further details may be found in *In Situ* RSD Testing (SASRI Reference: Issue 22) and Test for RSD (SASRI Reference: Issue 27).

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DEVELOP / EVALUATE ALTERNATIVE METHODS TO APPLY RIPENERS

Grower Issue Description
Describe the issue: Becoming very expensive to apply ripener. **Background:** Cost of aerial ripener application. **Desired End Result:** Finding cost effective ways for applying ripener.

SASRI Communication

On an industry-wide scale over 60 000 ha of sugarcane are ripened in a season with normal rainfall. At the current maximum application cost of ±R505/ha ripener application could cost the industry up to R30 million per season. Milling companies often subsidizes this cost therefore resulting in an even more favorable cost-benefit ratio to growers. In the subsidizing of ripening within a mill supply area the miller therefore spend substantial amounts of money per season. More cost-effective alternatives to apply ripeners could reduce these subsidy costs. Besides the fact that growers share in these costs to a lesser or larger extent (in some mill supply areas the full cost), they often also struggle to secure the services of crop spraying pilots at the right times within their harvesting schedules, especially in remote areas (e.g. Pongola), or during years where the majority of crops are not suitable for ripening and pilot visits to these areas are infrequent. Smaller, or irregular shaped, fields on both large-scale and small-scale grower farms are also often not suitable for aerial ripener application. This often results in very poor quality results in fields that needed ripening. In this light, three RD&E requests (miller, grower and extension-driven) have been received during 2016 requesting SASRI to investigate more cost-effective ripener application methods (issues no. 6, 18 & 26).

In terms of more cost-effective aerial application of ripeners it is recognized that unmanned aerial vehicles (UAVs) might potentially be the futuristic method-of-choice. However UAV technology is not yet suitable for commercial implementation partially because of the current 18 kg payload limit for most UAVs. There are also other limitations such as UAVs are required to fly very low during ripener application and still lack sufficiently sensitive surveillance technology to detect all types of physical obstacles (power lines etc.). It is estimated that UAV technology is at least five years away from overcoming these and other limitations.

However, there are other potential methods of applying ripeners on the ground such as through irrigation systems (center pivot, Venturi in overhead sprinkler system, sub-surface drip) and by other means (hand-held spray boom, tractor-mounted spray boom, high-rise tractor with spray boom, and mist-blowers).

The current reality is that, for purposes of applying ripeners, the system (hardware) and operating specifications and thresholds, user protocols, and efficacy results (i.e. suitability for ripener application) are not readily available for many of these potential alternatives. Growers are therefore unsure which alternatives would be the most effective out of a ripening and cost perspective, and also how to ripen crops with these methods.

With this in mind a technology development project, for inclusion in the 2017/2018 SASRI Programme of Work, with the following objectives will implemented:

- evaluate the suitability of the above-mentioned alternative ground-application methods for chemical ripening purposes;
- define for each suitable alternative the hardware and operating costs,

NEW PROJECT

SASRI is to initiate a project in 2017/2018 to investigate technologies for ground-based ripener application (subject to funding approval by the grower and miller leadership serving on SASA Council).

hardware and operating specifications and thresholds, and protocols for use; and

- evaluate the in-field efficacy of suitable alternative methods in collaboration with extension and growers in the form of commercial demonstration trials

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TEST FOR RSD (SASRI REF: ISSUE 27)

Grower Issue Description

Easy and quick ways to accurately test for RSD. **Describe the issue:** Local fast RSD test. Need feedback on work in progress. **Background:** Would like to make faster progress on RSD control. **Desired End Result:** Fast and accurate RSD detection. Feedback / communication on progress.

SASRI Communication

Please refer to 'In situ RSD testing' (SASRI Reference: Issue 22).

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WEED CONTROL (SASRI REF: ISSUE 28)

Grower Issue Description

Control of problem weeds (*Cyperus*, *Cynodon* etc.) **Describe the issue:** Growers are struggling to get proper control over a range of problem weeds in the Mpumalanga area. **Background:** Growers are finding that current herbicide recommendations are not often very effective in controlling problem weeds in the area. Growers are also uncertain about what new chemistries are available, their relative efficacies and the cost/benefit. **Desired end-result:** Update on the status of weed research in the area (are there sufficient trial work conducted in the area and are research findings from other regions applicable to Mpumalanga?), summary of latest trial results, and information on the latest chemistries available with a cost/benefit analysis attached to each.

SASRI Communication

The weed issue identified by growers in the Irrigated North Region has centred on improving management of five problem weeds: (1) a creeping grass, *Cynodon dactylon* (kweek); and (2) a sedge, *Cyperus rotundus* (rooi uintjies), as well as large tillered stools of two tufted grass species: (3) *Rottboellia cochinchinensis* (tarentaalgras/itchgrass) and (4) *Panicum maximum* (gewone buffelsgras). The biosecurity alien invader weed *Parthenium hysterophorus* (demoinia bossie) represents the fifth weed of concern in the region. The first two weeds are considered highest priority by growers.

1. *Cynodon dactylon* (kweek)

1.1. Kweek research findings and BMPs have been consolidated into a booklet for distribution. The draft booklet is currently with SASRI Extension Services for final comment.
1.2. A recommendations booklet, entitled "Integrated weed management (IWM) of creeping grasses", collates recommended tactics /control methods for three major creeping grass species in the industry. This booklet is currently being evaluated before being made available to interested growers before the end of this year.
1.3. A second publication assists planning on a whole farm scale for creeping grass control, and presents four commercial farm scenarios as examples to manage these serious weeds in sugarcane. This will be made available by early next year.
1.4. The dribble bar has been a successful commercial development, initiated by FarmAg chemical company for *Cynodon dactylon*. SASRI tested this apparatus on demoinia bossie, and it had good results with glyphosate for control of young plants. Some notes on dribble bar application have been published in the SASRI Herbicide Guide 2015 under the "Creeping grass management" section, and in one article (Weed control with the T-shaped dribble bar, Lowveld Insight,Issue 05,November 2015, , SASRI).

1.5. In a field trial in Komatipoort, Arsenal Gen 2 provided prolonged cynodon control in a long-fallow field when compared with glyphosate **during normal rainfall conditions.** (NB: Growers should understand use restrictions before using this product). In addition, one coded product in this trial was considered a possible candidate for further research effort.

2. *Cyperus rotundus* (rooi uintjies)

2.1. Potential new post-emergence herbicides were compared with Servian® in two screening trials in the North Coast Region and one trial in Komatipoort. Results from these trials indicated two out of three new coded products are candidates for further research effort. The two candidates will be tested initially in pot trials this year, and pending positive results, tested in field conditions.
2.2. Current pot trials comparing selected post-emergence herbicide - surfactant combinations aim to improve translocation from leaves to tubers. This might lead to a higher % death of tubers, with less spread and less competition with the crop. Preliminary recommendations are expected early next year.
2.3. Calibration tables are available from SASRI that enable more rapid calculation of liquid formulation of herbicides, insecticides and fungicides for knapsacks with different nozzle outputs. Now for the first time, the tables include a granule formulation of a product safe on cane, Servian®. Here, product volume in syringes replace weighing on balances. The advantage of this is that accurate application of this product will control *Cyperus rotundus* in small areas, preventing spread and so reducing competition for water during early cane growth and development.

3. *Rottboellia cochinchinensis* (tarentaalgras/ itchgrass)

Potential new late post-emergence coded herbicide treatments were compared with MSMA+ametryn, the industry standard treatmen (IS) for application to large tillered rottboellia seedlings in one trial in Komatipoort. Results indicated one coded combination provided equivalent control to the IS and is a candidate alternative mode of action.

4. *Panicum maximum* (gewone buffelsgras)

4.1. There are already pre-early post emergence products registered and available in moist soil conditions and, more recently, in dryland conditions. Refer to SASRI Herbicide Guide 2015.

4.2. Mr Alwyn van Graan identified a problem in Malelane with controlling large tillered stools of *Panicum maximum*. These grass stools were not responding to his shielded glyphosate spot-spray applications. The same problem of large tillered grass stools has since been identified on two farms in the North Coast, and in the Umfolozi Region.

4.3. Spot-spray calibration is problematic, with a high risk of over-dosage, having cost, environmental and/or crop damage implications, especially with application of products such as glyphosate or MSMA. To reduce these potential risks, a new spot-spray calibration method devised by the SASRI agricultural engineer, Peter Tweddle, was tested for control of large tillered stools on Mr van Graan's farm in Malelane. Various treatments were compared, but initial results did not kill larger grass stools, and modified calibration for correct application is required.

4.4. It is planned to revise this calibration method at a nearby North Coast site, using the best treatments found for *Panicum* control at Mr van Graan's farm and for *Rottboellia* in Komatipoort. Once correctly developed, this new calibration will be spread further to other growers with *Panicum* and *Rottboellia* species via a local newsletter.

5. *Parthenium hysterophorus* (famine weed/demoinia bossie)

This weed grows in dense strips mainly along roadsides and on field edges, and so might be considered a lower priority by commercial growers, when compared with the afore-mentioned weed species. However, it is a biosecurity weed, with serious health risks to all communities. SASRI research efforts have shown the following:

5.1. For late post-emergence control of coppiced (due to repeated mowing) flowering famine weed, one trial at SASRI Komatipoort Research farm showed that one tank mixture (Dinamic+MCPA+ametryn+surfactant) was as effective as metsulfuron methyl in controlling adult plants and reducing seedling numbers, while retaining desirable grass cover to stabilise soil. Glyphosate was also effective for use where grass cover is not desirable, or can be made more selective for established grass cover by applying the product before normal Spring rains, when grass is still seasonally dormant. More than one herbicide application will be required as seedlings are known to emerge for at least six years.

5.2. In one observation trial, two potential barrier hedges were tested at Komatipoort, namely molasses grass (*Melinis minutiflora*) and vetiver grass. While the molasses grass struggled to establish, vetiver grass showed some promise as a barrier hedge against famine weed. Vetiver grass planted on the edge of fields adjacent to the flood line or below existing infestations are expected to form a physical barrier to transport of famine weed seed via water into such fields. A further trial with vetiver grass is planned at SASRI Pongola Research farm this coming season. Results to confirm the effectiveness of vetiver as a barrier hedge are expected by March 2017.

5.3. Cover crops such as sunflowers, peanuts, velvet beans and kikuyu are candidates expected to stabilise soil and smother emerging famine weed seedlings in degraded or unproductive land nearby sugarcane fields. Sunflower and peanuts are potential cash crops that would offset input costs in these non-productive areas, with kikuyu grass valuable for stabilising waterways adjacent to fields, and velvet beans with value as a green manure. A trial where these species will be planted to compete with famine weed seedlings, is planned at SASRI Pongola Research farm this coming season. Recommendations to select the best cover crop species, with best cost:benefit ratio, are expected by the middle of next year. This will reduce the area of flowering famine weed adjacent to cane fields, thereby reducing its negative impact on the health of children and workers in nearby fields.

5.4. Several pre-early post emergence herbicide treatments are registered for broadleaf weed control. Some of these might be ineffective for germinating famine weed seeds. Determining the best active ingredients in pot trials will assist selection of herbicide treatment combinations for fields vulnerable to spread of famine weed seed via flooding or irrigation. Benefits to growers will be development of new recommendations to prevent establishment of famine weed seedlings in these fields.

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FAS RECOMMENDATIONS (SASRI REF: ISSUE 30)

Grower Issues Description

FAS recommendations for the area. **Describe the issue:** Growers are doubting if the current FAS recommendations are sufficient to sustain optimal yields in the area. **Background:** Growers are asking the question if current FAS recommendations are sufficient to sustain optimal yields in the area. For example, if a grower harvest 16 t RV/ha from a field, is the FAS recommendation for N, P and K sufficient to sustain this high productivity in following ratoon crops? Growers are also unsure about the cost/benefit of the various fertiliser options recommended by FAS. Are there sufficient crop nutrition trial work conducted in the area and are research findings from other regions applicable to Mpumalanga? **Desired end-result:** Assurance that current FAS recommendations are yield-based for the Mpumalanga region so that economically-optimal yields can be maintained. Cost benefit analysis (guidance to growers) about the best fertiliser options recommended by FAS.

SASRI Communication

FAS recommendations undergo continuous improvements in response to local and international research findings. The major improvements introduced to the recommendations package some five years ago made provision for yield targets ranging from 50 to 200 t cane/ha. Noteworthy aspects of the current recommendations package include:

- N, P and K recommendations are related to the yield target specified by the grower on the soil sample submission form. Over the years, SASRI has conducted numerous crop nutrition field trials in Mpumalanga, and the findings of these trials are accommodated in the recommendations package.
- Soil properties are taken into account in deriving the P recommendations. Thus P requirement is adjusted in accordance with the tendency of soils to 'fix' P.
- K recommendations are increased for the high base status soils found in Mpumalanga. In addition, higher K recommendations are made for winter-cycle crops in that region, since K uptake has been found to be very dependent on soil temperature.
- Micronutrients and silicon are routinely measured in all soil and leaf samples submitted to FAS.

It is noteworthy that FAS is the only lab service in Africa providing recommendations and analytical determinations inclusive of most of the above aspects.

Finally, growers in Mpumalanga are encouraged to make more use of FAS's leaf testing service. Research has repeatedly shown that leaf testing is very valuable for gauging the adequacy of nutrient supplies to an actively growing crop.

A workshop will be organised in 2017 in the Mpumalanga area with the purpose of informing growers of the legitimacy of FAS and its relevance to sugarcane farmers.

REMOTE SENSING (SASRI REF: ISSUE 31)

Grower Issue Description

Growers want information on remote-sensing options to monitor crop N-status, weed problems, canopy cover and yield estimates. Can SASRI provide advice on best high-resolution remote sensing technologies available and their pros/cons? **Background:** Growers are wanting to explore remote-sensing technologies in the area, but are not well-informed enough to make such decisions. **Desired end-result:** Update by SASRI on the use of remote-sensing options to monitor crop N-status, weed problems, canopy cover and yield estimates etc. with the pros/cons attached to each option. What is SASRI's stance on this and how are they involved in progressing the use of this technology?

SASRI Communication

Remote sensing is a tool that provides a synoptic view of the area in a non-destructive, non-invasive and objective manner. The advantages of using remote sensing is that it affords timely information over a larger area whilst proving a spatial dimension to the information. Remote sensing (RS) of biotic stress is based on the assumption that plant stress chemically interferes with photosynthesis and physical structures such as plant tissue and the canopy. The results of this interference thus affect the absorption of light and alters the reflectance in the different and respective regions of the electromagnetic spectrum. Research into the vegetative spectral reflectance can assist in understanding the resulting physiological and biochemical processes. There are numerous sources of remotely sensed data that can be evaluated.

A literature search has resumed to address the Issue 4 of 2015. With an interest in the sensing of Nitrogen (N) using RS, this section will be included in the literature search and the review. Nitrogen is the largest agricultural input when farming and optimizing its uptake is dependent on soil and plant water status. According to Tilling *et al* (2007) hyperspectral sensors were found to be robust in accounting for variability of the N status compared to the multispectral and thermal sensors. Indices can be developed for sugarcane is South Africa which measure the Canopy Chlorophyll Content. Schlemmer *et al* (2013) stated that leaf and canopy N status relate strongly to photosynthetic activity since the N is a strong factor which influences optimum light use efficiency and canopy photosynthesis rate. Baret *et al* 2007 found that canopy chlorophyll content can be used to quantify N at canopy level. Chlorophyll content is in physically sound quantity and it represents the optical path in the canopy where its absorption dominates the radiometric signal. Therefore, absorption by chlorophyll provides the necessary link between remote sensing observations and canopy-state variables that are used as indicators of N status and the photosynthetic capacity (Schlemmer *et al* (2013)).

In conclusion, the RS review of literature will include the potential in RS to quantify N. It will also include the platforms that have been developed internationally to automate the processes such that the results are easily accessible to the end-users.

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NEW INTERNATIONAL COLLABORATIVE PROJECT PROPOSED

In an exciting development, the University of Edinburgh, in collaboration with SASRI, is to submit a funding application in September 2017 to the UK's Biotechnology and Biological Sciences Research Council for a project entitled "*Sustaining African sugarcane production using precision agriculture technologies*". The aim of the three-year research project is to develop remote sensing technology to facilitate: (a) more accurate monthly estimates of crop production in the SA sugar industry; and (b) the calculation of an industry-wide monthly crop stress index which will be invaluable to eldana management.

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QUALITY OF SASRI SERVICE PROVISION (LACK OF AMBITION) (SASRI REF: ISSUE 32)

Grower Issue Description

Describe the issue: Growers arriving at the issues before being researched. Farmers ahead of research. **Background:** Precision farming. Mechanisation fan speed. Detrashing plant. Sub-surface drip depth. Thickness of trash blanket. Future uses of trash (valued added). Value of Pests and diseases. **Desired End Result:** Re-look at SASRI's future budget – 90% focus on future issues. Engage farmers with future projects.

SASRI Communication

1. Innovation in partnership

That many growers are great innovators is indisputable and SASRI researchers rely on the depth of experience and expertise of growers to partner in the development of innovations. This is a central tenet of SASRI's knowledge exchange philosophy in which partnerships between growers and scientists form the foundation of a significant portion of SASRI's agronomy and agricultural engineering research and development.

2. Mechanisation research

Collaboration is particularly important in areas such as mechanisation, as SASRI does not possess the appropriate equipment. So, partnering with growers is the only way in which many mechanisation-related solutions may be found. It's identifying these collaborative opportunities with growers for research and development that is an area of continuous improvement for SASRI and growers are asked to assist SASRI in this regard through liaison with their local extension specialists to identify and progress these opportunities. Refer to Mechanical Harvesting (SASRI Reference: Issue 20).

3. Remote sensing research

Remote sensing is an aspect of precision farming research in which SASRI has been involved over the past few years. Most recent involvement was in a Water Research Commission (WRC) funded remote sensing project, conducted in collaboration with multiple university partners, which tested and validated an algorithm that enabled the monitoring of sugarcane crop stress in Mpumalanga. One of the particular challenges SASRI faces with this type of research is product commercialisation, as the Institute is legally-bound to operate as a not-for-profit entity and, so, does not have a clear path to market. To overcome this, the intellectual property that emanated from the WRC project was shared with a company that provides commercial crop management and monitoring services to the sugarcane industry, which was the only way in which the technology is likely to reach growers. A further notable challenge with remote sensing is the high cost of satellite images, as well as the enormity of the processing capacity required for interpretation of the big data generated by satellite-based imaging. Implementation of Industry-wide monitoring by remote sensing platforms would require significant investment by the Industry and it is likely that contracting the services of a crop monitoring company would be the most cost-effective and viable approach.

Fortunately, it's not all gloom-and-doom with regard to remote sensing research by SASRI. In an exciting development, the University of Edinburgh, in partnership with SASRI, is to submit a funding application in September 2016 to the UK's Biotechnology and Biological Sciences Research Council for a project entitled "*Sustaining African sugarcane production using precision agriculture technologies*". The aim of the three-year research project is to develop remote sensing technology to facilitate: (a) more accurate monthly estimates of crop production in the SA sugar industry; and (b) the calculation of an industry-wide fortnightly crop stress index which will be invaluable to eldana and irrigation management. What is particularly promising is that the project aims to deliver a fully-customised web-based tool that will enable the monthly monitoring of crop production across the Industry. Unfortunately, the research will only provide proof-of-concept for stress monitoring and, should this prove successful, the manner in which the tool would be deployed commercially will require further investigation and funding once the project has been completed. Also refer to Remote Sensing (SASRI Reference: Issue 31).

NEW INTERNATIONAL COLLABORATIVE PROJECT PROPOSED

In an exciting development, the University of Edinburgh, in collaboration with SASRI, is to submit a funding application in September 2017 to the UK's Biotechnology and Biological Sciences Research Council for a project entitled "*Sustaining African sugarcane production using precision agriculture technologies*". The aim of the three-year research project is to develop remote sensing technology to facilitate: (a) more accurate monthly estimates of crop production in the SA sugar industry; and (b) the calculation of an industry-wide monthly crop stress index which will be invaluable to eldana management.

4. Precision fertilisation

Precision farming relies on the mapping of in-field variations in soil fertility and SASRI is in the process of developing a cost-effective soil fertility analytical package that will enable growers to conduct the grid-based soil analysis required for precision fertilisation. Information on progress with the development of the technology is available from Dr Neil Miles (SASRI Principal Soil Scientist) (Neil.Miles@sugar.org.za).

Please also refer to 'Precision Agriculture' (SASRI Reference: Issue 39).

5. Crop residue management

SASRI specialists have extensive experience and knowledge of the management, benefits and potential alternative uses of crop residues and much of the practical and theoretical information was captured in the 2015 RDE Committees' communiquè booklet (available on the SASRI 2015 InfoPack). In addition, additional information is provided in this booklet under Problems and Values of Trash (SASRI Reference: Issue 34).

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RESEARCH FACILITIES (SASRI REF: ISSUE 33)

Grower Issue Description

Describe the issue: Two more research facilities to cover also SSG. Lack of training facilities for future farmers in the area. **Background:** None representation of different areas. **Desired End Result:** Geographical representation of research facilities.

SASRI Communication

Large geographical distances understandably lead to a sense of isolation between specialists located at the SASRI main site in Mount Edgecombe and Industry participants operating at locations distant to the site, such as in the Mpumalanga Lowveld and the lower south coast of KwaZulu-Natal. It is in promoting a sense of connectedness across such large distances amongst Industry stakeholders that extension services play a crucial role. Over the coming months, SASRI is to work with Malelane and Komati Canegrowers' Associations to assess whether a return to a SASRI extension service presence in the Mpumalanga region is feasible.

Regardless of the absence of a SASRI extension service in Mpumalanga, SASRI works collaboratively with RCL and CANEGROWERS to ensure that the needs of growers in the region are fully serviced. It is perhaps in communicating the nature and extent of this service provision that the absence of a dedicated SASRI extension service in the region is most sorely felt. Hopefully, this perceived communication bottleneck will be overcome in the near future.

In terms of inadequate SASRI training provision to the region, particularly for small-scale growers, SASRI is currently engaging with TsGro and the Mpumalanga University to find creative ways to bridge this education and training gap.

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PROBLEMS AND VALUES OF TRASH (SASRI REF: ISSUE 34)

Grower Issue Description

Thickness of trash: Pest (Trash worms) & Diseases. Irrigation. Ratoonability. Fertiliser. Value added options. **Background:** Mechanical harvesting (green cane) vs trash blanket. Seedcane harvesting. Farmers investing in trash separating plants. Uses of trash from dead cane. **Desired End Result:** Mechanical harvesting trials at research stations / farmer's sites. Trash separation / harvesting and its use.

SASRI Communication

1. Introduction: general guidelines and summary relating to crop residue (mulching) management

The long term benefits of a crop residue blanket are typically (Donaldson *et al*., 2008) as described below.

- Improved yields:
  - 9-24 t/ha (Mbatha TP *et al*., 2011); and
  - 15-16% (Chapman *et al*., 2001).
- Improved moisture conservation for both rain-fed and irrigated systems:
  - 90 mm/annum (Thompson, 1966);
  - 68% of soil moisture conserved during early growth period (Chapman *et al*., 2001); and
  - the costs of irrigation reduced by 10% (Núñez *et al*., 2008).
- Improvements in soil conservation: soil surface protection, improved infiltration, reduced runoff and soil erosion.
- Improved weed control/reduced herbicide use:
  - crop residue blanket suppressed weeds by 83-92% (Lorenzi *et al*., 1989); and
  - the costs of weed control were reduced by 35% (Núñez *et al*., 2008).
- Increases in soil organic matter and microbial activity.
- Minimal pollution when compared to burnt cane.

Crop residue blankets may present challenges under certain conditions and as described below.

- High residue levels in conjunction with:
  - continuously wet soils, valley bottoms or periodically low water tables of <500mm (Donaldson *et al*., 2008),
  - exceptionally wet periods before crop canopy has been established (van Antwerpen *et al*., 2006),
  - cold temperature periods of less than 2°C and in frost prone areas (Donaldson *et al*., 2008; Murombo *et al.*, 1997).

- Challenges encountered by growers with crop residue blanket retention include:
  - higher harvesting costs in both manual and mechanical operations;

- harvester productivity reduced by 43% (Núñez *et al*., 2008);
- chopper harvester throughput decreased by 17% and fuel consumption increased by12% (Ma *et al*., 2014); and
- payloads of the extraction and haulage vehicles decreased by 2.3 % per % increase in crop residue (Kent *et al*., 2003);

- Fire hazards relating to high crop residue retention levels are a concern, particularly if a fire occurs in young cane regrowth;

- Residue movement in high winds: Residues are light and can be easily picked up and moved across fields or deposited along wind breaks, fence lines etc.

Olivier (2015) reports "*Crop responses to the presence of a trash layer have been investigated in a number of irrigated field trials conducted in Pongola and Komatipoort. The major advantage of a trash blanket is the significant reduction in irrigation requirement. For overhead irrigation, average savings of 15% (183 mm) were achieved, while somewhat smaller savings of 6% (77 mm) were possible with drip (above-ground) irrigation. These savings were mainly brought about by a reduction in the surface evaporation loss, especially in the period leading up to full canopy cover (first 3 to 4 months of the growing season). Increased drainage was observed under trash covered crops which emphasises the importance of adjusting the irrigation scheduling practice so that these savings can be realised. Crop coefficients for calculating crop water requirements of partially covered fields (only cane tops) as well as fully trash covered fields are available. The Canesim crop model is also capable of calculating water requirements of trash blanketed crops.*

Trash layers have a negative influence on the rate of canopy development, tillering and radiation interception. Generally soil temperatures were found to be between 3 to 4˚C lower under a trash blanket compared to a bare soil surface which could explain the delayed emergence of tillers. Peak tiller population was reduced by an average of 25% (10 tillers m^{-2}*) which resulted in a delay of between 8 to 20 days in the time to reach 50% canopy and a reduction of 5% in radiation intercepted. Tillers naturally compete for radiation, nutrients and water which lead to tiller death late in the growing season. Final tiller population and stalk length of trash covered fields were found to be similar to that of fields without trash. Final cane yield of trashed fields was on average 9% lower than bare crops, but was not statistically significant.*

The trash effect on the soil water balance, soil temperatures, tillering and canopy development is strongest during the partial canopy period and diminishes with age as the canopy starts to shade the soil surface. Very little or no stalk growth occurs during this partial canopy period suggesting limited impact on later growth and yield.

Crop response to trash is strongly dependant on variety. Some varieties do not tolerate trash conditions very well as emergence, tillering and canopy development is very poor under these conditions. Current knowledge on how South African varieties react is increasing for the coastal, midlands and irrigated regions of the Industry as a result of the research being conducted by Dr Sanesh Ramburan (SASRI Variety Scientist) in Project 07RE03 (Variety and Trash Interactions).

Frost damage is a danger to crops with trash blankets especially in colder years and in lower lying areas. Minimum air temperature tends to be 1 to 2 ˚C lower above a trash blanket compared to bare soil increasing the probability of frost occurrence.

Under the hot and humid conditions experienced in the Lowveld, the trash blanket is broken down very quickly and very little is left by the time of harvest. Trial results have shown that a layer consisting of only cane tops can cause similar savings in crop water requirements to that of a full trash blanket. Excess trash material could thus be removed from the field, leaving just enough material to maintain cover of the soil surface for the partial canopy period."

1.1. How much residue is appropriate?

An effective residue blanket reportedly consists of **approximately 10 tons per hectare** equating to about a 60 tons per hectare yield for South African conditions (Donaldson *et al*., 2008). Kent (2013) reported the following: "*Several models have been developed to predict the benefit of leaving trash in the field (Thorburn et al., 2005; Purchase et al., 2008). Manechini et al. (2005) reported an attempt to experimentally determine the amount of trash to be left in the field. Of the 6.7 t/ha to 14.9 t/h total trash in the field, they found that* ***7.5 t/ha to 9.0 t/ha*** *was required for weed control and that the amount of trash required to preserve yield varied considerably with cane variety, climate and pests.*" In India a suitable trash blanket of as low as **3 tons per hectare** was reported (Prabhakar *et al.*, 2010).

Desired trash levels are highly dependent on a number of factors including: varieties, aspect and location of fields, anticipated weather conditions during regrowth. A partial trash blanket of tops should at least be maintained. Partial removal or displacement of trash may be required under high trash yields. Early regrowth may be setback under a full trash blanket but final populations and yields would need to be compared at harvest as research has often shown little differences later in the season. There are a number of benefits of a residue blanket such as potential yield improvements; moisture conservation/irrigation savings; weed suppression and weed cost benefits; increasing in soil health, organic matter, microbial activity, runoff and erosion mitigation; reduced air pollution and associated particulate matter with burning that make residue conservation attractive. The negative aspects typically reported are: reduced productivity associated with green cane harvesting; runaway/arson fires scorching regrowth; frost damage; wind moving residues; poor regrowth under certain conditions (cold and wet);

Residue removal from fields can be achieved via a number of methods, namely:

a) Burning

There is minimal recovery of agronomic or energy value from the dry leaf portion as it is burnt. Timing and nature of the burns makes a large difference to the amount of leaves that are effectively removed and can also impact on cane value deterioration through delays from burning, harvesting to crush (BHCD). Where the cane green leaf and tops are spread, these offer the partial benefits of a trash blanket. Burning improves manual and mechanical performances. Lower extraneous matter (EM) levels assist in reducing mechanical harvester losses but the gains are generally offset by losses due to longer BHCD.

b) Green cane harvesting

Green cane harvesting may be accomplished with:

- Chopper harvester and high EM removal (losses expected to be high but harvester performance is also high);
- Chopper harvester and low EM removal (losses expected to be low but harvester performance is also low. Higher EM levels also impact on milling operations);
- Manual green cane harvesting (performance reduced); or pre-trashed (additional separate operation required)
- Residue handling and/or collection (moved from rows to inter-rows; incorporated, mulched for quicker breakdown, raked and/or baled)

1.2. What options are there for residue handling and collection?

Options include moving, shredding, spreading, incorporating, densifying or removing the residue.

The primary consideration is the proposed use of the brown and green leaf portions. For instance, for cogeneration purposes, there is concern that the higher K and Na content of field residues compared to bagasse as a boiler fuel may lead to deleterious effects on the mill boilers. As such, the ideal would be to remove only the dry brown leaf portion for cogeneration purposes. The raking of the field with full residues is not desirable as this will mix these components. The option of pre-processing or removing the tops may be possible. The agronomic benefits of a residue layer need to be considered in each case. Purchase *et al.* (2008) reviewed trash collection studies from various countries and proposed that trash separation in-field would be most appropriate for South Africa for a number of reasons. The study included scenarios of trashing versus burning where a partial trash blanket equivalent to green top proportion was left on the soil surface for agronomic reasons. The surplus trash was baled and sold at various costing scenarios. The results indicated that the agronomic benefit for a residue blanket in the coastal sands had much value. In the northern irrigated areas the study showed a lower agronomic benefit and that higher biomass production combined with surplus residue sales would make residue collection and sales highly profitable at the coal equivalent price when the study was conducted.

Many items of equipment are available for a range of residue processing and handling options to cater for both agronomic needs and commercial harvesting purposes.

Use of forage harvesters to pick up leaf/residue materials, chop and spread or remove the trash

Partial and full trash rakes

Field layout showing partial raking of the crop residue off the crop rows and onto the wider inter rows

Hand raking.

Residue mover: Brush sweeper.

Residue mover: Orthmann/Carter/Yetter etc.

Flail mowers or mulchers are often used to break the residue into finer sizes for more rapid deterioration.

“Lawson Canemaster” for semi-incorporation of the mulch.

Raking and baling operations following harvesting.

In a recent study, Smithers (2014) upon reviewing biomass recovery systems internationally, indicated that the most efficient way to recovering the residues would be to use a chopper harvester with separation systems partially or fully turned off. This is described as an integrated system and deemed to have the lowest trash recovery cost than separation systems conducted in-field such as bulk trash handling or bailing options. For South African conditions, where the majority of the crop is manually harvested and where mechanical harvesting may not be suitable, alternative residue recovery routes were proposed namely: whole stick harvesting with residue recovery either occurring with the harvested stalk, or separate collection infield or further densification processes occurring to the collected residues.

Such on farm processing and densification of residues are worthy of consideration. From a range of options, the most attractive from a cost perspective appears to be highly dependent on proximity to the mill (Rees *et al.,* 2014). Smithers *et al.* (2015) reporting on various residue recovery strategies, noted that for distances less than 20km the best operation was to separate at the mill; for 20 to 40km the best options appeared to be separation at field and subsequent pickup using forage harvester and for distances exceeding 40km on farm processing and densification of the residues on site appeared to be the best option. The best on farm processing options were deemed to be torrefaction, torrefaction and pelleting followed by pelleting (Rees, 2015).

1.3. Of what should trash ideally consist?

Ideally this should consist of the green leaf portion of the crop and the balance of dry brown leaves. The trash blanket should typically be scattered uniformly across the field or in certain instances can be on the inter row areas of the field. Excess dry brown leaves may be removed for processing or alternative revenue.

In the case of burnt cane operations, a 'cool burn' will increase the amount of crop residue left in the field. The scattering of the green leaf material should provide most of the benefits of a full trash blanket. Lower topping of the low sucrose stalk top would further contribute an additional 1.5 to 2 tons per hectare (Donaldson *et al*., 2008).

Under green cane harvesting, this can be achieved by allowing the topper of the chopper harvester to operate, but leaving the chopper harvester extraction fans turned off or set to low speed. This is a good option if the dry leaf material is able to be processed at the mill. Lower fan speeds also helps to reduce cane losses. Trade-offs against these benefits are that the **chopper harvester throughput is likely to be slowed down by about 17% and fuel consumption increased by 12%** (Ma *et al*., 2014). **The payloads of the extraction and haulage vehicles are likely to be reduced by about 2.3 % per % increase (0 to 10% range) in trash content** (Kent *et al*., 2003).

Alternatively, the chopper harvester can be used as normal and the higher trash levels dealt with at the field level. This is not ideal if wanting to use the crop residues for cogeneration as there will be a mixture of tops (undesirable to burn but valuable as a soil mulch) and dry leaf materials (desirable for combustion although very low density) during the field collection operations. Various density improvement techniques have been trialled including: shredder fan inclusion; billet length adjustments; compaction; vibration of bins and topping of cane (Kent, 2013).

2. Growing cane under trashed conditions

2.1. Cultivars and trashing

According to Ramburan (2015), "*Three trials were established to investigate the responses of commercial varieties to trashing. The trial conducted in the midlands region showed that ERC yields were reduced with trashing in 7 out of 8 varieties in a first ratoon crop that ratooned through summer as well as a third ratoon crop that ratooned through winter. The* *trashed treatments showed delayed emergence, and reduced stalk populations compared with the burnt treatment. This was associated with reduced soil temperatures under the trash blanket. There was a higher soil water content that was measured under the mulch blanket for most of the growing period, showing that trashing does conserve soil water.*

The trial conducted under irrigated conditions in Pongola showed that there were no significant differences in ERC yields between burnt and trashed treatments of all varieties over three ratoons harvested in October (R1, R2, and R3). When harvested for two crops (R5 and R6) in winter (July), however, all varieties showed reductions in ERC yields which were not statistically significant. Stalk populations and emergence were generally delayed with the trashed treatments. However, there were generally no differences in stalk height and stalk populations at harvest. The major benefit of trashing under irrigation seems to be associated with water and electricity savings. Cultivar responses to trashing seem to be minor, and no cultivar showed any alarmingly poor responses to trashing.

The trial conducted under rainfed conditions at Empangeni showed highly significant improvements in ERC yields with trashing in all varieties over all crops harvested. This included three crops harvested in October (R1, R2, and R3), and one crop harvested in winter (July). The ERC yield improvements ranged from 15% to 92%. In this trial, stalk populations and emergence were delayed with trashing as well. However, stalk elongation rates and final stalk heights were much greater in the trashed treatments. Soil moisture levels were consistently higher in the trashed treatments throughout the growing season. Soil temperatures were consistently lower under the trash blanket, until canopy closure, after which temperatures were comparable with the burnt treatment. All varieties showed a general delay in canopy establishment with trashing. However, this delay did not negatively affect final cane and ERC yields.

In summary, trashing was beneficial to ERC yields under coastal rainfed conditions, detrimental to ERC yields under cooler midlands conditions, and had no effects on ERC yields under irrigated conditions."

One of the benefits of green cane harvesting that was not quantified here was the effects on reducing risk associated with post-harvest deterioration. Large commercial fields that are left standing after burning (a common occurrence) are more prone to deterioration compared with green cane harvested fields. Growers in the midlands or irrigated areas may therefore also benefit from trashing in this way, even when yield responses are minimal.

2.2. Soil temperatures and ratooning

Slower shoot emergence, fewer stalk numbers, slower canopy are commonly reported with residue layers. Final yields are often reported as being similar or of insignificant difference.

- **Soil temperatures:** cooled by 2 and 4°C under a trash blanket (Chapman *et al*., 2001); at 60 mm depth were on average 4 to 5°C lower under the trash treatment in the partial canopy period (Olivier *et al*., 2009)
- **Ratoon emergence:** delayed by 38% or 15d (Chapman *et al*., 2001); Initial stalk population in the trash treatment was 50% lower and peak stalk population reached 16 days after control (Olivier *et al*., 2009).

Below is a selection of findings from the literature:

- **Murombo *et al*. (1997):** Where there was a trash blanket, the shoots took longer to emerge above the trash. In some instances, especially during the cold months, some stools rotted and hence there was no regrowth. Where there was regrowth, the shoots struggled to come through the trash. Continuous parting of the trash was necessary because the heavy trash kept sliding back over the cane. The cane emerged faster where there was no trash blanket.

- **Chapman *et al*. (2001):** Green cane harvesting is now practiced by 83% of Mackay canegrowers, which is greater than the Australian average of 65%. The four experiments reported here were important in promoting the high level of trash conservation in the Mackay area (Queensland, Australia). Experiment 1 involved 8 sugarcane cultivars (H56-752, Q124, Q135, Q136, Q138 and Q159) subjected to green-no-cultivation or burnt-cultivation in a field in Mackay. Experiments 2, 3 and 4 involved first or second ratoon crops of Q124 subjected to green-trash or burnt-trash (there was no burnt-trash treatment in experiment 4) in fields in Palmyra, Dumbleton, and Marian, respectively. Experiments 2 to 4 were also irrigated. **Conserving green-trash rather than burning it increased cane and sugar yields by 15% and 16%** in five ratoon crops. Green-trash crops had fewer and heavier stalks but no other change in composition. Sugar yields of varieties that varied significantly, with Q124 and Q135 having the highest yields. Varieties did not interact with trash management or cultivation. Three short-term experiments evaluated the effects of trash incorporation and raking the trash off the cane row. Results indicated that **no trash management was necessary for maximum production**. Soil compaction in the inter-row from harvesting operations may have limited cane yield in trash conservation treatments, but there was **no benefit from cultivation**, which reduced this compaction. **The trash blanket cooled soil temperatures by 2 and 4°C. This increased the time from harvest to ratoon emergence by 38% (39 to 54 days)**, after early season harvest. Damage by armyworms (*Mythimna separata*) to leaves was increased and damage to tillers by wireworms (*Coleoptera: Elateridae*) was decreased with green-trash. Trash conservation had no effect on spore counts of *Pachymetra*. Green-trash reduced evaporation of soil water and increased availability for transpiration. **Soil water loss in early growth under green-trash was only 32% of that from burnt-trash**. Water loss was similar for both green and burnt-trash in late growth. Green-trash increased cane yield equivalent to the application of 2 ml/ha of irrigation water, an important benefit in a region with inadequate water for full irrigation. Green-trash increased suckering, but sucker growth was insufficient to significantly affect sugar content.]

- **Olivier *et al.* (2009, 2010):** Preliminary results from a drip irrigation trial with treatments of, (i) a trash blanket applied at a rate of 18 t/ha, 160 mm thick, and (ii) control treatment with no trash blanket: **Initial stalk population in the trash treatment was 50% lower than the control treatment and reached peak stalk population 16 days after that of the control treatment**. Frost was observed in the trash treatment on three occasions during June and July which could have had a further negative effect on stalk appearance rate. **Soil temperatures observed at 60 mm depth were on average 4-5°C lower under the trash treatment in the partial canopy period as compared to the control.** Midday growing point temperature of the trash treatment between 90 and

210 days after the crop start (July to October) was 3-4°C greater than that of the control treatment. No significant differences in soil and growing point temperatures could be observed in the full canopy period. No differences were observed in the peak (51 stalks/m2) and final stalk population (16 stalks/m2). At harvest, cane stalks in the control and trash treatments were of similar length. An earlier overhead irrigation trial showed contrasting yield responses (Olivier *et al*., 2009).

- **Olivier and Singels (2012):** The objective of this study was to quantify the effect of 2 different types of residue layers on crop growth, cane yield and evapotranspiration of fully irrigated sugarcane. A layer of cane tops and dead leaves (Trash) and a layer of green tops (Tops) were applied to the soil surface of sugarcane crops (plant crop and first ratoon crop of variety N14) grown on lysimeters at Pongola, South Africa. Observations of crop growth (stalk population, stalk height, canopy cover), cane yield and evapotranspiration for these treatments were compared to that of a bare soil treatment. **Initial stalk population in the plant crop and radiation capture in the plant and ratoon crop were affected negatively by crop residue layers, but without significantly reducing final stalk population and cane yield**. Peak stalk population occurred later in crops grown in residue layers, but peak and final stalk populations were unaffected.

2.3. Irrigation management considerations

Increased drainage has been observed under residue layers. This emphasises the importance of accurate irrigation scheduling to avoid water logging and deep drainage losses (Olivier and Singels, 2012). Burnt cane tends to have a greater response to irrigation than mulched fields. Mulched fields conserve water better and provide the higher water use efficiency. This is particularly important during drier periods, where irrigation is not available or where variable moisture cycles persist. Generally, yields under mulched conditions are more sustainable, less variable and on the longer term higher than under burnt conditions.

- **Gosnell JM (1970):** Trials conducted in Zimbabwe (1966-1969) showed that by increasing irrigation levels from 37% to 84% of Class "A" Pan evaporation produced a linear increase in cane yield from 65 to 146 tons/ha. The response with burnt cane was greater due to more severe moisture stress, and there was also an increase in cane yield between 84% and 100% Pan which was absent in trashed cane. Different levels of' irrigation were best for different criteria: 100 % Pan gave highest yields of sucrose/ha with burnt cane. 84% Pan gave highest yields of sucrose/ha with trashed cane. 68 % Pan gave highest yields of sucrose per unit of water applied and also highest cane quality. 84/60 % Pan (AB treatment in 2nd ratoon), with burning was probably the optimum treatment, as it achieved the highest yield of sugar/ha together with one of the highest efficiencies of water use. In conclusion it must be reiterated that the above levels of irrigation were taken on a net basis, and for practical purposes should be multiplied by the following approximate factors: Sprinkler irrigation 1.2, Efficient furrow systems 1.2-1.4, Less efficient furrow systems 1.4-1 .6.

- **Olivier and Singels (2012):** The objective of this study was to quantify the effect of 2 different types of residue layers on crop growth, cane yield and evapotranspiration of fully irrigated sugarcane. **Evapotranspiration was reduced by both residue layers,**

mainly due to a slower developing canopy (reduced transpiration) and reduced evaporation from the soil, during the pre-canopy phases. **Increased drainage was observed under residue layers**, emphasising the importance of accurate irrigation scheduling to avoid water logging. It is important that irrigation scheduling practices be adjusted to realise the potential water savings of sugarcane production systems that make use of residue layers.

2.4. Trash worm management

Carnegie and Dick (1972) describe the range of caterpillars that inhabit cane residues following harvesting. Larvae numbers appear more pronounced where trashing rather than burning has been practised i.e. after cutting, the trash is removed unburnt from the crop and spread as a blanket or placed along the inter rows as a surface mulch. The caterpillars, which are nocturnal in habit, use the residue to shelter by day and emerge at night to feed. The species, *Mythimna phaea* Hamps was found to be to feed on young cane for the first few weeks of cane regrowth, while other species were found to feed on the trash residue itself (Carnegie, 1977). The trash blanket shelters the caterpillars and pupae from many natural enemies, adverse climatic conditions, and from insecticides. Fields of high trash levels including fields with incompletely burnt trash and cane tops are more susceptible as they afford sufficient shelter for the caterpillars. Trash caterpillars are indigenous, are grass inhabiting insects, and attack sugarcane only between May and late November, during which period cutting is in progress and young rationing cane is available. Ratoons are attacked only during the first few months of growth. With the advent of early summer rains and warm weather there is an increase in natural control and outbreaks cease.

Carnegie and Dick (1972) also describe the **control of trash caterpillars through natural enemies** (especially Tachinid flies); Hymenoptera; Fungus; Virus and insecticides. Infestations were generally noted as being “sporadic and patchy” and once detected, the worst of the infestation was generally over. **Insecticides were not found to be effective** and it was thought that the trash protects the caterpillars and that insecticides were adversely affecting the numbers of natural predators in conjunction with the caterpillars. Little research data are available on the population dynamics relating to different residue layer depths.

SASRI Entomologists have recently conducted a project investigating trash moth control in Swaziland (Project 10CP05). See SASRI POW 2013/2014. Page 27. 10CP05 Technology development. However, the results of that study were inconclusive due to the erratic appearance of trash moths. SASRI information sheet 8.4 contains further information on trash caterpillars and leaf eaters.

2.5. Weed management

Campbell (2015) reports **“***In general, a full trash cover is required to be effective for weed control. Once it breaks down, there should be canopy to shade weeds. Any gaps in the trash cover will stimulate weed seed germination. Moisture in soil under trash benefits weeds but also helps cane growth to develop canopy to shade out weeds.*

- ***Creeping grasses:*** *it is not so effective or allows them to spread further in the field*

- ***Tufted grasses like barbi:*** *Seeds are small and shallow germinators. Seed will germinate readily in light gaps, trash will have some – good effect under thicker cover.*
- ***Deep germinators like morning glory:*** *can emerge through a trash blanket*
- ***Broadleaf:*** *eg blackjacks and khakibos – trash cover is generally effective because they germinate in response to light – trash can reduce a full cover spray requirement to spotsprays for about 6% weed cover ie 94% effective.*

Best treatments are those soluble in water that can permeate down through trash eg Velpar. Certain herbicides have use restrictions in trash eg Merlin"

Further studies report:

- **Lorenzi et al. (1989):** In Brazil, following the harvesting of green cane (variety SP 71-1406), **the trash blanket suppressed 83-92% of the weed** infestation when compared to conventional burnt cane. Weed suppression by trash was found to be due to allelochemical substances being continually leached from the trash. Ratoon growth was initially suppressed by the trash blanket but later recovered completely. Where the trash was raked, cane rows contiguous to the trashed inter rows were found to have significant cane yield reduction.
- **Van Antwerpen (2015):** Locally N27 shows signs of allelochemical effects- References: Detrashing project, BT1 records.
- **Murombo (1997):** "*Substantial savings are possible through reduced weed emergence through the trash blanket and the associated weed control costs*."

3. Canesim trash modelling for northern irrigated regions

The SASRI Agronomy modelling section can conduct Canesim model simulations to investigate:

a) Typical ratoon emergence delays for high residue layer load and whether this translates into an actual yield impact by the end of the season and if so, by how much,

b) What are the optimal range of residues (min vs max) to be left in the field to not cause yield losses for a typical cold period in the Northern Irrigated area.

4. Equipment: Chopper harvester BMPs

Minimising yield loss through infield traffic compaction and stool damage:

The yield impact of the chopper harvesting systems are expected to be high relative to other systems due to the high amounts, repeated passes, and high impact of associated infield traffic. The ability to practice controlled traffic would mean that the infield traffic, preferably fitted with GNSS or alternative effective guidance system, would constrain the high levels of infield traffic to the inter-rows and may possibly be less damaging than systems with high impact equipment used infield that cannot practice controlled traffic principles. These hypotheses still need to be tested and is the subject of research currently being conducted at SASRI.

Minimising stool damage. Poor ratoonability can be aggravated through poor chopper harvester settings and operations. The following items are all items affecting base cutting operations:

- Field profile;
- Base cutter setup (height, profile and speed of cutter);
- Blade parameters such as hardness, inclination, wear/sharpness etc.;
- Cane presentation;

The Harvester BMP manual from Sugar Research Australia (SRA) (www.sugarresearch.com.au) describes a number of guidelines to produce quality cane economically. Listed are a summary of considerations:

- Cane harvested green produces higher quality raw sugar (ash content and dextran levels) than burnt cane;
- Clean cane, lower losses, less soil and less stool damage improves at lower harvester pour rates which are achieved by slowing down the harvester – all at the expense of higher harvesting costs;
- Optimum topping height should be set;
- Gathering spirals are optimised for speeds of 6-8 km/h;
- The type (profile) and setup of floating shoes can be adjusted in order to best gather stalks;
- Height control settings of the gathering fronts is essential to pick-up all the crop;
- Forward feed controllers regulate the supply of cane evenly and consistently into the base cutters and can cause stool damage if not setup correctly;
- Knockdown roller assists primarily in non-erect cane to position the cane away from the harvester for butt first feeding. Setup is important to minimise stool damage, soil in cane, extractor losses etc.
- Finned rollers help moderate the cane supply across the basecutters. Their speed of rotation is important;
- Basecutters cut the cane at ground level and feed the cane into the feed train and are also the source for stool damage and soil ingress; Setup considerations includes: number of blades, sharpness, angle of leading edge, blade length, blade speed (rpm), surface profile, blade thickness, blade design, hardness, soil surface characteristics encountered,
- The butt lifter roller is used to guide cane into the feed-train butt-first. Roller tip speed of the butt roller needs to be considered;
- The roller train accepts and conveys cane to the chopper box evenly. Speed adjustment will affect the feed roller speeds and harvester feed through the machine. Critical ratios of relative speeds of the sets of rollers is essential to ensure good billet quality and minimum deterioration;
- Rubber coated rollers are required for quality seedcane billets with minimum damage. Ratios of roller to chopper speeds are essential;
- Rotary chopper systems- factors affecting losses include: roller speed ratios; pour rate; blade sharpness & variety and crop condition;
- Primary extraction chamber is where the cane is cleaned via extractor fan. Correct setup is essential;
- The deflector plate controls the trajectory of the cane from the chopper;

- Elevator conveyor is the next phase of getting the cane to the haul out equipment;
- The secondary extractor is located on top of the elevator for final clean-up of extraneous matter from the cane. Balancing of the primary and secondary extractor workload is required by the operator;
- Cane losses are an inevitable part of the process of separating trash from cane on the harvester. Cane losses through the extractor are essentially invisible with typically less than 20% cane loss as visible cane stalks. For each ton of trash not extracted an additional 2 to 5 tons of cane is recovered compared to normal harvesting operations.

The full manual on harvester best practices is available on the Sugar Research Australia website:
http://www.sugarresearch.com.au/page/Growing_cane/Harvesting/Publications/
Weblink address:
http://www.sugarresearch.com.au/content/FlippingBooks/Harvesting%20Best%20Practice%20Manual/ Accessed 24/06/2015.

Vaux *et al.* (2004): Green cane chopper harvesting was used successfully at Ramu Sugar in Papua New Guinea during 1980's and early 1990's, to assist in the control of vigorous weeds. A substantial benefit was also seen in the control of damage caused by cicada nymphs. The continuing evolution of farming systems, agronomy and harvester capacity instigated gradual changes in strategy. This resulted in the greater use of pre and post-harvest burning to facilitate **cultural operations such as centre-busting (compaction relief) and re-hilling, to enhance yields and re-form the row profile to minimize harvesting losses**. Burning was also used to facilitate the tillage operations associated with the planting of fallow legume crops and re-establishment of the new cane crop. The recent move to a dual row cropping system, incorporating controlled traffic, has allowed a re-focusing of efforts to maintain high levels of green cane trash blanketing. In parallel, there has been a concerted effort to move into minimum tillage and integrated pest management programmes, all strategies for a lower cost sustainable cropping system. Central to this strategy has been the need to **adopt harvest best practice (HBP) strategies to minimize direct and indirect, invisible and visible losses, and to reduce the need for row profile maintenance during the crop cycle. HBP has involved major changes to both harvester set-up and operating strategies**. Similarly, the move to minimum tillage has involved the **rapid evolution of tillage and planting machinery**. The rationale behind, and the benefits accruing from, the changes to the farming system are described.

Núñez *et al.* (2008): To evaluate the feasibility of green cane harvesting at San Carlos Sugar Mill in Ecuador, agronomic parameters that may be affected when changing from burned cane harvesting to green cane harvesting were evaluated. Two sites subjected to manual green cane harvesting were compared with two adjacent sites subjected to manual burned harvesting. Measurements were made from 2004 to 2006 in fields with cane varying from the first to the fourth ratoon of cultivars Ragnar, CC8592 and CR74250. Manual green cane harvesting was not feasible for San Carlos Mill due to the prohibitive increase in harvesting cost caused by the reduction in productivity of 68% of the field labourers. Subsequently, an experiment undertaken with mechanical harvesters comparing six sites that had been cut green and another six adjacent sites that had been burned before harvesting. Under mechanical green cane harvesting, **machine productivity was**

reduced by 43% and the trash content in the delivered cane was increased by 38%. Crop residues that remained in the field after mechanical harvesting were significantly greater under green harvesting (17.31 t/ha) than under burned harvesting (3.7 t/ha). P and K concentrations in residues were the same, but N content in green harvesting residues (0.85%) was significantly higher than that in burned residues (0.55%). **After green cane harvesting, the costs of weed control and irrigation were reduced by 35 and 10%**, respectively. Sucrose recovery was not affected, and sufficient data were not available to draw valid conclusions on cane yield. **Economic analysis favoured burned cane harvesting**.

Chopper harvesters can be set to switch off fans in order to recover the bulk of the residues during harvesting. These residues will thus be harvested with the crop for recovery at the mill. Harvester speed will typically be reduced to cope with the extra material being conveyed through the harvester. Densities of the cane with residue will be less than the stalks and impact on payloads and reduce transport efficiencies to the mill.

Normal chopper harvesting and subsequent gathering of full residues from the field is not ideal as:

- cane losses are high
- the green tops and dry leaves are all mixed during gathering
- additional field traffic is required to further gather the residues.

5. Equipment: Residue management BMPs

Field based operations to deal with residue layers may include any of the following:

- Leave the high residue levels untouched- this may be problematic in certain times of the year where either a) cold temperatures are frequently encountered hampering cane regrowth or b) wet periods are encountered where the soil may become waterlogged and difficult to dry out due to the presence of the trash layer. Such waterlogged conditions are likely to affect cane regrowth and will hamper field access by mechanical means;
- Raking of the entire field into windrows for subsequent processing such as a) bailing; flail mowing or similar;
- Bailing: the pickups should ideally be elevated to leave a small proportion for the benefits of a partial cover;
- Teddar: to spread the leftover windrow material across the field;
- Mulcher: to further process the leaf materials infield into smaller pieces;
- Partial raking of the leaf material: To move the residues covering the crop row to the adjacent inter-row areas. This is more practical in a raised bed tramline type planting configuration where the wider inter-rows (hollows) can contain the higher trash levels.

Raking of field with full residues is not ideal as the tops and dry leaves are then mixed. Unless the tops are pre-processed ie: Flail mowing and scattering of tops is a possible option so that these remain on the field during raking of dry leaves (Figure 1). The costs associated would need to be determined to see if this operation is economically viable though.

Figure 1: Use of forage harvesters to pick up leaf/residue materials

Figure 2: Partial and full trash rakes

Figure 3: Field layout showing partial raking of the crop residue off the crop rows and onto the wider inter rows

- **Cock *et al.* (1997):** In Colombia, sugarcane yields average >130 t/ha, with individual fields often yielding up to 200 t/ha; there is no specific season for maturing cane, and **the quantity of tops and dry leaves produced is high, 50-100 t/ha**. Left in the field after green cane harvesting, **these quantities of cane trash lead to poor germination in wet periods**, and create problems for traditional agricultural practices. At present, problems associated with harvesting cane and managing crop residues are overcome by pre- and post-harvest burning, but with increasing environmental constraints, all cane will have to be harvested green by the year 2005. In conjunction with the sugar industry, Cenicaña (the Colombian Sugarcane Research Centre) is developing an integrated production package for green cane harvesting. This includes evaluation of **erect self-trashing varieties with less top and high sugar content**, to improve cane harvestability. To overcome the problem of poor germination under wet conditions, the **cane will be grown on ridges**. Machinery for use immediately after harvesting is being developed which will **finely chop the residues** and allow them to fall into the interrows where they will decay rapidly.
- **Rees *et al*. (2014):** This work investigates various residue recovery modes and a range of processing techniques and plants. These options were also modelled economically to determine the most feasible processes. The models developed require validation for local conditions and scale of operations (pending work).
- **Viator *et al.* (2009):** Louisiana sugarcane (*Saccharum officinarum* L.) growers are increasingly harvesting fields 'green', without pre-harvest burning to eliminate leafy material. The post-harvest residue, however, is generally burned on the ground to avoid the debilitating effects of the residue on the subsequent ratoon crop in the production cycle. A best management practice (BMP) that allows for the retention of the residue to minimize surface runoff and increase the soil fertility status would be viewed as both environmentally sound and producer friendly. The objectives of this study were to evaluate the effects of four post-harvest residue management treatments on surface water quality and sugarcane development and yield at two locations in the Vermilion-Teche watershed. **Treatments included two approaches designed to mitigate the adverse effects of retained residue on sugarcane, the application of stabilized urea plus composted tea (generated from sugarcane bagasse, poultry litter and corn gluten) and the shredding of the residue for accelerated decomposition; and two treatments currently employed by the industry, ground burning of the residue and full post-harvest retention of the residue.** "Edge-of-field" runoff collections were made using automated samplers. Rainfall collection-event load averages for all of the principal water quality parameters (total suspended and total dissolved solids, biological oxygen demand, nitrate and total phosphorus) for the four residue management treatments were not significantly different. Seasonal differences in soil erosion rates among the residue management treatments, however, indicated that exposed soil in the burned areas would be subject to higher sediment removal with high rainfall during the period from post-harvest burning to full-crop canopy. **Neither of the residue management treatments designed to hasten residue decomposition was effective, with the urea-compost tea treatment producing elevated N levels in runoff and the shredded-residue treatment generating the greatest volume of surface runoff. The urea/compost tea and shredded-residue treatments were also ineffectual in either enhancing cane and sugar yield or promoting residue decomposition. Burning of the residue did not result in higher yields than retaining the residue.**

6. Economics of trashing

- **Lecler *et al.* (2009):** The costs and benefits of having a green cane trash blanket (GCTB) under irrigated conditions are investigated in this paper. For the case studies reported, the direct **cost savings in water, energy, herbicides and fertiliser, were offset by an average increase in harvesting and haulage costs of 22% under a GCTB system**. Although per hectare partial margins for both systems were similar, a GCTB farming system could allow a relatively larger area of cane to be irrigated for a given amount of irrigation water and this should result in increased overall returns. For example, in Pongola it was shown that the same amount of water used to irrigate an area of burnt N14 could be used to irrigate a 33% larger area where a GCTB system was used. The opportunity cost of water in the above example was R3544/ha converted to a GCTB system. For sectors of the industry which may face significant reductions in irrigation water allocations, the option to try and maintain production and supply of cane to Sugar Mills through conversion to a GCTB farming system should be considered. If a GCTB system is considered unfeasible due to harvesting constraints, early morning or 'cold' burns should be adopted. The larger amount of trash and tops which remain relative to a 'hot' burn should then be scattered to cover the soil surface and the fields watered as if they were fully trashed.
- **Wynne and van Antwerpen (2004):** This paper steers away from the environmental debate and focuses on the economics of trashing versus burning. A reasonable trash blanket left in the field after trashing inhibits weeds, thereby reducing herbicide costs. The additional organic matter above and below the soil surface improves moisture retention and soil health, which can significantly improve cane yields and profits. Trashing, however, is not appropriate in wet, low lying and cooler areas because the trash blanket increases the risk of stools rotting and inhibits ratooning respectively. The volume of trashed cane is also higher than burnt cane, which increases transport costs.
- **Van Antwerpen *et al.* (2008):** A decision support program (DSP) was developed at the South African Sugarcane Research Institute (Wynne and van Antwerpen, 2004) but needed verification before it could be released to the industry. This poster summary reports on the verification process and the performance of the DSP when estimating real economics on farms, comparing burn with no-burn at harvest. The trash recovery methods as described by Rees (2014) were added to the DSP.

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ECONOMICS MODEL (SASRI REF: ISSUE 35)

Grower Issue Description

Farmers are not aware of how to unlock potential of their farms. **Background:** Infrastructure cost could be covered by future crops / yields. **Desired End Result:** Integrated SASRI's BMPs into an economic model for irrigated region (all BMPs including for an irrigation farm).

SASRI Communication

CANEGROWERS are available to guide growers on the economics of their farming enterprises, while BMPs are neatly captured in the SUSFARMS® manual, which includes an irrigation module. Specific advice on SUSFARMS® may be sought from Michelle Binedell (SASRI Knowledge Manager) (Michelle.Binedell@sugar.org.za). How the full potential of a farm might be realised is frequently specific to a particular farm and the unique circumstances of each grower. Consequently, growers are advised to consult their local CANEGROWERS regional economist and extension specialist, who will work collaboratively with growers to develop an appropriate solution.

Information on a collaborative SASRI-CANEGROWERS project to develop a tool that will assist grower decision-making is available in this booklet under Arable Rotation (SASRI Reference: Issue 17).

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MECHANISATION AND VARIETIES (SASRI REF: ISSUE 36)

Grower Issue Description

Describe the issue: Different varieties respond differently to mechanical harvesting: ratooning, handling (cutting and wastage) – thick vs thin cane. **Background:** Mechanical harvesting is growing i.e. shattering, cutting height fan speed. **Desired End Result:**

Mechanisation trials on irrigated varieties. Recommendations on variety information sheets: cane stalk thickness – losses at ha; Shattering, gaps, disease spread / stool damage.

SASRI Communication

Please refer to Mechanical Harvesting (SASRI Reference: Issue 20). For further, context-specific information, an Extension Request for Advice (ERA) may be submitted to SASRI Extension (Shirley.Brink@sugar.org.za).

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VARIETY RELEASE AND AGEING CANE

Grower Issue Description

Describe the issue: Variety released in Autumn? – NovaCane will solve? Ageing cane? Eradicate Nov- fallow summer. Optimum age of cane. Accurate testing of varieties for recovery. **Background:** After drought + wet feet tolerance of. **Desired End Result:** Economic analysis of optimum age of cane. Drought tolerance of varieties evaluated.

SASRI Communication

For information on harvest age, please refer to Harvest Age (SASRI Reference: Issue19), while drought tolerance is addressed in Drought tolerance of SASRI varieties (SASRI Reference: Issue 4).

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MALELANE AND KOMATI RDE COMMITTEES

EFFECTIVE WATER MANAGEMENT (SASRI REF: ISSUE 1)

Grower Issue Description

Development on how to manage water optimally (more crop per drop).

SASRI Communication

Please refer to Optimal Water Use (SASRI Reference: Issue 21).

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RATOON LONGEVITY (SARI REF: ISSUE 2)

Grower Issue Description

Variety development for longevity and relative drought resistance tolerance.

SASRI Communication

Please refer to Variety Development for Longevity and Relative Drought Tolerance (SASRI Reference: Issue 24) and Drought Tolerance of Varieties (SASRI Ref: Issue 4).

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MECHANICAL HARVESTING (SASRI REF: ISSUE 3)

Grower Issue Description

Mechanical Harvesting: (a) Cost / Benefit analysis; and (b) RCL is doing trials, but we can't get data – SASRI must find a way to do the same and gather the data in MP.

SASRI Communication

Please refer to Mechanical Harvesting (SASRI Reference: Issue 20) on p. 16.

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PONGOLA RDE COMMITTEE

DROUGHT TOLERANCE OF VARIETIES (SASRI REF: ISSUE 4)

Grower Issue Description

Test the drought tolerance and ability to recover after drought of all existing and future varieties accurately in the rain shelter.

SASRI Communication

The issue description requests accurate information on the drought tolerance of SASRI varieties and their ability to recover after drought. While a number of varieties have been tested physiologically for their response to drought (e.g. N19, N31, NCo376 and a released hybrid clone 04G0073), it is a very long and expensive field trial process in which a maximum of two varieties per year could be tested. It is important to note that drought events that cause crop death and permanent stool damage occur only approximately every 20 years and it is not possible to breed for plant traits that can sustain a drought of that severity.

Tolerance mechanisms

The term drought “sensitive” and drought “tolerant” also describe different strategies by the plant to tolerate drought. A “tolerant” variety would be one that extracts water aggressively during periods of water stress, continuing to grow through the stress but has the potential to collapse if the duration of stress is very long. A “sensitive” variety would stop growing during periods of water stress, limiting yield potential but preserving the crop, and when water is available again, growth would resume. Data from the variety Information Sheets has been compiled into the crop model and relative variety tolerance to drought have been established, including for irrigated varieties.

SASRI has encouraged growers in the irrigated regions to take note of variety response to drought, particularly in newer varieties, which currently have limited available information on drought tolerance. Anecdotal evidence has shown that N53 has not performed well during drought whereas N57 has coped during stress. However, any anecdotal evidence on variety response to drought needs to be accompanied by information on soil type and depth as soil plays an overriding factor in varietal response to drought (especially in irrigated regions where some soil forms are very deep).

Management during drought

Management factors e.g. managing irrigation water use effectively during drought, will outweigh varietal tolerance to drought. The application of the correct amount of water at a specific crop stage will safeguard crop growth against drought stress more than planting varieties based on their variable tolerance to drought. An article on how drought stress affects the different crop growth stages of sugarcane appeared in The Link May 2016 and a number of SASRI Information Sheets on irrigation and irrigating during water limited periods are available.

- IS_5.2 Irrigation strategies for water limited periods
- IS_5.4 Irrigation Scheduling Toolbox

Selecting for tolerance

Future research at the SASRI rainshelter and Komatipoort research farm (due to commence in 2017) involves the investigation of drought tolerance traits in existing varieties using high throughput phenotyping and drone technology. Simple, easy-to-measure plant growth or physiological traits will potentially be identified during the experiments with the long-term possibility of these measurements being included in the SASRI plant breeding programme to breed for drought tolerance.

PROJECT TO COMMENCE IN 2017

SASRI is to start a project in 2017/2018 (which was placed on-hold in 2016/2017 due to budget constraints) that will examine the potential of proximal sensing technologies (thermal and spectral imaging and analysis) to identify sugarcane genotypes possessing traits associated with drought tolerance. The ultimate goal will be to use UAVs carrying these sensors to select potential drought tolerant genotypes during variety selection.

Climate change modelling indicates a mid-century future in which extreme climate events are likely to become more prevalent, particularly the potential for an increased frequency of high rainfall events alternating with extended dry periods. So, varieties adapted to these harsh conditions will become increasingly important for Industry sustainability. Due to the challenges in developing a drought tolerance trait, SASRI has adopted three approaches to increasing drought tolerance: (a) introgression breeding; (b) genetic engineering; (c) mutagenic breeding.

A new approach for tolerance breeding

Introgression breeding is based on the reintroduction of stress tolerance genes present in the ancestral species from which modern commercial hybrid varieties were derived, which may have been lost during focused breeding for high sucrose. In a complementary approach, close relatives of sugarcane have also been identified as potential sources of genes for stress tolerance. Introgression breeding is a long-term and arduous process, in which commercial varieties are crossed with generally low-sucrose, stress-tolerant ancestral or closely related plant species and then repeatedly back-crossed with the commercial variety to restore the high sucrose trait. Two major challenges that SASRI has faced with introgression breeding include: (a) many of the commercial N varieties flower at different times to the ancestral and related species under the sub-tropical conditions of the east coast of South Africa; and (b) only a limited set of ancestral and related species are available in the SASRI germplasm collection.

To overcome some of the hurdles faced by the introgression breeding programme, eight suitable pre-release genotypes from the SASRI breeding programme have been selected for export to the West Indies Central

NEW COLLABORATIVE INITIATIVE

Sugar Cane Breeding Station (WICSCBS) in Saint George, Barbados, where the crossing will take place under the direction of Dr Anthony Kennedy. These SASRI pre-release genotypes are to be crossed with selected ancestral and related species in the extensive WICSCBS germplasm collection; a process which is easier under the tropical Barbadian conditions. The exported seedlings will be planted in Barbados in 2016 and crossed in 2018, with the resulting seed imported back into South Africa in 2019

SASRI is to collaborate in introgression breeding with the West Indies Central Sugar Cane Breeding Station (WICSCBS) in Saint George, Barbados. Crosses between selected South African varieties and sugarcane ancestral and related species are to be made in Barbados and the seed reimported into South Africa for selection.

Biotechnological approaches for tolerance

SASRI has been involved in research to improve sugarcane drought tolerance by genetic engineering for four years and in 2014, entered into a research agreement with the Institute of Plant Biotechnology at Stellenbosch University to pursue the approach more actively. Several transgenic lines have been produced by both SASRI and the IPB which are to shortly enter testing under contained glasshouse conditions. In this research, many different avenues for improving sugarcane drought tolerance are explored, which is necessary due to the complexity of potential mechanisms that may make the plant more tolerant of stress.

Sophisticated, targeted approaches to mutagenic breeding have been used successfully by SASRI to enhance the tolerance of N12 to the herbicide imazapyr. Given that success, the approach is being modified by SASRI for application to mutagenic breeding for stress tolerance. Preliminary research conducted in 2015 and 2016 has shown promising results and the approach is to be expanded in a new project that is to be implemented in 2017/2018, subject to project funding approval by the grower and miller leadership serving on SASA Council.

NEW PROJECT TO COMMENCE 2017

SASRI is to implement a new project in 2017/2018 that will use targeted mutagenic breeding to improve sugarcane stress tolerance (implementation subject to project funding approval by the grower and miller leadership serving on SASA Council)

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ALTERNATIVE METHODS FOR RIPENER APPLICATION (SASRI REF: ISSUE 6)

Grower Issue Description

Develop and/or evaluate alternative methods to apply ripeners. Aerial application is becoming extremely expensive due to the rand x dollar exchange rate.

SASRI Communication

Chemical ripening is a very well-established BMP within the South African sugarcane industry with a highly favourable cost-benefit ratio. Aerial application of a single ripener product can cost in the region of R730/ha of which ±R505/ha can be the actual application cost. On the other hand, RV yield benefit of R3600 to R7200/ha are often realized under commercial conditions provided ripeners are applied correctly to sufficiently immature crops. Hence, chemical ripening is a lucrative and widely-adopted BMP.

On an industry-wide scale over 60 000 ha of sugarcane are ripened in a season with normal rainfall. At the current maximum application cost of ±R505/ha ripener application could cost the industry up to R30 million per season. Milling companies often subsidizes this cost therefore resulting in an even more favorable cost-benefit ratio to growers. In the subsidizing of ripening within a mill supply area the miller therefore spend substantial amounts of money per season. More cost-effective alternatives to apply ripeners could reduce these subsidy costs. Besides the fact that growers share in these costs to a lesser or larger extent (in some mill supply areas the full cost), they often also struggle to secure the services of crop spraying pilots at the right times within their harvesting schedules, especially in remote areas (e.g. Pongola), or during years where the majority of crops are not suitable for ripening and pilot visits to these areas are infrequent. Smaller, or irregular shaped, fields on both large-scale and small-scale grower farms are also often not suitable for aerial ripener application. This often results in very poor quality results in fields that needed ripening. In this light, three RD&E requests (miller, grower and extension-driven) have been received during 2016 requesting SASRI to investigate more cost-effective ripener application methods (issues no. 6, 18 & 26).

In terms of more cost-effective aerial application of ripeners it is recognized that unmanned aerial vehicles (UAVs) might potentially be the futuristic method-of-choice. However UAV technology is not yet suitable for commercial implementation partially because of the current 18 kg payload limit for most UAVs. There are also other limitations such as UAVs are required to fly very low during ripener application and still lack sufficiently sensitive surveillance technology to detect all types of physical obstacles (power lines etc.). It is estimated that UAV technology is at least five years away from overcoming these and other limitations.

However, there are other potential methods of applying ripeners on the ground such as through irrigation systems (centre pivot, Venturi in overhead sprinkler system, sub-surface drip) and by other means (hand-held spray boom, tractor-mounted spray boom, high-rise tractor with spray boom, and mist-blowers).

The current reality is that, for purposes of applying ripeners, the system (hardware) and operating specifications and thresholds, user protocols, and efficacy results (i.e. suitability for ripener application) are not readily available for many of these potential alternatives. Growers are therefore unsure which alternatives would be the most effective out of a ripening and cost perspective, and also how to ripen crops with these methods.

With this in mind a technology development project, for inclusion in the 2017/2018 SASRI Programme of Work, has been proposed with the following objectives:

a. evaluate the suitability of the above-mentioned alternative ground-application methods for chemical ripening purposes;
b. define for each suitable alternative the hardware and operating costs, hardware and operating specifications and thresholds, and protocols for use; and
c. evaluate the in-field efficacy of suitable alternative methods in collaboration with extension and growers in the form of commercial demonstration trials.

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WATER STRESS AND WATER-LOGGING (SASRI REF: ISSUE 7)

Grower Issue Description

Test and quantify the effect of both drought stress and water saturated soil on sugar cane growth and yield. E.g. when do the stomata close due to temperature, drought stress or "wet feet"? What is the effect of drought or "wet feet" on yield during each growth stage (look at time under stress for yield to be affected, etc.). How long does it take cane to recover or again have productive growth after moisture stress (drought & wet feet). "How much stress" is required in each growth stage to cause stool mortality.

SASRI Communication

The issue requires that both drought stress and water-logging / saturation be tested and quantified for sugarcane growth and yield.

Water stress can differ in terms of duration and severity and is categorised briefly into three types. The first is little or no water stress is imposed on a crop (most likely in irrigated regions where water is not restricted). Second is mild, chronic drought which is the most frequent type of drought and continued extraction of water from the soil during this period is most favourable (e.g. drought "tolerant" varieties can continue to extract water under water limiting conditions). The third type of drought is a severe, acute drought which is infrequently occurring and would require a drought "sensitive" variety (one which stops extracting water and thereby stops growing) in order to maintain stool survival.

Previous research on the impact of water stress on crop growth stages has been performed at SASRI, and an MSc and SASTA paper (Rossler *et al*., 2013) have been published based on the research conducted at Komatipoort Research farm. The findings of this research show that reasonable economic yields (>90% of potential) are achievable provided the stress periods are short and mild (i.e. chronic stress) and that water stress most negatively affected yield during the stalk elongation stage. An article on how water stress affects growth in the different crop growth stages has also recently appeared in The Link (Patton and Adendorff, 2016). Plant growth stages least sensitive to drought stress are ripening, emergence and tillering, whereas stalk elongation (or what is referred to as grand growth stage) is the most sensitive to water stress.

Current research on deficit irrigation is being conducted to provide a water allocation decision-support tool (DSP) that provides information to growers on how to allocate restricted irrigation water depending on the crop growth stage. The model is run for a specific field or farm scenario and will prioritise allocation of water to fields that will result in the highest gross margins at the end of the season.

Similar to water stress, the extent to which flooding affects sugarcane is dependent on the type of waterlogging, the conditions of the flood water and the soil type. Flooding has been reported to decrease cane yield and quality primarily because sugarcane roots cannot respire because they no longer receive oxygen in the soil. Floods can stimulate the production of adventitious roots, which can offset the negative effects of flood damage on yield. Extensive research on flooding on South African sugarcane varieties has not been performed at SASRI but international sugarcane research suggests that the most sensitive crop growth stage to flooding is that of the stalk elongation phase, when cane formation and yield build up (as with water stress). Management to improve drainage in areas prone to flooding is particularly important to reduce the extent to which a particular crop will suffer from flooding stress (see Information Sheet IS_3.3: Drainage in irrigated fields).

Also refer to Variety Tolerance of Waterlogging (SASRI Reference: Issue 9).

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REGIONAL RSD TESTING (SASRI REF: ISSUE 8)

Grower Issue Description

Easy and quick way to accurately test for RSD, preferably without the need to send samples away.

SASRI Communication

Please refer to 'In situ RSD testing' (SASRI Reference: Issue 22).

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VARIETY TOLERANCE OF WATER-LOGGING (SASRI REF: ISSUE 9)

Grower Issue Description

Test the tolerance of all existing and future varieties accurately for tolerance to water saturated soils with high water table.

SASRI Communication

- Research conducted by Gosnell (1971) on NCo310 indicated that cane yield was reduced by 63% and 35% at 25 cm and 50 cm water table depths, respectively. That author further demonstrated that a water table at 75 cm did not to affect yields. Yield from the plant crop to the second ratoon is reduced by 62% and 40% for a constant water table depths of 25 cm and 50 cm, respectively.
- Rostron (1974) revealed that NCo376 was more tolerant to water logged conditions compared with variety CB36-14 (Rostron, 1974).
- In Florida, it was noted that the variety not affected by the occasional presence of a high water table was able to develop aerenchyma, which facilitate oxygen diffusion to flooded roots (Glaz *et al*., 2004). Not all varieties have this ability to produce alternative pathways for oxygen transport under un-aerobic conditions.
- Lowering the water table by 1 cm increased cane and sugar yields by 0.21 and 0.025 kg/m^2 respectively. Each day of flooding decreased cane and sugar yields by 0.19 and 0.025 $kg.m^2$ respectively (Glaz *et al*., 2004).
- The tolerance of current SA cane varieties to water logging is not known and is very difficult and costly to ascertain experimentally. Further discussion of practical and cost-effective ways to determine such tolerance is invited (Sanesh.Ramburan@sugar.or.za), particularly through collaboration with interested growers in conjunction with the local SASRI Extension Specialist.

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ROUNDUP READY CANE (SASRI REF: ISSUE 9)

Grower Issue Description

When will Roundup Ready cane be available?

SASRI Communication

A workshop with members the elected Industry leadership from the South African Canegrowers' Association (CANEGROWERS) and the South African Sugar Millers' Association (SASMA) was held in October 2013 to gain a consensus view from grower and miller leaders on the Industry position on potential future commercialisation of a GM sugarcane variety. The workshop revealed unanimous grower and miller recognition of the value that commercialisation of a GM variety would add to the Industry. In particular, Bt insect resistant cane was identified as a priority, based on the current losses due to early cutting cycles required to manage eldana infestations on the coast, direct economic loss due to eldana and sesamia damage and the cost of insecticide application and other pest management interventions. Subsequently in October 2014, a business case for Bt cane was developed by an external consultant with input from SASRI specialists. This was presented to the SASRI Committee (a committee comprising Industry Principals which maintains strategic oversight of SASRI affairs) in February 2015 and was discussed again at the May 2015 meeting, where further interrogation of the return on investment was made. A full feasibility study was requested, which was presented to the Committee on 11 August 2016. A few minor issues raised by the Committee are to be addressed, after which the study will be presented to the Council of the South African Sugar Association.

It is important to note that it is likely to take more than 10 years to develop and test the transgenic cane, and a further four years to assess it for food and feed safety and for it to be passed through the regulatory framework. Unfortunately, a shorter route is not possible as there are specific legislative requirements by government for testing GM crops under different conditions and for rigorous safety and risk testing. Although Bt is the primary gene of interest, herbicide tolerance is also likely to be considered as part of the GM package.

It is unlikely, however, that glyphosate (the active ingredient of Roundup) will be selected as the herbicide tolerant trait as increasing negative publicity is associated with its agricultural use. SASRI have been working on imazapyr tolerance as this chemical is more effective at controlling the creeping grass, *Cynodon dactylon*. SASRI has produced and field-tested imazapyr-tolerant sugarcane plants produced by mutation breeding which are capable of germinating in soil that has residual herbicide activity and that survive subsequent application of the herbicide in a weed control programme. Research is ongoing and GM plants tolerant to imazapyr will be produced over the next two years. Field testing will follow.

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WONDER PRODUCTS' TESTING (SASRI REF: ISSUE 10)

Grower Issue Description

A request that might not be so much a request for research but also a request for advice / guidance: How to obtain impartial / unbiased evaluation of all the wonder products to enhance growth, soil, etc.

SASRI Communication

SASRI is aware of the large range of agricultural products continually coming onto the market, which representatives of the companies concerned either request SASRI (sometimes via Extension) to test on sugarcane and provide a 'rubber stamp' of approval (which SASRI explicitly cannot do), or they directly approach growers with the intention of convincing them of the product's worth. Many of these products have not been scientifically tested in pot or field trials, and their mode of action has not been established, despite the claims made by the vendors in their advertising and brochures (Miles and van Antwerpen, 2009; Redshaw, 2016). Furthermore, it is illegal to use any product not registered for use in sugarcane or to use a registered product but not according to the label (i.e. "off-label"). Growers are therefore strongly cautioned against wasting a considerable amount of money and effort in purchasing and applying new "wonder" products without being able to objectively assess their true effects (if any) on soil health, cane growth, yield etc., as well as the legal implications of misuse of products.

SASRI does not have the capacity to test all these products and will in any event only test products that have clear scientific and economic potential for use in the sugar industry, and preferably that have already been registered for use in other crops (in the case of agrochemicals such as herbicides and pesticides). All such requests are channelled through SASRI's SAR (Specialist Advisory Request) Panel, who make an assessment of the scientific credibility of the product, its likely benefits to the industry, and whether there is capacity among SASRI specialists and technicians to take on the work of testing it in sugarcane (Botha, 2007: Anon, 2009; Berry, 2011; Redshaw, 2011).

However, in light of these issues raised by growers, the SAR Panel will also produce a document that will serve as a guide for growers and Extension Specialists to use for their own initial assessment of whether to give any such products consideration in the first place. The document will provide a series of questions that need to be answered to satisfy growers or their Extension Specialists that the product either is, or is not, worthy of further consideration for use on their farms or in their region, and possibly for testing by SASRI. Should growers, based on this initial assessment, decide that they wish to pursue their own testing of a product on their farm, then they are advised to perform an observational trial with the guidance of their Extension Specialist (Berry, 2007)

Also refer to Snake Oils (SASRI Reference: Issue 16).

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MIDLANDS NORTH (UCL AND NOODSBERG) RDE COMMITTEE

CANE DETERIORATION (SASRI REF: ISSUE 41)

Grower Issue Description

With the increased amount of spiller cane accepted by Noodsberg mill, due to diversions from other mills, bundle growers cane is often not crushed until the weekend when deliveries slow down. This causes the cane in these bundles to deteriorate. Growers would like to know what the financial implications of the perceived losses are. A study showing loss of weight, sucrose levels etc. should be done over a period of time to illustrate the kinds of losses/changes over time, under Midlands' conditions.

SASRI Communication

Introduction

Post-harvest deterioration is a natural process that affects all crops and extensive research has been carried out to study the process and understand the impact on the quality of the product and loss of value in the supply chain. This will determine the effort in management and investment in systems that can be made to decrease the deterioration and loss in value and improve profit. The main factors that determine the rate of deterioration are temperature, time, physical damage to the product, exposure to and contamination by elements such as microbes. This is no different with sugarcane which starts to lose value the moment it is burnt or cut. There is overwhelming evidence from past research which indicates that any delay in the crushing of sugarcane after burning or cutting will result in a loss of recoverable sugar and a subsequent loss in revenue (for example: Bacci and Guichard, 1994; Boote, 2011; Cox and Sahadeo, 1992; Eggleston *et al.*, 2001; Kirby, 1968; Lauritzen *et al.*, 1948; Lionnet, 1986; Lyne and Meyer, 2005; Morel du Boil, 2001; Ravnö and Purchase, 2005; Sibomana and Bezuidenhout, 2013; Sibomana *et al.*, 2016; Turner and Rojas, 1980; Watt *et al.*, 2007).

However, deterioration is a complex process and because there are so many interdependent factors which determine the losses, it is very difficult to model or predict the losses which vary on a daily basis and the particular circumstances. Currently, there is no reliable or cost effective method to estimate losses and carrying out any further experiments is unlikely to improve the situation in the short term. This means that there is no easy answer to the UCL/Noodsberg query. In spite of this we believe the losses are greater than people would like to assume and every effort should be made to keep losses to a minimum. Boote (2011), who worked on cane supply and stockpiling at the Umfolozi Mill, talks about the "*crippling effect of cane deterioration*" where an increase of 24h in a stockpile in combination with high temperature resulted in a significant increase in deterioration. In this case they could not justify increasing the stockpile to improve the cane supply to the mill.

Cane deterioration

Deterioration of sugarcane is a complex process which involves a number of factors:

- The oxidation of the sugars, where sugars combine with oxygen to produce carbon dioxide (CO_2), water and heat, this is a process of respiration and sugars are lost.
- The mass of the cane is reduced by the loss of CO_2 and evaporation of water (the original moisture and that which is produced by respiration).
- Microbial activity which consumes sugars, the microbes respire and contaminate the cane with products such as dextran.
- The respiration of cane and microbes produce heat which accelerate the deterioration process.
- The rate of these processes increases with delay and all are affected by green or burnt cane, type of burn, variety, physical damage, contamination, the environment, temperature, humidity etc. These factors are mostly interdependent and challenging to measure making it difficult to model the process. Many attempts have been made to measure the deterioration with a quick and inexpensive method and so far this has not been successful.

The consequences for cane are a loss in mass, sucrose and quality. Because of the complexity and variation in circumstances these are all difficult to quantify, but, by making many assumptions one can arrive at an estimate. The challenge is setting acceptable assumptions.

1. Losses

A great deal of work has been carried out to understand, quantify and limit the losses due to post harvest deterioration.

1.1. Estimating the loss in cane

Boote (2011) investigated the impact of increasing the stockpile at the Umfolozi mill to reduce the number of no-cane stops as a result of rain on the Umfolozi flats. The increased stockpile improved the cane supply to the factory, but, because of the increased BHTCD, the overall benefit was negative.

Boote (2011) used the equation developed by Lionnett (1986) to quantify the losses and because the equation is essentially temperature and time driven, that author (Boot, 2011) developed a temperature and delay model. A Stochastic model for climatic conditions was developed to generate temperature and rainfall data for the Umfolozi flats, the rainfall data was used to estimate the delays that could be expected from the rain.

Boote (2011) gave an example showing that at an average temperature of 22 °C and a delay of 24 h there would be a loss of 0.73 % of the sucrose present. It should be noted that there are many assumptions made to arrive at this number and it should only be used for showing trends.

To exacerbate the situation the deterioration process is exponential. Figure 1 shows the impact of temperature and Figure 2 shows the impact of time (Watt *et al*., 2007).

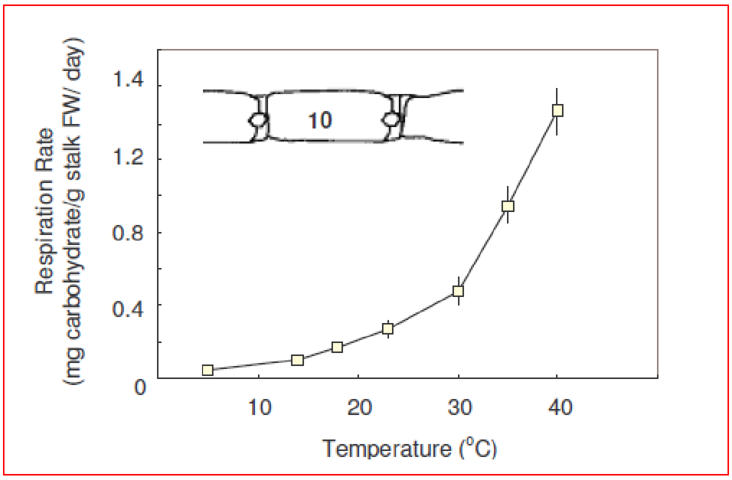

Figure 1: Influence of temperature on post-harvest respiratory activity in sugarcane. (Watt *et al.*, 2007)

Equation 1 below shows the variation in respiration with temperature shown in Figure 1.

$$y = 0.0112e^{0.0973x} \qquad \textbf{(Equation 1)}$$

where: y = mg of sugars consumed per gram of stalk per day and x = temperature.

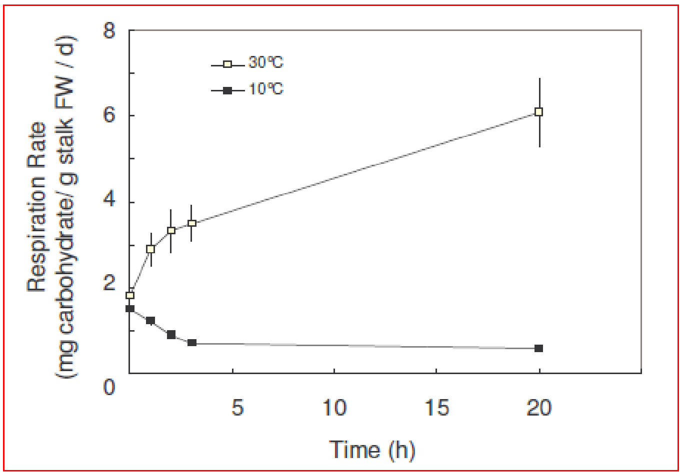

Figure 2: Post-harvest respiratory activity in the sugarcane stalk over time (Watt *et al.*, 2007)

The deterioration increases exponentially with increase in temperature and in addition in the case shown in Figure 2 increases threefold in 20 hours!

Efforts have been made to collect sufficient data to enable one to use this type of information to model the process, but, so far with little success.

Small (2016) used an electronic nose (E-Nose) to sense volatiles given off by cane, once calibrated this instrument can give quick and easy readings of particular volatiles. He attempted to develop a relationship between the E-Nose output and the time between the sugarcane burn and the time of measurement. This was an attempt to develop a quick and easy method to quantify BHTCD and although the technique does show promise further work is necessary to make the method useable.

Further work is currently being carried out at a mill level in an attempt to determine the impact of delay and it is hoped the results will be available in 2017.

1.2. Estimating the loss in the factory

There is general consensus (Morel du Boil, 2001; Ravnö and Purchase, 2005) that the losses in the factory are significant. Again the actual losses are difficult to determine and their conclusion was that any delay should be reduced to the minimum level practical.

1.3. Reducing the rate of deterioration

The BHTCD, cane damage and contamination should be kept to a minimum, particularly at the beginning and end of the season when the temperatures are higher and harvesting becomes more difficult in the wetter conditions.

Hansen *et al.* (2002) showed in a study in one mill area that by implementing daily burn schedules they could reduce their delay by up to 27h.

Watt *et al*. (2007) indicate that base cutting after burning will stop the demand for sugars by the root system.

Sibomana *et al.* (2012) discuss methods of reducing the rate of deterioration in various commodities, two of which may be useful in a sugarcane stockpile. Antimicrobial solutions are in use to minimise deterioration in a number of commodities including sugarcane to supress the microorganisms responsible for deterioration. Fogging systems could be used to both saturate the immediate atmosphere to reduce temperatures and limit dehydration. Although impractical in the field, these might be useful in a stockpile.

1.4. Revenue

Although difficult to quantify, the revenue will decrease with delay. Estimates from work by Lionnet (1986) and Cox and Sahadeo (1992) would put losses at around 0.75 to 1% per day, but, this does not take into account that these rates increase significantly with time or the losses that are incurred in the factory.

Conclusions

It has been shown that the process of deterioration is affected by many interrelated and interdependent factors which make it difficult to model. Many researchers have tried to quantify the process and have generally concluded that one should keep the harvesting delays to a minimum. Estimates can be made of the losses and establish trends, but, detailed information of many parameters is necessary. As can be seen from the above it would not be possible to quantify the losses incurred by bundles in the stockpile and it is unlikely that a study showing the loss of weight, sucrose levels etc. carried out over a period under Midlands' conditions would result in improved information. A much deeper understanding of the process is required. The impacts will be exaggerated at the beginning and end of season when the temperatures are higher and there is likely to be more damage and contamination due to wet conditions.

BMPs that can be considered to reduce the revenue losses are:

- More frequent burning of less area and cutting cane green could significantly reduce BHTCD and reduce the losses of those bundles in the stockpile.
- The cane should be cut as soon as possible after burning.
- Try to ensure less damage and contamination of the cane.
- In a situation such as Noodsberg where bundles are in a single location antimicrobial solutions and fogging/misting could be considered to minimise the rate of deterioration.

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UMFOLOZI RDE COMMITTEE

APHIDS (SASRI REF: ISSUE 11)

Grower Issue Description

Aphid – What are the potential issues that aphid can cause? What has happened elsewhere in the world where sugarcane aphid has become a problem? Spread of viruses etc.

SASRI Communication

A new project to investigate yield loss due to yellow sugarcane aphid (YSA) commenced in November 2014. However, success in estimating yield loss due to YSA has been hampered in this project due to an absence of YSA infestations in the field trials. Therefore, an approach using pot trials with sugarcane artificially infested with YSA will be considered as a means to estimate yield loss to YSA in South African varieties.

Research in North America (from whence YSA originates) indicates that yield reductions usually occur due to feeding damage to early plant growth stages, including reduced tillering. An infestation within the first 3 months of growth that leads to just four live leaves beneath the top visible dewlap leaf (youngest fully developed leaf) with more than 50% green leaf tissue (i.e. average of two to three badly damaged leaves), is still enough to reduce yield at harvest by up to 6%. Significantly greater yield reductions occur with each additional pair of leaves showing >50% aphid damage. Damage to and death of 3 pairs of leaves due to aphid feeding can result in up to 19% yield loss. Feeding initially results in yellowing and reddening of leaves, while prolonged feeding can lead to premature death of leaves and ultimately entire plant death. However, yield loss from late season feeding damage to sugarcane can also occur. Most yellow sugarcane aphid damage in the USA occurs during the spring and mid to late autumn. Aphid population development within a crop should be closely monitored to ensure that natural enemies are keeping the density low enough to prevent premature leaf yellowing and death. Sugarcane leaf damage symptoms are a good indicator of season long growth and yield effects.

In the USA, use of cultivars resistant to yellow sugarcane aphid feeding is an important management strategy. A SASRI project currently in progress has also recorded significant differences in resistance (using leaf damage symptoms) of commercial varieties to YSA feeding. The outcomes from this project will be made available to growers once the final analysis of results is completed during 2016.

The ability of YSA to transmit *Sugarcane mosaic virus* is currently being investigated at SASRI (Project 14CP01). Recent results from Ecuador suggest that the aphid is not a vector of the virus.

An insecticide (Allice®) is now registered to provide some control of YSA should natural enemies or heavy rainfall fail to keep populations in check. Timing of insecticide treatment is critical to avoid yield loss. Aphid populations can quickly build to numbers too large to count for monitoring purposes. However, a scouting method for YSA to determine presence of aphid colonies and a heuristic (rule-of-thumb) will be developed to enable growers to reach a decision on when to spray insecticide to prevent infestations that could lead to yield losses.

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CANE QUALITY (SASRI REF: ISSUE 12)

Grower Issue Description

Cane Quality – Why is Umfolozi consistently at the bottom of the pile of mills in South Africa with cane quality? An unbiased study to look at the contributing factors and establish a real benchmark would be useful.

SASRI Communication

This issue is best addressed by means of an extension project. Knowledge of local conditions and practices past and present are all vital elements in providing an answer to perceived low quality issues. Extension is best placed to co-ordinate such a project as they have both the broad overall picture of the mil area as well as an intimate knowledge of individual farms and practices. The request has arisen out of the apparent trend that in so-called 'normal' years Umfolozi mill is most often in the lower half of the table of cane quality (RV%) when compared to other mills in the industry. This gives rise to the impression that there are possibly shortcomings in farming practices or other factors linked to cane supply that lead to this particular pattern. However, making such comparisons does not necessarily provide the complete picture given the extremely diverse nature of the South African sugar industry. Furthermore, focusing solely on cane quality could be misleading in terms of measuring the overall productivity and profitability of cane farming in the area. However, it is possible that cane quality could be improved if the crop is not being managed optimally in terms of agronomic and harvesting practices. It is these factors that should therefore be examined in detail in order to see if there are opportunities for improvement. A baseline exercise should be undertaken to determine the cane and sucrose yield potentials for all the homogenous climate zones within the Umfolozi mill cane supply area. With this knowledge an assessment can be made of current performance relative to the potential. This particular part of the project could be completed through means of an Extension Request for Advice (ERA). Thereafter, the project should examine, both individually and collectively, current agronomic and harvesting practices which could impact on cane quality. In so doing, those practices which provide opportunity for improvement can be highlighted and may be acted upon. In addition past data should be examined to determine for how long the trend to lower quality has persisted and if changes are evident over time that could be linked to certain practices or cane supply patterns.

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HERBICIDES (SASRI REF: ISSUE 13)

Grower Issue Description

Herbicides need a certain amount of water before they can be effective. Look at non mechanical weed control measures that are effective when sufficient moisture is not available for traditional chemicals. The ability for the weeds to get away with little moisture and the poor canopy from cane makes for serious weed pressures as a secondary problem to drought pressures.

SASRI Communication

The issue mainly involves a need for weed control recommendations in stressed cane with no canopy, caused, for example, by prolonged drought, and for any innovative alternatives to hand-weeding large weeds that have become prevalent over large areas during such conditions.

This issue will be best addressed via an Extension Request for Advice (ERA) from the local SASRI Extension Specialist (ES). This will involve regional visit(s) by the SASRI Weed Specialist to gain further insights into local problems, and in collaboration with the ES and selected farmers, to classify them into two or three representative situations. Best management practices (BMPs) can be assessed and assigned in appropriate combinations to each of the defined problem situations. These can be demonstrated in a desktop case study on a "whole-farm" scale, so assisting with prioritising fields for weed management, and using available farm resources. Once the case study is completed, it can be presented firstly to a relevant local study group, then via a local Extension letter for other local farmers, and finally via an article in *The Link* to other regions of the Industry.

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FERTILISER (SASRI REF: ISSUE 14)

Grower Issue Description

Fertiliser options – What are the best options for fertiliser application at Umfolozi? Taking into consideration the water table, the access to NH_3 and the fact that most N is incorporated, what are the best strategies? Split? How many splits? What are the governing factors? Perhaps a decision tree to help make the right decisions field by field.

SASRI Communication

Given the generally low organic matter status of soils on the Umfolozi, effective management of fertiliser N supplies to the crop is of paramount importance in terms of yield optimization. The following considerations should be borne in mind in this regard:

- Anhydrous ammonia (injected) will be efficiently used, provided the slit behind the applicator blade closes. If the soil is hard, cloddy or excessively wet, this will not happen, and resultant losses may be large.
- In the 12-month crops at Umfolozi, N should ideally be applied in at least two (equal) splits. This will result in the more efficient use of N, relative to single applications.
- Note that with high water tables, an ammonium form of N is preferable to nitrate, as the nitrate will be prone to loss by denitrification.
- Given the numerous pathways for N loss, 'tools' for monitoring crop N status become very important. These include leaf analyses and the use of the 'N monitor plot' approach. Effective use of these strategies should contribute to the optimization of crop N supplies, and thereby production.
- An N trial (with split N applications) on the Umfolozi Flats is currently in its third season (Project 09CM01). This trial also includes P, K and micronutrient treatments.

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RSD IN N25 (SASRI REF: ISSUE 15)

Grower Issue Description

RSD – RSD in N25 is very worrying. It is highly susceptible to the point where it needs to be looked at for de-gazetting at Umfolozi. An infield rapid test would be very useful in combatting the RSD problem at Umfolozi.

SASRI Communication

RSD is not regarded as a biosecurity threat because it is not airborne and has no known insect vectors. It is one of the easier diseases to manage and consequently there should never be occasion to de-gazette a variety because of it. Since sugarcane is the only known host of the RSD bacterium in nature, ensuring the thorough eradication of the old crop before replanting is an effective means of control. A minimum of 3 months totally free of cane, after the removal of the last volunteer, is recommended for commercial planting. By replanting only with certified or approved seedcane, from nurseries established with tested and hot water treated source material, the risk of reintroducing RSD can be minimised. However, even with good management, infection levels are known to increase in older ratoons due to spread by harvesting equipment. It is therefore vital that best management practices are followed when replanting and that RSD free seedcane is sourced.

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