Sustainable solutions to production constraints – a report on the 2015 ISSCT Agricultural Engineering, Agronomy and Extension workshop

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Abstract   The International Society of Sugar Cane Technologists (ISSCT) joint Agricultural Engineering, Agronomy and Extension Workshop was held at Salt Rock north of Durban South Africa from 24 to 28 August 2015. The theme of the Workshop was Sustainable Solutions to Production Constraints. The aim of this paper is to provide a record of the Workshop and summaries of all the papers and posters that were presented and discussions on particular topics. The workshop consisted of five working sessions, two field trips and a summation and conclusions session, spread over five days. The working sessions had separate themes: Sustainable Sugarcane Production, Sugarcane for Energy, Innovative Systems and Technologies, Improving Adoption, and Extension – Approaches and Systems. A total of 131 delegates from 25 countries attended the workshop with a total of 16 oral presentations and 31 posters. An important characteristic of the workshop was the break-out sessions that enabled delegates to interact and discuss a diverse range of topics. The report-back sessions enabled a synthesis of information and a summary for future consideration. As in the past, Early Career Awards were presented for the best presentation/poster by a senior author < 35 years old. Prior to the close of the proceedings, possible locations for the next joint Agronomy, Agricultural Engineering and Extension Workshop were identified.

Key words   Sugarcane, agronomy, agricultural engineering, extension, workshop, South Africa

INTRODUCTION

The International Society of Sugar Cane Technologists (ISSCT) joint Agricultural Engineering, Agronomy and Extension Workshop was held at Salt Rock north of Durban South Africa from 24 to 28 August 2015. The theme of the Workshop was Sustainable Solutions to Production Constraints. It was attended by 131 delegates from 25 countries. The Workshop consisted of five working sessions spread over three days (Monday, Wednesday and Friday) and a summation and conclusions session (Session 6) on the Friday prior to the official close. Delegates were welcomed to the workshop by Dr Rianto van Antwerpen from the South African Sugarcane Research Institute (SASRI) and Chairman of the local workshop organising committee. Prof Robert Gilbert (Chair of the ISSCT Technical Program Committee) addressed the delegates and provided information about ISSCT and the aims of the Society and the Section Workshops. The working sessions each had their own themes, and consisted of oral presentations, poster viewing, break-out group discussions and report-back opportunities (Tables 1, 2, 3, 4 and 5). The break-out groups included predetermined participants with facilitators and record keepers drawn from among the delegates. Two field trips were included in the program. On Tuesday 25 August the delegates were taken to Zululand, about 150 km north of Salt Rock, in two coaches that travelled alternatively to the Bell Equipment Factory at Richards Bay and the Umhlatuzi Valley Sugar Company (UVSC) near Felixton Mill. The field trip on Thursday 27 August took delegates to the higher-altitude Midlands region of KwaZulu-Natal and included visits to the Noordsberg Mill Small Scale Growers and Hillermann Brothers Farm.

The aim of this paper is to provide details, information and outcomes from the Workshop and summaries of the papers and posters that were presented and discussions on particular topics covered within the working sessions.
**SESSION 1: SUSTAINABLE PRODUCTION**

**Oral presentations**

The oral presentations in this session (Table 1) provided higher level considerations within the topic of ‘Crop nutrition, irrigation and soils’.

*Table 1.* Summary of activities and topics presented and discussed in Session 1 (Sustainable Production) of the 2015 ISSCT Agricultural Engineering, Agronomy and Extension Workshop.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Presentations / topics</th>
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<tbody>
<tr>
<td>Oral presentations</td>
<td>Calcino DV, Schroeder BL. Tracking the success of the SIX EASY STEPS nutrient management program.</td>
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<td></td>
<td>Krontal Y, Hardy Y, Martin D. Sugarcane drip irrigation in saline and sodic soils and water conditions.</td>
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<td></td>
<td>Meyer JH, Heathman WZ. Best practice soil management guidelines for sustainable irrigated sugarcane production.</td>
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<td>Mardamootoo T, Du Preez CC. The need for a management tool to assess risks of P loss from sugarcane fields in Mauritius.</td>
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<td>Sousa RTX, Korndörfer GH. The effect of organo-mineral versus mineral fertiliser on plant and ratoon cane.</td>
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<td>Skocaj DM, Everingham YL. The effect of spring and summer rainfall on the N requirement of ratoon sugarcane crops in the Wet Tropics region of Australia</td>
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<td>Mellis EV, Quaggio JA, Teixeira LAJ, Vieira RC. Micronutrient application in the furrow for sugarcane production.</td>
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<td>Schroeder BL, Skocaj DM, Salter B, Hurney AP, Wood AW. Is it possible to reduce N input rates and increase NUE in older ratoons in the sugarcane crop cycle</td>
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<td></td>
<td>Miles N, van Antwerpen R. Towards more environmentally-sustainable management of P in the South African sugar industry: soil sampling/testing considerations.</td>
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<td></td>
<td>Nxumalo N, Ramburan S. Differential yield responses to mulching in three sugarcane regions in South Africa.</td>
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<td></td>
<td>Jones MR, Singels A. Exploring sugarcane agronomic adaptations to climate change.</td>
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<td>Yana Yana B, Viremouneix T, Ngako A. Composting and agricultural evaluation of organic wastes from sugar cane process: experiences in the sugar industry in Cameroon.</td>
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<td>Ng Cheong LR, Dove JH, Pene CB, Kouakou Y, Bringa G, Kouame D, Kouassi C. Deficit irrigation as a solution to limited water availability for sugarcane production in Cote D’Ivoire.</td>
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<td></td>
<td>Della Lucia TMC, Martins HC, Braganca MAL, Muchovej RMC. Biological control of pest ants in sugarcane plantations: a possible future strategy in management practices in Brazil.</td>
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<td>Pene CB, Dove H, Kouame DK, Nicolin GL. Agronomic performance of commercial sugarcane varieties as influenced by early, mid and late season dates of harvest in Ferke, northern Ivory Coast.</td>
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<td></td>
<td>Pene CB, Boua BM, Quattara Y, Vangoor D, Nicolin GL. Investigating the lower sucrose content of cane delivered over the early 2014-15 harvest season at the Ferke sugar mills, northern Ivory Coast.</td>
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<td>Odero DC, Duchrow M, Havranek N. Does critical timing of fall panicum removal influence sugarcane yield?</td>
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<td>Boote DN, Smithers JC, Jumman A, Lyne PWL. The development and application of an energy calculator for sugarcane production.</td>
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<td></td>
<td>Singh MP, Zhao D, Shine J, Polacik K, Singels A. Variation in growth, physiology and yield of six sugarcane cultivars from across the globe grown in Florida, USA.</td>
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<td></td>
<td>Paillat J, Marion D. Organic matter from residual sources as a sugarcane fertiliser and amendment: design details of a Reunion Island study.</td>
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<td>Break away discussions</td>
<td>Soil health, crop nutrition, crop husbandry and farming systems: various groups</td>
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<td>Report back</td>
<td>Summarising information generated from the break-away discussions: Prof Bernard Schroeder (Friday: Session 6)</td>
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Calcino and Schroeder (Table 1) described the delivery mechanism for the SIX EASY STEPS best practice nutrient management system in Australia. They explained the importance of this approach and the nutrient management workshops that have been delivered across the industry. This is particularly relevant given the background of increasing environmental scrutiny from the community, environmental groups and government. The success of the SIX EASY STEPS is believed to be due to the sound scientific basis for the nutrient guidelines, the collaborative approach in developing the program, and the audience-targeted and interactive nature of the workshops.
The TPC Ltd sugarcane estate in the semi-arid region of Northern Tanzania provided the backdrop to the paper delivered by Krontal et al. (Table 1). This site was used to determine appropriate irrigation methods for saline/sodic soils. Although drip irrigation is considered a sustainable method for utilising limited water reserves and an appropriate means of removing salts from the root zone, little was known about its suitability for sugarcane production under such conditions. They reported average yields of 167 t/ha over three years with drip irrigation. In contrast furrow irrigation resulted in a decrease from 140 t/ha in plant cane to 66 t/ha for ratoons over the same period. Low-flow drippers (0.6 L/h) were found to be less effective in flushing salts from soil before planting than overhead irrigation. Precipitation of bicarbonates in the drippers continues to be problematic.

Meyer and Heathman (Table 1) highlighted the wide range of climatic conditions and soils that exist across the world sugar industries. This diversity has a marked effect of potential yields and requires tailored management practices. However in many instances, particularly on estates in Africa, there is a lack of adequately scaled soil maps that could enable better use of resources. 'One size fits all' approaches to on-farm management commonly occur particularly in relation to fertiliser applications and irrigation rates/practices. Research evidence from South Africa and Australia has indicated that best management practices based on soil type contribute to successful ‘triple bottom line’ approaches that include environmental considerations. Decisions that can be linked to soil type include choice of variety, irrigation scheduling, fertilizer inputs, pest and disease management, ripener applications, and harvesting/loading operations. It is likely that on-farm agronomic practices will, in future, become more diverse and will need to be reflect differences in soil properties.

**Posters**

The posters in this session covered a wide range of topics (Table 1). Seven posters included information and reports of recent work in evaluating nutrients and fertiliser options/formulations.

Nitrogen (N) [Skocaj et al., Schroeder et al., Sousa and Korndörfer (Table 1)] and phosphorus (P) [Mardamootoo and Du Preez, Miles and van Antwerpen, Sousa and Korndorfer (Table 1)] were most topical. Use efficiency, and balancing productivity and environmental considerations were common goals of these posters. Three posters [Sousa and Korndorfer, Yana Yana et al., Paillat and Marion (Table 1)] addressed the issue of organic fertilisers and value-added organic products. The importance of applying micronutrients in low fertility soils was highlighted by Mellis et al. (Table 1).

Several posters dealt with farming systems issues. Sandhu and Singh (Table 1) concluded that reduced tillage practice in organic soils in Florida, USA, did not reduce yields of various sugarcane cultivars but had the ability to improve soil sustainability. They suggested that long-term conservation tillage may result in improved yields in due course. Further sugarcane varietal issues were covered in three other posters. Nxumalo and Ramburan (Table 1) indicated that although responses to post-harvest leaf residue retention (mulching) were regionally dependent in South African conditions, varietal responses were similar within regions and were surpassed by environmental effects. Ng Cheong et al. (Table 1) evaluated the use of deficit irrigation in an attempt to utilise limited water supplies. Their experiences in Cote d’Ivoire showed that this type of approach could not be recommended in areas of high evaporative demand.

Several posters provided information that related to crop models. Singh et al. (Table 1) evaluated the growth, yield and physiological responses of six sugarcane cultivars from across the world on high organic soils in Florida. Not surprisingly the results indicated variability in the various physiological and growth parameters that were measured. This dataset will be used to evaluate the ability of crop models to simulate genotype x environment (GxE) interactions. Jones and Singels (Table 1) reported on the results of an assessment of potential agronomic adaptation strategies to climate change in South African simulated agro-climate zones (ACZs). They reported increased annualised simulated sugarcane yields in most ACZs and at industry scale with reduced harvest age when compared to non-adapted future scenario. Although simulated sucrose yields decreased in some ACZs, this will need to be verified. Preliminary results suggest that residue retention increases water-use efficiency and yields in many rainfed ACZs and reduces irrigation requirements.

Two posters dealt with pest control. Two species of grass-cutting ants (Atta capiguara and Atta bisphaerica) are important insect pests in Brazil that are ineffectually controlled by chemicals. Della Lucia et al. (Table 1) evaluated species of Phoridae flies (parasites of workers of A. bisphaerica) as biocontrol mechanisms. Although the rate of parasitism appeared to be low, it appeared to interrupt the foraging activity of the ant colonies. As this could result in reduced colony growth in infested areas, work is continuing to determine if these natural enemies may be used in the Integrated Pest Management program in Brazil. In Florida, USA fall panicum (Panicum dichotomiflorum) is a most troublesome annual grass weed associated with sugarcane. Results of field investigations [Odero et al. (Table 1)] showed that sugarcane tolerance to early-season interference from fall panicum was variety dependent. Panicum must be controlled timeously to reduce yield effects and prevent seed bank replenishment and re-infestation in subsequent years.
Optimizing the period of harvest of commercial sugarcane varieties grown in the northern Cote d'Ivoire was investigated by Péné et al. (Table 1). Cultivars SP70/1143 and VMC95-37 were confirmed as best suited to early season harvest, M1400/86 as a mid-season cultivar, SP71/1406 as moderately adapted to late-season, and R579 with slight decreases in sugar content when harvested late-season. The overall significant reduction in cane and sugar yield (20-30%) when harvest occurred in December/January indicated the agronomic benefit of not prolonging the harvest season.

Boote et al. (Table 1) reported on the development of an energy calculator for sugarcane production in South Africa. It estimates fossil fuel energy use (EU) on-farm and an ability to estimate greenhouse gas (GHG) emissions. The energy calculator will assist growers to minimise on-farm EU and reduce input costs, and provide researchers with a means of benchmarking and profiling EU in sugarcane production.

Break-out session

The topics of soil health, crop nutrition, crop husbandry and farming systems (Table 1) were allocated for discussion by the predetermined groups during the break-out session. The tasks were to identify (within each of the topic areas):
- a) Major accomplishments during the past 10 years,
- b) Major challenges that have arisen over the past 10 years,
- c) Major challenges that are likely in the next 10 years, and
- d) Priorities that should be addressed to improve progress and delivery.

Report-back

A synthesis of the discussions during the break-out session was presented by Prof Bernard Schroeder during the final session of the Workshop. The following provides a summary of the points raised that are generally accepted or are in practice in many of the international sugar industries:

1. Soil health
   a) Recognition that cane burning has serious implications for soil health.
   b) Movement towards trash retention, but widespread adoption is still a challenge (for various reasons).
   c) Recognition that unrestricted in-field use of heavy machinery and repeat/unnecessary tillage leads to soil degradation and stool damage.
   d) Movement towards controlled traffic and minimum till systems, but widespread adoption is still a challenge (for various reasons).
   e) Recognition that continued cane production leads to decreases in soil fertility, especially organic carbon.
   f) Movement towards break cropping and legume fallows, but widespread adoption is still a challenge.
   g) Recognition that we are moving onto more marginal and challenging soils.
   h) Movement towards integrated practices that improve soils – chemical, physical and biological (use of various practices and materials).

2. Crop nutrition
   a) Recognition that ‘one-size fits all’ approaches to crop nutrition is not appropriate.
   b) Movement to systems that target soil types and production capabilities, but widespread adoption is still a challenge (for various reasons).
   c) Recognition that fertiliser supply strategies need to minimise N losses and therefore productivity losses.
   d) Movement towards targeted applications (splits, irrigation, etc.), but widespread adoption is still a challenge (for various reasons).
   e) Recognition that supply strategies need to optimising N supply and N demand – sustainable production (profitability and environmentally responsible).
   f) Movement towards PA-based strategies that consider temporal and spatial management options.
   g) Recognition that we need to increase nutrient use efficiencies.
   h) Movement towards integrated strategies that offer a range of options to growers – targeting their specific circumstances (according to objectives, economics, scales, etc.).

3. Crop husbandry
   a) Recognition that specific practices are needed for specific issues (weeds, pest and diseases, etc.).
   b) Control measures relatively well adopted, but ongoing need for less harsh options.
   c) Recognition that crop growth and yields need to optimised.
d) Movement towards targeted strategies (planting and ratoon timing, ripeners, etc.), but not always possible or applicable.

e) Recognition that growers need access to tools for informed decision making.

f) Movement towards providing information and systems (varieties, practices, inputs, etc.) that empower growers to make appropriate choices, but widespread availability and adoption are still challenges.

g) Recognition that specific practices are needed for specific issues (weeds, pest and diseases, etc.).

h) Control measures relatively well adopted, but ongoing need for less harsh options.

i) Recognition that crop growth and yields need to be optimised.

j) Movement towards targeted strategies (planting and ratoon timing, ripeners, etc.), but not always possible or applicable.

k) Recognition that growers need access to tools for informed decision making.

l) Movement towards providing information and systems (varieties, practices, inputs, etc.) that empower growers to make appropriate choices, but widespread availability and adoption are still challenges.

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k) Recognition that growers need access to tools for informed decision making.

l) Movement towards providing information and systems (varieties, practices, inputs, etc.) that empower growers to make appropriate choices, but widespread availability and adoption are still challenges.

4. Farming systems

a) Recognition that newer innovations (irrigation technologies, New Farming Systems, etc.) offer potential benefits.

b) Movement to these systems but widespread adoption is still a challenge for various reasons.

c) Recognition that growers are increasingly required to operate in challenging circumstances (urban encroachment, regulation, 'right to farm', restrictions, climate issues, resource availability, etc.).

d) Movement towards providing options, but individuals are not always able to respond for various reasons.

e) Recognition that economies of scale are increasingly important.

f) Movement towards consolidation, realignment, rectification, etc., but not always achievable.

g) Recognition that the farming system needs to embrace new technologies (automation, robotics, suit diversified product range, etc.).

h) Movement towards integrated strategies but options are costly, not always easily available, and generally adoption not guaranteed.

The following conclusions were drawn and offer opportunities/challenges for the future:

a) Recognition of ongoing attention to, and adoption of, strategies and practices that allow profitability in combination with socially acceptance and environmental responsibility – basis for BMPs!

b) Progress is being achieved, but it is not always perceived as easy or economical.

c) Recognition that growers are operating in increasingly difficult circumstances.

d) Need to provide information, systems and other means that ensure informed decision making and confidence to adopt newer more appropriate options.

e) Recognition that millers are facing challenges to remain competitive and viable.

f) Need to provide strategies and options for maintaining and, hopefully, improving cane supply.

g) Recognition that the world sugar industry is under pressure / scrutiny.

h) Need to continue to seek means of improving sugar productions and creating alternative uses for this unique crop to enable sustainability and prosperity of stakeholders.

SESSION 2: SUGARCANE FOR ENERGY

Oral presentations

Two oral presentations were delivered in this session. They dealt with systems to harvest, collect, process and transport sugarcane biomass for energy purposes (Table 2).

Although it is recognised that sugarcane biomass including residue (brown/dead leaves and green leaves and tops) has potential as a renewable and sustainable energy source, it needs to be collected, transported and processed appropriately. Rees et al. (Table 2) described a model that enables the cost of these aspects to be estimated for various potential residue recovery routes. Simulations included different methods of harvesting, separation of residue from cane (in-field or at the mill), a method of residue collection, residue processing, and transportation of the residue. Methods to increase the bulk density of the residue prior to transport were also evaluated in terms of improving efficiency. These included torrefaction and pelleting. Their results indicated that the best residue extraction route is site specific and is dependent on localised operational conditions.

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Table 2. Summary of activities and topics presented and discussed in Session 2 (Sugarcane for Energy) of the 2015 ISSCT Agricultural Engineering, Agronomy and Extension Workshop.

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<tr>
<th>Activity</th>
<th>Presentations / topics</th>
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<tbody>
<tr>
<td></td>
<td>Norris S, Landers G, Norris C. Efficient crop residue collection for utilisation as an energy source.</td>
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<tr>
<td>Posters</td>
<td>Chopart JL, Sergent G, Goebel FR. Cropping systems for energy cane grown on volcanic soils in a tropical climate: initial results on planting dates, cycle duration and pest pressure.</td>
</tr>
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<td></td>
<td>Chopart JL, Sergent G. Root biomass quantification of sugar and multipurpose cane varieties for sustainable production.</td>
</tr>
<tr>
<td></td>
<td>Singels A, Eksteen AB, Zhou M, Olivier FC. The potential of sugarcane as a biofuel feedstock in South Africa: a mini review.</td>
</tr>
<tr>
<td></td>
<td>Sandhu HS, Gordon VS, Gilbert RA, Comstock JC, Korndörfer P. Evaluation of energy cane clones as lignocellulosic ethanol feedstock in Florida.</td>
</tr>
<tr>
<td>Break away discussions</td>
<td>Varieties and agronomy for bioenergy, biomass and residue management - harvesting, extraction and transport, and farm design and field layout for bioenergy: various groups</td>
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<tr>
<td>Report back</td>
<td>Summarising information generated from the break-away discussions: Dr Neil Lecler (Friday: Session 6)</td>
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Norris et al. (Table 2) re-emphasised the potential of sugarcane residue (trash) as an underutilised energy-resource. They stressed that it can be exploited without compromising food production. However, use of best practice recovery strategies could actually increase the value of the sugarcane crop. Although maximised residue blanketing can be obtained through aggressive cane cleaning during mechanical harvesting, cane and sugar losses can be substantial leading to reduced profitability. Their presentation compared several residue recovery strategies and provided an evaluation of the cost of residue recovery. This included the actual amount of residue recovered, any agronomic trade-offs and losses in the sugar production value chain.

**Posters**

Four posters dealt with related topics in this session. Studies conducted in Guadeloupe in the West Indies investigated the production of total above-ground sugarcane biomass for energy purposes (Chopart et al.; Table 2) following a previous study that had shown a strong linear relationship between total dry above-ground biomass and energy yield. In the recent study planting date did not affect yield, and cumulative biomass of three harvests was comparable to two harvests in a two-year period. There were indications of possible reductions in weed control measures and fertiliser inputs. Aspects of soil organic matter (SOM) with high biomass were considered and discussed. In particular, root biomass may become especially important when the whole above-ground biomass is used for energy purposes (Chopart and Sergent; Table 2). The dry root biomass density (RBD) of commercial cane and cane planted for energy ranged from 2 to 3 t/ha depending on cultivar.

Despite a high potential for producing energy from cellulosic ethanol or direct combustion from so-called energy canes, seed cane sources were found to be limited in Florida, USA. Sandhu et al. (Table 2) reported on a cooperative energy cane selection program that was established to produce high-yielding, disease-resistant energy cane germplasm. Of the eight genotypes planted at three sites, five were found to have potential to be cultivated for lignocellulosic ethanol production on marginal soils.

Singels et al. (Table 2) highlighted the importance of sugarcane crop forecasts to optimize sugarcane production, milling and sugar selling in South Africa. They reported that crop forecasts from the CaneSim® crop forecasting system can be improved by using remote sensing (RS) technology to determine canopy cover and evapotranspiration data. Work is underway to roll out this methodology across the industry.

**Break-out session**

The topics of variety and agronomy for bioenergy, biomass and residue management and farm design and field layout for bioenergy (Table 2) were allocated for discussion by the predetermined groups during the break-out session. The tasks were the same as those for the prior break-out session (see above).
Report-back

A synthesis of the discussions during the break-out session was presented by Dr Neil Lecler during the final session of the Workshop. The following provides a summary of the points raised that are generally accepted as applicable to many of the international sugar industries:

1. Historical context - The following may describe historical circumstances and characteristics of some international sugar industries:
   a) Inefficient mills.
   b) High sucrose bias.
   c) ‘Cheap’ labour.
   d) High sugar prices.
   e) Sugar considered an acceptable energy food.

2. Present context
   a) Pressure on sugar businesses to survive and therefore investigate using sugarcane as a source of sugar and energy.
   b) Sugar is under pressure as a less acceptable food crop.
   c) Energy demand from renewable sources but policies are often unclear/unhelpful.
   d) Differentiated supply and distribution systems for electricity often stifle/complicate potential developments.
   e) Like water, a significant opportunity cost is applicable if no supply of energy exists.
   f) Inappropriate/outdated sugarcane farming and milling systems.
   g) Many misconceptions.
   h) Range of different aspirations.

3. Opportunities
   a) Conversion to better and more profitable controlled traffic farming and irrigation systems. This needs to be phased in with replacement of machinery over at least 5 years.
   b) Approximate 20% land to rotation food crop such as soybean could be achieved in many places.
   c) Conversion to more efficient mills.
   d) Multi-lateral agreements to ensure all stakeholders are supportive of changes.
   e) Knowledge exchange with governments on the energy potential of sugarcane.
   f) High fibre/High yielding cane – more robust and better yielding – ‘market’ for fibre not only sucrose, breeding takes time and should have started.
   g) GM energy cane – ‘easy’ release - no ‘food/health’ issues.
   h) Optinol cited as an example of a company claiming it can produce cost effective bio-butanol (much better fuel than ethanol and can be blended with diesel relatively easily…..).
   i) New development – energy factories vs sugar factories (an energy factory may be far less expensive).
   j) Biogas – extra benefit and potentially mitigate handling/safety issues of by-products.
   k) Energy cane harvesters (without complicated cleaning mechanisms) – potential for simpler, lighter and cheaper ‘energy cane’ harvesters, especially if combined with post-harvest ‘cleaning’.
   l) Additional ‘energy’ income streams – likely to be ‘better’ than sugar, depending on local market trends/.

SESSION 3: INNOVATION SYSTEMS AND TECHNOLOGIES

Oral presentations

Five oral presentations were delivered within this session and covered the topics of controlled traffic systems and remote sensing.

Franco et al. (Table 3) reported on an investigation of six sugarcane planting configurations in Brazil. They found that amount of planting material was reduced and yields increased when precision planting techniques were used compared to conventional planting configurations. The development and practical implementation of controlled traffic farming system (CTFS) for overhead and surface irrigated systems in Zimbabwean sugarcane were described and discussed by Lecler (Table 3). Challenges and solutions to adoption of the CTFS were identified. Twedde (Table 3) presented a comparison of estimated traffic-induced yield losses between harvesting systems typically used in South Africa. He indicated that that there was a significant difference in yield responses between row and inter-row traffic, and that soil properties, soil water
content and traffic impact were found to have an influence on subsequent yields. The aim was to assist decision makers in choosing systems that were most appropriate for their farming operation.

Crop forecasts are an essential component to optimize sugarcane production, milling and sugar marketing. Singels (Table 3) presented results of a study to determine whether the accuracy of crop forecasts from the CaneSim® crop forecasting system can be improved by using remote sensing technology such as the Surface Energy Balance Algorithm for Land (SEBAL). The results suggested that remotely sensed canopy cover and evapotranspiration can improve model-based sugarcane crop forecasting. Mackinnon et al. (Table 3) then described the use of remote sensed and meteorological data in combination with the SEBAL model via a new web platform in CanePro to understand crop and water variables in commercial cane throughout the sugarcane growing season in South Africa. This system enables decision making at field-scale and in-season feedback on agronomic actions. The data collected over the season supports optimisation of practices at field scale for subsequent years.

**Table 3.** Summary of activities and topics presented and discussed in Session 3 (Innovation Systems and Technologies) of the 2015 ISSCT Agricultural Engineering, Agronomy and Extension Workshop.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Presentations / topics</th>
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<tbody>
<tr>
<td>Oral presentations (Controlled traffic)</td>
<td>Franco HCJ, Rossi Neto J, Kölln OT, Ferreira DA, Carvalho JLN, Souza ZM, Braunbeck OA. Will traffic control and precision planting increase sugarcane yield? Lecler NL. Projects and strategies to introduce a synergetic controlled traffic farming system to Zimbabwe. Tweddle PB, Lyne PWL, Bezuidenhout CN. Comparison of traffic induced sugarcane yield loss estimates for typical cane harvesting operations in South Africa.</td>
</tr>
<tr>
<td>Break away discussions</td>
<td>Precision Agriculture (Systems), Precision Agriculture (Crop monitoring), Innovations for small-scale operations; various groups</td>
</tr>
<tr>
<td>Report back</td>
<td>Summarising information generated from the break-away discussions: Prof Gaspar Korndörfer and Dr Brent Griffiths</td>
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</table>

**Posters**

A number of posters dealing with a range of innovative technologies and developments were included in this session. Two of these related to projects being undertaken in the fully-irrigated Burdekin region of Australia. Salter and Hanks (Table 3) provided information on sugarcane farming systems trials conducted in the Burdekin region of Australia. The first trial was used to determine the effect of planting time, fallow length and type on sugarcane production, and the second trial was used to compare different crops (mungbean, soybean, cotton) and crop sequences (soybean, maize, mungbean and cotton, maize, mungbean) within extended fallow periods, on sugarcane production. Gillies et al. (Table 3) described a project aimed at developing and demonstrating an adaptive automated furrow irrigation system. This will be done by integrating existing software, hardware and control systems with specifically developed sensors and control valves. It will
allow growers to monitor, control and schedule sequential sets of irrigated furrows over the internet using a computer or smart phone.

De Reynald et al. (Table 3) reported on the installation of herbicide sprayers on mechanical harvesters in Martinique. This innovation that was designed to improve the efficiency of pre-emergence herbicide. Pre-emergence herbicide is applied prior to the crop residues reaching the ground.

Innovations/developments from South Africa included revamping and upgrading of MyCanesim®, which is a web-based crop simulation system designed to support agronomic research and sugarcane production [Paraskevopoulou and Singles (Table 3)]. The potential value of the improved system was demonstrated using case studies. Van Antwerpen et al. (Table 3) described the use of electromagnetic induction to estimate soil textural variability. This technique produced repeatable results that could be used with confidence to map the variability of clay in the field.

An innovation from Florida, USA, included the assessment of sugarcane growth and yield using canopy reflectance measurements [Zhao et al. (Table 3)]. Data collected from a field trial showed that the best time of measuring canopy reflectance for sugarcane yield assessment (in Florida) was in May or during early vigorous growth. This occurred across the various cultivars that were included in the study.

Due to the Mauritius sugar industry becoming increasingly mechanized an instantaneous weighing system for mechanically harvested sugarcane was developed and assessed [Riviere et al. (Table 3)]. The results of the assessment showed that this new system is as good as the classical manual harvesting technique. An additional benefit is the direct determination of the adaptability of new varieties to mechanized harvesting. The instantaneous weighing system has now been adopted in the cane breeding program.

Break-out session

The break-out session was used for discussion of topics related to precision agriculture (PA): a) systems and b) crop monitoring; and innovations for small-scale operations (Table 3.) This was done using the same system of predetermined groups.

Report-back

The following is a synthesis of the discussions during the break-out session as summarised and presented by Prof Gaspar Korndörfer and Mr Brent Griffiths:

Precision Agriculture (Systems):

1. Past Accomplishments
   a) Spatial mapping
   b) Accuracy
   c) UAVs
   d) Collection and movement of data
   e) Modelling
   f) Variable rate application
   g) Variable land forming
   h) Water use efficiency
   i) Controlled traffic
   j) Adoption of technology
   k) Improved background communications infrastructure
   l) Use of smartphones

2. Past Challenges
   a) Back-up of the technology and support services
   b) Making technology available at a low enough cost
   c) Lack of financial resources/assistance for technology adoption for small-scale operations
   d) Lack of environmental information available (GIS/LUP)
   e) Validity of soil sampling due to variability in fertiliser/water application
3. Future Challenges
   a) New harvesting and mechanical harvesting systems
   b) Effectively using the data
   c) Demonstrating tangible value of technology to motivate uptake
   d) Broadening the scope of what can be measured
   e) Calibration
   f) Deciding on best/most appropriate technology for an operation
   g) Human capital and skillset
   h) Making technology simple
   i) Legislation for use of UAVs

4. What Can Be Done To Improve Adoption
   a) Making strong and robust cases for industry to evaluate and adopt technology
   b) Incentives for adoption
   c) Evaluate technology on-farm
   d) Relationships between growers/millers/vendors must be strong
   e) Continual back-up and support from technology vendors

5. Knowledge Gaps
   a) More precise drying-off using precision technologies
   b) Evapotranspiration measurement for PA
   c) Accurate yield mapping

Precision Agriculture (Crop Monitoring):

1. Past Accomplishments
   a) Growers have benefited economically
   b) Better interpretation tools are available
   c) Access to satellites, UAVs and remote sensors (MIR/NIR)
   d) Free Google Earth
   e) Improvement in GPS technologies
   f) Availability of technology for variable rate application
   g) Improvements in soil sampling/tests for mapping
   h) Increased access to web-based data

2. Past Challenges
   a) Too much data
   b) Interpretation and calibration of data
   c) On-time data from sensors/satellites/UAVs is a challenge
   d) Technology is expensive
   e) Theft
   f) What is actually happening in the soil
   g) Challenge of cloud-cover for satellite imagery
   h) Trust between growers and vendors
   i) Capabilities and skillset required from growers
   j) Agriculture not always viewed in a positive light

3. Future Challenges
   a) Calibration of cane varieties
   b) Cost justification and cost effectiveness
   c) Overcoming ‘missing’ data
   d) Working with ‘Big data’
   e) Research keeping up with technology
   f) Green-cane harvesting – extra biomass – production constraints

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4. What Can Be Done To Improve Adoption
   a) Marked reduction in cost needed
   b) Improve accuracy and turn-around time
   c) Detection of biosecurity threats
   d) Yield estimations
   e) Centralised control
   f) Training and improved skill-sets
   g) Closer working relationships
   h) Project collaboration/resource sharing

Innovations for small-scale operations:

1. Past Accomplishments
   a) Development of small mechanical harvesters
   b) Subsidies from government
   c) Integrated cash-flow packages
   d) Extension attached to millers and involvement funds
   e) Co-operatives – allows adoption of technology due to critical mass
   f) Integrated pest management programs
   g) Solar-power pumps
   h) Relationships with extension/vendors/small-scale growers

2. Past Challenges
   a) Economies of scale
   b) Lack of financial business-based operations
   c) Lack of promotion
   d) Extension programs not sustained
   e) Sub-division of land
   f) Aging of grower groups
   g) Gender involvement?
   h) Removal of the status of the individual farmer
   i) Social challenge due to ‘haves and have-nots’

3. Future Challenges
   a) Economies of scale versus individual freedom
   b) How sustainable is a small-scale grower?
   c) Sub-division of land
   d) Sustainable innovations specific to the small-scale grower
   e) Urbanisation
   f) Aging group
   g) Small-scale growers being required to farm ‘commercially’
   h) Capacity building

4. What can be done to improve adoption?
   a) Understand the ideas of sustainable economies of scale
   b) Increased efficiency – identifying waste/loss and propose remedies
   c) Simple/effective/relevant and cost-effective technologies
   d) Integrated management options
   e) Create good interaction between small-scale growers, millers and innovators

Conclusions (Innovative farming systems, technologies and practices):

1. Past Accomplishments
SESSION 4: IMPROVING ADOPTION

Oral presentations

Three oral presentations were delivered within this session and were all related to some aspect of adoption.

Table 4. Summary of activities and topics presented and discussed in Session 4 (Improving Adoption) of the 2015 ISSCT Agricultural Engineering, Agronomy and Extension Workshop.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Presentations / topics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Van Heerden PRD. Chemical ripening of sugarcane – bridging the research, technology development and knowledge exchange continuum.</td>
</tr>
<tr>
<td></td>
<td>Norris C, Landers G, Norris S. Successful adoption of machine harvesting: managing the challenges.</td>
</tr>
<tr>
<td>Posters</td>
<td>No posters in this session</td>
</tr>
<tr>
<td>Break away discussions</td>
<td>Improving adoption of new technologies and better management practices (BMPs)</td>
</tr>
<tr>
<td>Report back</td>
<td>Summarising information generated from the break-away discussions: Prof Robert Gilbert</td>
</tr>
</tbody>
</table>

Jumman et al. (Table 4) delivered a paper that explained System Dynamics (SD) modelling as a means for framing, describing, understanding and communicating complex problems or processes. This approach aims to provide transparent identification of underlying assumptions and causes of complex problems and to enable solutions via appropriate debate. Irrigation scheduling is an example of a complex issue that is suited to this approach. Here Jumman et al. used the Pongola region in South Africa as the case study. The model suggested, for example, that when the importance of water management is elevated in the minds of growers, adoption is faster despite the presence of barriers to adoptions.

Van Heerden (Table 4) used chemical ripening of sugarcane to demonstrate ‘how an effective bi-directional continuum of knowledge flow between researcher and grower provides impetus to research and technology development, and also increases adoption of this crop management practice’. Despite the results of replicated scientifically-based field trials being presented to growers at meetings and workshops, on-farm demonstration trials involving partnerships of growers, extension providers and researchers are critical in ensuring effective bi-directional interaction. A summary of outcomes obtained through several of these partnerships was showcased. Evidence of increased adoption of chemical ripening was presented using the Mpumalanga irrigated sugarcane regions in South Africa as a case study.

Norris et al. (Table 4) explained that the proportion of the global sugarcane crop that is machine harvested in increasing annually due to several factors. Introduction by ‘parachuting in’ harvesters often results in immediate and longer-term yield losses and reduced cane quality. On the other hand, well planned and implemented mechanisation can lead to immediate
increases in value and long-term productivity gains due to reduced costs and improved soil quality. This presentation used several case studies from various international sugar industries to quantify impacts of sub-optimal mechanisation strategies. This was compared to situations where the compromises inherent to mechanised farming was well-managed.

**Break-out session**

In the break-out session the groups were asked to consider new technologies and how a designer or creator of an innovation will know if the product or process will be easy to use or adopt. The groups were made up researcher and development specialists (5 groups), extension specialists (2 groups) and technology users (2 groups).

**Report-back**

The following is a summary of some of the outcomes of the break-out session that were presented by Prof Robert Gilbert:

A list of key attributes that were identified by the various break-out groups as important for assessing the adoptability of an innovation is shown in Table 5. The research and development specialist, the extension specialist and the technology user groups all identified economics and ease of use as important factors. The groups were asked to consider specific BMPs and assess their adoptability according to the key attributes that they had identified earlier. A summary of some of the outcomes from the groups is presented in Table 6.

**Table 5. Summary of attributes identified by the various break-out groups as important for assessing the adoptability of an innovation.**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Research and development specialist groups n = 5</th>
<th>Extension specialist groups n = 2</th>
<th>Technology user groups n = 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economics</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Ease of use</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Ability to be trialled</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Sustainability</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Reduced risk</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Marketing</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Universality</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Longevity</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Regional relevance</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Industry driver</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Grower problem addressed</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Legislation</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Community Impact</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Participatory approach</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Table 6. Summary of the assessment of the ease of adoption of some BMPs through the process used at the workshop.**

<table>
<thead>
<tr>
<th>BMP</th>
<th>Ease of Adoption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertigation</td>
<td>Not easy to adopt due to technical skills required.</td>
</tr>
<tr>
<td>Green Manures</td>
<td>Not attractive where short-term losses not possible. We thought it was easy but now consider it more complex. Yes, finances clearly in favour.</td>
</tr>
<tr>
<td>Irrigation Scheduling</td>
<td>Lack of trust that it will work Easy to adopt, moving from inefficient to efficient system. Yes, for large scale growers.</td>
</tr>
</tbody>
</table>
SESSION 5: EXTENSION – APPROACHES AND SYSTEMS

Oral presentations

Three oral presentations were delivered within this session. They considered various aspects of extension/implementation.

Garcia-Garmendia and Jensen (Table 7) reported on the development of a novel tool for growers and advisors to identify and manage key constraints and limiting factors in sugarcane production in Australia. The framework is based on the Hazard Analysis and Critical Control Point (HACCP) system. It has been incorporated into a smartphone application and leads users through a six-step process. A number of case studies were presented with constraints such as harvesting, water availability, soil health, weeds, and pests and diseases used as the initial focus of the study. The framework results are used to estimate what productivity and profitability levels would be achieved if appropriate technologies were in place to monitor and control the most limiting productivity problems.

Naudé (Table 7) delivered a paper dealing with extension strategies and their impact on sugarcane production on the North Coast of the KwaZulu-Natal, South Africa. He identified the loss of productive capacity of sugarcane growing soils as a key factor in causing yield decline. Multiple stresses that could include soil acidification, macro and micronutrients deficiencies and loss of organic matter appear to be rendering crops more susceptible to pests such as the African sugarcane borer (Eldana saccharina). The extension of BMPs aimed at addressing these issues has been found to be more successful with younger growers. Testimonials from growers detailing higher yields and better economic returns are accelerating the adoption of BMPs throughout the region.

A strong link between appropriate R&D, effective technology transfer and stringent pest and disease control is essential in improving sustainable crop production [Adendorff (Table 7). The Pongola sugarcane producing area in South Africa, was used as an example where extension support and pest and disease services had ceased. Adendorff (Table 7) described the redevelopment of an extension/pest and disease control service (based on traditional extension methods and on-farm demonstration trials) from 2009 onward. It aimed at adoption of BMPs (grouped as short, medium and long term) and supported by input from researchers. This, together with other socio-economic dynamics has resulted in an improvement in the average yield of between 13-20% within 4 seasons.

<p>| Table 7. Summary of activities and topics presented and discussed in Session 5 (Extension – Approaches and Systems) of the 2015 ISSCT Agricultural Engineering, Agronomy and Extension Workshop. |</p>
<table>
<thead>
<tr>
<th>Activity</th>
<th>Presentations / topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral presentations</td>
<td>Garcia-Garmendia A, Jensen TA. An innovative framework to implement precision technologies</td>
</tr>
<tr>
<td></td>
<td>Naudé AC. Targeted extension and better management practices in the South African sugar industry</td>
</tr>
<tr>
<td></td>
<td>Adendorff MW. Re-establishing extension and pest and disease control services at Pongola.</td>
</tr>
<tr>
<td>Poster</td>
<td>Nkala J, Chonco B, Mngadi J. Review of a successful land reform beneficiary project resulting from coordinated service delivery within the South African sugar industry</td>
</tr>
<tr>
<td>Discussion session</td>
<td>Led by Rowan Stranack</td>
</tr>
</tbody>
</table>

Discussion session

All delegates were included in a general discussion period facilitated by Mr Rowan Stranack. The following questions formed the basis of robust discussion amongst the larger group:

1. What is extension?
2. Is there a need for extension?
3. What is the ‘state of health’ of extension?
4. What factors lead to success?
5. What are the attributes of a good extension officer?
SESSION 6 FEEDBACK AND CLOSING SESSION

Feedback presentations from the working group discussions (as detailed in the previous sections) were delivered during this session.

As this was a combined Section Workshop (Agronomy and Agricultural Engineering) two Early Career Awards were presented for best presentations/posters by a senior author < 35 years old. The Agronomy Award was presented to BNN Nxumalo (SASRI) for the poster entitled ‘Differential yield responses to mulching in three sugarcane regions in South Africa’ and accepted in his absence by Dr Sanesh Ramburan (the co-author). The Engineering Award went to DN Boote (Bosch Stemele (Pty) Ltd) for the poster entitled ‘The development and application of an energy calculator for sugarcane production’. The co-authors were JC Smithers, A Jumman and PWL Lyne. A letter and certificate were sent to the recipient by the ISSCT Secretariat after the Workshop. These award winners will compete with early career award winners from other ISSCT workshops for a sponsored trip to the next appropriate workshop.

Mr Kitt Choonhawong, Thailand Society of Sugar Cane Technologists and Congress Chairman of the 29th ISSCT Congress in Chiang Mai, delivered a PowerPoint presentation highlighting the planned features of the 2016 Congress in Thailand.

Two bids, from Vietnam and Réunion, were made for hosting the next Agronomy, Agricultural Engineering and Extension Workshop (presumably in 2018). A final decision will be made and communicated after the ISSCT Congress in Thailand.

Prof Robert Gilbert, in his capacity as the Chair of the ISSCT Technical Program Committee, commented on the high standard of the workshop and the oral and poster presentations. He expressed sincere thanks to Dr Rianto Van Antwerpen and the local Organising Committee for rising to the challenge posed at the previous Agronomy and Agricultural Engineering Workshop, ie to provide a more interactive workshop on themes of interest to the delegates and the sugar industries they represent.

Prof Bernard Schroeder, as ISSCT Agricultural Commissioner, thanked the local organisers for their hospitality and organising a well-run and interesting Workshop. He thanked the delegates for making time to attend the workshop, for their input and their enthusiastic participation. He declared the 2015 ISSCT Agricultural Engineering, Agronomy and Extension Workshop closed - ‘Nkosisikele! ’Afrika’.

Solutions durables aux contraintes de production - un rapport sur l'atelier de travail 2015 de l'ISSCT en génie agricole, de l'agronomie et de la vulgarisation


Mots-clés: Canne à sucre, agronomie, génie agricole, vulgarisation, atelier, Afrique du Sud

Soluciones sostenibles a los limitantes de la producción – un informe del 2015 ISSCT Taller de Agronomía e Ingeniería Agrícola

Resumen. El Taller de Agronomía e Ingeniería Agrícola de la Sociedad Internacional de Técnicos de la Caña de Azúcar (ISSCT por sus siglas en inglés) tuvo lugar en Salt Rock, al norte de Durban, Sudáfrica desde el 24 al 28 de agosto del 2015. El tema del Taller fue Soluciones Sostenibles a los Limitantes de la Producción. El objeto de este artículo es aportar un registro del Taller, un resumen de todos los artículos
y pósteres que fueron presentados y discusiones de temas específicos. El taller duró cinco días y consistió en cinco sesiones de trabajo, dos excursiones de campo y una sesión de resumen y conclusión. Las sesiones de trabajo tuvieron temas distintos: Producción Sostenible de Caña de Azúcar, Caña de Azúcar para Energía, Sistemas y Tecnologías Innovadoras, Mejorando la Adopción, y Extensión – Estrategias y Sistemas. Un total de 131 delegados de 25 países asistieron el taller con un total de 16 presentaciones orales y 31 pósteres. Una característica importante del taller fueron las sesiones divididas que permitieron interactuar a los delegados y debatir diversos temas en grupos reducidos. Las conclusiones de estas sesiones fueron recopiladas y resumidas para tener en cuenta en el futuro. Como en el pasado, se otorgaron premios para la mejor presentación o póster por un autor de carrera temprana menor de 35 años. Antes del cierre de las actas se identificaron posibles localizaciones para el próximo Taller de Agronomía e Ingeniería Agrícola.

**Palabras clave:** Caña de azúcar, agronomía, ingeniería agrícola, extensión, taller, Sudáfrica