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2020 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 topics raised in 2020 by representatives of the regional RD&E committees from the northern irrigated regions of the industry. In instances where essential knowledge is lacking, certain issues have led to proposals for new projects for implementation in 2021/2022, subject to funding approval by the industry. These new projects are highlighted in the document. In addition, due to the complexity of some of the topics raised, communication more comprehensive than that contained within these communiqués is required. In these instances, a brief description of communication planning is also noted.

The 2020 RD&E Committees workshop was convened in Malelane on 12 March 2020 and hence, issues relevant to sugarcane cultivation under irrigated conditions predominate in this document. As agreed by the RD&E committees, the annual workshops will alternate between the irrigated and rain-fed regions, with the next workshop planned for Mount Edgecombe in March 2021.

ACKNOWLEDGEMENT

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

CONTENTS

1. Due to their production and socio-economic circumstances, small-scale growers need adaptable varieties with good ratoonability and objective advice when selecting these.

Current economic pressures facing growers throughout the SA sugar industry necessitate the mitigation of risk in all aspects of the sugarcane growing process. With replanting costs in the irrigated regions, including the costs of irrigation, exceeding R50 000 per ha, it is critical for growers, particularly small-scale growers, to be able to obtain both maximum productivity and ratoon life from the varieties they plant in their fields. An essential prerequisite for ensuring long ratoon life is the planting of good disease-free seedcane. However, the variety chosen for the site is equally important, as it needs to: (a) be suited to the particular soil type; (b) have the requisite pest and disease resistance; and (c) be suited to management practices in accordance with other limiting factors prevalent at the site. Fulfilling all of these requirements is necessary to maximise profitability in the long-term. In this regard, the most productive varieties may not necessarily be best for small-scale growers, particularly if a variety does not have high ratoonability, which might necessitate more frequent replanting. A better choice for these growers might very well be varieties with slightly lower productivity but with more all-round adaptability and pest and disease resistance. Given the challenges posed by some soils in the irrigated regions plus the pressure on water supplies at times, this approach makes good sense. Also, it is clear that experience with a variety over different seasons with regard to cutting cycles and water management regimes is something which can only be gained over a long period of time. Hence, it may be advisable that that small-scale growers choose from a suite of varieties which have stood the test-of-time and proven their worth. Therefore, planting relatively new SASRI varieties, for example those with less than five years' commercial use since release, to any great extent on small-scale farms, is risky and should be avoided.

Choosing appropriate varieties for small-scale grower farms in the irrigated regions is a critical decision and demands careful consideration. Using commercial production data from different varieties provides a useful pointer to possible suitable varieties. However, the most effective way of comparing the performance of different varieties grown under the same conditions is by means of a replicated variety trial. To obtain maximum benefit these, trials should be designed, overseen and evaluated by SASRI and subjected to the typical commercial crop management practices of the local area. This provides an excellent basis for comparison, particularly if the trials can extend over several seasons. There are already such trials in the irrigated regions and there are plans for more. If enough trials are planted, these should, with time, provide the necessary confidence in the range of varieties available grown under the conditions within which the small-scale growers farm.

Extension services for small-scale growers serve a vital role in providing the necessary interpretation of variety trial results and translating these into appropriate advice on variety choice. The wide exposure extension enjoys within a region and access to production data from farms in the area could further assist growers to make the best choice. There are efforts currently underway to consider the reinstatement SASRI small-scale grower extension in Mpumalanga. Small-scale grower extension in KwaZulu-Natal relies heavily on the demonstration plot field school approach to extension amongst small scale grower communities and it is envisaged that should extension return to Mpumalanga they would use this method to promote both better management practices and correct variety choice.

In addition, SASRI has currently underway two projects which address the issue of the need for objective advice regarding variety choice for small-scale growers. Project 19TD07 (S*mall-scale producer technology development: variety choice and* *management*), will provide an excellent vehicle to address this need. This project will again rely heavily on the variety trial demonstration plot methodology to deliver outcomes. The methodology will not focus solely on variety choice but will also address variety management, including BMPs which, if correctly applied, will ensure the maximum possible ratoon life. Also, the project 17TD01 (A*n interactive variety information tool*) will further assist in generate objective advice around variety choice for extension and growers to be presented in both isiZulu and isiSiswati.

With an increasing number of varieties now being available to growers it is critical that objective unbiased advice is available to small-scale growers. The presence of SASRI extension, variety trials, demonstration plots, technical publications and a decision support program will all contribute toward assisting small-scale growers make the best choices for their circumstances.

2. Accessible variety information is needed for small-scale growers.

Small-scale growers (SSGs) have small farms that are best suited for the planting of stable, broadly adapted varieties. As such, it is proposed that a variety booklet suitable for SSGs be developed, describing up to five varieties for each broad region (coastal, midlands, irrigated) recommended for SSGs across a range of growing conditions. This variety booklet would be available in isiZulu and siSwati and reviewed every two years or when newer varieties are released, older ones are phased out or newer more profitable varieties become available.

Due to the high risk associated with having "all your eggs in one basket" and the reality of only having one variety planted on a small farm, SASRI recommends that new varieties should be tested commercially for five years, or at a minimum for at least one ratoon cycle, before making any firm recommendations regarding their use for SSGs (also, please refer to Communiqué 1, which discusses issues that should be considered when advising SSGs on appropriate variety choice).

The development of this SSG variety booklet will be a product of an existing project, namely 19KE06, since this project aims to review and update all variety information pertinent to both large-scale and SSGs

In addition to this variety booklet, a simple online variety information tool is being developed within an existing project (17TD01) that will assist in variety choice for specific growing conditions. Extension specialists will be available to assist in using the tool and interpreting results.

3. There is a need for small-scale grower extension in the Lowveld.

SASRI has for some time advocated the re-introduction of SSG extension in the Mpumalanga Lowveld. This has been in response to numerous calls by SSGs in the region for such a service to be re-introduced. A possible option was explored whereby collaboration with the Mpumalanga Department of Agriculture, Rural Development, Land and Environmental Affairs (DARDLEA) would enable the utilisation of their extension officers to provide an extension service the SSG communities where they already operate, providing advice on a range of crops, including sugarcane. However, it was felt that without a SASRI person on site to co-ordinate, guide and support, their work would not be fully effective. Extension support to SSGs is also provided through TSGro which could also benefit from a SASRI person being based locally to provide a direct link to SASRI's sugarcane specialist support and other services. A major stumbling block in the provision of extension to SSGs in the region has been funding. In KwaZulu-Natal, SSG extension is supported by partial funding through the extension venture agreement (EVA) with the KZN Department of Agriculture and Rural Development (KZN DARD). However, unfortunately, the EVA does not allow for activities across provincial boundaries and currently SASRI's extension support to SSGs is provided through its regional extension service to large-scale growers as well as other *ad hoc* interventions by SASRI. Over the past year, there have been increased efforts to motivate for SSG extension in Mpumalanga and currently there is such a proposal being considered at industry level.

4. Grower participation in late-stage variety selection process would be advantageous.

Grower days are to be planned for showcasing promising pre-release varieties in trials. Current plant breeding trials at SASRI's Pongola and Komati research stations are set up with all varieties inside in early and late season trials planted outside the trials as guard rows making it easy and accessible for show casing the varieties to growers. This is to be planned for after the harvesting of the second ratoon crop when varieties likely to be released can be predicted.

5. An easy-to-use comparator of variety characteristics for decision-making would be beneficial.

A current project (17TD01) is developing a simple online variety information tool that extension specialists and growers can use to assist them with making variety choice decisions and comparisons between varieties for their specific growing conditions. The tool is planned to be released in March 2021.

6. Concern exists that newer variety releases do not have the same level of ratooning ability (RA) as the older varieties.

A number of questions were considered in addressing this issue.

- Does the plant breeding and selection process ensure good ratooning ability of released varieties?
- What proof does SASRI have that ratooning ability is not influenced by choice of variety?
- Do the variety evaluation trials address this issue?
- If varieties are not causing yield decline, what are the possible causes and recommendations?
- Should ratooning ability be considered when it comes to variety choice?

On-going extension and knowledge exchange activities are required to:

- change beliefs and opinions about ratoon longevity of newer varieties;
- promote a newly refined decision support program (DSP) to aid replanting decisions; and
- promote a new variety information DSP

Plant breeding processes

The plant breeding processes at SASRI ensures ratooning ability is accounted for in selection. Stalk population is one of the traits associated with ratooning ability of a variety that is evaluated during selection. A recent increase in the number of controls and regular data analysis has allowed SASRI breeders to continuously evaluate and select for high ratooning ability for all varieties. The plant breeding project does ensure that varieties released have a high ratooning ability, which means ratooning ability of commercial varieties is influenced by something else other than the choice of variety.

At the time of release, some varieties are recommended for specific environments to which they are best adapted. When planted in these environments, variety ratooning will be optimal. However, when a variety is planted in an environment to which it is less well-adapted, lower yields and potentially poor adaptability and ratooning ability may occur. Therefore, planting varieties in environments to which they are adapted and for which they are recommended would reduce some of the issues of ratooning ability that may be largely associated with poor adaptability.

Variety N26 has specific adaptability, requiring good growing conditions, good soils and harvesting within the early season for successful cultivation. Deviations from these requirements will reduce yields and ratooning ability. Most varieties recently released for irrigated conditions have shown specific adaptability because of the current trial site setup in the breeding programme. There are currently two trials at both the Pongola Research Station and Komati Research Station located on good soils, which enables the selection of varieties adapted to good soils and good growing conditions. However, there consequences to such specific adaptability. Cultivation of a variety specifically-adapted to one environment in a different environment may result in lower than expected yields and ratooning ability. This situation can be resolved by facilitating breeding for broad adaptability. Breeding for broad adaptability requires testing promising genotypes for broad adaptability in diverse sites representative of the environment they will be grown.

What proof does SASRI have that ratooning ability is not influenced by choice of variety?

Efforts were made at SASRI in understanding varietal differences in relation to ratooning ability. Requests were received from growers for extensive evaluations of ratooning ability of newly released varieties. To investigate this issue, SASRI started a project in 2010 (Project 10VI03). The planting of variety trials of identical design in two contrasting environments was staggered over 2011, 2012 and 2013 and harvested over four years (2014, 2015, 2016, 2017). The results of the project were reported by Ramburan *et al.,* (2011, 2012, 2013, 2015, 2018). An article in *The Link* was also published in September 2011 to address this issue and the key findings were as follows.

- Environmental conditions and management practices were identified as more important than variety in affecting ratooning ability. The data indicated that newer varieties ratoon better or similar to the older ones (Figure 1).
- The recommendation made was that growers can make more progress in sustaining yields by improving management practices rather than trying to select varieties based on perceptions of their ratooning ability.
- In the irrigated northern regions, the study revealed that the older varieties, N23 and N25, do not necessarily ratoon better when compared with the new variety N53 (Figure 1).
- The speed and vigour of regrowth after harvesting should not be confused with ratooning ability. Some varieties may re-establish themselves slowly after harvesting, but are still able to sustain RV yields over many ratoons

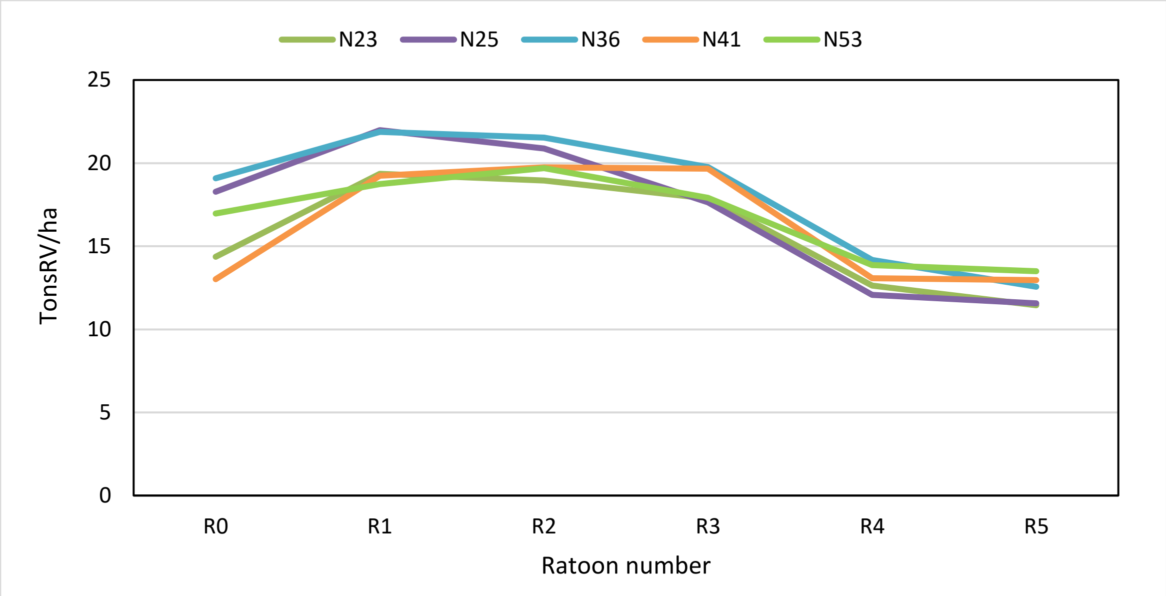

Figure 1

An example of data from an ongoing variety evaluation trial in Komatipoort showing ratooning ability of old versus new varieties.

Do SASRI's variety evaluation trials address the ratooning ability issue?

Variety evaluation trials are conducted in partnership with collaborating growers, some of whom continue these trials for as many ratoons as their commercial fields. SASRI recommendations are based on data from three to four crops on particular soil type and environment, which show variety consistency in maintaining good RV yields over the years. However, information sheets and variety booklets are updated when more data on variety performance become available. When variety performance data are distributed to extension specialists, they usually include ratooning ability data for older trials, from the second ratoon. In most cases, no significant differences between the old and new varieties performance over the years are detected. Some differences may be observed in the early years (Figure 1).

Moving forward, concerns regarding ratooning ability can be addressed by:

(i) Routine reporting of ratooning ability data in extension newsletters after the harvesting of variety evaluation trials;
(ii) engaging with the growers in small groups to listen to their concerns about ratooning ability and share information;
(iii) targeting a region where concerns are prevalent to share latest information from plant breeding and variety evaluation trials with the growers; and
(iv) embed ratooning ability into knowledge exchange activities of related projects

Possible causes of yield decline

SASRI has undertaken a number of studies on the possible causes of yield decline across ratoons. Many factors, other than variety, may underlie yield or ratoon decline, including pests and diseases, soil fertility (acidity or salinity/sodicity), stool damage, climatic conditions and weed competition. Ratoon yield decline is mainly influenced by the environment and management practices, with less influence from genetic factors. SASRI researchers and extension specialists will continue to encourage knowledge exchange with growers regarding the importance of adopting best management practices, including with SSGs.

In a further SASRI research (Project 16TD05), generic ratoon yield decline trends were analysed from commercial data sets for different regions in order to evaluate alternative replant strategies to address ratoon yield decline. A decision support tool (DST) was created to evaluate the profitability of different ratoon (replant) cycles. The DST can be applied to assess interactions between various starting yields and rates of ratoon decline, based on either the commercial decline characteristics or on a user defined customized decline % for scenario testing.

Should ratooning ability be considered when it comes to a choice of variety?

No, the traits associated with ratooning ability are already selected in the plant breeding trials. Also, the science literature SASRI research results show that most variation in trials are influenced by variety x site interactions and not so much about variety x crop interaction. Choosing varieties based on site potential has been proven to be more influential in terms of how a variety will perform over a number of years. Implementing best management practices (BMPs) to reduce risk factors like stool damage from in-field traffic, pest infestations, diseases, weed competition and poor soil health can substantially improve ratoon longevity.

In a further SASRI project (17TD01), an interactive variety information tool is currently under development to assist growers in choosing the varieties best suited to their fields. This decision support tool will help growers to identify varieties based on their site potential, agronomic and management factors.

7. Niche late-season varieties are problematic when there is forced carryover into the next season. Growers need a core of broadly-adapted / general-purpose varieties supplemented with niche late- and early-season varieties for tactical farming.

The breeding programme for the irrigated areas of the industry has released some broadly (N53) and specifically (N70, N71) adapted varieties. N73, while recommended for late season, is expected to do well in the early season with chemically-induced ripening. N60, released only for the southern regions, due to smut susceptibility, is probably one of the best broadly-adapted irrigated variety released in recent years. However, while N70, N71, N73 are recommended for late season, they do produce good yields outside of late season, although they are not the best available varieties for the early season.

One potential approach would be for growers to plant a combination of late season and more broadly adapted varieties in the late season and ensure only broadly adapted varieties are carried over to reduce the yield penalty. For example, N70, N71 can be planted together with N73, N53 and only N53 and 73 would be carried over in the event the mills closes earlier than planned. A long-term solution would be to develop varieties that are broadly adapted. This will require setting up more representative testing sites that would facilitate development and testing for broad adaptability. The current trial setup at the SASRI Pongola and Komati Research Stations is good for developing narrow/specific adaptability.

Discussions on this topic may be held at a grower day during which more detailed information can be provided on the adaptability of the released varieties and how to optimise their positioning in commercial plantings. Updating of variety information sheets will be undertaken to incorporate some of these recommendations.

8. Expansion of trial network is needed to identify broadly adaptable varieties.

Expanding the SASRI breeding programmes to encompass additional testing sites is to be explored. Currently, five irrigated variety trials are being conducted: two at each of the Pongola and Komatipoort Research Stations and one off-station trial in Pongola. Given this relatively restricted number of sites, testing of varieties on the full array of types, management and other environments is not currently possible. This may reduce the identification of broad adaptability of varieties.

Despite the desirability of testing on multiple sites to identify broadly-adaptable varieties, ongoing pressures on SASRI to streamline research activities make expansion of the trial network challenging. Observations suggest that the Komati cane-growing area is warmer than Malelane, with the Malelane area also having sandier soils. Discussions with RCL staff have further indicated that Komati has more uniform and deeper soils than Malelane, which is rockier in some places and having a lower clay content.

SASRI is currently testing breeding populations in high potential soils in Pongola and Komati, which leads to narrow adaptability. For example, among all the recently released varieties, only N57 has produced high yields in the sandy/poorer soils in Malelane and Komati while the other varieties produce lower yields in these environments. Further, the current setup means in future it will be more difficult to breed for broad adaptability. The populations are currently being largely shifted to specific adaptability with loss of genetic background required for broad adaptability. To regain that lost genetic background will take more breeding cycles and years at greater cost and probably with fewer varieties during the development process.

To ensure breeding can deliver broadly adapted varieties, plant breeding trials must be planted in the broad range of environments fully representative of the Lowveld. While grower participation for smaller trials maybe a challenge, plant breeding trials have been successfully hosted by growers in the coastal and midlands areas producing valuable results and broadly adapted varieties in recent years. What is required are at least two sites with soils different from that at Pongola and Komati stations. The land requirement is 5 to 10ha per site, depending on field uniformity, and then trials will be rotated in that piece of land. This approach has been used in the midlands and coastal trials and has worked very successfully.

10. Updating of variety information sheets is needed as more information becomes available.

At the time of release of a new variety, variety information sheets are prepared that capture all relevant details of that variety. These include best and limiting features, yield and quality information, reaction to diseases and pests, as well as agronomic and milling characteristics. This information is the result of analyses of data collected throughout the lengthy eleven to 15 year plant breeding and selection process.

After release, varieties are further tested in different agro-climatic regions across the industry within a variety evaluation programme (VEP) which is a network of variety trials across different regions. These trials, many of which are accommodated on the farms of grower co-operators, run for at least three-to-five years in order to fully evaluate the performance of newer varieties under commercial conditions. The objective is to fully understand the performance of new varieties in different soil environments across sugarcane growing regions.

The results of these post-release variety trials are shared through regular extension specialist visits, extension newsletters, grower days or formal publications such as *The*

Link or *Inged*e. Once robust testing has been undertaken and enough data have been collected to make conclusive findings on the performance of the variety, information sheets are then updated. This normally takes between three-to-four years to enable the inclusion of data from the second ratoon.

Updated information sheets are printed and posted to growers, while electronic copies are also housed on the SASRI website's eLibrary at www.sasri.org.za/elibrary

11. Update on the de-gazetting of N41 is needed.

The variety N41 has not been de-gazetted in any Local Pest, Disease and Variety Control Committee (LPD&VCC) control area in the industry. However, over the past three seasons the Pongola area experienced an explosion in smut mainly due to growers not implementing adequate control measures such as roguing, volunteer control and the use of disease-free seedcane. In 2016, 7% of fields surveyed in Pongola recorded levels of smut higher than the local hazard level. This increased the following year to 10% and then increased dramatically the following year, 2018, to 35% of fields surveyed being above the local hazard level. This situation demanded a response and numerous roguing and plough out orders had to be issued. The varieties N41, N25 And N23 were found to be worst affected. However, with N41 making up approximately 35 % of the area under cane, and with 85% of the fields surveyed of this variety surveyed having levels of smut above the hazard level this variety was obviously a major source of infection in the area.

12. Ability of varieties to maintain performance under drought conditions is important.

Testing variety performance under drought would become more robust if additional testing sites were added to the plant breeding trial network, when certain sites could be designed to receive less water/irrigation to simulate a drought. This would provide adequate data for a recommendation at the time of release (see related Topic 8). Unfortunately, ongoing pressure for SASRI to streamline activities makes the immediate expansion of the trial network challenging.

13. Information is needed on variety performance and agronomic characteristics in relation to mechanical planting and harvesting operations.

In countries where mechanical planting and harvesting are common practice, breeding programmes plant and harvest their trials mechanically to select for traits favourable to mechanised production systems. Unfortunately, this approach will be very difficult for SASRI implement, as all trials are currently hand-planted and hand-harvested, as this is the dominant practice in the SA industry. Without mechanical planting or harvesting of plant breeding and variety evaluation, SASRI is only able to use very indirect trait evaluation for mechanical planting and harvesting suitability and provide some limited recommendations based on these data.

Feedback from the industry on the variety agronomic characteristics they consider suitable for mechanical planting and harvesting will assist SASRI's evaluations. Crop management and field layouts may play a greater role in crop performance under mechanical harvesting and planting, although certain agronomic characteristics of a variety may be advantageous. An integrated approach, considering management and variety agronomic characteristics is required (refer also to Topic 40a).

14. Supply by SASRI of Novacane® plantlets of older varieties would be beneficial, when seed is not available and the old variety needs to be resurrected in a nursery.

The Novacane® facility at SASRI was built to: (a) provide growers with improved access to newly released varieties (with a view to enhancing penetration into the industry of these superior varieties); and (b) provide source material for the seedcane schemes to improve grower access to certified seedcane.

SASRI supplies two commercial tissue culture laboratories (Du Roi and Dube Agrilab) with fresh source material of all SASRI released varieties on request. This arrangement (which was established some years ago and is formalised with memoranda of agreement) enables these commercial laboratories to supply growers with tissue culture plantlets on request.

The hot-water treatment (HWT) facility recently erected in Pongola will help going forward. However, to start the seedcane scheme, a pressing problem is the lack of availability of sufficient quantities of certified seedcane of all the varieties cultivated in Pongola, Mkuze and Makhathini. Sufficient certified material is required for N23, N36, N49, N53, N57 (and to a lesser extent N14, N19, N40).

The SASRI Pongola Research Station may be able to assist in the following ways.

- Small amounts of seedcane (3-4 tons per variety) may be available and the Extension Specialist should liaise with Farm Manger.
- The HWT tank is available for growers wanting to treat seedcane. Growers would need to provide labour to cut and strip the cane and chop into setts for the HWT tank, following strict procedures with regards to clean cane knives and the use of Jeye's fluid.
- The SASRI Farm Supervisor oversee the process but the grower's staff will be required to fill and remove the baskets. The tank will be drained and refilled weekly by the SASRI Farm Supervisor

15. Cane grown from tissue culture plantlets of many varieties (e.g. N40, N41) have thin stalks.

Micropropagation of sugarcane via *in vitro* culture is a well-established practice in many parts of the world (Jalaja *et al*. 2008). Some of the advantages are that it is more rapid than conventional stick-based propagation and small (<1mm) meristem excision followed by shoot tip multiplication can facilitate virus elimination (Ramgareeb *et al*. 2010; Snyman *et al*. 2011). Phenotypic effects such as thinner stalks and prolific tillering have been reported when this material was hardened-off and transferred to the field but these characteristics normalised after the plant crop (Lourens and Martin 1987). Our own trials conducted on cultivars N12, N31, N41 and N48 showed that Novacane®-derived stalks are thinner and tiller more profusely than the conventionally-derived material and that this is genotype dependent, but that there is no yield compromise (Shezi and Ramburan 2018).

One of the aims of the recently completed SASRI research (Project 15VI04: Evaluation of *in vitro* mitigation treatments to reduce Novacane® phenotype anomalies in the field) was to add cobalt chloride to the *in vitro* culture medium. This compound has been reported to reduce the build-up of ethylene, which causes excessive tillering (Mishra *et al*. 2014). Novacane® plants of cultivars N41 and N48 were assessed in the field after such treatment and showed no difference in stalk height, population (tiller number), biomass and estimated recoverable crystal content (ERC) when compared with conventional, sett-derived plants during the first year of cultivation (plant cane) (Snyman *et al*. 2018). The study also found that in the first ratoon crop, the only difference observed was in N41 stalk population where tiller number in Novacane® plants was higher after secondary meristem initiation compared with regular Novacane® and conventional plants. This practice is used for cryopreservation (Banasiak and Snyman 2017) and cryotherapy (new findings in SASRI Project 00VI03), so it is important to investigate the plants being bulked up using those explants. The results of the field evaluation suggest that although there may be some genotype specific response to *in vitro* propagation using Novacane®, overall yield is not compromised in either the plant or first ratoon crops (Snyman *et al*. 2018).

In the future, planting in bulking plots will include conventional sett-derived material for comparison purposes and genotype specific information will be communicated with growers from the release of N74 and onwards.

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17. There is a need for support of small-scale growers in soil sampling methods and interpretation of FAS reports (Topic 17) and Small-scale growers need objective advice on crop nutrition and fertilisers (Topic 18).

The absence of SASRI small-scale extension in the region appears to be the at the heart of the problem, where lack of support and guidance from independent and neutral parties has allowed contractors, sales consultants and individuals with socio-political agendas that undermine best practices as advised by SASRI. However, this issue has been recognised and acknowledged in several regions and across almost all scales of sugarcane farming and several projects have been initiated to produce content to help guide growers with best practices. These initiatives are outlined below.

Project 18KE01: Revision of Crop Nutrition and Soil Health Information Sheets

From a similar issue from the 2018 RD&E meeting (issue 7 and issue 19) a project was established to revise all the soils and crop nutrition information sheets. Project 18KE01 commenced in April 2019 with the aim of revising and/or creating a complete set of crop nutrition and soil health information sheets to guide growers on the principles and best practices for crop nutrition. The key intent is to use these information sheets as baseline/core documents and information sources to guide and develop grower knowledge. The project has to-date has seen the revision of 14 information sheets with the recently released sheets available online via SASRI eLibrary webpage as of 1 May 2020. These include:

7.1 Developing a Nutrient Management Program
7.2: N Management
7.3 N Monitor Plots
7.4 P Management
7.5 K Management
7.6 S Management
7.7 Ca/Mg Management
7.8 B Management
7.9 Fe Management
7.10 Mn Management
7.11 Cu Management
7.12 Zn Management
7.15 Sugarcane Leaf Sampling (video guides are also available in English and isiZulu)
7.16 Soil Sampling (video guides are also available in English and isiZulu)

Brochures on how to read/interpret FAS reports completed include:

- Routine Top and Subsoil Fertility Reports,
- Leaf Report,
- Water Quality Report,
- Salinity/Sodicity Report

These, along with other guidance material, is available from the newly created Crop nutrition page on the SASRI website (https://sasri.org.za/crop-nutrition/) or FAS website (https://www.fasagrilab.co.za/)

Other information sheets currently being prepared and that are expected during 2020 as part of project 18KE01 include the following.

- Simple guide to reading and calculating fertiliser requirements.
- Classification and use of various organic and industrial amendments (manures, CMS, filter-cake, litters, compost, ashes, sawdust etc).

Additionally, brochures that that aim to guide a grower through the requirements to fill in a sample submission form reports have been drafted and are currently undergoing review (expected in third quarter of 2020). These include brochures on how to complete submission FAS forms.

- Routine Top and Subsoil Fertility,
- Leaf

- Water/Salinity/Sodicity
- Fertiliser and Organic Amendments

These information sheets and brochures will be used to form the basis of further knowledge exchange products and for use in grower days and other contact events. This will include guide videos to explain concepts, practices or give instruction on various nutritional aspects. Written articles in The Link, Ingede and FAS newsletter will support these knowledge exchange products. A fertiliser optimiser calculator tool is also proposed to assist in deciding on optimal fertiliser rates based on available fertilisers, amendments and the FAS provided recommendations (see Topics 19 and 21 of 2020 RD&E communique for details).

Project 20TD04: Long-Term Monitoring Demonstration Plots

To demonstrate the value of adopting SASRI BMPs, a multi-faceted project was proposed in 2019 (Project 19CM02). One of the objectives of the project was to establish a series of long-term monitoring demonstration plots (monitor field plots) across the sugarcane growing areas in SA. However, based on the discussions from the 2020 RD&E Workshop, it has been agreed to restructure the demonstration plot part of Project 19CM02 into a separate project (20TD04) which includes the irrigated regions. This work is detailed in Topics 38 and 39 of this document. In brief, Project 20TD04 aims to establish a network of demonstration plots where SASRI advised best practices are applied and monitored against grower practices for at least a full crop cycle. It is proposed that these plots be adapted to allow for grower days where activities required for plot establishment, such as soil sampling, are demonstrated. Follow-on grower days at these demonstration plots will then highlight the benefits gained from undertaking the best practices, thus linking action to outcome.

Project 19TD03: Soil Conservation Learning Resources for Small-Scale Extension

This project aims to develop a modular course and easy-to-use demonstration tools to highlight key concepts and practices to SSGs. SSG extension will be equipped and trained in the use of teaching aids. They, in turn, will use the information and resources in their soil talks and lectures to SSGs. This course and teaching aids will also have relevance to crop nutrition, as key constraints can be identified and explored.

Project 20TD03: Fertiliser Optimiser Software

A project to develop a simple fertiliser optimisation software or tool has been proposed and accepted for scoping in the 2021 budget cycle. Such a software tool could be used to establish how well a bulk or standard blend provided to a grower achieves the field target requirements and will allow the grower to estimate the need for top-up fertilisers to better match fertiliser applications to requirements, while considering cost options. Further details of this are provided in the Communique 19/21.

The Need for Comprehensive SSG Extension Services

For the above information and demonstration work to have effect, regular intervention and interaction amongst SSG communities and suitably qualified extension specialists are required. The extension specialist will be required to arrange grower days to facilitate interactions between SSGs and relevant specialists to help explain and guide the growers in the SASRI advised best practices. Ideally, these grower days should be conducted in suitable language for the group as many SSGs are not English or Afrikaans first language speakers. Additionally, interaction and training events with grower associations may also be required to ensure that representatives from these groups are made aware and become familiar with SASRI advised practices.

19. Small-scale growers have difficulty adhering to FAS recommendations when they have no control over the formulation of available fertiliser (issue 19).

21. A tool is needed to enable growers to optimise their fertilisation regimes – maximum yield for minimum cost, balancing inorganic.

Response to Topics 19 and 21

FAS recommendations are based on many decades of research and are aimed at recommending optimal nutrient application rates for optimal crop growth for the sample test values and agronomic information supplied with the sample. The specifics of these recommendations have been previously detailed the 2018 RD&E communique (Topics 7 and 19) and new instructional and educational content is being developed to guide growers (see Issue 17/18 for detail on these activities). However, it is essential that growers understand that it is not feasible or possible for FAS to either tailor the field nutrient requirement to a fertiliser type or to provide recommendations for all possible type or combinations of fertilisers. In the first instance, deciding your nutrient requirements based on a fertiliser type is incorrect practice as it is unlikely that you will effectively meet the nutrient requirements of the crop. The fertiliser type and rate must be selected based on the soil and crop requirement. This is a fundamental principle of nutritional best practices and is a key reason for undertaking fertility testing. In the second instance, providing fertiliser recommendations for all the potential combinations available to growers would be impossible, as there are just too many combinations, many of which are unknown to FAS. Custom blends that some fertiliser companies can supply, further complicate the matter. While some examples are provided in the FAS report (based on some of the most common types of fertiliser blends), specific fertiliser requirements need to be adapted according to local fertiliser availability and the site-specific needs. Accounting for all sources of nutrient inputs must also take place for optimal nutrient management. This would include application of manures, compost and other related products. Providing this information from a soil test value in the FAS report is not possible. This must be done after the fertility requirements from the soil analysis are known, usually in conjunction with an Extension Specialist or agronomic advisor qualified to do so.

The complexity and often tedious nature of optimising fertiliser combinations and rates for a specific nutritional requirement are fully recognised. Thus, in addition to undertaking activities that aim to improve grower knowledge (see Topics 17/18 and 23), it is also proposed that a tool be developed that will allow for the optimisation and evaluation of fertiliser types and rates for a given soil test requirement. This is detailed below.

Fertiliser Optimiser app

It is proposed that a calculator or application be developed that allows the determination of optimal rates and combinations of fertiliser for a given nutrient requirement. The software will allow the user to input their nutrient requirements (i.e. the N, P and K requirement from the FAS routine soil fertility report), and either allow for selection fertiliser types (including organic amendment), either from pre-populated standard lists or allow for custom user inputs. The application will then develop an optimal fertiliser application rate through the use of linear programming (automated optimisation functions). Over- or under-supply of particular nutrients will be indicated and the user will be able to adjust fertiliser options to optimise the application requirements. Additionally, a costing function will be developed that will permit costs for fertilisers to be added so that the scenarios to minimise costs for the optimal or desired fertiliser applications can be evaluated.

The application proposed above is based on the software tool originally developed for SASRI Extension by Dr Arnold Schuman and Jan Meyer in 1999. The “Six-Pack”, as it was called, consisted of six modules that allowed an extension officer to upload FAS results and recommendations and determine various treatments and fertiliser requirements. Several aspects of the calculator have since been incorporated directly into FAS reports (e.g. lime requirements, N volatilisation risk). Unfortunately, due to the programming language used to develop this original software package, major changes in the FAS database system and also changes in the methods used by FAS, the software package was never maintained or updated and was eventually lost from use.

It is proposed that a revised, user-friendly version of this application be developed for use by extension services and growers. It is envisaged that the application will provide users with the ability to:

- calculate nutrient amount supplied by a given fertiliser type or blend in relation to the crop requirement, highlighting over- or under-supply for any chosen combination;
- optimise the amount and types of several fertiliser types or blends (including organic manures, litters or other sources) to best match the nutrient requirement for a field;
- select alternative combinations to develop best case scenarios for their fields
- define fertiliser or amendments nutrient ratios (custom blends etc);
- link to FAS reports, possibly through a grower portal, to enable real-time scenario development;
- evaluate the economics of optimised fertiliser combinations based on user-defined pricing of fertiliser; and
- optimise across multiple fields and linked to GIS (a possible second phase of development).

Such a tool should allow a grower to rapidly assess and evaluate scenarios based on their FAS soil recommendations, which would empower them to make better decisions. The interface will be simple, intuitive and user-friendly and be developed on a software platform that is accessible, upgradeable and transferable to ensure long term viability of the application.

22. More detailed micronutrient recommendations are needed.

Micronutrients (iron, manganese, copper, zinc, boron) are required at very low levels by the plant, while they also are present at low concentrations in the soil. Developing accurate soil-based guidelines has proven unsuccessful for most crops, including sugarcane. Soil testing is suggested for use as a potential indicator of developing problems or deficiencies. Leaf testing remains the preferred approach to evaluating crop uptake, but this will only be a guide to indicate if the crop is taking up the element in sufficient quantities. It is, however, not possible to provide micronutrient ameliorative rates based on soil or leaf test values as is done for elements such a phosphorus or potassium. As these guidelines are based on empirical responses from past trials, they tend to be generic, while being conservative to avoid causing toxicity (given that over application of micronutrients can lead to plant toxicity).

Calibration trials are generally not considered practical or useful as many trials are required to establish guidelines and are generally not very successful. Even where extensive trials have been conducted, guidelines tend to remain generic. As such, current advice reflects the available state of knowledge and practice.

Very specific guidelines based on test values for the micronutrients remain elusive and this situation is unlikely to change in the near future. However, in an effort to better assist growers and guide micronutrient management practices several new micronutrient information sheets have been developed (under project 18KE01 as described in Issue 17/18 of this RDE Communique). These information sheets, which are available from the SASRI website (https://sasri.org.za/crop-nutrition/), include:

7.8 Boron management
7.9 Iron management
7.10 Manganese management
7.11 Copper management
7.12 Zinc management
7.15 Sugarcane Leaf sampling and interpretation

Further guidance will be given to growers in the series of "How to read your FAS analysis report" brochures for both leaf and soil tests (produced under Project 18KE01 and available from (https://sasri.org.za/crop-nutrition/)). An additional Information Sheet that contains useful management guidance to undertake farm testing for refining nutrient application rates is Sheet 7.3 – Nitrogen Monitor Plots, which has a section describing how the N strip-plot on farm testing approach can be adapted to test for responses to micronutrient applications.

It is also worth noting that much of this information is also available in the SASRI Soils Handbook (Understanding and Managing Soils in the South African Sugar Industry - 2013).

Recent articles in The Link may also be of interest.

- Zinc deficiencies: Occurrences, causes and remedial measures - September 2017
- Boron in sugarcane crop nutrition - May 2018
- Managing micro-nutrients – September 2020

To improve the usefulness of the FAS reports, changes to the "Agronomic Comments" section of the report will be made to better guide growers on possible actions when low micronutrient levels are detected in their soil. Due to space limitations on these reports, this advice may direct the grower to the relevant content referred to above (namely Information Sheets). Inclusion of these changes is planned for later in 2020, but subject to the finalisation of the transfer of the existing FAS programming onto a new software platform (currently in progress).

It is also worth noting that local Extension Officers or SASRI Research Specialists are invaluable in guiding best practices for managing micronutrients in sugarcane and should growers are advised to contact them should they have queries or are in doubt as to the best micronutrient management practices for their soil and crop.

23. Lack of large-scale grower / miller-cum-planter confidence in FAS recommendations, seemingly stemming from an historical recommendation of identical rates for fields with different yield targets.

Similar issues have been raised at a previous RD&E workshops for the Irrigated Northern Areas (Communique 2016 Topic 30: *Validity of FAS recommendations*; Communique

2018 Topic 19: *Nutrition requirements in the Lowveld*). These explanations are not repeated here, and the reader is referred to those Communiques for the detailed responses. The lack of confidence appears to stem from many years that SASRI did not have dedicated Extension representation in some of the irrigated regions. The consequence was that there was little information sharing taking place, with growers becoming less informed about the best practices researched and advised by SASRI, while new developments in both methods and recommendations were not being explained or promoted. Combined with ill-informed advice from external parties promoting unfavourable practices such as base-cation-ratio management, led to extremes in recommendations and a distrust into the generally more conservative best practices advised by SASRI. Fundamentally, it appears to be a lack of understanding of how SASRI and FAS generate recommendations and how these have been developed to accommodate the range of can growing conditions in South African, including irrigated regions. It is also apparent that there is a lack of understanding on the strong link to a target yield, and for N, organic mineralisation potential, to guide N and K application rates, which is seldom considered by external parties advising on fertiliser rates in sugarcane. Nonetheless, since Marius Adendorff was appointed as the Extension Specialist in Komatipoort, and in collaboration with Pat Brenchley (RCL-Malelane), several activities have been initiated an effort to communicate SASRI/FAS nutritional advice and best practices. These include the following.

Revision of Crop Nutrition and Soil Health Information Sheets (Project 18KE01)

From the 2018 RDE Communique, Project 18KE01 was established to revise and update all soil and crop nutrition information sheets and to use this content to expand the knowledge exchange offerings (as detailed in Topics 17/18 and 22 in this communique booklet). The revised information sheets, along with the “How to guides” include information on key parameters that FAS uses in developing nutrient recommendations. The revised information sheets will be used as a base/core to guide and expand the grower knowledge on SASRI best practices. These activities are described below.

Media and Articles for Growers

Much of the content developed for the information sheets has be or will be distilled to core information to be shown in the SASRI publication *The Link*. Furthermore, discussion with external media providers (e.g. *Landbou Weekblad*) are also underway to explore the potential to produce relevant content for use in the irrigated regions. Such content is aimed at supporting the core information available to growers.

Recent articles in *The* Link include the following.

- Getting the best out of your dress! The Four Cs of Nutrient Management. *The Link*, May 2019.
- Where has all my nitrogen gone, I’m sure I put enough down? *The Link*, September 2019.
- Water quality for soil health. The *Link*, January 2020.
- Managing organic matter (What is organic matter, organic amendments, green manuring, tillage impacts, residue management and grower case study). *The Link (Special Edition)*, May 2020.
- Managing phosphorus. The *Link*, September 2020.

Extension Newsletters are also produced and sent to growers highlighting relevant and topical information.

Grower Interaction Events and Activities

A key step to improving grower understanding and adoption appears to be direct interaction with the growers, both in groups and individually. As such, several grower days in the region have been arranged by Marius Adendorff and Pat Brenchley (in conjunction with the Soil Scientists at SASRI, Louis Titshall and Rian van Antwerpen), with the aim of highlighting basic concepts and how they relate to the advisories provided by SASRI and FAS ("Back-to-Basics"). In the last two years these included the following.

- Soil classification: Key aspects to look for to improve soil and nutritional management. SASRI Grower Days Malelane and Komatipoort, 10/11 March 2020
- Getting the best from your fertiliser. SASRI Grower Days in Malelane and Komatipoort, September 2019
- Improving N use efficiency in sugarcane. SASRI Grower Day, Komatipoort, March 2018

Direct one-on-one interactions are also being undertaken between extension and growers where required, while periodic visits by specialists are being used where possible.

Further workshops and interactions with growers are planned to further highlight and discuss the best practices and highlight the value of the FAS provided recommendations. Discussion are also underway to develop a modularised course in the region, the aim being to create a more interactive experience between the presenter and grower.

Long-term Monitoring Demonstration plots (Project 20TD04)

To demonstrate the value of adopting SASRI BMPs, SASRI commenced research (Project 19CM02) to demonstrate the value of BMPs using a network of demonstration plots. Based on the discussion from the 2020 RD&E, it has been agreed to restructure the demonstration plot component of Project 19CM02, which is now to include the irrigated regions, as a separate project (Project 20TD04). This work is detailed in Topics 38/39 of this 2020 RD&E communique document. In brief, the project aims to establish a network of demonstration plots where SASRI advised best practices are applied and monitored against grower practices for at least a full crop cycle. Grower days and field schools at these demonstration plots will be used to highlight the value and sue of SASRI BMPs

24. Growers require information on the nutrient load in irrigation water and how they could benefit from it.

Growers suspect that water used for irrigation contains a meaningful amount of nutrients and that this could be used to offset their fertiliser application against it.

All water contains nutrients and the quantities are extremely variable. Factors that affect the nutrient load in water include the source (borehole, river, farm dam, mill effluent) and the local environment (rainfall intensity, parent material of the region and distance from the sea). The quality of water from rivers and streams are affected by runoff from fields, inorganic fertiliser, up-stream industrial activities, up-stream human settlements, parent material of the region, distance from the sea and season. Unless fortified or polluted, the concentration of nutrients in water is low.

FAS analyses water samples for pH, K, Ca, Mg, Na, bicarbonates (HCO_3) and electrical conductivity (EC) and calculate sodium adsorption ratio (SAR), adjusted SAR (ASAR) and effective EC (EEC).

In Table 1 below, examples of the nutrient load in water and the variability of water quality are presented. These data indicate that rainfall and irrigation water load more Na on to soils than any other nutrient. Nitrogen and P values are absent because FAS does not analyse water samples for these nutrients. The world literature was examined to obtain an idea of the quantities of these nutrients in rainwater. The only potentially useful nutrient in rainwater is N. However, it is not a reliable source due to the variability of N per rainfall event. In Texas, it ranged between 0.02 to 0.35 kg/ha per rainfall event which translate to 0.76 to 9.6 kg/ha when converted to receiving 800 mm of rain or a low mean of 2.25 kg/ha for a total rainfall of 800 mm (calculated from data in USGS, 1999). In Gambia, N received in 800 mm rain ranged between 11.7 to 63.6 kg/ha with a mean of 25.7 kg/ha. The mean amounts of other nutrients were 0.24 kg/ha P, 8.21 kg/ha K, 3.31 kg/ha Ca and 10.30 kg/ha Na (Thornton, 1965). Thus, in rainwater, the nutrient present in the highest concentration is N followed by Na. K, Ca and Mg alternates depending on the region and P is present in extremely small quantities.

Table 1

Examples of nutrient content in unfortified water if 800 mm irrigation is applied. Note that Na is applied in the largest quantity in all cases.

Region	Km from sea	pH	K kg/ha	Ca kg/ha	Mg kg/ha	Na kg/ha	HCO_3 kg/ha	EC mS/m	SAR	EEC mS/m	ASAR
Rainwater	30	5.82	6	17	43	139	37	3	1.5	1	0.8
Midlands[1]	56	6.92	30	29	35	184	683	26	2.0	13	1.6
Zululand[2]	30	6.77	19	85	148	238	756	24	1.5	12	2.1
Mill effluent	56	7.36	288	485	202	713	4263	103	2.6	51	6.0
Seepage	62	8.03	22	317	230	3318	6297	205	12.2	103	30.5

1 = Unpolluted stream 2 = Canal water coming from the Goedertrou dam

EEC = Effective Electrical Conductivity converted from EC by taking the dilution effect of the annual rainfall into account (800 mm in this example).

ASAR = Adjusted Sodium Adsorption Ratio converted from SAR by taking the bicarbonate (HCO_3) load into account.

To put the numbers in Table 1 into perspective, Table 2 reflects the typical uptake of nutrients by irrigated sugarcane. K is typically required by sugarcane in large quantities, but it was present in relatively small quantities in the water samples. In contrast, Na is taken-up in extremely small quantities. Thus, Na which naturally occurs in larger quantities in irrigation water, will not be removed in significant quantities by the crop. If the soil is not well drained, Na will accumulate over time leading to a loss in the production potential of the soil and yields.

Table 2

Typical nutrient uptake trends of nutrients by irrigated sugarcane. (Note the low uptake of Na).

Component	N kg/ha	P kg/ha	K kg/ha	Ca kg/ha	Mg kg/ha	S kg/ha	Si kg/ha	Na kg/ha
Green leaves	40	6	75	10	8	10	59	0.6
Brown leaves	26	2	9	29	12	18	132	0.8
Cane stalks	145	35	345	20	51	70	115	2.8
Total	211	43	429	59	71	98	306	4.1

The sodium content in water is, therefore, a greater concern than the potential nutrient benefit. To determine if the quality of water is suitable for irrigation, data in the last two columns in Table 1 (EEC and ASAR) are used with the diagram in Figure 2. The Zululand water sample in Table 1, for instance, is of a very good quality (low in both EEC and ASAR). Assuming an annual rainfall or irrigation of 800 mm, the Zululand water sample, despite being of a high quality, will apply more than two tons of Na per hectare if used continuously for 10 years, while removing only 41 kg/ha Na in this period. Thus, even water that is classified as “Good” will supply significant amounts of Na per year It is for this reason that all irrigated fields must be well drained (naturally or artificially) in order to be able to leach salts from the profile.

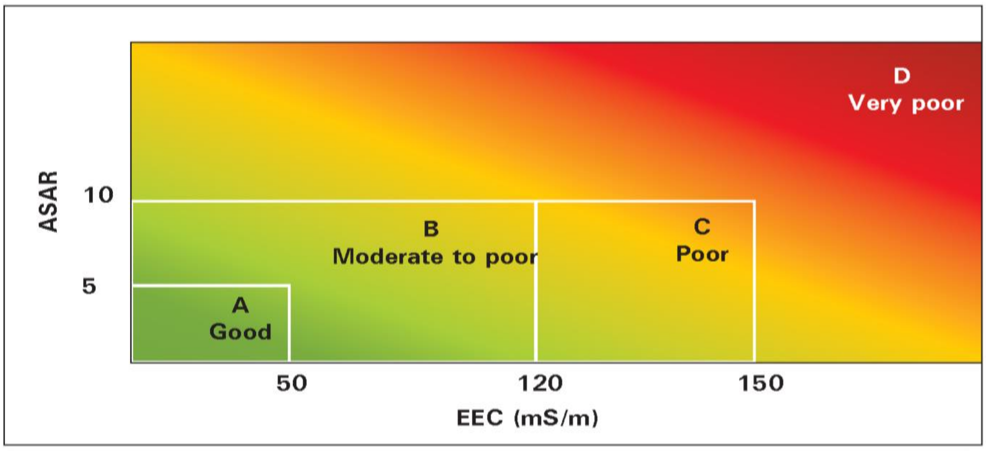

Figure 2

Diagram to interpret water quality in terms of ASAR and EEC.

For irrigation water to be classified as class 1 (top quality) it must adhere to the values given in Table 3 below, but this is not a guarantee against salt build-up in soils. The mill effluent (Table 1) is an interesting option as it can supply 288 kg/ha K. But at the same time, 713 kg/ha Na will be applied which could lead to all sorts of Na related problems such as structure collapse, crusting, reduced water infiltration, increased runoff and increased risk of erosion. It is therefore unlikely that waters with a high nutrient content, and not fortified by the irrigator, can be used repeatedly to supplement the fertiliser requirement without causing salt related problems. Irrigators should therefore have their water analysed as a precaution to manage salts and to maintain the production potential of their fields.

Table 3

Threshold values for class 1 irrigation water

Parameters	Threshold values
pH	6.5 – 8.4
SAR	< 1.5
ASAR	< 5
EC (mS/m)	< 40
EEC (mS/m)	< 50

Unless purposely fortified, the nutrient content in water used for irrigation is very low and will make an insignificant contribution to the nutrient requirement by the crop. At best nitrogen (N) is present in reasonable quantities (up to 64 kg/ha in 800 mm rain in certain regions) but represents only a fraction of the N required by the crop. This portion might be useful in subsystems farming but it is simply insufficient in commercial farming. The sugarcane crop will take up all the nutrients applied with rainwater and unfortified water from other sources. However, N is extremely variable in rainwater as it is affected by many factors. Sodium (Na) is also expected to be present in reasonable quantities in all water used for irrigation. Because it is barely taken up by the sugarcane crop the chance is good that it will accumulate in the soil profile leading to a reduction of the production potential. Water used for irrigation should therefore be analysed annually and managed to prevent the development of saline / sodic soil conditions.

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25. Efficiency of nutrient supply by fertigation compared with standard application methods

While many growers in the irrigated regions are considering or have adopted fertigation systems to better control nutrient applications, some concern over the efficiency advantages have been raised. Given that installing and maintaining fertigation systems is both costly and time consuming, requiring a long-term commitment, many growers seek greater clarity and certainty over the efficiency advantages of fertigation before large scale adoption occurs.

Fertigation is a method of fertilising crops through the irrigation system and is often used in conjunction micro and surface or sub-surface drip systems, though overhead systems are sometimes used for high use nutrients such as nitrogen and potassium (though not typically encouraged due to potential leaf scorching risk and higher irrigation equipment maintenance requirements). Advantages reported include reduced nutrient application rates, more uniform crop growth, similar or better yields over traditional fertiliser management and reduced pollution. The advantages are mainly as a consequence of being able to supply nutrients on a crop demand basis (“tea-spoon feeding”) which matches the growth curve. In addition, fertigation requires that soluble fertiliser sources be applied, with these being delivered in a water medium to the rooting zone. This approach achieves some of the key requirements for optimising nutrient availability and efficiency (i.e. plant available nutrients in a moist environment).

Literature surveyed thus far indicates that nutrient use can be reduced between 15 and 40% to achieve yields similar to conventional top dressed applications (Table 4). The exact benefit does, however, depend on the soil type, irrigation system, scheduling approach and form of the nutrient.

Table 4

Examples of nutrients reductions due to the use of drip fertigation to achieve a similar yield as compared to conventional top dressed fertiliser applications

Reference	**Nutrient saving (%)**	**Nutrients tested**	**Fertigation type**
Kwong *et al*. 1998	33	N	Surface drip
Ridge 1998	25	N	Surface drip
Dart *et al*. 2000	25	N	Surface drip
Vaishnava *et al*. 2002	20 - 40	N, P and K	Surface drip
Weigel *et al*. 2008	30%	N	Surface drip
Naragouda and Hiremath 2015	25	N, P and K	Surface drip
Sathiyaraj and Sathyapriya 2017	25%	N, P and K	Surface drip
Mahesh *et al*. 2018	>25	N, P and K	Sub-surface drip

However, such systems are costly to install and require regular maintenance (further adding to cost). In addition, incorrect nutrient rates can lead to large leaching losses and potentially negatively affect crop yields. Nonetheless, some studies indicate that the cost-to-benefit of adopting fertigation system is favourable. The exact benefits will, however, depend on site-specific conditions.

The irrigation working group (IWG) at SASRI, tasked with guiding irrigation related research and fostering associated knowledge exchange activities, has previously identified the lack of information and guidance available to growers seeking to adopt fertigation practices. Interim and longer term actions being undertaken to address these concerns include the following.

- Preliminary development of simple fertigation (drip, overhead, furrow) scheduling for use by growers.
- Project 19KE05 (commenced in April 2020) aims to undertake a comprehensive revision of all irrigation related information sheets, including fertigation. This will include a simple review of available literature of fertigated sugarcane, with the outcomes of this forming the basis of the more comprehensive fertigation guidelines.
- Using the above review information, a desktop evaluation of cost-to-benefit of fertigation against traditional fertilisation practices will be considered.
- Depending on the review work outcomes and grower needs, trials will be proposed to refine nutrient scheduling and evaluate cost-to-benefit aspects.

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27. A preventative / prophylactic treatment for YSA is needed.

The only current products that are possibly preventative/prophylactic are Bandit in the furrow at planting, and Bandito, either in the furrow at planting or surface banded in ratoons. Bandito is claimed to provide protection for more than 15 weeks post application against nematodes, YSA and thrips due to its slow-release granular formulation. The duration of protection given by Bandit is shorter. Any economic benefit will depend upon pest pressure actually materialising and whether or not the well-known stress alleviating plant physiological effect of imidacloprid comes into play. The application of preventatives might therefore be seen as “insurance” and should be targeted to the greatest risk. As well as application at planting in the furrow, preventative treatment could be beneficial in ratoons for susceptible varieties, in fields where the aphid has occurred before, and in ratooned cane ahead of aphid and Thrip population increases (in the latter case there may be sufficient rainfall in November/December to wash Bandito into the soil where growers are using sub-surface drip irrigation). It should, however, be noted that the benefits of Bandito are not as well characterised in ratoons as they are in plant cane. In a recent ratoon trial conducted in the Midlands, Bandito significantly reduced YSA and thrips damage in varieties rated as susceptible to these pests. SASRI will endeavour to investigate this further. In addition, there may in the future be other preventatives that SASRI can investigate (via the SAR route) or in research within the SASRI long-term project (00CP04) that serves to discover new chemistries for pest, disease, nematode and weed control for the industry.

28. Clear guidelines needed on responsive / reactive management of YSA.

During 2013, the yellow sugarcane aphid, *Sipha flava* (YSA), was recorded in the South African sugarcane industry for the first time. YSA are small (<2 mm), brightly coloured aphids with numerous hairs covering the head, thorax, and abdomen. YSA reproduces without mating (i.e. parthenogenetically) in warm climates and produces live young.

However, low winter temperatures induce sexual forms and egg laying. Intensive surveying of sugarcane field verges on the North Coast has revealed very low overwintering populations of YSA on grasses, and overwintering on sugarcane has also been observed, particularly in the irrigated North. Thus, the aphid never completely disappears and awaits suitable environmental conditions before making an explosive comeback.

YSA development occurs more rapidly on several grass genera (*Digitaria, Echinochloa, Panicum, Paspalum, Pennisetium* and *Sorghum*) than on sugarcane. Development from nymph to reproducing adult takes about 8 days on *Sorghum*, but 18 to 22 days on sugarcane and is highly dependent on environment, especially temperature. Females produce one to five nymphs per day for between 16 – 25 days on these host plants. This suggests that a single female could produce up to 125 offspring depending upon factors such as temperature, humidity, host plant (variety) and predation.

Temperature (optimally mid to high 20s^{o}C) and low humidity are prime drivers of YSA outbreaks. Under warm dry weather conditions in spring, natural enemies are slower to develop and lag behind the aphid, but eventually can become abundant during summer. However, control may not occur before the aphids have caused visible plant damage. Likewise, with higher humidity during summer, entomo-pathogenic fungi can also limit aphid infestations.

YSA often attacks young sugarcane prior to the development of multiple internodes. The aphids prefer to feed on the underside of more mature leaves eventually causing yellowing/reddening of tissues leading to premature senescence and chlorosis. Feeding on young plants can cause major damage under high levels of infestation. In the USA, chlorosis of 2–3 leaves early in the growing season has been reported to reduce sugar yields up to 6% with losses of up to 19% occurring when >6 leaves are chlorotic.

In a controlled trial conducted by SASRI that excluded natural enemies, 6 week-old plants that experienced 50-60% leaf area damaged during 4 weeks of continuous infestation showed an average yield reduction of 50% when harvested 4 months later. In the field, YSA tends to infest patches for 2-3 weeks during which time predators appear, before moving on to another patch suggesting that yield loss may not approach 50% but could still be significant.

YSA taps into the phloem vessels of parallel leaf veins of their grass hosts. This aphid tolerates dense populations on the leaves and usually begins to move to other leaves or plants only after the host leaf or plant has become mostly yellow and is about to die. The apparent preference of YSA for lower leaves suggests that it benefits from leaf senescence. During senescence of older leaves, nutrients particularly nitrogen in the form of amino acids, are recycled to younger plant parts via the phloem. Aphid development benefits from this nutritional enrichment of phloem sap. Once numbers build up sufficiently the aphid itself seems to be able to induce premature leaf senescence through weight of numbers. High numbers are then able to overwhelm the defences of younger leaves higher up the plant

A possible role of excessive nitrogen application on aphid performance is therefore likely where a higher rate of aphid growth could be attributed to a higher concentration of amino acids in the phloem sap. Potassium and phosphorous deficiencies, and mild water stress (e.g. due to restricted irrigation) can also lead to premature leaf senescence and increased concentration of amino acids in the phloem. These factors have been tentatively linked to repeated early infestations in certain fields.

Growth and development of YSA on resistant sugarcane cultivars is reduced several fold relative to susceptible cultivars, though mechanisms of resistance have not been studied. Feeding by YSA on resistant cultivars also causes less leaf senescence and chlorophyll loss than in susceptible cultivars suggesting that any yield loss will be less apparent in resistant cultivars. Resistance is therefore a useful tool in managing YSA. A slower aphid population growth rate allows natural enemies to keep up in terms of their own population growth, further limiting aphid infestation intensity.

In the USA, chemical control is not consistently recommended, as there is little evidence that insecticide applications targeting only YSA improve yields. Further, there is concern that insecticides, particularly pyrethroids, may disrupt natural enemy populations resulting in pest resurgence. Registered insecticides are systemic when they are applied to the soil (Bandito) or limited to the leaves contacted by foliar sprays (Actara, Allice). Once taken up into leaves these insecticides can give extended control, of up to 4 months in the case of Bandito.

YSA control depends upon the early detection of potential infestations, well before symptoms become visible. Observation suggests that sugarcane fields adjacent to natural areas are prone to early YSA infestation. Aphids also colonise grasses in waterways and field breaks and increasing populations may be detected ahead of their movement into sugarcane, which is often, but not always, first detected along field edges.

Growers should also select at least two fields for repetitive scouting on a farm. These fields should include one that the aphid has first infested in previous years (“early warning”) and one considered to be at risk, e.g. a susceptible variety between 2-7 months of age. Scouting must begin before visible symptoms appear. Scout the fields at two-weekly intervals. Whilst traversing the fields take note of any obvious aphid presence.

In the absence of obvious infestation, a more intensive approach can be taken in which 20 stalks divided between four rows (at least 20m apart depending upon field size) are searched. At each location in a row, intensively search one stalk in a stool. Inspect all live leaves below and including the TVD leaf. Record presence or absence of the aphid for the stalk as a whole. Pace approximately 20 metres to the next stool and repeat.

Once aphid presence has been detected, it is important to determine whether the initial infestation is developing into one likely to cause excessive damage. Factors, which may limit infestations from becoming damaging, include varietal resistance, optimal plant nutrition, reduced plant stress and the presence of natural enemies. Reduced aphid population growth rate allows natural enemies to keep up in terms of their own population growth, further limiting aphid infestation intensity.

This scouting method is more labour intensive (but necessary if an informed decision on reactive insecticide application is to be made) in that the determination of percent leaves infested must be made at weekly intervals. At each of 20 sampled stalks, number of leaves searched and number of leaves infested are recorded. A leaf is infested whenever there is at least an adult aphid and its daughter together. Note the presence or absence of natural enemies on each leaf as this should influence control decisions.

Calculate the % of YSA infested leaves.

Some general rules developed in Colombia could be applied to guide control decisions.

- If less than 15% of leaves are infested then no control is recommended.
- If greater than 30% of leaves are infested then control is recommended.
- If between 15 and 30% of leaves are infested make a second evaluation 7 days later.

- If the infestation has declined then no control is recommended.
- If the infestation has increased then control is recommended.
- If the infestation has not changed then make an additional evaluation 7 days later.

Current SASRI projects include: (a) assessment of the species diversity of natural enemies; (b) the testing of additional insecticidal modes of action; and (c) continuous cultivar resistance evaluation in all production regions. Ground-truthing of scouting procedures is also a priority. A manual detailing control options is being planned.

In the mean-time, growers are advised to: (a) take note of current and ongoing newly determined cultivar resistance ratings; (b) ensure adequate K and P nutrition; (c) fertilize with N according to actual yield potential (not desired yield); (d) utilise Bandito in the furrow at planting; and (e) assess Spring ratoon application of Bandito in strip trials, especially where nematodes and thrips might be additionally problematic.

29. A YSA risk index based on climate data would be useful.

It recognised that YSA represents a threat to sugarcane farming, potentially reducing yields significantly. An index of YSA risk, calculated from weather data and soil information, could be valuable in following ways:

- to inform the decision as to whether or not it is economically worthwhile to apply Bandito at crop start to prevent YSA; and
- to alert growers to periods of high risk of YSA infestation and when to undertake in-field scouting (as when YSA infestations are detected in the field, much of the damage is already done).

We hypothesise that a YSA risk index can be developed to predict (with acceptable accuracy) conditions that favour YSA infestation and development. This index will be driven by observed climatic variables over a 28-56 day window.

At this stage, we are unsure if the data we have already collected are sufficient to develop a robust relationship between YSA damage and climatic drivers. We have proposed a technology development project, for possible inclusion in the 2021/22 Programme of Work, to analyse existing datasets and scientific literature in an attempt to develop a YSA risk index.

If we are successful, the findings of the project may feed into a subsequent project to develop a web- or app-based tool for calculating YSA risk and generating warnings. Additionally, we intend to generate paper-based tables of long-term YSA risk for each region, for wet, dry and normal-rainfall conditions. These are expected to assist with Bandito application decisions at planting, and may be helpful for in-season risk assessments.

30. Trials are needed in the Lowveld to determine YSA resistance / susceptibility ratings of irrigated varieties.

A new project (19TD02; "*Yellow sugarcane aphid varietal susceptibility*"), commencing April 2020, has been approved in order to update the existing variety susceptibility categories of commercial varieties assessed under a previous project (14CP03; "Rating commercial varieties for thrips and aphid susceptibility") and during 2019 YSA assessments of released variety trials around the industry. The most recently updated ratings, based on combined data from all previous projects and assessments, have been published in *The Link*, September 2019 (pg. 6). While trial data exists for YSA damage to all commercial varieties, including irrigated varieties, the published ratings have been produced only for varieties for which there was sufficient data to enable a statistically reliable result (specifically, where there was data from 80 or more plots across all trials assessed). Because the irrigated varieties, especially more recently released ones, had a limited amount of data compared with rainfed varieties, this largely excluded most of the irrigated varieties from the recent analysis. In the new project, efforts will be made to include as many irrigated varieties as possible in the assessments, where the trials are of a suitable age (4-5 months) and at a suitable time of the year (spring to late summer, when YSA outbreaks are expected), in order to increase the sample size and allow reliable assessments to be made.

As for previous projects, the new project (duration of 3 years), will conduct plot-by-plot assessments of YSA leaf damage in existing, 4-5 month old variety evaluation project (VEP) trials across the industry (and therefore under a wide range of growing conditions), as well as in variety x ripener trials (northern irrigated area) and, where feasible, late stage unreleased variety selection trials in the irrigated north. The possibility of planting a trial with all the released and soon to be released irrigated varieties at Pongola and Komati will be investigated during the course of 2020. All trials selected for YSA damage assessment will require initial confirmation by Extension or Biosecurity staff that they have in fact been infested and damaged by YSA. The assessments themselves will be conducted by trained SASRI technicians.

Updated ratings will be communicated via *The Link* on an annual basis until completion of the project. The project should indicate the potential to make the ratings a routine and ongoing exercise in released or late-stage pre-release variety trials.

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31. Pesticide application through irrigation systems needs to be explored, particularly for YSA control (see topic 37).

Although application of chemicals through an irrigation system is seen as a more efficient method of chemical delivery, there are various factors that need to be taken into consideration when following this route (see information sheet 5.5). Previous SASRI research (16TD07), focusing on ripeners, has shown that application via overhead irrigation is not feasible as it exceeds the maximum water threshold stated on the label. Although the research was focused on ripeners, the outcomes suggest that the excessively high water output (between 6 and 20 times the maximum water threshold) make it not only an illegal method of delivery but also an unsafe and ineffective method of delivery for chemicals (see May 2019 edition of *The Link*: *Can ripeners be applied by overhead irrigation?*). The only feasible option for chemigation is thus drip irrigation. In the interests of safety, SASRI recommends that only blue or green label products be applied via irrigation systems and as such will only investigate those products. As with any chemical work undertaken by SASRI, the appetite of the chemical company for registration of the product or method is critical to getting the product or method to the market. Of the currently registered products, Allice and Actara are suitable for application through irrigation systems. However, Allice is no longer widely used (Arysta also has a new product registered for YSA) and the use of Actara is limited due to growers using cheaper unregistered alternatives. It is thus unlikely that companies owning these registrations will be interested in this new application method. Potential exists for new products currently being investigated to be tested in this manner.

Exploratory work within 00CP04 (the agrochemicals project), can be conducted should the chemical company be interested. Ultimately, however this work should be explored as an SAR. It must be reiterated that SASRI's role within agrochemical research is limited to exploratory work due to SASRI being unable to apply for registration of a product. The company that owns the product must be willing to invest in the research required to get it registered before it can be brought to the market. Should a company not be interested, growers can fund the research required for registration, but it still must be handed over to the chemical company for registration. SASRI, through its agrochemicals project (00CP04), its interactions with the Registrar's office and its SAR system have engaged with chemical companies in order to raise the needs profile of the sugar industry and this approach to date has resulted in a number of new products being registered within the industry. SASRI however must operate within the confines of Act 36 of 1947 and as such its options are limited. It must also be acknowledged that growers play a role in attracting new active ingredients and methods to the industry by only using registered chemicals (see September 2018 edition of *The Link*: *Accessing new chemistries for pest and disease control*).

32. Small scale growers need support in controlling weeds with herbicides.

The South African sugarcane industry is made up of a large number of small-scale sugarcane growers (SSGs). In 2015, a paper by Dubb reported that the number of SSGs had decreased from approximately 50 000 in the early 2000s to roughly 14 000 by 2011. This decline in number is alarming as the industry is dependent on SSG production. However, the socio-economic statuses of commercial growers compared with SSGs are vastly different, and any initiative made to assist and improve yields among SSGs needs to be modified and tailored differently to have a significant impact on the success of SSG projects.

While SSGs face numerous problems, Zulu *et al* (2019), stated that a key constraint among SSGs is issues with weeds. Many weed species are aggressive and can persist for many years. Dense stands of such aggressive weed species can have a high competitive pressure against the crop for water, nutrients and light, and can results in significant losses in yield, for example up to 100% yield loss from dense *Cynodon dactylon* (Campbell, 2017) and 30% for *Cyperus rotundus* (Turner, 1984).

The spread of weeds is also an issue for all growers. For example, a recent North Coast problem was failure to control spread of *Panicum maximum*, a highly competitive tufted grass, due to consistent rains and cloudy weather rendering normal chemical applications ineffective. The resultant spread was so bad that growers estimated it would take four years to clean up affected fields to their initial level of infestation. Controlling such persistent and tough weeds requires an increase in costs, of effective chemicals; and more aggressive methods to control them. The increased cost of herbicides may be one of the most significant factors limiting chemical control on small farms thus resulting in the reluctance of SSGs' to adopt chemical control methods. The reluctance to adopt chemical control methods, and the misunderstanding that chemical control costs more than accrued profits needs to be addressed and special attention must be given to this issue.

Strategies to assist SSGs in weed management through the optimum use of herbicides are required. In addition, a collaborative initiative between SASRI, Extension and researchers is required to assist SSGs to understand the concept of chemical control and to promote adoption of this practice, rather than total reliance on continual hand-weeding operations. A cost to benefit analysis of this adoption would need to be presented to SSGs.

Recommended Intervention

The initiation of project 19TD08 (*Small-scale producer technology development: Weed control*) will be instrumental in assisting SSGs in understanding and observing the benefits of using herbicides as part of a weed management programme on farms. This project is expected to impact all grower areas with a focus on assisting grower communities to adopt best management practices.

Project 19TD08 will aim to bridge the gap in understanding of why SSGs are not using herbicides or as effectively as they could. Much effort will be invested in engaging with grower communities by means of grower days and farm visits. These activities will aim to improve the knowledge exchange barrier and lack of precise understanding of the weed control needs of each community. In order to support and facilitate SASRI's initiatives in promoting BMPs amongst SSGs' in other regions, SSG extension specialists play an important role. However, it is important to note that, at present SASRI does not provide an extension service to small-scale growers in the Mpumalanga region. Therefore, efforts to engage with and encourage participation in projects managed by SASRI researchers in this region, will be limited to the extent that SASRI's extension service to large-scale growers, together with the extension service offered to small-scale growers by the milling company, can assist.

Various workshops have already been attended and have been very helpful in understanding the role that social context plays during the sharing of technical information. In understanding the underlying social issues within different grower regions, the tools needed to bridge the gap in knowledge exchange can be carefully structured and 'customised' to have maximum impact.

At the planned grower days, practical examples of knapsack calibration, correct and safe mixing of herbicides and correct application methods will be demonstrated. In addition, a costing table and yield profit table will be worked on during the earlier phases of the project, and the cost effectiveness of employing chemical control will be presented.

Weed control is complex, with many herbicide programmes, multiple generic products and conflicting advice from rival agrochemical companies. Consequently, decision-making on the best method of weed control can be very confusing for all growers. To ease grower decision-making, we need to get back to the basics and build up from there. Project 19TD12 currently has an online Herbicide Selector to assist selection of registered treatments. In addition, a number of calculators are being developed that automatically calibrate correct application of the selected herbicide treatments. The aim of project 19TD12 (*Protocols for creating and maintaining decision-support tools for herbicide selection and application*) is to assist commercial-scale growers and SSGs alike. Where possible, the SASRI Herbicide Selector will be used by Extension to enable their growers to better understand herbicide combinations and active ingredients. The feasibility of adopting this tool will be established via a needs assessment, using interviews with stakeholders (DARD Extension officers, SACGA staff, SAFDA staff and mill staff)

Another aim of the project is to establish observation plots in different grower areas for use in knowledge exchange activities. This methodology has been shown to be highly effective in technology transfer. The purpose of the observation plot will be to effectively show the improvement in cane quality, and the subsequent yield improvement, which can be achieved by employing best management practices from the beginning of the season. While this will actively involve grower participation, we are hopeful that interested SSGs will be persuaded to be involved based on information imparted to them at farmers' days. This will promote buy-in by other growers and eventually lead to the improvement of practices which will benefit the grower as well as the industry. A successful example of this type of initiative was in the Noodsberg area, which according to extension specialist William Gillespie, is currently still successful.

While this is the planned intervention in the upcoming financial year, as well as the following years; to date, workshops, literature review and a farmers' day in San Souci have been attended. These events have been attended with the intention of improving the understanding of the project manager (Surashna Huripurshad) and to get experience with farmers' days.

33. Too few pre-emergent herbicides are available and that there is insufficient knowledge around apparent build-up of weed resistance to the available pre-emergent herbicides.

There are two parts to the query from a large-scale grower in Malelane: (a) Length of control and herbicide efficacy; and (b) Updating the Herbicide Selector.

a) Length of control and herbicide efficacy

The main concern of the grower is that the length of control (duration) and efficacy of herbicides is less than it used to be. Is this perhaps due to weeds developing herbicide resistance?

- *Registration trials*

One factor was raised that might influence duration and efficacy was that of product testing during the registration procedure. Was testing only done in dryland conditions, and only in other growing regions? Were results for herbicide efficacy and duration then <u>extrapolated</u> to the Irrigated North, where growing conditions are entirely different; under regular irrigation, and with more heat units for growth of cane and weeds?

It has been in the past normal procedure for agrochemical companies to test new or generic products for efficacy and phytotoxicity over a number of years and over a wide range of soil and climatic conditions, as per requirement of the Registrar (Act No. 36 of 1947). This included testing of pre-emergence products in the irrigated northern region by major role-players in the agrochemical industry, frequently contracting with local consultants who were familiar with the local soils, irrigation methods, growing conditions and common problem weeds. In addition, SASRI researchers have conducted 13 phytotoxicity and nine efficacy trials at Pongola over the years (these can be found in the library of Agronomist Association Reports). Currently, the locally experienced consultants are still available to test new product formulations or combinations for agrochemical companies, on request, and who advise product use by local farmers in the region.

Disclaimers: Note that there is normally a disclaimer paragraph on herbicide labels which is a warning that there is a lack of efficacy under certain conditions, as follows:

'*Although this remedy has been extensively tested under a large variety of conditions, the registration holder does not warrant that it will be efficacious under all conditions because the action and effect thereof may be affected by* *factors such as abnormal soil, climatic and storage conditions, quality of dilution water, compatibility with other substances not indicated on the label and the occurrence of resistance of the weed against the remedy concerned, as well as by the method, time and accuracy of application. The registration holder furthermore does not accept responsibility for damage to crops, vegetation, the environment, or harm to man or animal or for lack of performance of the remedy concerned due to failure of the user to follow the label instructions or to the occurrence of conditions which could not have been foreseen in terms of the registration. Consult the supplier in the event of any uncertainty*'.

Length of control of herbicide combinations in the Herbicide Guide (1990-2017) were inserted over the years in consultation with relevant agrochemical companies. In recent editions a note can be found at the bottom of each Treatment Selection Table. This note states:

'*Length of control may vary according to soil and climatic conditions. Inspect your fields earlier to make sure weeds e.g. broadleaf and* Panicum maximum *are not emerging early'.* This note will be added to the Herbicide Selector in the online product.

- *Are weeds in the Irrigated North developing herbicide resistance?*

We are all more familiar with use of glyphosate-resistant crops e.g. cotton, maize and soybeans. Weed resistance is a less familiar topic. For context on an international scale (USA) an example is given with a weed that is problematic locally in the Midlands South, Conyza (nTitimbile). In a recent conference, it was reported that only glyphosate was used for its control in the USA for many years, and that glyphosate resistance had developed in populations found in 2/50 states. Due to wind dispersal of seeds, this resistance had spread to 18/50 states. For background context in South African agriculture, according to Professor Duke, a world authority on the topic of herbicide resistance, true herbicide resistance is actually relatively rare. What is thought to be a "resistant weed population or species" has actually become dominant in fields for other reasons; for example, escaped weeds, or species that are naturally tolerant to an herbicide, or where herbicide selection and application was incorrect or not ideal, with poor efficacy. In other words, there was another problem in the affected field. True herbicide resistance is inherited, being passed on by parent to daughter plants via seed. To find whether a weed population is resistant, there is an established procedure where seed is collected and germinated and the new seedlings are tested against the suspect herbicide, according to Dr Pieterse at Stellenbosch University. According to Professor Duke, the risk of developing herbicide resistance in the sugar industry in the near future is low, mainly because herbicide combinations normally used contain products with different HRAC modes of action. This is unlike the situation for agriculture in parts of the Western Cape, where it is such a serious issue in some districts that the value of the farm having resistant populations (mainly to glyphosate or paraquat or products with mode of action B) plummets. Unless remedial actions are taken and have succeeded in eradicating such populations, with a certificate issued, the farm may not be sold (Dr Pieterse). One important weed here is a grass, *Lolium rigidum*, where in some vineyards exclusive application of glyphosate over 20 years has resulted in true herbicide resistance developing, with 24L/ha glyphosate 360 not killing the weed. Some weeds found in winter cereals have also been found in parts of the W. Cape. This is attributed to too much reliance on use of herbicide products with the “B” mode of action. Refer to the Herbicide Guide (2015-2017) for products in this category in the sugar industry. Of interest, the weed (theoretically) with the highest risk of developing true resistance is Cynodon when it is growing on verges. Some farmers practice repeated chemical mowing with sub-lethal dosages of glyphosate, and this in theory will promote development of resistance to glyphosate. However, the genetics of the species are complex and against its development (Dr. Lloyd Evans) and production of viable seed is very low, and with poor germination, so parent plants cannot easily pass resistance to the next generation via seed.

- *Can I avoid it developing as a medium to long-term strategy for weed management on my farm?*

  The SASRI Herbicide Guide that has been available up to 2017 includes a section on herbicide resistance. This section is currently under review to form a new Information Sheet.

  If you are practicing the following, then you have already significantly reduced the risk of weed populations becoming resistant to herbicides that have a similar mode of action the following apply.

  – Keep accurate spraying records for each field, give reasons for poor efficacy.
  – Apply herbicides according to label recommendations, e.g. correct application rates and stages of weed growth for optimum use of the products. Do not reduce the recommended rates or experiment with your own ‘cocktails’. Use accurately calibrated equipment with properly arranged, suitable nozzles and an efficient agitation mechanism. Poor efficacy will increase the risk of developing herbicide resistance.
  – Rotate herbicides or use tank mixtures which contain products with different modes of action.
  – Apply herbicides to small weeds before they produce seed (pre- or early post-emergence growth stage). This will prevent the seed of resistant plants returning to the soil seed bank
  – Integrate other control methods (chemical, cultural, biological) into weed control programmes.
  – For specific information on resistance management contact the registration holder or the SASRI weed control specialist.

- *Make sure you get the basics right for good pre-emergence control*

  This is especially important for the section on labels dealing with ‘Application Recommendations’. An example is given, taken from several herbicide labels.

  – Apply with a correctly calibrated tractor-mounted boom sprayer that is in good working order.
  – Use the recommended nozzle type and output to obtain the best coverage. E.g. Apply 200 to 300 litres spray mixture per hectare for overall ground application.
  – Ensure that application equipment is correctly calibrated.
  – Ensure that only clean water is used.

- Treat water for high pH or for excess salt content if recommended for the product.
- Thoroughly flush out spraying equipment at the end of the spraying operation.
- Do not leave product in spray tanks overnight.
- Soil preparation for pre-emergence application: A fine tilth is required. Apply to a clod-free surface. Prepare a fine, even and firm seedbed free of weeds, trash and clods.
- Harrowing after application may reduce weed control if untreated soil is thrown into deep planter furrows.
- A uniform and even distribution of the spray material over the target area is essential.
- Get the timing right. An herbicide label might state, for example, to ‘apply the product and any tank mixes containing the product preferably at planting or immediately after planting, but not later than 3 days after planting’.
- Comply with product rainfall requirements. For example, ‘10 to 20 mm rain within 7 to 10 days after application is necessary for good results’.
- Pre-mixing of the product into a paste may be required before adding into the tank.
- The order of mixing products in a spray-tank is normally given for optimum compatibility.
- Continual agitation might be required before and during use.
- Practice field hygiene, e.g. where machinery, equipment, clothing and boots are washed, especially during periods when seeding of weeds is high. This will reduce the risk of spreading seed between fields.

• *What some newer herbicide labels say about herbicide resistance:*

With respect to avoiding herbicide resistance, follow the recommendations on herbicide labels of products used. Take particular note of the following.

- The HRAC herbicide group code E.g. C1
- Resistance warning

‘*Any weed population may contain individual weeds naturally resistant to this product and others in the same group e.g. C1. The resistant individuals can eventually dominate the weed population if these herbicides are used repeatedly. These resistant weeds may not be controlled by this product or any other group code C1 herbicide*’.

In order to delay herbicide resistance.

- Avoid the exclusive and repeated use of herbicides from the same herbicide group code. Alternate or tank mix with products from different herbicide group codes.
- Integrate chemical and cultural control methods into weed control programmes.
- For more information on resistance management, contact the registration holder.
- Since the presence of resistant weeds is difficult to detect prior to herbicide application, it is of the utmost importance that treated areas be inspected at regular intervals to timeously identify the occurrence of herbicide resistant weeds. Agrochemical companies will not accept liability for failures in

herbicide efficacy in the event of a build–up of resistant weeds resulting from inadequate resistance management practices.'

b) Updating the Herbicide Selector

- *Description of the Herbicide Selector tool*

  Correct selection of the above herbicides is assisted by the online SASRI Herbicide Selector. The Herbicide Selector assists with selection of registered treatments at all weed growth stages. The user enters the weed growth stage (pre-emergence, early post emergence, post-emergence or late post-emergence) and the weed spectrum (e.g. broadleaf, grasses, yellow watergrass) and the registered herbicide treatment options are automatically generated. These can be printed out as tables for each growth stage, comparable to tables in the old Herbicide Guide.

- *Product updates*

  Product updates are planned for twice per year and forms two parts. Collection of new herbicide labels, and entering the new products into the Herbicide Selector. The May 2020 updates are in progress.

  - The Herbicide Guides from 2015-2017 had notes section on Herbicide Resistance, Herbicide Toxicity, Management of Creeping grasses, Water Quality and Herbicide Performance, and calibration of a knapsack sprayer.
  - Of these, Management of Creeping grasses has already been updated and presented as the publication 'Integrated management of Creeping Grasses', available from SASRI.
  - Notes from the other sections; Herbicide Resistance, Herbicide Toxicity, and Water Quality and Herbicide Performance, will be updated to form new SASRI Information Sheets. This is in progress.
  - The product is under further development for application, with the addition of a number of calculators that automatically calibrate correct application of the selected herbicide treatments. This aims to assist ALL growers and will replace the notes section 'Calibration of a knapsack sprayer'.

- *Product development for Small Scale Growers*

  There will be a needs assessment of the Herbicide Selector using interviews with existing staff, (DARD Extension officers, SACGA staff, SAFDA staff and mill staff).

34. Smut incidence on N41 is of concern.

One of the key principles and strategies in biosecurity is the mitigation of risk and one of the major risks faced by sugarcane growers is the impact of a serious pest or disease on a susceptible variety. History has shown on numerous occasions how popular varieties and widely planted varieties have succumbed to pests and diseases to the point that these varieties can no longer be grown. The eradication of these varieties and the replanting of new varieties has been done at great cost to growers. An obvious way to mitigate this risk is to not plant large areas to any single variety on a farm or across an area. To this end SASRI strongly recommends that no more that 30% of the area under cane on a farm or across and area be planted to a single variety and even smaller areas if varieties are particularly susceptible to a disease or pest e.g. N25 and smut. In this way the economic impact of a sudden outbreak of a pest or disease on growers is greatly reduced. With several serious external biosecurity threats still present, such as *Chilo sacchariphagus* and orange rust, which could impact severely on certain varieties, it makes good sense therefore to adopt a principle of limiting the area under any one variety. As an industry rule such a policy would be difficult to implement and enforce. However, at a local level, such as an LPD&VCC control area, it might be possible to introduce such a rule. To support this the introduction of a seedcane scheme could also effectively control the extent to which varieties are planted within an area. Improving the health and quality of seedcane and spreading risk by planting a range of varieties will reduce pest and disease pressure which in turn will slow the rate at which varieties might succumb to these pressures.

Shifts in the resistance of varieties to pests and diseases (e.g. rust) have been observed periodically in other countries including the US where in some instances, there has been evidence to suggest the pest and disease strains are being exposed to some selection pressure where more virulent strains that survive on a particular resistant variety increase and cause a breakdown in resistance. This situation can be mitigated by frequent release of varieties and encouraging growers to plant a different variety every time they eradicate and replant a field to reduce the effect of higher pest and disease pressure carryover.

It is important to note that no varieties are immune to smut. Even resistant varieties can become infected over time if disease pressure is high. Varieties that are identified as being susceptible in the smut screening trials at Pongola are not released to the northern, irrigated areas where smut is endemic. There was however, until recently, a policy to release ‘intermediate’ varieties to allow the regular supply of new varieties to the region. The high proportion of the irrigated north has been under intermediate varieties for some time. These varieties are particularly prone to fluctuations in disease prevalence and severity (apparent shifts in resistance) with variable environmental conditions. This is more apparent in some intermediate varieties than others. For this reason, the intermediate category has now been split into intermediate-resistant, intermediate and intermediate-susceptible. Varieties such as N25 and N41 fall into the intermediate-susceptible category and under current restrictions, would not have been accepted for release in the irrigated north. Variety N60 is rated intermediate and has also not been considered for release given the current smut situation, which has been favoured by the relatively warm, dry winters, intermittent rainfall and regular water restrictions.

35. Value of foreign varieties in efforts to manage pests and diseases

Use of Mascarene Island varieties in the SASRI breeding programme

Given the close proximity of the Mascarene Islands (Réunion Island [France] and Mauritius) sugarcane breeding programmes to South Africa, it’s completely understandable that our growers and industry stakeholders are curious about the potential value that these exotic varieties might bring to their farming and milling businesses. In fact, SASRI plant breeders also look very closely at the varieties produced by these countries to identify those that could enhance the development of new varieties specifically adapted to SA conditions. Recently, our breeders conducted an irrigated trial on the SASRI Pongola Research Station to compare the performance of nine Mauritian[1] and five Réunion[2] varieties with popular SA irrigated varieties (N25, N41, N53, N57). The trial also included twelve Australian varieties and one from Louisiana. While some of the varieties maybe interesting and produce similar yields to some of SASRI elite genotypes,

[1] M133484, M139786, M140086, M223889, M225688, M259392, M262792, M295494, M70389

[2] R579, R840075, R850252, R851334, R900144

to-date none of these varieties meet the threshold to be considered for release. The comparative testing of local and foreign varieties is undertaken routinely to identify exotic varieties that could be used as parents in the SASRI breeding programme. Breeding for well adapted varieties requires a focus on maximising biomass and sugar yield, while ensuring that agronomic and pest and diseases resistance characteristics are appropriate for local growing conditions.

Breeding of varieties adapted to local agro-climatic conditions

The primary goal of the SASRI breeding programme is to produce varieties that are adapted to the agro-climatic conditions in the irrigated, midlands and coastal regions of the industry, and which have acceptable levels of resistance to important pests and diseases to mitigate biorisks. It is for this purpose that SASRI was established by the SA industry. Unsurprisingly, the Mascarene Island breeding programmes have the same objectives for their own sugar industries. In terms of agro-climatic variation, the Mauritius programme develops varieties for the sub-humid (~1,200 mm average annual rainfall), humid (~2,500 mm) and super-humid zones (~3 250 mm), while the Réunion programme breeds for humid coastal zone (~1 470 mm), the per-humid coastal zone (~3 290 mm), the irrigated dry coastal zone (~614 mm) and the dry high lands (~870 mm). Included in these programmes is the development of irrigated varieties for the sub-humid and highland areas and it is these varieties that are the primary interest to our breeders. The Mauritian and Réunion rain-fed varieties are adapted to a far higher average annual rainfall than is experienced in the rain-fed areas of the SA industry and hence, are of lesser interest.

Breeding for resistance to local diseases

Breeding for resistance to diseases that are of major local economic importance is a priority of the programmes in the Mascarenes and in SA. All three countries experience pressure from similar diseases (smut, rust, mosaic, ratoon stunt), although, in the Mascarenes, gumming (caused by *Xanthomonas axonpodis* pv *vasculorum*) and leaf scald (caused by *Xanthomonas albilineans*) are particularly serious problems due to the tropical, high rainfall climates. The Mauritian industry actively selects for resistance to these diseases during breeding. In SA, the main targets for resistance breeding and selection are smut, mosaic and rust, as it is these diseases that have the most negative economic impact.

Breeding for resistance to local pests

Resistance to pests is a characteristic that, like agro-climatic adaptation, differentiates the varieties produced by the Mauritius, Réunion and SA breeding programmes. The Mascarene Islands do not have the African sugarcane stalk borer, eldana (*Eldana saccharina*), which is the most severe biological constraint on sugarcane production in our sugar industry. Estimated direct and indirect losses to the SA industry is approximately one billion Rand per year. For this reason, eldana resistance breeding has been a major objective of our programme over several decades.

In Réunion, the most prevalent insect pests are white grubs (*Hoplochelus marginalis*) and the spotted stalk borer (*Chilo sacchariphagus*), which are managed primarily by biological control agents. In Mauritius, biological control, natural enemies and cultural practices are used to limit the damage of the major pests: moth borers (spotted cane borer [*C. sacchariphagus*], African pink stemborer [*Sesamia calamistis*], grey sugarcane borer [*Tetramoera schistaceana*]; scale insects (sugarcane scale [*Aulacaspis tegalensis*], cottony grass scale [*Pulvinaria iceryi*]); and white grubs (*Heteronychus licas*, *Alissonotum piceum*, *Phyllophaga smithi*). Hence, as eldana is not a pest of sugarcane in the Mascarene Islands, there is no active resistance breeding programme.

The value to the SA industry of varieties bred in the Mascarene Islands

The primary objectives of the sugarcane breeding programmes in SA and the Mascarene Islands are to develop high biomass and sucrose yielding varieties that are adapted to local agro-climatic conditions and as resistant as possible to major pests and diseases. In some instances, varieties specifically developed for each of these countries have characteristics that are desirable and potentially useful to other countries. Hence, SASRI scrutinises Mascarene Island varieties to identify those that have characteristics that may be of economic value to our industry. These may then used as parents to produce varieties adapted to our own agro-climatic conditions and pest and disease pressures but which display all or some of the desirable exotic characteristic. The use of foreign varieties as parents for breeding, rather than directly as commercial varieties, is essential due not only to differences in agro-climatic conditions but also differences in pest and pathogen populations and pressures, consideration of which are critical for industry biosecurity.

36. The possibility of moving away from a three-stage nursery and removing the need for hot-water treatment by using tissue culture processes.

Novacane® for the establishment of certified nurseries

Novacane® plantlets provide a good source of healthy, true-to-type planting material, especially for certified nurseries. However, it currently costs approximately R35 000 / ha to establish a nursery seedbed with hot water treated (HWT) whole-stick seedcane, R60 000 for establishment with HWT single-budded sett transplants and around R150 000 / ha using Novacane® plantlets from Dube (R5.29 / plantlet plus estimated planting costs) or R535 000 using plantlets from duRoi (US$1.10 / R20.61 per plantlet plus estimated planting costs). In addition to the high cost of Novacane® plantlets, this method of nursery establishment is currently not viable since the regular supply of plantlets cannot be guaranteed at this stage.

Removal of hot water treatment from the nursery system

By removing HWT from the process, seedcane suppliers would not be in a position to recycle the seedcane produced from Novacane® plantlets back into the system. However, a full economic evaluation of the various nursery establishment scenarios has been proposed.

Moving away from the three-stage nursery system

It would not be possible to move away from a three-stage nursery system i.e. Fallow, plant and 1R crops, whether establishing with Novacane® plantlets, HWT seedcane or single-budded HWT transplants. A 12-month fallow is necessary to ensure the complete eradication of old stools from the previous crop, while the risk of infection through the plant and 1R crops and the need for routine inspections applies to both plant sources. The option of taking additional cuts from Novacane® blocks has been discussed but was not approved due to the risk of infection after planting in the field.

37. Replacements for Temik are needed that can be applied through sub-surface drip irrigation (also see topic 31).

For all information pertinent to chemigation in general and the role of SASRI and growers within agrochemical research, please refer to communiqué for issue no. 31. With regards specifically to replacements for Temik, research has been underway at SASRI since 2012 looking for a suitable replacement (within Project 00CP04 and via the SAR system). Posters and papers to this effect have been presented previously at SASTA (2015, 2019). In 2019, a new nematicide/aphicide/thripicide was launched by Arysta (developed in conjunction with SASRI), which provided a suitable replacement. However, although the product is safer than Temik, it is still a red label. Safer chemicals are currently being tested by SASRI (within 00CP04 and via a SAR) to assess their efficacy in sugarcane. In 2018, discussions began between Marius Adendorff and Prabashnie Ramouthar to explore application of these chemicals via irrigation in Mpumalanga. In 2019, Netafim was recruited to the project and two potential trial sites identified. One in Mpumalanga and one in KZN. A pilot trial using one product was treated in KZN last season and will be assessed this coming season. The trial in Mpumalanga was unfortunately not planted due to the decision made by RCL not to plant any fields last season. Should this field be replanted this season, the trial will go ahead. A new trial is also planned for KZN this season. When approached initially, chemical companies owning the active ingredients contained within these products were interested in pursuing registration in sugarcane and through irrigation, should the results be favourable. It must however be reiterated that the final decision to register still lies with the chemical company. It has previously happened that a suitable nematicide was identified and tested by SASRI, but the product still has not made it to the market.

38. Small-scale growers need advice on soil compaction from poor contractor behaviour.

39. Controlled traffic demonstration trials would be of value, possibly to also demonstrate BMPs that could improve soil health

<u>Issue 38 and 39 merged into single response</u>

The value of alleviating compaction and minimising the impacts is well documented at SASRI. Recent work by Peter Tweddle has demonstrated that adoption of controlled traffic systems can greatly improve crop yield and that it is economically viable to convert to such traffic control systems. Relevant literature includes the following.

Information sheets

- 6.2 Compaction
- 14.4 Infield Traffic Management

Link articles

- May 2002 “Soil compaction - a matter of managing risk” by E Meyer
- May 2011 “Do you have a compaction problem?” by Rian van Antwerpen and Peter Tweddle
- Sep 2014 “Why should I consider controlled traffic?” By Rian van Antwerpen, Peter Tweddle and Peter Lyne
- Jan 2017 “Compaction and crusting” by N Miles and Rian van Antwerpen

Previous RD&E communiques

- 2018 issue 15 “Long term effects of mechanised cropping systems”
- 2020 issue 41 “Compaction and stool damage losses”

Theses and dissertations

Tweddle, PB (2016). Estimating traffic induced sugarcane losses for various harvesting, loading and infield transport operations in South Africa. Unpublished PhD thesis. Bioresources Engineering, School of Engineering, University of KwaZulu-Natal.

Available at: https://researchspace.ukzn.ac.za/xmlui/bitstream/handle/10413/14727/tweddle_peter_brian_2016.pdf?Sequence=1&isallowed=y. Accessed: 20 September 2018.

SASTA congress presentations and proceedings

- Tweddle, PB, Lyne, PWL and Bezuidenhout, CN (2015). Estimating Crop Production Losses for Various Infield Sugarcane Extraction Systems. Proceedings of the South African Sugar Technologists Association, 88: 392-395.
- Tweddle, PB (2016). Estimating Traffic Induced Sugarcane Losses for Various Harvesting, Loading and Infield Transport Operations in South Africa. Unpublished PhD thesis. Bioresources Engineering, School of Engineering, University of KwaZulu-Natal. Available at: https://researchspace.ukzn.ac.za/xmlui/bitstream/handle/10413/14727/Tweddle_Peter_Brian_2016.pdf?sequence=1&isAllowed=y. Accessed: 20 September 2018.
- Tweddle, PB and Lyne, PWL (2018). Poster Presentation: Estimating Traffic Induced Sugarcane Losses for Various Infield Cane Extraction Systems. Proceedings of the South African Sugarcane Technologists Association. 91:103. Available at: https://sasta.co.za/mdocs-posts/2018-tweddle-pb-and-lyne-pwl-poster-summary-estimating-traffic-induced-sugarcane-losses-for-various-infield-cane-extraction-systems/. Accessed: 22 February 2019.

In addition to the above, several issues from other RD&E discussions relate to the understanding and use of BMPs to improve soil health and crop nutrition (refer to Issue 17/18, 19/21, 23). Several knowledge exchange products and activities are currently being developed and rolled out to various grower sectors to improve basic understanding of key concepts and promote adoption of BMPs (Refer Issue 17/18 and 19/21 for further details). However, to more practically demonstrate the value of adopting best management practices (BMPs) a demonstration plot network is proposed.

Demonstration trial network

In addition to the above, several issues from other RD&E discussions relate to the understanding and use of BMPs to improve soil health and crop nutrition (refer to Issue 17/18, 19/21, 23). Several knowledge exchange products and activities are currently being developed and rolled out to various grower sectors to improve basic understanding of key concepts and promote adoption of BMPs (Refer Issue 17/18 and 19/21 for further details). However, to more practically demonstrate the value of adopting best management practices (BMPs) a demonstration plot network is proposed for the following purposes.

- Engage and educate growers (and other stakeholders) on identifying an appropriate stack of BMPs to suite their particular situation.

- During the establishment of the demonstration plots, “field schools” will be run to show how the BMPs selected for a site are correctly implemented (e.g. best soil sampling practices, establishment of controlled traffic systems, weed control).
- Post establishment site visits (grower days and field training, will be used for further engagement and education of the impacts of adopting the stacked BMPs.
- The engagement will be repeated at harvest and subsequent ratooning to educate on follow-on and continued BMPs
- Growers will be encouraged to explore the development of their own demo plots, using the guidance from the project team and learning from the established plots.
- Outcomes from this work will be used to develop relevant materials that can be used to guide expected standards and benchmarks, as well as serve as instruction manuals for further training and self-learning.

It is expected that such a trial network will clearly demonstrate the value of adopting BMPs, but also provide the key learning opportunities to identify, select, implement and evaluate the benefits achieved. Providing specific timelines is difficult at such an early stage, but broadly it is envisaged that the project will be deployed as follows (subject to funding approval).

- April 2021 – March 2022
  - Workshopping of framework and design for demonstration plots (BMPs, sites, representation) – initially internally to create a framework, then with growers and other relevant stakeholders to develop site specific plans for deployment.
  - Identify willing growers to host sites and negotiate trial establishment protocols.

- Oct 2021 – ongoing
  - Where ready, establish first sites, coinciding these activities with grower focussed training and guidance workshops at those sites
  - Depending on capacity, 2 – 4 sites per region will initially be considered.

- Post establishment (maintenance phases of each plot)
  - Run grower days/workshops at demo sites to showcase changes and improvements.

- Harvesting (12 to 18 months after planting depending on region)
  - Run grower days/workshops at demo sites to showcase changes and improvements – also consider harvesting.

- Plot re-establishment (ratoon)
  - Repeat grower focussed training on reestablishment practices of harvested sites.

- New sites
  - Establish further sites in regions as required

Such a demonstration plot network will be used for foundational training and demonstration purposes across the different grower sectors. The aim would be to encourage growers to be active participants alongside research and extension services in deciding on required BMPs through a learning process, while the actual demonstration plot will both teach and show the grower the value of adopting those BMPs. Opening such training up to grower associations and contractors would also create common understanding of BMPs and their proper use.

40. a. Information needed on the interactions between varieties, mechanisation and ratoonability.

Mechanical harvesting reduces crop cycle lengths

Common experiences across all industries abroad that have adopted mechanical harvesting is the reporting of accelerated yield declines and reduced crop cycles (Kingston, 2003; Norris *et al*. 2015). A report from Australia (Kingston, 2003) showed that countries using mechanical harvesting had lower ratoon cycles (4-8) compared to those using hand harvesting indicating that adopting mechanical harvesting will reduce ratoon yields and ratoon cycles. The increased tendency towards shorter cycles were noted to occur with increased mechanisation and weights of infield transport. Southern African cane production was noted as achieving the longest ratoon cycles typically in excess of 12 years. There is a strong qualitative link between low impact mechanisation systems and longevity of ratoon cycles. Longer crop cycles are generally associated with good soils, soil health and soil fertility. The report suggests controlled traffic as a way of minimising traffic damage, yield losses and curbing accelerated ratoon decline. The Australian industry was reflected to have maximum exposure to the adverse effects of mechanical harvesting combined with the adverse effects of monoculture practices. Issues raised included: Mismanagement of controlled traffic principles, poor base-cutter heights, forward speed of harvesters mismanaged resulting in shattering and stool damage and stool removal. In order to address such yield decline and crop cycle reductions, many industries have undertaken intensive research to determine how to minimise the impact of mechanical harvesting operations. The lessons learnt from other industries should be used to adopt and manage harvesting best practices in the harvesting supply chain.

Management and maintenance of harvesters is essential to minimise losses

Harvesting under wet field conditions and poor harvester operations greatly exacerbate associated crop damage leading to yield and value loss. Mechanical harvesting under dry conditions had less impact on variety early growth and ratoon yield than mechanical harvesting under wet conditions (Jackson *et al*. 2000). The traffic treatments under wet field conditions had a large adverse effect on early growth and on final ratoon yield. There was significant genotype x treatment interaction for early growth and canopy development. For South African irrigated areas, mechanical harvesting should have a sufficient drying off period to limit the negative impacts on soil compaction and ratooning. Growers must avoid mechanical harvesting of fields to be ratooned after heavy rains and wet field conditions. All industries have reported on the negative issues of gaps formed from mechanical harvester induced stool damage and stool splitting. Crops with poor root anchorage are particularly susceptible. These situations are typically exacerbated by wet field harvesting (Kingston, 2003). Bernache *et al*. (2020) reported on adverse losses and poor ratooning due to excessive mechanical harvester blade wear.

Varietal responses to mechanical harvesting and implication on plant breeding

Jackson *et al*. (2000) reported high genetic correlations indicating that breeding for ratooning under mechanical harvesting would be effective. This result also reflects the progress made in the USA where all plant breeding trials are mechanically harvested, and ratooning has increased in newer varieties from 2 to 4 ratoons or more in cultivars such as LCP85-384.

Kingston (2003) noted that early maturing varieties tended to be more susceptible to poorer ratooning characteristics (lower fibre and higher sucrose) through mechanical damage. Higher tillering varieties of higher populations of thinner stalks seemed to have better ratooning potential but also more susceptible for harvester induced losses in a mechanised harvesting scenario.

Chen (2012) reported that stubble height and stubble damage was significantly higher for mechanical than manual harvesting. This was aggravated by lodging and level of leaf residue. High levels of fibre content resulted in less stubble damage. The germination of subsequent ratoon crops are generally negatively affected by mechanical harvesting compared to manual harvesting.

Research done at Canal point (Glaz *et al*. 1996) showed significant differences in ratooning among cultivars. The study also showed that lodging and straight stalks were poor predictors of suitability to mechanical harvesting and ratooning after mechanical harvesting. Therefore, cultivars that do lodge less may be attractive to mechanical harvesting, they may not necessarily ratoon after harvesting and the yield penalty and reduced ratooning cycles would need to be evaluated. The results suggest the need to test pre-release varieties for response to mechanical harvesting.

These various responses may suggest that as mechanical harvesting increases, establishing at least two trials that can be harvested mechanically for the full crop cycle would help to quantify the response of our cultivars to ratooning after mechanical harvesting.

Maintenance of harvesters is essential

Experiences from other industries give a range of focus areas to minimize losses, namely:

- Harvester setup: fan speeds vs extraneous matter (EM) levels, billet lengths (15 to 40 cm) vs load densities, harvester speed vs base cutter speed, extractor system
- Base cutter blade maintenance: length, numbers, blade speeds, sharpness and profiles, blade angles
- 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 affect EM levels: lodged vs erect; thin vs thick stalks; varietal responses
- Compaction and stool damage resulting from uncontrolled traffic and row spacing mismatching
- EM levels: transport density; mill performance- crush rates, sugar extraction, sugar quality, length of milling season (LOMS) increased,
- Divergent goals: harvester output (speed and pour rates); transport (billet length) and milling (EM - extractor speeds). A harvester best practices manual is available on the Sugar Research Australia website: http://www.sugarresearch.com.au/page/growing_cane/harvesting/publications/

Some key indicators of harvester induced field damage

- Gaps or ‘gappiness’ issues in fields that are harvested mechanically
- Compaction and stool damaged associated with mechanization
- Base cutting height – particularly in green cane harvested fields
- Base cutting quality – shredding or shattering of stalks and stool damage through poor blade cutter maintenance
- RSD spread is elevated through mechanical harvesting operations.

What can be done to minimise the impact of harvester damage (grower/harvester/miller)

- Field cleanliness and row profile to ensure best possible base cutting operations
- Avoid wet period harvesting or manage harvester operations with upmost care
- Practice controlled traffic principles to avoid unnecessary compaction and stool damage – ensure the matching of row and track spacing's
- Adjust harvester setup and operations to suit field and crop conditions:

  - Setup based on desired EM levels. The higher EM levels tolerable, the less losses;
  - Longer billet lengths result in lower losses and higher EM levels;
  - Harvester speed and base cutter speed: adjusted for poorer row profiles, field preparation, rough fields, lodging, wetter field conditions.
  - Lower fan speeds reduce losses but increase EM. Varieties with high populations of thinner stalks are more prone to losses.
  - Lower fibre varieties and brittle varieties are prone to poor base cutting and stool damage. Base cutter blade sharpness is essential to minimise crop damage.

- Extraneous matter levels affect various aspects of the supply chain: payload density; mill performance- crush rates, sugar extraction, sugar quality, LOMS
- Strict harvester maintenance especially with regard to base cutter blade sharpness is essential
- Harvester cleaning and disinfecting is essential to minimise spread of RSD between fields and farms
- Adopting harvester "best harvesting practices" to target minimal losses and higher recoveries in order to be comparable with hand cut operations. Blade sharpness, precise base cutting, optimum forward speeds are important aspects and particularly so for wet period harvesting and early maturing varieties.

Research needs

Research trials may be of value to test pre-release varieties for response to mechanical harvesting and to quantify the longer term responses of cultivars to ratooning after mechanical harvesting.

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40. b. Information needed on harvester decontamination to restrict RSD spread

Ratoon stunt (RSD) is considered to be a manageable disease provided the recommended management procedures are followed (primarily planting approved seedcane, decontaminating farm implements and ensuring that there are no volunteers by allowing for adequate fallow periods before replanting). 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. The use of cane cutters through contractors increases the risk of farm-to-farm spread. However, it is possible to easily and effectively decontaminate cane knives before entering another field or farm and, provided the recommendations are followed, the risk of spread is low.

Although RSD incidence has traditionally been high in the Lowveld, efforts to reduce levels are beginning to pay off. Mechanical harvesters are now being used in the area to harvest commercial and seedcane fields. The risk of RSD spread by mechanical harvesters is high given the difficulty in effective decontamination of the machines Australian researchers reported an RSD infection rate of 97-100% when harvesters were not decontaminated between infected and healthy blocks. Of most concern, especially for growers who have strict RSD management practices in place and whose farms are currently RSD-free, is the increased risk of spread into seedcane nurseries (including the Malelane mother block where 1R seedcane is cut mechanically for RCL) as well as farm-to-farm spread if harvesters are not properly cleaned and disinfected before entering farms.

As part of project 16TD02, SASRI has been in discussions with RCL and the contractor in the Lowveld regarding the research and procedures required to reduce the risk of RSD spread by mechanical harvesters. Other disinfectants are also being investigated as alternatives to Jeyes fluid and methylated spirits.

A trial block at Komati research station that was due for eradication was used to test the harvester decontamination procedures recommended in the Australian sugar industry. A harvester from the iZolima fleet was used for the assessment. Before commencing with the trial, the harvester was washed down with water as thoroughly as possible, before the application of a disinfectant (quaternary ammonium compound - 3%) to all parts that potentially come into contact with the cane row. In two tramlines, the harvester cut RSD-infected spreader sections and moved into the healthy tramlines with no decontamination. In another two tramlines, once the RSD-infected spreader section had been harvested, the harvester was decontaminated before moving into the healthy cane rows. RSD spread was evident in the tramlines where no decontamination had taken place during harvest, with 9 of the 80 stools (11%) testing positive for RSD. While the decontamination procedure seemed to be effective in the one tramline harvested, one stool was infected in the other indicating that the decontamination procedure was not completely effective in this instance.

Two further trials have been conducted and will be reported on when the results are available.

For all three trials, the decontamination procedure took two people between 28 and 40 minutes to remove as much plant and soil debris from the harvester as possible before washing down with water and applying the disinfectant. This included the required 5 minute contact time for the disinfectant. A 200L water cart with the pump / delivery hose pressure set as high as possible was fairly effective in washing the harvester but it was not possible to remove all the plant and soil debris at the field edge. Once the harvester was back at the depot, more thorough cleaning was possible. The disinfectant was applied with a knapsack.

Further reading

Taylor PWJ, Ryan CC and Birch RG (1988). Harvester transmission of leaf scald and ratoon stunting disease: demonstration and evaluation of methods of decontamination. Sugar Cane 4: 11-14.

Note: RCL has prepared an SOP and checklist for the use of mechanical harvesters and planters on their farms

41. Quantification of damage and production losses caused by compaction and stool damage is needed.

The long term effects of mechanization on soil compaction and stool damage has been researched. The impact of mechanisation on fields is exacerbated during wet field conditions. Expected yield losses have been measured to be as high as 50% over the point of impact. Fortunately, only a small fraction of the field has such traffic. Seasonal soil moisture changes will also tend to reduce this worst case example on an annual basis as most of the crop is harvested over the drier seasonal period.

Estimated yield losses on an average field basis taking variable moisture conditions into account across the season and the proportion of the field trafficked has been estimated for a range of typical mechanisation systems used in the South African sugarcane industry. These are presented in the paper titled: “Estimating Crop Production Losses for Various Infield Sugarcane Extraction Systems” by Tweddle *et al*. (2015) and indicate the estimated range in yield loss of 1-9% between the least and most damaging systems. A chopper harvesting system was subsequently investigated to add to the compliment of systems analysed. The chopper harvester operation cut two lines per pass and followed controlled traffic principles and was thus deemed to be one of the lowest impact chopper harvesting systems available. Despite these better practices in place, the mechanised chopper harvester system was still estimated to be one of the most damaging due to the magnitude and extent of heavy traffic passing throughout the field. The yield loss in this system was estimated to be approximately 8-9% Tweddle (2016) and Tweddle and Lyne (2018). Table 5 summarises the systems investigated and the relative yield losses under worst case (wet soil conditions).

Table 5

*Traffic induced yield loss based on traffic impact, traffic extent and event condition***s**

System	Impact: 1 to 5	Extent of traffic (% field)			Estimated yield loss %	
		%R	%IR	%No T	[A] % Wet, Seasonal	[B] % Mixed, Compound
Single stack self-loading trailers	2	5	8	87	1%	0.8%
Double stack self-loading trailers	2	6	11	83	1.2%	0.9%

Slew loader + Double axle field to zone tip trailer	4 5	1	24	75	3.3%	2.4%
3 wheel loader (1 windrow swath) + box field to zone trailers	2 2	21	29	50	4.7%	3.3%
Slew loader + 2 x double axle spiller trailers	4 5	9	14	77	5.1%	3.5%
3 wheel loader (2 windrow swath) + Box field to zone trailers	2 2	26	39	35	6.0%	4.0%
Chopper harvester + Single axle field to zone tip trailer	3 4	5	46	49	8.5%	5.4%
3 wheel loader (3 windrow swath) + 3 axle spiller trailer	2 5	38	58	4	9.2%	5.7%
3 wheel loader (3 windrow swath) + 3 axle spiller truck tractor field-mill	2 5	38	58	4	9.2%	5.7%

In the study conducted by Tweddle (2016) the relative costs for the commercial harvesting operations are indicated in Table 6.

Table 6

Relative costs per each of the commercial systems (15 km lead) based on 2016 costs

System	Yield penalty [a]	20000t			60000t		
	Penalty (R/t)	Cost (R/t)	Total (R/t)	Rank	Cost (R/t)	Total (R/t)	Rank
Single stack self-loading trailers	4	81	85	3	68	72	2
Double stack self-loading trailers	4	86	90	5	71	75	3
Slew loader + Double axle field to zone tip trailer	11	73	84	2	53	64	1
3 wheel loader (1 windrow swath) + box field to zone trailers	16	81	97	6/7	64	80	6
Slew loader + 2 x double axle spiller trailers	17	80	97	6/7	74	91	7
3 wheel loader (2 windrow swath) + Box field to zone trailers	19	70	89	4	60	79	5
Chopper harvester + Single axle field to zone tip trailer	26	142	168 >200 %	9	101	127 200%	9
3 wheel loader (3 windrow swath) + 3 axle spiller trailer	27	87	114	8	67	94	8

3 wheel loader (3 windrow swath) + 3 axle spiller truck tractor field-mill	27	53	80	1	50	77	4

The relative costs for the chopper harvester even under high utilization conditions harvesting 60000 tons per annum was about double the cost of the lowest cost manual harvesting systems available to the industry. The chopper harvesting operation was 35% more expensive than the highest cost manual harvesting system.

The study excluded other commonly reported issue of gaps or stool damage that occur following mechanical harvesting. This is reported to be a risk when harvesting occurs on crops with shallow or poor root systems and particularly when fields are harvested under wet field conditions. Further losses may be associated with mechanical harvesting depending on the level of operator proficiency and the management associated with the chopper harvesting system.

From a ratoonability perspective, the damage caused to the stool has been established primarily as a function of poor field conditions, crop conditions, harvester selection and setup combined with chopper harvester operation management. The greatest value loss is caused through a mismatch of various sub-factors linked to the above categories.

For more details a comprehensive overview of preparing for mechanical harvesting and the issues relating to adoption thereof is provided in the 2016 RD&E communiques (issue 20).

References

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42. Assistance with the determination of costs associated with mechanisation are required, including haulage operations and manual versus chopper harvesting.

The mechanisation reports have worked examples on how to cost various equipment based on the grower'sgrower's daily allocations and associated utilization of equipment. In addition, cycle times for haulage equipment are scenario specific and will further change the costings substantially.

A template of each of the mechanization costing examples has been created to assist in customization of the costing examples for case specific details as per Appendix A.

In the case of mechanical harvesting, Meyer (1998) describes a model used to estimate the costs for a mechanical chopper harvesting system. The complexity of costing a system accurately are noted as there are a number of factors that affect the performance and costs of a chopper harvesting system. The main factors include: annual cane tonnage throughput; operating hours per day; length of milling season; field and cane conditions.

For the harvester: cane yield; row length; row spacing; harvesting speed; turning time; haulout distance; waiting for infield transport; down time.

For the infield transport: number of transport units per harvester; payload capacity; haulout distance; harvesting rate; travelling speed; turning time; offloading time; down time.

From the above factors it can be seen that these factors are quite specific for a particular system. Burnt versus green cane will affect the harvesting speed. Row spacing will affect whether 1 or 2 rows can be harvested which in turn affects the harvesting speed and harvester throughput. Numerous field and crop factors affect harvester performance. Meyer (1999) indicated that average chopper harvesting rates typically vary between 30 and 45 t/h.

Row length and harvester speed were shown to greatly influence harvester performance output by 166% when increasing from 50m to 400m row length and by 191% when speeds increase from 4 to 6 km/h.

A desktop analysis by Meyer (2000) compared mechanical harvesting at various speeds for a potential 63 500 ton mechanical harvesting operation. The analysis indicated that the break-even costing (with a 30% mark up for contractor management and profit margin) required a harvester output of 37 t/h which was achievable at a speed of approximately 4 km/h. This was for an average field yield of 76 t/ha and average row length of 396 m and infield haulage distance of 1.1 km. For yields higher than indicated, the profitability would be increased. An advantage of the chosen harvester was that its front wheel track was 3 m making it relatively stable on slopes (assumed stable on slopes up to 20%) and it was able to harvest 2 rows per pass covering a swath of 2 m per pass. Three accompanying field to zone 55 kw tractors with 6 t single axle high lift trailers of off-loading reach of 4.4 m were costed in the analysis. The haulage vehicle comprised a 6x4 truck tractor coupled to tri-axle spiller trailers. The analysis did not consider the costs of compaction or stool damage nor losses associated with the harvesting method.

Meyer (2001) reported on various mechanical harvesting trials conducted to compare machinery performances. The Austoft harvester ranged between 47 and 92 t/h instantaneous harvesting rate. Losses between different systems were also measured. The results in both trials clearly showed that, where cane was manually cut and mechanically loaded, infield losses were lower (2.63 and 3.37 %) compared with cane that was chopper harvested (4.38 to 5.06 %).

John Deere have also produced a chopper harvester costing model for the specific costing of the John Deere chopper harvester models. This is available from your local John Deere supplier and was demonstrated at a farmer day held in iSwatini in 2011. The costing model was included in the delegation packs for all the attendees of the grower day.

For the purposes of comparative costs, the following scenario has been based on the assumptions contained in the SASRI mechanization report and costed for a 100 000 t burnt cane harvesting operation. A length of milling season of 220 d/y, cane yields of 80 t/ha, haulout distance of 1km and road haulage transport distance of 30 km lead was assumed.

For the mechanical harvester a number of assumptions were made. These include: an average row length of 350 m, a 2 m effective harvesting swath, a harvesting speed of 3.5 km/h. This scenario provided an average harvesting performance of 42 t/h. For a cane yield of 100 t/ha this increased to approximately 47 t/h.

A comparative costing to compare a range of manual harvesting operations compared to mechanical harvesting operation were conducted. These are listed in Table 7. Each of the harvesting systems consisted of the following operations:

- A cut and stack system with manual cutting and stacking, self-loading trailers, trans-loading and road haulage
- A cut and windrow system with manual cutting, grab loading, field haulage, trans-loading and road haulage
- A cut and windrow system with manual cutting, slew loading, field haulage, trans-loading and road haulage
- A mechanical harvesting operation with field haulage, zone loading and road haulage

For each of the systems a compaction and stool damage loss was attributed in accordance with the work by Tweddle *et al* (2015), Tweddle (2016) and Tweddle and Lyne (2018).

Table 7

Comparative costings between three different manual harvesting systems And a mechanical harvesting operation

<table>
<tr><th colspan="4">Manual Harvesting Operation</th><th>Mechanical Harvesting Operation:</th></tr>
<tr><th>Item</th><th>Cut & Stack</th><th>Cut & Windrow (Grab Loader)</th><th>Cut & Windrow (Slew Loader)</th><th>Chopper Harvester</th></tr>
<tr><td>Cutting (R/t):</td><td>26</td><td>26</td><td>26</td><td>-</td></tr>
<tr><td>Stacking (R/t):</td><td>13</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Harvesting (R/t):</td><td>-</td><td>-</td><td>-</td><td rowspan="2">50.46</td></tr>
<tr><td>Infield loader (R/t):</td><td rowspan="2">17.05</td><td>6.1</td><td>4.6</td></tr>
<tr><td>Infield transport (R/t):</td><td>14.15</td><td>7.81</td><td>7.60</td></tr>
<tr><td>Transloader (R/t):</td><td>10.94</td><td>9.61</td><td>5.2</td><td>5.62</td></tr>
<tr><td>Road haulage (R/t):</td><td>43.88</td><td>43.88</td><td>43.88</td><td>43.88</td></tr>
<tr><td>Total (R/t):</td><td>110.87</td><td>99.74</td><td>87.49</td><td>107.56</td></tr>
<tr><td>Compaction & stool damage loss (R/t):</td><td>0.99</td><td>5.96</td><td>3.28</td><td>8.45</td></tr>
<tr><td>Total (R/t):</td><td>111.86</td><td>105.70</td><td>90.77</td><td>116.01</td></tr>
</table>

These results show that for a large scale operation that has well utilized equipment, that the mechanical harvesting operation is the most expensive of all the operations. The lowest cost operation is the slewing loader, but in this case, it is assumed that controlled practices are strictly adhered to.

In the case of the mechanical harvester, a higher harvesting speed will reduce costs. Operating at higher speeds require well prepared fields and row profiles to aid mechanical operations. At higher speeds the risk of stool damage increases particularly under wet field conditions. Field harvesting losses have not been taken into account in these analyses. At higher speeds, the risk of harvester losses generally increase relative to the manual harvesting operations. Relative system losses and cane quality deterioration losses have not been accounted for in this analysis.

References

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- Meyer, E (1999). Some measurements of mechanical sugarcane harvester performances. Proc S Afr Sug Technol Ass 73: Ixvi-Ixix.
- Meyer, E (2000). Assessing the viability of a fully mechanised harvesting operation for a large sugarcane estate. Proc S Afr Sug Technol Ass 74: 187-191.
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Appendix A

Costing template for the Mechanization Costing Report 1

https://sasri.org.za/mechanisation/

Scenario: Example 2 of the mechanisation reports…

15 000 tons of cane are to be transported per year from the field to a loading zone. Average one-way distance is 1,5 km. Using a 55 kw 2wd tractor and a single stack self-loading trailer working 200 days, 8 hours per day, calculate the number of tractor-trailer units required, and the cost per ton. Average stack size is 5 tons and one conductor is used with the self-loading trailer.

Cane to be transported per year from the field to a loading zone (tons)	A	15000
Length of milling season (days)	B	200
DRD (tons per day)	C=a/b	75
Working hours per day	D	8
Average one-way distance	E	1.5
Payload	F	5

Number of transport units required
Infield tractor-trailer speed is about 15 km/h (table 2), and to travel to and back from the field will require 2 x 1,5 km) ÷ 15 km/h x 60 min/h = 12 minutes.

Speed – table 2	G	15
Travel time (to and back from field)	H=2.e.60/g	12

To load one stack of cane onto a self-loading trailer takes about 5 minutes (table 2), unloading requires another 5 minutes and allowance must be made for downtime, say another 2 minutes.

The total cycle time for this operation should thus be: 12 + 5 + 5 + 2 = 24 minutes. There are 480 minutes in an eight-hour day, so 480 min/d ÷ 24 min/cycle = 20 cycles per day are possible.

Loading time per stack – table 2	I	5
Unloading time per stack – table 2	J	5
Cycle time:	K=h+i+j+10%	24

The crop is 15 000 tons per year, or 75 tons per day are to be moved. Payload is 5 tons, so 15 cycles will be sufficient. One tractor-trailer unit can do 20, so it will be adequate.

Number of trip cycles required	L=c/f	15
Number of trip cycles possible	M=d.60/k	20
Number of tractor trailer units required? Round-up the answer	N=l/m	1

Annual utilisation
The number of operating hours required per year for this operation must be calculated. Each cycle takes 24 minutes, but the tractor and trailer is not operating for all of these 24 minutes. In fact, only the travelling and the loading time should be considered, i.e. 12 + 5 = 17 minutes per cycle.

Operational time per cycle	O=h+i+10%	19

This figure is usually increased by 10% to allow for contingencies and the total annual operating hours are then calculated as: 17 minutes operating cycle + 10% = 19 minutes; therefore time for 15 cycles/day for 200 days = 19 x 15 x 200 = 950 hours.

Operational time	P=l.o.b	950

Cost of haulage
From figure 1, a 55 kw 2wd tractor working 950 hours per year will cost R207.06/h. From figure 3, a single stack, self-loading trailer working 950 hours per year will cost R71.81/h. Total cost is thus R278.87/h, or R278.87/h x 950 = R264 927 per year to haul 15 000 tons, i.e. R17.66/ton.

Tractor cost: a kw wd tractor working p ( ) hours per year	Q=fig 1	207.06

Trailer cost: a single stack, self-loading trailer working p ( ) hours/year	R=fig 3	71.81
Total cost per hour	S=q+r	278.87
Total cost per year	T=s.p	264927
Total cost per ton	U=t/a	17.66

Costing template for the mechanization costing report 1

[Https://sasri.org.za/mechanisation/](https://sasri.org.za/mechanisation/)

Scenario: Example 3 of the mechanisation reports…

15 000 tons of cane are to be loaded from small hand-made bundles with a hi-capacity bell 125 (3 cylinder) loader into a 6 ton basket trailer for a 1,5 km haul to a loading zone. The trailer is pulled by a 55 kw 2wd tractor. Calculate the number of units required and the cost per ton for this operation.

Cane to be transported per year from the field to a loading zone (tons)	A	15000
Length of milling season (days)	B	200
Drd (tons per day)	C=a/b	75
Average one-way distance	D	1.5
Payload	E	6

Loading

Assume overall annual loading rate is 22 t/h (table 2)	F	22
Calculate annual utilization - hours	G=a/f	682
Total cost per hour	H=fig 4	320.68
Total cost per year	I=g.h	218663
Total cost per ton	J=i/a	14.58

Haulage:

Speed km/h – Table 2	K	15
Loading rate t/h - Table 2 – instantaneous rate infield	L	30
Travel time (to and back from field) – minutes	M=2.d.60/k	12
Loading time – minutes	N=e.60/l	12
Unloading time – (1 bundle) – Table 2 - minutes	O	5
The total cycle time for this operation should thus be	P=m+n+o	29
Remember to add an allowance for downtime/delays of 10% of cycle	Q=p+10%	32

No of daily trips required for trailer of e tons payload – no. (roundup)	R=c/e	12.5 →13
Haulage hours per day	S	8
No of daily trips possible – no.	T=s.60/q	15
So the number of tractor trailers required are – no. (roundup)	U=r/t	0.8 → 1 unit

Haulage utilization:

Cycle operating time – engine time while loading say 50%? (+10%)	V=m/2+n+10%	18+1.8=19.8
Utilization = operating time per day x days per year – hours	W=v.r.b/60	858

Tractor cost = r/h	X=fig 1	220
Trailer cost = r/h	Y=fig 3	81
Total cost per hour	Z=x+y	301
Total cost per year	Aa=z.w	258207
Total cost per ton	Ab=aa/a	17.21

System costs:

Total system cost per ton = loading + haulage costs =	Ac=j+ab	31.79

Costing template for the mechanization costing report 1

Https://sasri.org.za/mechanisation/

Scenario: Example 4 of the mechanisation reports…

15 000 tons of cane per year are to be transported 15 km from a loading zone to a mill. Calculate the cost for transloading by tractor trailed crane and for haulage. Bundles average 4 tons each.

Transloading:

Cane to be transloaded at the loading zone (tons)	A	15000
Payload	B	4
Bundles: loading and unloading (table 2) – 5 min + 5 min	C	10
No of bundles – no.	D=a/b	3750
Annual operating hours	E=c.d	625
Total cost per hour – fig 8	F	472
Total cost per year	G=f.e	295156
Total cost per ton	H=g/a	19.68

Haulage:
An 8 ton truck can carry two bundles at a time. If bundles average (b=4) tons each, (a/b) = 3750 bundles must be hauled per year, i.e. 1 875 trips.

One way distance - km	I	15
No bundles per truck – no.	J	2
No of trips – no.	K=d/j	1875
Trip distance - km	L=2.i	30
Total annual distance – km utilization	M=l.k	56250
Total cost per hour – fig 7	N	10.05
Total cost per year	O=n.m	565313
Total cost per ton	P=o/a	37.69

43. Technical guidance to growers is needed to empower them in their negotiations with contractors.

Whenever service providers are contracted to supply a particular service to growers (whether it be harvesting, fertiliser application, or weed control), it is beneficial for the grower to have a certain level of knowledge and understanding on how efficiently the practice should be undertaken and what a reasonable charge for that service would be.

This knowledge can be gained through a number of ways, some of which include reading manuals on best practice, watching videos, attending courses, or through advice from extension specialists. The costs associated with farm operations can be obtained through local grower associations, namely SAFDA and SACGA, and can be used to determine whether a contractor is charging a reasonable fee or not.

If growers empower themselves on what best practice looks like (and what it costs), they will be better placed to negotiate with contractors up front, but will also enable them to evaluate the standard of work once completed.

In some industries (for example, the construction industry), regulation of service providers (e.g. through the master builders association), provides some level of quality assurance to people who use contractors. This is a possible route that the sugar industry could explore to ensure a consistent, cost-effective and reliable delivery of services by contractors.

Growers are encouraged to contact their grower association to establish what industry initiatives are in place to facilitate the negotiations between growers and contractors.

44. Guidance required to assist small- and large-scale growers when irrigating to cope with the effect of load shedding on irrigation.

Almost all irrigation in the SA sugarcane industry is dependent on electrical pumping systems to provide adequate water pressure for irrigation. Interuptions in the electrical supply cause pumping down time which result in reduced water supply and the associated crop water stress and yield reductions. Load shedding, therefore, affects both large scale and small-scale growers (LSGs and SSGs). The concern, however, was greater for SSGs who cultivate smaller plots and share bulk water supply on a rotational cycle. Due to the lack of flexibility in the infrastructure, load shedding can result in individual small-scale growers missing irrigation cycles. If the yield of one field is negatively affected, many SSGs don't have other fields to serve as a buffer. In addition, SSGs typically don't live on their farms and therefore don't irrigate at night. A further loss in pumping time during the day due to load shedding could be more harmful, in comparison to large-scale growers.

Ideally, SASRI would like to be able to assist growers with the following.

- Quantification of the yield reduction and resultant economic impact of load shedding scenarios in order to provide an indication of what investment can be justifiably spent on load shedding solutions.
- An inventory of technologies that can help manage the occurrence of load shedding (e.g. Automatic restarting of pumps after power has been restored).
- A consolidated and updated costing of alternative or back up energy supplies in order to provide a useful reference/benchmark for decision making.

SASRI , unfortunately, does not have all the information required and, for this *reason,* a project will be proposed with the following objectives.

- To map out how load shedding affects the irrigation operations and practices on small- and large-scale grower farms. This will include understanding the flexibility and adaptability of irrigation infrastructure and operating rules.
- To understand what interventions are envisgaed by the grower community.
- To use computer models to quantify the yield loss and economic impact for typical/historical load shedding scenarios.
- To investigate, cost and appraise back-up or alternative energy supplies.

Research on alternative energy supply for irrigation is ongoing in South Africa and globally. There are also examples of implementation success on pilot scales (solar, hydro–electric, on-farm pump-storage-gravity schemes, biogas digester and/or diesel to be used in internal combustion engines). These alternative energy options, however, have not been considered in the context of load shedding. In addition, technologies that can help manage the occurrence of load shedding will be researched within the proposed project. These can include: (a) cell phone apps which communicate Eskom's scheduled electricity interruptions, ahead of time; (b) other notification systems to indicate when the pump station power is down or has been restored; or (c) technologies to automatically, rapidly and remotely restart pumps after power failures to minimise lost pumping time. The project will start in April 2021 if the proposal is accepted.

45. Advice is required on the most efficient systems and operations to use generally and also under water restrictions (most efficient irrigation systems and operations to use generally, and also under water restrictions)

The issue has three components:

- guidelines on irrigation system efficiency;
- guidelines in irrigation system operation in general; and
- irrigation management guidelines under water restrictions.

To fulfil this request from growers, on-going extension and knowledge exchange activities are required to:

- increase the awareness and accessibility of available resources on these topics; and
- increase knowledge levels, skills and competence of the grower community

No new projects are required to generate additional data. The information is currently either available and requires on-going knowledge exchange and extension initiatives or is already being addressed in existing projects.

Irrigation system efficiency

Table 8 below presents the efficiency and uniformity norms and standards for the range of irrigation systems typically found in the sugar industry. This information is presented and explained in information sheet 5.1 (irrigation fundamentals). The efficiency of an irrigation system is related to water loss. For example, if a system is said to be 90% efficient, this implies that 10% of the total water extracted from the water source will be lost and not available to the crop. Losses can occur through wind drift, interception by leaves, evaporation from the soil surface, runoff, deep percolation beyond the root zone, conveyance losses or pipe leaks, amongst others.

Table 8

Acceptable performance benchmarks of irrigation systems

Irrigation systems		Efficiency		Uniformity
		Typical values	Ideal/ acceptable values	
Overhead sprinkler	Dragline	70%	83%	CU > 80%
	Semi-permanent	70%	83%	CU > 80%
	Permanent/fixed	75%	90%	CU > 80%

	Centre pivots	80%	90%	CU > 85%
	Travelling big guns	65%	78%	CU > 80%
Drip	Surface drip	90%	95%	Slope < 2% => EU > 95% Slope > 2% => U > 90%
	Sub surface drip	90%	95%	
Surface/flood	Furrow (earth canals)	60%	86%	DU_{lq} > 70%
	Furrow (lined canals)	70%	93%	DU_{lq} > 70%
	Furrow (piped supply)	80%	98%	DU_{lq} > 70%

CU = coefficient of uniformity, EU = emission uniformity, DU_{lq} = low quarter distribution uniformity

Source: Reinders *et al*. 2010. Standards and guidelines for improved efficiency of irrigation water use from dam wall release to root zone application. WRC Report TT 466/10.

SABI norms for the design of irrigation systems. Accessible from: http://www.sabi.co.za/design.html

Irrigation operation - routine operation, scheduling and maintenance

Routine operation: all irrigation designers should equip farmers with a set of operating specifications or general operating rules for the system. These rules and specifications are generally specific to the design and site. Operating rules and specifications could include, for example:

- the maximum number of blocks or number sprinklers/emitters which can be operated simultaneously;
- stand times (operating hours per shift) and number of shifts per day;
- cycle lengths (interval between successive irrigation applications); and
- the minimum pressure or flow rate required at strategic points such as the pump station, block inlet, or furthest/highest sprinkler/emitter.

These operating rules must be adhered to for uniform and correct application of water, as per the target application depth. If these operating rules are not available, growers should approach the original designer, as a first preference, or other irrigation designers/engineers to request for help to derive the information. Extension Specialists can also be approached for assistance.

Scheduling: Irrigation must be scheduled to match crop water requirements according to stage of growth and the time of year. Most irrigation systems are designed to meet the peak crop water requirements, which usually coincide with hot summer months or at full canopy. For this reason, the irrigation applications (or cycle length) must be reduced to match the reduced crop water requirements in winter months or for younger crops which have not yet reached full canopy. Irrigation can be scheduled using direct methods such as soil water sensors or indirect methods such as climate-based computer models. More information of irrigation scheduling can be found in Information Sheet 5.3 (*Basics of Irrigation Scheduling*) and Information Sheet 5.4 (*Irrigation Scheduling Toolbox*).

Maintenance: Another important aspect of irrigation operation is preventative maintenance. General guidelines in the form of preventative maintenance schedules for each irrigation system (sprinkler, drip and centre pivots) is available in the SUSFARMS® irrigation module. These will soon also feature in a new information sheet. (Project

19KE05 aims to ensure that all recommended irrigation and drainage BMPs are relevant, updated, adequately captured and readily available in farmer friendly formats). As an example, the preventative maintenance guideline for pumps is shown in Table 9 below.

Table 9

Typical maintenance schedule for pumps

Monitor	Interval			
	Monthly	1 000 operating Hrs	Bi-annually	Annually
Check alignment / settings			X	
Replace oil			X	
Inspect and clean bearings		X		
Inspect all parts for wear and do hydraulic test [a]	X			
Inspect the gland packing leakage (it must leak slightly, because it is lubricated by water)	X			
Replace the gland packing				X
Inspect cables and electric equipment			X	

[a] hydraulic test: close stop valve and take a pressure reading at the pump outlet. A drop in pressure in comparison to when the pump was installed indicates pump wear.
Source: Reinders *et al*. 2010. Standards and guidelines for improved efficiency of irrigation water use from dam wall release to root zone application. WRC Report TT 466/10

Irrigation management under water restrictions

Guidelines for managing irrigation during water limited periods is presented in information sheet 5.2. A summary of the most pertinent material is presented here.

Figure 3 depicts the sensitivity of final crop yield to water stress at the different crop growth stages (upper half of figure), in addition to the generalised crop water requirement for each stage (lower half of the figure). Based on this figure, water can be withheld to some extent, or delayed, for fields at the tillering and dry-off stages, while the limited water can be directed to fields at the germination and stalk elongation stages. In practice, irrigation can be delayed for the tillering phase by setting the allowable depletion (irrigation trigger point) to 60 or 70% of the total available water (taw), depending on the level of water restrictions. Chemical ripening should be avoided if crop stress is expected. Delaying replanting and extending fallows can also be used to make more water available for other fields.

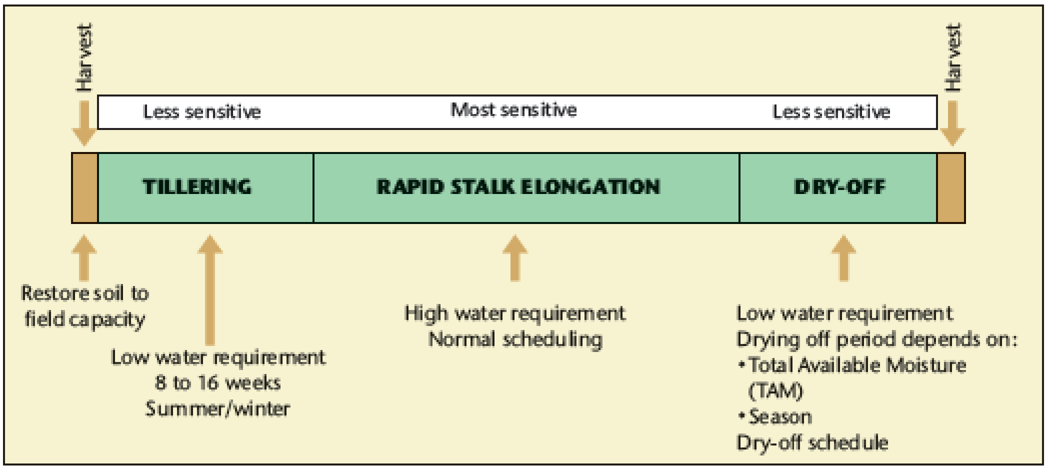

Figure 3

Critical stages of crop water requirements

Reducing the area irrigated by abandoning fields is a drastic step that should only be considered under severe water restrictions. The long-term consequences can be very costly.
Should the water restrictions be severe enough and fields have to be abandoned, the following should be prioritised:

- Fields with high pest and disease levels (smut, mosaic & RSD)
- Fields with serious weed problems such as creeping grasses and knot-grass
- Fields with poor plant population
- Old ratoons especially on marginal soils
- Fields that is close to be replanted

Seedcane fields should also be prioritised to receive adequate water to allow for a rapid replanting program after the drought.

Finally, a follow-on project (18KE04) aiming to explore implementation pathways for the newly developed drought irrigation program (drip) started in April 2020. The excel program uses a crop and water balance model to calculate the impact of specified irrigation strategies on crop yield and survival under assumed future water allocation and climate scenarios. Farm level gross margins for three consecutive years are calculated from simulated yields and production costs at field level. Irrigation strategies that can be explored include (1) growth phase specific soil water depletion thresholds, (2) reduced irrigation amounts and/or longer irrigation cycles, and (3) abandoning low potential fields. As a part of the project, the drip tool will be implemented on a selection of pilot case study farms. The selected farmers will apply the tool in order to develop site specific and customised drought management strategies for their respective farms. The experience and feedback from the case study farmers relating to ease of use, value derived, software packaging preferences and further refinement/development needs were considered necessary steps to test market readiness. The project will also make use of the pilot case studies to explore and develop a roll-out strategy. The release and roll-out of the drip tool, supplemented with the associated training activities, will further aid in increasing the knowledge and skills amongst irrigators to better manage water restrictions.

46. Guidelines are needed to assist growers when choosing amongst the large number of available systems and service providers

The expected outcome of this communication is as follows.

On-going extension and knowledge exchange activities are required to:

- Increase the awareness and accessibility of available resources on these topics; and
- Increase knowledge levels, skills and competence of the grower body

No new research projects are required. There is adequate information available and requires on-going knowledge exchange and extension initiatives. Information sheet 5.7 is dedicated solely to the topic of irrigation system selection. The content in the info sheet is largely based on information presented in the ARC Irrigation Users' Manual (updated in 2019). Pertinent information from both sources is reproduced below:

Choosing an irrigation system is site and context specific. A system can only be considered appropriate when it is well matched to the landscape, topography, soils, cropping regime, agronomic practices, water sources, energy supply, finances, labour, knowledge and skills of the farmer/manager. For this reason, there is no best irrigation system (silver bullet), only better systems for different constraints and circumstances.

Table 10 below provides information on a range of factors which allow for easier comparison of different irrigation systems. Traditionally, capital costs used to be the overwhelming factor which dictated which system was selected. Increasing water scarcity, and the rapid increase in electricity and labour costs, however, have strengthened the influence of the operating costs in irrigation systems selection. Operating costs over the lifespan of the system far outweigh the capital costs.

Table 10

Typical ballpark costs for the different irrigation systems (dated: 2019)

Irrigation systems		Capital cost estimates (in-field equipment only) (r/ha x 10^3)	Operating cost factors				
			System efficiency (%)	Life expectancy (years)	Labour (ha/labour)	Annual maintenance costs (% of capital	Pressure requirements At emitter (kpa)
Overhead sprinkler	Dragline	12 – 14	75	10	25	4	250 – 400
	Semi-permanent	11 – 15	83	12	25	2	250 – 400
	Permanent	25 – 27	90	15	50	1	250 – 400
	Centre pivots	19 – 22	90	15	100 +	5	150 – 300
	Linear move	16 – 19	90	15	100 +	6	150 – 300
	Travelling big guns	10 – 12	75	10	25	6	400 - 900
Drip	Surface drip	12 – 24	95	2-10	30	2[A]	100 -

							250
	Sub surface drip	21 – 26	98	10	25	3	100 - 250
Surface /flood	Furrow	N/a[B]	86	10	15	5	0

Source: ARC Irrigation User's Manual.
Note: the estimated capital costs exclude the costs of the pump station, supply system, distribution system and installation of the equipment
[A]maintenance cost of thin walled drip pipe installed above ground surface is estimated to be 30% of the capital costs.
[B]n/a – no costs available

If water is limiting, and there is a greater imperative to use water more efficiently, the system efficiency column in the table can be considered. A higher system efficiency indicates which system is adept at using water more effectively (higher efficiency = lower water losses).

If the cost of electricity is a concern, the pressure requirement at the emitter (last column) is an indication of energy requirements and the relative cost differences that can be expected across systems. A higher pressure requirement at the emitter indicates a higher energy requirement.

If *labour is limiting*, the table provides an indication of how the different systems compare in terms of labour requirements.

Finally, an irrigation system is an asset and the benefit of investing in high capital systems is dependent on the longevity of the irrigation systems. For this reason, monitoring, evaluation and preventative maintenance to maximise the life span of the irrigation systems is very important. The respective life span and the required investment for maintenance, as shown in table 10, must also be duly considered when selecting a system.

47. Guidelines are needed to assist growers with using soil moisture probes effectively.

The issue raises the following concerns.

- There were too many soil water monitoring tools available resulting in uncertainty about what is good or not.
- There is a need to better understand the calibration of the probe, i.e. How the full (field capacity), refill (stress point) and empty (wilting point) lines are set in the probe software
- How to interpret probe data (for SSGs) i.e. Knowing how to translate the probe data into the number of hours to irrigate for or how much water to apply to get the probe reading back to a desired level.
- Guidance required on where to place the probes.

The expected outcomes of this communication are as follows.

- New or updated publications with the relevant information to address the above-mentioned issues.
- Development and implementation of a specialised modular course on soil moisture probes for irrigation management.

- On-going extension and knowledge exchange activities to educate and train growers on the use of soil moisture probes for irrigation management.

No new research projects are required. Available material from the internet and other sources can be collated and synthesised into useful information and training packages.

Guidelines on selecting appropriate tools and service providers

SASRI does not align themselves with any product or brand name. This is necessary to maintain the integrity and objectivity of scientific research. For this reason, SASRI cannot promote or endorse any specific products or companies.

Nevertheless, we acknowledge that choosing a service provider can be a daunting task. A set of guideline questions are presented below in order to help growers assess the quality of irrigation scheduling service providers/products. These guideline questions will be refined and included in a new information sheet so that they are freely available/accessible to all growers.

(a) 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?
(a) 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)?
Software:	– How easy is the software package to use? – What are the initial and annual cost of package?
(b) Installation and after sales service	
Method:	– 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.
(c) Is the company reputable?	
Local or international:	– Who and where is the owner/manufacturer of the company, probes, data transmitters, software?
Address:	– 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?
Consultants:	– 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?
(d) 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?
Communication:	– 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?

Although selecting an appropriate scheduling system may seem fairly complex, it is unwise to agonise endlessly over this decision. Remember, it is considerably better to have some irrigation scheduling system in place than no system at all. Pilot testing viable options on a small-scale can also help to alleviate doubt and uncertainty before adopting on a wide scale.

Guidelines on placement of soil water sensors

Correct placement of soil water monitoring devices is critical as this will affect the quality of data. Devices should be placed in a representative position within a field and preferable at more than one position. Where overhead irrigation systems are used, devices can be placed in close proximity to the row (about 15 to 30 cm). In the case of drip irrigation, the placement in relation to the emitters is very critical. As a guide, devices should be placed ¼ of the emitter spacing away from the emitter and ⅓ of emitter spacing away from the line. It is highly recommended that a trench be dug to look at the lateral water movement and root distribution and to use this information as a guide for placement of soil water monitoring devices. It is always desirable to place a rain gauge at each measuring position not only to measure the exact application amounts, but also to act as a marker.

Calibration, interpretation and placement of soil water sensors

Existing projects are listed below, in which knowledge exchange material will be developed, in conjunction with the planning and implementation of extension and training initiatives.

- The aim of an existing project (19KE05) is to review and update all SASRI publications to ensure that all recommended irrigation BMPs are relevant, updated, adequately captured and readily available in farmer friendly formats. Within this project, a new information sheet will be drafted to address these specific issues (probe placement, calibration and interpretation of soil moisture data).
- Before learning how to interpret soil water sensor data, one needs to have good knowledge on soil water principles. Project 19TD03, currently on the go, aims to developing a customised soils modular course for SSGs. Simultaneously, project 19TD11 has the specific aim of developing teaching resources and creating learning opportunities for SSGs in irrigation. Within this project, there is an opportunity to develop specific material for a very modular course on soil moisture probes. Once the material is developed, it could easily be adapted and shared via appropriate platforms with large-scale growers.
- Once developed, the new information sheets and modular course will be built into the extension program of work to ensure awareness and that the material and training is readily available.

48. Information needed on the role of soil type in determining the design and management of irrigation systems.

The expected outcome of this communication is as follows.

On-going extension and knowledge exchange activities are required to:

- Increase the awareness and accessibility of available resources on these topics, and
- Increase knowledge levels, skills and competence of the grower body

No new research projects are required. There is adequate information and ongoing knowledge exchange is required.

The time and effort to investigate, classify and map the soil in terms of soil water holding capacity and infiltration rates must be invested at the irrigation design stage. Thereafter, standard irrigation design norms and principles are applicable. Qualified and/or SABI accredited designers are preferred. Any irrigation designer, irrespective of the type of system, should use the properties of the soil to guide irrigation design.

Figure 4 was extracted from the ARC Irrigation Design Manual and depicts an overview of the irrigation design process in a flow chart format. The soil factors are demarcated in a different colour. As shown in the figure, the available water holding capacity (mm/m) must be determined along with the soil depth at the outset. These factors are than used, along with the crop rooting depth, to determine the size of the soil reservoir available to hold water (Total Available Water (TAW)). For irrigation design purposes, only a fraction of the TAW is allowed to be depleted if water stress is to be minimised. The allowable depletion indicates the soil water level at which crop stress is expected to begin. Generally, allowable depletion is set at 50% and the readily available water (RAW) is calculated as 50% of the TAW.

The RAW represents the fraction of soil water reservoir which can be depleted by the crop without experiencing stress and replenished by irrigation. For this reason, the depth/volume of water applied per irrigation event (Gross Irrigation Requirement (GIR)) should not exceed the RAW. Irrigation designers, therefore, must necessarily calculate the cycle length, stand times and GIR according to both crop demand (Net Irrigation Requirement (NIR)) and the RAW. In other words, the cycle length, stand time and irrigation applications must be designed to be able to meet the peak crop demand, while simultaneously <u>not</u> applying more water than what the soil can store. Excess irrigation, beyond the storage capacity of the soil, however, can be considered when salinity is a concern and harmful salts must be periodically leached out of the root zone.

The second soil related aspect is depicted on the bottom right hand corner of the figure below (check: Gross Application Rate [GAR, mm/h]). After calculating the required sprinkler/emitter flow rate and selecting an appropriate sprinkler/emitter, the designer must check to ensure that the gross application rate (rate at which water is applied) is less than the soil infiltration rate (rate at which the soil can absorb the water) in order to eliminate the risk of soil erosion.

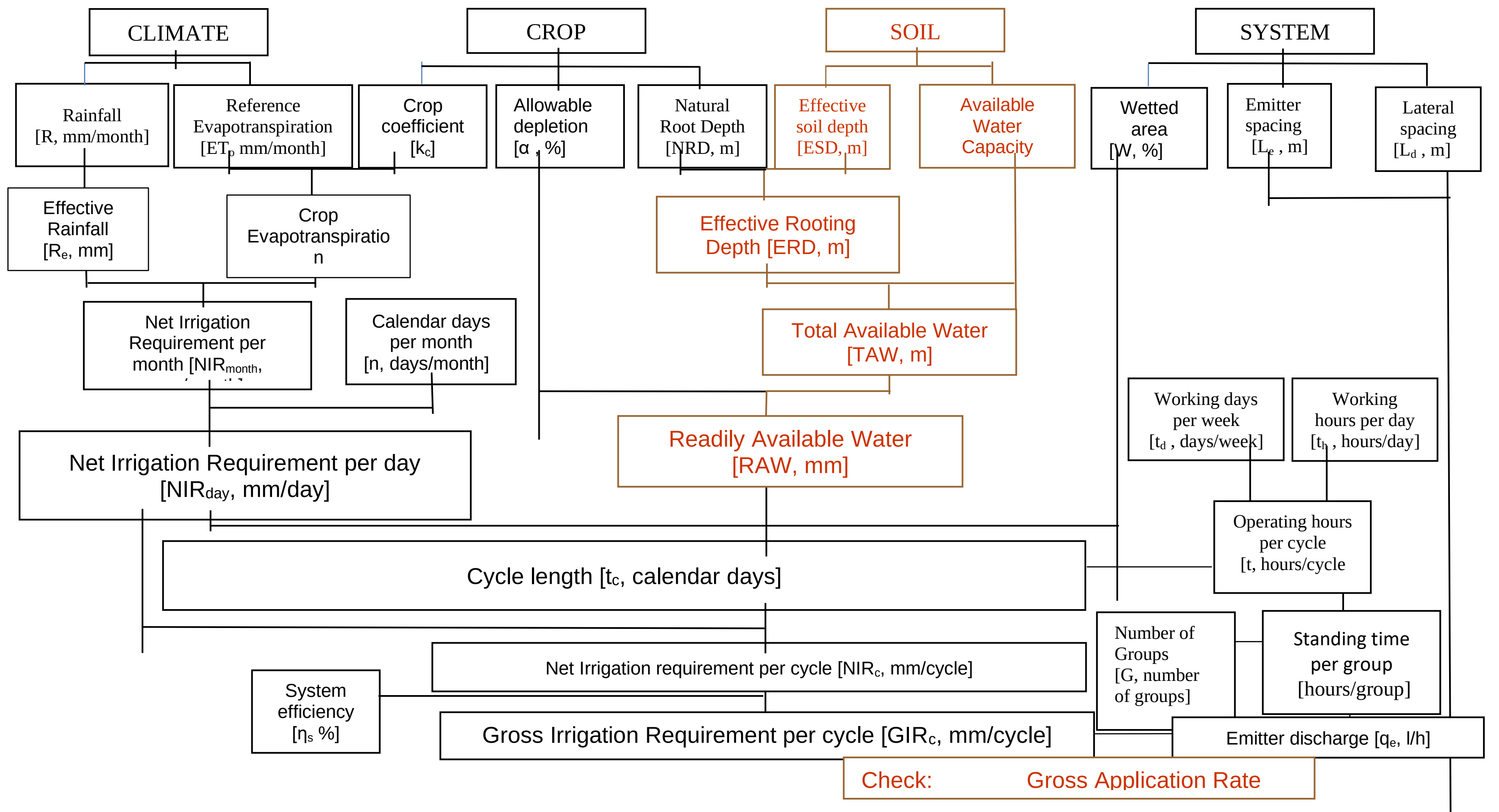

Figure 4

Irrigation planning flow chart (source : ARC Irrigation Design Manual)

The above discussion together with the figure 4 outlines how soil factors influence the design of an irrigation system. Table 11 below is also presented to provide an account of limitations/constraints for the different irrigations systems in relation to selected soil properties.

The following symbols are used in the table below to indicate the degree of limitation or obstacles that might occur:

O - no limitation
X - little limitation
XX - moderate limitation
XXX - severe, requires further thorough investigation by an expert.

Table 11

Possible soil limitations for different irrigation systems

Criteria	Furrow	Sprinkler		Drip	Big gun	Centre pivot
		Dragline/ hop a long	Permanent			
Soil texture						
> 20% clay	X	X	X	XX	XX	XXX
10 - 20% clay	X	O	O	O	X	X
< 5% clay	XX	O	O	XX	O	O
Soil depth						
< 600 mm deep	XXX	X	O	X	X	X
600 - 1200 mm deep	XX	O	O	O	O	O
Initial infiltration rate of soil						
< 20 mm/h	X	XX	X	X	XX	XXX
> 150 mm/h	XXX	O	O	O	O	O
Salinity						
Salinity > 2 000 ppm	X	XX	O	XXX	XX	XX

Source: SABI design norms and standards (www.sabi.co.za)

Drip irrigation

The design of drip irrigation systems has an additional consideration in terms of soil characteristics. The lateral and emitter spacing, along with the emitter flow rate influences the wetted area under the emitter. The resultant shape and size of the wetting profile, thereafter, is a function of the soil texture (and the inherent ability to move water laterally via capillary forces) (Figure 5).

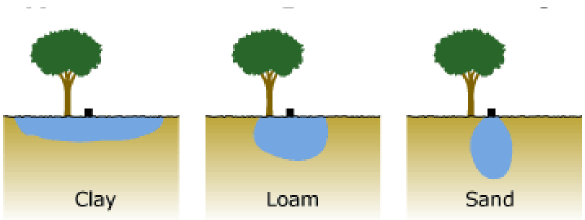

Figure 5

Typical water distribution pattern with point application

For this reason, the wetted area is used in the design process and is much more sensitive for drip irrigation compared to other systems. The wetted area is defined as the fraction wetted relative to the soil surface area for a single emitter. Since the wetted area is a function of emitter spacing, flow rate and inherent properties of the soil, it is not an easy parameter to estimate at the design stage. Table 12 below was generated based on a number of observation experiments for surface drip and can serve as a basic guideline for estimating wetted area.

Table 12

Percentage wetted surface area under emitters with different delivery rates, Spacing and soil textures

Emitter delivery rates	2 l/h			4 l/h			8 l/h		
Soil textures	Coarse	Medium	Fine	Coarse	Medium	Fine	Coarse	Medium	Fine
Wetted diameter under emitter (m)	0.39	0.78	1.24	0.78	1.24	1.26	1.24	1.62	2.10
Max. Emitter spacing, on lateral (m)	0.30	0.60	1.00	0.60	1.00	1.30	1.00	1.30	1.70
Dripper line spacing (m)	Percentage wetted area (% wa)								
0.8	50	100	100	100	100	100	100	100	100
1.0	40	80	100	80	100	100	100	100	100
1.2	33	67	100	67	100	100	100	100	100
1.5	26	53	80	53	80	100	100	100	100
2.0	20	40	60	40	60	80	60	80	100
2.5	16	32	48	32	48	64	48	64	80
3.0	13	26	40	26	40	53	40	53	67
3.5	11	23	34	23	34	46	34	46	57
4.0	10	20	30	20	30	40	30	40	50
4.5	9	18	26	18	26	36	26	36	44
5.0	8	16	24	16	24	32	24	32	40
6.0	7	14	20	14	20	27	20	27	34

Source: Reinders, FB, Grove' B, Benade' N, van der Stoep V and van Niekerk AS. 2012. Technical aspects and cost estimation procedures of surface and subsurface drip irrigation systems. WRC report no. TT 525/12. Vol 2, WRC, Pretoria, RSA.

Alternatively, site-specific (on-farm) observations can be made at the design stage in conjunction with the irrigation designer for a selection of appropriate/relevant emitter spacing and flow rates, using the following process:

- Lay-out dripper lines, preferably 20 m to 30 m long, on the soil that is to be irrigated, with different inter dripper spacings.
- Connect these to a water source which will render a continuous and stable supply.

- Switch on the system at the required operating pressure and irrigate for about 12 hours on the heavier soils and about six hours on sandy soils.
- Allow the water to penetrate the soil for a further 24 and 12 hours respectively, without any interference, in order that the wet zone can reach its maximum dimensions.
- Then dig longitudinal and cross profile furrows and do the necessary observations and measurements to establish whether the proposed system will satisfy all requirements. The wetted surface area of the soil (wetted radius) should be appropriate for the corresponding emitter and lateral/crop row spacing. The depth of wetting should be appropriate for the respective soil and effective rooting depth. Overall, the wetting onion profile should ensure that there is an adequate water supply for a likely distribution profile of crop roots.

49. Cost-benefit analyses needed for precision irrigation systems, including variable rate application (VRA) systems for centre pivots.

The expected outcome of this communication is a report documenting a site-specific cost benefit analysis for the VRA centre pivot irrigation system in Malelane

In centre pivots, variable rate application can be achieved in two ways. The first, and cheaper option, is to alter the speed of the wheels of the centre pivot towers for different segments of the pivot circle. When the pivot structure travels faster, there is less time available for application over a given area and therefore a lower application. Conversely, a slower speed results on greater time over an area and, therefore, larger application. This option can be referred to as variable speed irrigation (VSI). VSI with centre pivots, however, only allows for water application to be varied in pie/pizza slice shapes within the pivot circle. This can be inhibiting when field shapes and soil variability differ.

The second option is more flexible, but also much more sophisticated and expensive. In the second option, sprinklers which are capable of adjusting the nozzle diameter are used to control the amount of water applied spatially across the field, i.e. by making the nozzle diameter wider or smaller, more or less water can be applied at precise/specified positions in the field. Each sprinkler/nozzle is connected to a solenoid (micro switch) and sophisticated control panels which are programmed to adjust the nozzle diameter, depending on the position of the pivot structure relative to the field and pre-programmed rules. This second type is commonly referred to as variable rate application (VRA).

VRA centre pivots allow for more precise irrigation, especially on variable soils, or multiple fields with crops at different growth stages on different plant/harvest cycles. When a soil or crops across different fields displays high spatial variability, the benefit from VRA is expected to be greater. The cost to benefit ratio is, therefore, very site-specific.

SASRI, however, does not have data for a VRA system to do a cost benefit analysis. These systems are new, and few pivots are equipped. Data is also not yet available from literature. For this reason, SASRI will welcome the opportunity, where a grower has installed or is planning to install such a system, to conduct a cost benefit analysis on such a system. The data pertaining to costs, soils and crops at pilot implementation sites, however, must be provided.