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Program and Abstracts

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Conference Program

AUSTRALIAN SOCIETY OF SUGAR CANE TECHNOLOGISTS



44th Annual Conference Working Together, Growing Together

Cairns Convention Centre
Tuesday 18th April - Friday 21st April 2023

ASSCT acknowledges the following:

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TIME	TUESDAY 18 TH APRIL 2023
07:30-13:30	AG field day at Meringa SRA Station
13:00-17:00	Kent - Asset Reliability Workshop
18:30	Welcome Drinks

WEDNESDAY 19 TH APRIL 2023			
TIME	AUDITORIUM		
09:00-10:30	Opening Session Industry Roadmap and Panel Q&A Guest speaker: Dr. Robert Speight, Director, Advanced Engineering Biology Future Science Platform		
10:30-11:00	Break		
11:00-11:30	Sugarcane bagasse pyrolysis for green energy production - Douglas, et al		
11:30-12:00	Diversification done differently: Feedback from the ISSCT Co-products Commission - Lavarack		
12:00-12:30	Development of the decision- support tool ‘Harvest Mate’: agronomic algorithms - Patane, et al		
12:30-13:30	Lunch		
	AUDITORIUM	M5/6	M7/8
13:30-14:00	Development of the decision - support tool ‘Harvest Mate’: economic calculations - Nothard, et al		Negligible interplot competition of cane yield in four-row plots - Natarajan, et al

14:00-14:30	Determining extraneous matter and billet length in sugarcane supplies using machine learning - Denman, et al	Supplier's Case Study: 10 minutes each for presentation and discussion <ul style="list-style-type: none">An alternative evaporator technology for first and second effects - Rosettenstein, et alKelly's Australia – Boiler Tube CleanerSRI - Australian Sugar Industry Training website courses now and into the future – KingNHP - Motor starting in a modern world – PiltABB Australia - Optimisation of drive technologies in sugar production - Schouw	Validation of using EC mapping to account for site variability in the early stages of selection in the Sugar Research Australia breeding program - Wei, et al
14:30-15:00	Modelling the harvester's front end to reduce billet and stool damage - Plaza, et al		Characterising the potential association of invertebrates with Yellow Canopy Syndrome of sugarcane - Xu, et al.
15:00-15:30	Break		
15:30-16:00	Feed forward control of mill chute level - Kent, Atkins	Use of mill by-products in the fallow in sugarcane production in Australia - Larsen, et al	Identification and implementation of markers for smut resistance in sugarcane breeding - Aitken, et al
16:00-16:30	Modelling the sugarcane crushing process with the software ABAQUS and LS-DYNA - Craw, Engler, Plaza	Macronutrient accumulation and partitioning in sugarcane biomass grown in the Burdekin region - Connellan	Decrypting the sugarcane genome architecture for pre-breeding applications - Piperidis
16:30-17:00	An improved model of pol extraction for mills and diffusers - Thaval, Kent	Micronutrient accumulation and partitioning in sugarcane biomass grown in the Burdekin - Connellan	Highlights from the new varieties - Piperidis, et al
17:30-18:30	Happy Hour		

THURSDAY 20th APRIL 2023			
TIME	AUDITORIUM	M5/6	M7/8
08:00-08:30	24–32 tonne Canefield locomotive final drive improvement - Santarossa, Dutta	Increasing our understanding of supersaturation and the use of massecuite dry substance in pan control – parts 1, 2 and 3 - Broadfoot, Fraga	Local Expert Analysis (LEA): An objective approach to identifying constraints and opportunities - Magarey et al
08:30-09:00	24–32 tonne Canefield locomotive reversing box improvement - Santarossa, Dutta		Tully growers refine the SIX EASY STEPS® Toolbox guidance for their late-season ratoons and a final-ratoon crop - Skocaj, et al
09:00-09:30	Sugarcane-locomotive control-system upgrade - Safer, Cheaper, Simpler - West	At-line purity measurement system – Moller	Reviewing the results of soil tests identifies opportunities to improve nutrient management in the Wet Tropics - Skocaj
09:30-10:00	24–32 tonne Canefield locomotive design - Santarossa, Smith, Titmarsh	Performance of the SRI Radial Design Evaporator in the final-effect position at Victoria Mill - Gilberd, et al	Learnings from the Hinchinbrook Community Feral Pig Management Program - Di Bella, et al
10:00-10:30	Break		
10:30-11:00	Posters: 5 minutes each for presentation and discussion <ul style="list-style-type: none"> Marian Mill treatment ponds and wetland - Stuart, Kuskopf Alkalinity generation from cation - exchange water softening for boiler feedwater at Wilmar's Inkermann Mill – Campbell Impact of lime saccharate addition to mud filter feed on mud loss and station retention - Richter, Norton Milling-train performance dashboard – Campbell 	Posters: 5 minutes each for presentation and discussion <ul style="list-style-type: none"> i-RAT: a tool to facilitate discussion between irrigators and advisors on increasing profitability and sustainability - Collins, et al Economic impacts of introducing rotational legume harvested crops into a sugarcane farming system: results from the Burdekin fallow-management trial - Connolly, et al 	

11:00-11:30	<ul style="list-style-type: none"> Comparing install methodologies for pans and evaporators - Bonassi Investigating diversion strategies for B molasses to improve sugar recovery - Mitchell Optimising bagasse diffuser juice application – Rains Transition to site-produced panstage graining slurry – Copnell INV SWP Roller Arcing Effectiveness – De Bella 	<ul style="list-style-type: none"> Effect of liquid calcium application on sugarcane yield in a fifth-ratoon crop in the Herbert River district - Park, et al Adjusting plant-cane nitrogen rates following legume cover crops in the Murray district - Rincon, et al SugarPath: a novel handheld diagnostic device for on-farm spatial and temporal pathogen surveillance - Strachan, et al Beyond the conventional method for nucleic acid isolation and quantification for detection of sugarcane pathogens - Chakraborty, et al Revisiting variety ratings for ratoon stunting disease - Ngo, et al Exotic moth borers – preparing for any incursion - Powell, et al Seasonal population dynamics and comparative trapping of above-ground invertebrate pests in Australian sugarcane – Powell Solving the mystery of yellow canopy syndrome in sugarcane - are invertebrates the missing link? - Powell, Xu <p>Supplier's Case Study: 10 minutes each for presentation and discussion</p> <ul style="list-style-type: none"> Stoller and Sugar Cane plant root development – Stoller 	
11:30-12:00			
12:00-12:30	Manufacturing section meeting	Agriculture section meeting	
12:30-13:30	Lunch and Viewing Posters		
13:30-14:00	On-line monitoring of C seed graining using the ITECA Crystobserver to improve pan-stage performance - Selby, et al	Early detection of sugarcane diseases through hyperspectral imaging and deep learning - Bao, et al	Effects of farming practices on end-of-paddock run-off water quality in the Central region - Schembri, Fillols
14:00-14:30	Development, analysis and testing of a dimple tube to improve vacuum-pan performance - Rosettenstein, et al	SugarPATH: a handheld device for advancing sugarcane disease diagnostics - Shiddiky, et al	Potential of sugarcane farming systems in the Lower Burdekin to sequester soil carbon - Power, et al
14:30-15:00	Use of a Neltec purge sensor to improve the efficiency of batch centrifugal operation - Broadfoot, et al	A step-change in disease diagnosis: pathogen detection in cane delivered to the sugar factory - Magarey, et al	Profitability and environmental implications of innovative practice changes and irrigation improvements - Connolly, Renouf, Nothard, Milbank, Poggio
15:00-15:30	Break		
15:30-16:00	When it is not so hot in a boiler – Mann	Comparing RSD screening methods for sugarcane and the real costs of diagnosis - Di Bella, et al	Upgrading the Farm Economic Analysis Tool (FEAT): a decision-support tool to assess farming options - Millbank, et al
16:00-16:30	Towards improving airheater design to minimise corrosion: modelling of a single tube - Ralph, et al	A rapid method of screening sugarcane clones for resistance to red rot - Bhuiyan, et al	Effect of application timing of nitrogen fertiliser on sugarcane crop performance and NUE - Salter, Kok
16:30-17:30	Annual General Meeting		
18:30-22:00	Gala Dinner [Pullman Cairns International Hotel]		

Venue Legends:

AUDITORIUM

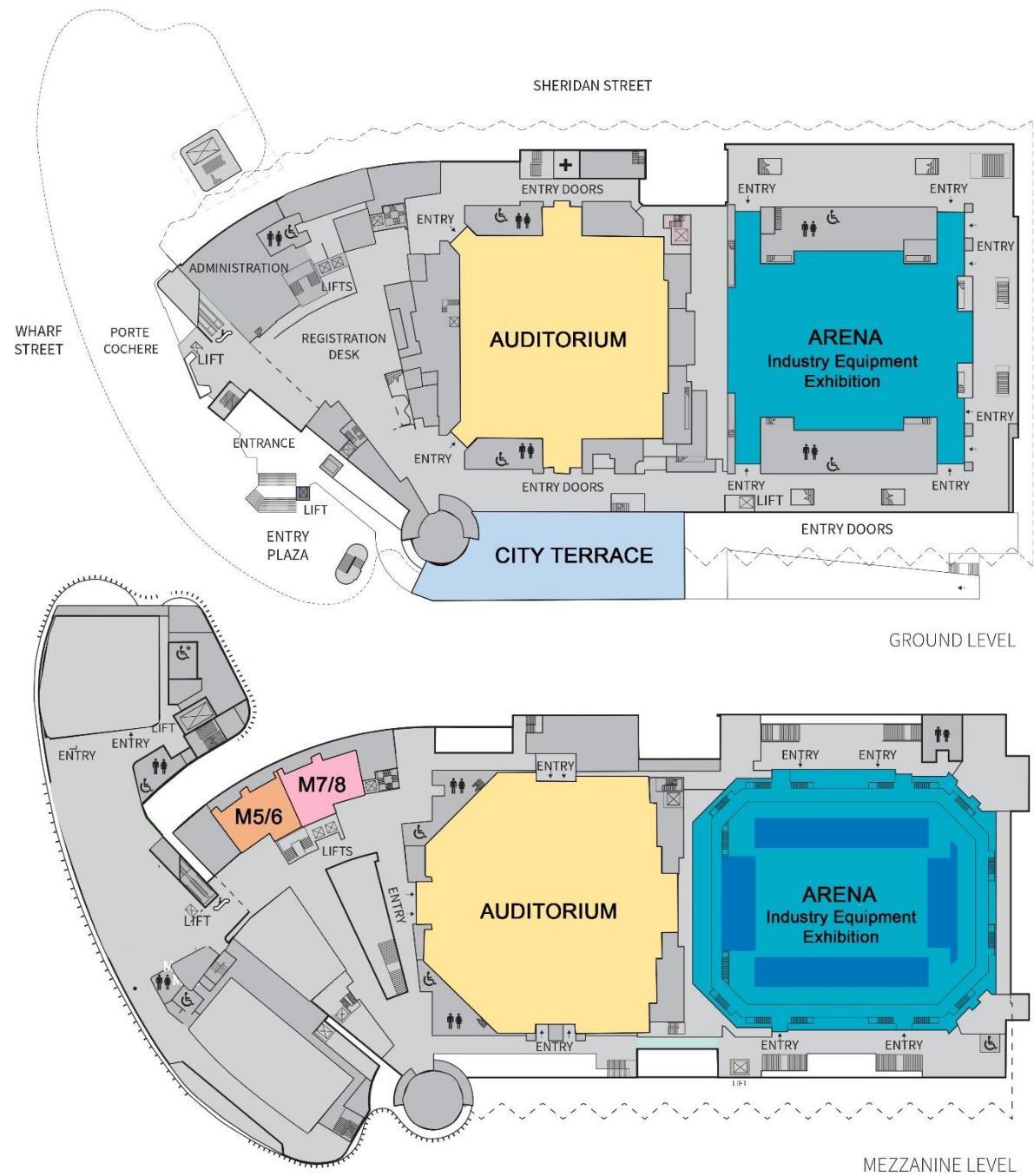
M5/6

M7/8

CITY TERRACE

ARENA

Note: Each activity is coloured according to the venue in which they are being held.



Aitken, et al.

Identification and implementation of markers for smut resistance in sugarcane breeding

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Sugar Research Australia Limited: ²Indooroopilly; ³Woodford; ⁴Mackay; ⁵Meringa

Sugarcane smut is arguably the most important sugarcane disease. It is present worldwide, complex and, despite extensive study, it is still little understood. Caused by the fungus *Sporisorium scitamineum*, in a severe epidemic combined with either a susceptible or intermediate variety up to 62% yield loss can occur. Recent studies have shown that resistance is controlled by two major mechanisms, an external resistance probably due to the thickness of bud scale and an internal resistance due to a cascade or defence mechanism that includes the induction of *R* genes, anti-microbial compounds and increase in lignin at point of pathogen entry. Understanding what triggers this cascade of defence mechanisms and determining how we harness its power to generate resistance in a variety has been a major study area worldwide. The development of the Affymetrix Axiom sugarcane SNP array has enabled whole-genome searches to identify smut resistance regions that can be interrogated for useful markers which can then be implemented into the sugarcane breeding program for selection for resistance. The methods used to date to identify these resistant and susceptible regions of the genome and how we are working to identify the most efficient method to incorporate them into the Australian breeding program are discussed.

Bao, et al.

Early detection of sugarcane diseases through hyperspectral imaging and deep learning

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Early detection of sugarcane diseases is essential for the development of management strategies. Disease detection and monitoring in sugarcane rely heavily on visual inspection, which can be expensive and subjective. Many diseases can show symptoms only later in disease development, with the initial infection invisible to the naked eye. These challenges motivated us to explore technologies based on hyperspectral imaging and deep learning for detection of sugarcane diseases. Key steps included trial preparation, hyperspectral image dataset construction, hyperspectral image pre-processing, deep-learning model development, and validation of the effectiveness of the developed technology. Outcomes suggest that the proposed technology is promising for the detection of sugarcane smut and mosaic diseases, in some cases earlier than visual symptoms emerge. Diseases can be detected with high accuracy as early as 8 weeks after inoculation for smut and 2 weeks after inoculation for mosaic, before the symptoms become visible in week 10 and week 8 for smut and mosaic, respectively.

Bhuiyan, et al.

A rapid method of screening sugarcane clones for resistance to red rot

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Red rot, caused by the fungus *Colletotrichum falcatum*, is an important sugarcane disease. It is the most damaging disease in some South Asian countries causing significant yield and crop losses. In the Sugar Research Australia (SRA) variety-development program, advanced clones in the final stage of selection are screened for resistance to red rot before being released for commercial production. The conventional method of red rot rating in the field using 12-month-old mature cane is time-consuming, labour-intensive and is impacted by the weather and crop lodging. A rapid method of screening for resistance to red rot was

developed (two-eye-setts method) and compared to historical ratings obtained from a conventional method. In addition, two other methods, controlled condition testing (CCT), a method used in India, and a leaf midrib inoculation method were tested. In the two-eye-setts method, six clones with known ratings were inoculated with red rot culture through holes made in the middle of the two-eye-setts and incubated at 30°C and 90% relative humidity for 2 weeks. Inoculated setts were split longitudinally and visually assessed for symptoms using standard disease indices and photographed. The images were analysed using the machine-learning algorithm Classification and Regression Tree to estimate the percentage of symptomatic pixels as image cover. Symptom expression was poor in the setts inoculated using the CCT method. The leaf midrib method showed no differences among the inoculated leaves. The two-eye-setts method produced excellent symptoms in all inoculated setts, and visual indices of disease showed strong correlation ($r=0.99$) with the historical ratings of clones. Image cover correlated strongly with disease indices ($r=0.93$) and historical red rot rating ($r=0.88$). The two-eye-setts method along with image analysis can substantially shorten the time required for screening for red rot s from over a year to about 3weeks. This approach will be implemented to screen for resistance to red rot in the SRA variety-development program.

Broadfoot, Fraga

Increasing our understanding of supersaturation and the use of massecuite dry substance in pan control – part 1

R Broadfoot and G Fraga

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Australian sugar factories currently use massecuite conductivity to control the feed rate of syrup and molasses to pans. The system works well but does not provide a signal that describes either the mother molasses supersaturation or the crystal content that are the key variables for control of crystallisation. The signal is a combination of these two parameters, but its value is also strongly affected by other factors, notably the conductance of the impurities, which changes with variations in the cane supply and with some processing operations. In practice, the pan stage operators must closely monitor the massecuite condition and, when needed in order to maintain appropriate massecuite conditions, change the conductivity set points. Substantial gains in pan stage productivity could be achieved if independent measurements (or reliable estimations) of supersaturation and crystal content could be made. Currently, neither of these parameters are able to be measured directly. The use of available correlations to define suitable operating ranges for supersaturation that would achieve fast crystal growth rates but avoid fine grain formation is investigated. Correlations for the mother molasses dry substance are proposed for the run-up and pan drop operations for the range of boiling duties. The measurement of massecuite dry substance using microwave technology is being increasingly adopted in overseas factories and refineries, and the suitability of this measurement for pan control in Australian factories is investigated. The paper provides data for a further two parts to this investigation - Part 2 progresses the investigation into the use of massecuite dry substance measurement for pan control, and Part 3 examines the profiles for massecuite dry substance for the various pan boiling duties. Comparison is made in Part 3 to the conventional use of conductivity for pan control. The overall aim of this three-part study is to provide a foundation for improved methods for controlling pan boiling operations in Australian factories.

Broadfoot, Fraga

Increasing our understanding of supersaturation and the use of massecuite dry substance in pan control – part 2

R Broadfoot and G Fraga

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Part 1 of this study calculated the supersaturation and mother molasses dry substance for a range of operations typically experienced during the run-up and heavy-up phases of the boiling of high-grade seed massecuite, and A, B and C massecuites. Correlations for the solubility of pure sucrose, solubility coefficient for cane syrups and molasses, and boiling point elevation were used. Further investigations are undertaken to understand the operating range for mother molasses dry substance in the growth zone between near zero growth rates and high growth rates, where nucleation is likely to occur. In addition, the sensitivities of

the supersaturation of the mother molasses to rapid changes in the head-space pressure and to changes in the sucrose solubility as a result of a change in the RS/ash ratio are examined. The investigations are extended to include using massecuite dry substance for the control of the run-up and heavy-up phases for the various pan boiling duties. These data provide suitable operating ranges for massecuite dry substance transducers, such as microwave transducers. The results from this paper are applied in Part 3 of this study, where the profiles for massecuite dry substance are examined for the various pan boiling duties undertaken in the three massecuite flowscheme adopted by Australian factories.

Broadfoot, Fraga

Increasing our understanding of supersaturation and the use of massecuite dry substance in pan control – part 3

R Broadfoot and G Fraga

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Australian factories use, almost exclusively, the measurement of massecuite conductivity to regulate the feed of syrup/molasses to batch and continuous pans. In recent years, the dry substance of massecuite as measured by microwave transducers is being used increasingly in overseas factories. Following investigations into the supersaturation levels typically experienced in the various boiling duties in Australian factories, the profiles of massecuite dry substance values have been determined during run-up and heavy-up prior to pan drop. As for the use of massecuite conductivity, the massecuite dry substance must be regulated tightly through all stages of the pan cycle to achieve fast enough crystal growth rates to suit the required production rate, but not so high as to form nucleation (fine grain). This paper examines the profiles of massecuite dry substance in typical high-grade seed, A, B and C massecuite boilings, C seed production, magma preparation and fine-grain washing. Comparison is made between the use of conductivity and massecuite dry substance as the process variable for the control of the feeding rate of syrup/molasses.

Broadfoot, et al.

Use of a Neltec purge sensor to improve the efficiency of batch centrifugal operation

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A purge sensor (Neltec, Denmark) was fitted to the outside of the casing of a batch centrifugal to measure the impact of the molasses/wash water on the casing. This signal correlates with the flow of molasses/wash water leaving the basket. A comprehensive series of investigations was undertaken with B massecuites to understand the response of the sensor to a wide range of settings of the centrifugal parameters. The test program demonstrated that the signal from the purge sensor is highly reproducible for the same test conditions and the response aligns very well with observations in the centrifugal, e.g. the intensity of the purge signal rises rapidly at the same time as the colour of the face of the crystal bed lightens. Analysis of the logged data has shown that the signal can be used by fugal operators to select the optimum time to commence the wash water application. The purging qualities of the massecuite can also be determined from the purge signal. A shorter series of investigations was undertaken with A massecuites on a different centrifugal and those tests confirmed the observations with B massecuites. As expected, for A massecuites the purge of molasses occurs at a lower basket speed than for B massecuites and the response of the purge signal has different characteristics.

Connellan

Macronutrient accumulation and partitioning in sugarcane biomass grown in the Burdekin region

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Developing an understanding of how nutrients accumulate and partition in sugarcane is important for fine-tuning fertiliser recommendations to improve nutrient-use efficiency in a profitable, productive and ecologically sustainable farming system. The commercial sugarcane varieties Q253[®], Q208[®] and KQ228[®], which are grown in the Burdekin, were sampled several times throughout the growing season to study the accumulation of the macronutrients nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca) and magnesium (Mg) in above- and below-ground biomass. In sugarcane, the accumulation of macronutrients in above-ground biomass peaked by 270 days after planting (DAP). The concentration of these nutrients was monitored from 200 to 365 DAP and showed a general decline in all components from 200 DAP onwards. Sugarcane exhibited three distinct phases of growth, the first being a lag phase, followed by a period of rapid development, and a final phase of sucrose accumulation. A positive relationship between stalk dry matter yield and macronutrient accumulation in above-ground biomass was identified. Below-ground biomass which included roots and stool of Q208 was monitored at 200 and 365 DAP. The concentration of all macronutrients except N remained unchanged or declined over this period. In contrast, N concentration during this period increased significantly. Surface trash biomass for Q253, Q208 and KQ228 was sampled at 365 DAP with macronutrient accumulation compared across the three varieties. Due to the free-trashing characteristics of Q208 it produced considerably more surface trash compared to Q253 and KQ228, consequently this variety accumulated considerably more macronutrients in surface trash. These data provide insights into the key periods of macronutrient uptake and their partitioning in above- and below-ground biomass during sugarcane development.

Connellan

Micronutrient accumulation and partitioning in sugarcane biomass grown in the Burdekin

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For sugarcane to achieve maximum cane and sugar yield nutrients need to be readily available for the plant to accumulate. Although required in small quantities, micronutrient availability is essential for this to be achieved. Understanding how micronutrients are accumulated and partitioned is important for fine-tuning fertiliser recommendations to improve nutrient-use efficiency whilst maintaining profitable, productive and sustainable farming systems. The commercial sugarcane varieties Q253[®], Q208[®] and KQ228[®], which are grown in the Burdekin, were sampled several times throughout the growing season to study the accumulation of the micronutrients iron (Fe), zinc (Zn), copper (Cu) and manganese (Mn) in above-ground biomass. In sugarcane, the accumulation of micronutrients appeared to peak by 270 days after planting (DAP). The concentration of these nutrients was monitored from 200 to 365 DAP and showed a general decline in all components from 200 DAP onwards, but this was not always the case. The accumulation of micronutrients followed dry-matter accumulation, but it was also influenced by micronutrient concentration at the time of sampling. A positive relationship between stalk dry-matter yield and micronutrient accumulation in above-ground biomass was identified. The data provide insights into the key periods of micronutrient uptake and their partitioning in above-ground biomass during sugarcane development.

Connolly, et al.

Profitability and environmental implications of innovative practice changes and irrigation improvements

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The economic and environmental benefits of practice changes and irrigation improvements are explored based on three grower case studies in the Bundaberg, Burdekin and Mackay regions that consider grower investments in best management practices, including irrigation changes. How the practice changes influenced farm economic and environmental performance are determined. Economic, biophysical and farm management data before and after the changes were used to calculate the economic benefit (Annualised Equivalent Benefit) with the Farm Economic Cane Analysis (FEAT) tool and an investment analysis. The economic benefit was positive for all farms, ranging from \$29 to \$377 per hectare per year. The same data were used to calculate indicators of environmental performance (per tonne of harvested cane) using the Cane Life Cycle Assessment (CaneLCA) tool. There were reductions in fossil-fuel use, greenhouse-gas emissions, and a potential for water pollution curtailment. For the Bundaberg case, a transition from furrow to low-pressure boom irrigation increased electricity use, which was offset by energy savings from other aspects of the production system changes. For the Burdekin case, improved water-use efficiency, on a farm with permeable soils, resulted in less electricity use and greenhouse gas emissions. For the Mackay case, improved utilisation of water allocation increased cane productivity and contributed to improved economic and eco-efficiency outcomes. While total water use increased, it is noted that water availability is not a constraint for the Mackay region outside of drought impacts. The Mackay case also involved a supplementary analysis of solar energy use. Overall, the case studies showed that the suites of irrigation improvements and practice changes resulted in both economic and eco-efficiency benefits.

Craw, et al.

Modelling the sugarcane crushing process with the software ABAQUS and LS-DYNA

H Craw, O Engler and F Plaza

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Current milling technologies such as four- and six-roller units will remain the main components of milling stations for the foreseeable future. Better understanding the milling process is likely to result in modifications that improve performance such as for dewatering. Previous investigations concluded that the mechanical compression, shear and volume behaviour of prepared cane and bagasse followed the behaviour detailed in soil mechanics, while fluid flow through the porous biomass follows Darcy's law. Similarly, it was previously identified that a finite element modelling software LS-DYNA had most or all of the capabilities to model cane crushing in a milling unit, including mechanical and flow models, contact with non-deformable surfaces and automatic re-meshing in the same simulation. This paper provides detail of progress in the modelling of cane crushing using two software packages, ABAQUS and LS-DYNA.

Denman, et al.

Determining extraneous matter and billet length in sugarcane supplies using machine learning

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In Australian sugar factories the physical properties of the cane supply are currently not measured prior to processing through the factory (except for some cane consignments at Tully Mill) and thus parameters such as extraneous matter (EM) content and billet lengths are not routinely monitored. This project has used computer-vision and machine-learning methodologies to investigate the feasibility of measuring on-line EM% cane and billet length for each cane consignment entering the factory. A camera and lighting rig were installed above the cane conveyor belt operating between the tippler and shredder at Tully Mill, and computer facilities were installed to allow captured images for each consignment of cane to be analysed using machine-learning models. Tully staff undertook manual sorting and weighing of grabs of cane to provide the mass percentage of stools, tops, billets, and trash. Randomly selected billets removed from the grab samples were photographed on a graduated board to provide estimates of billet length. These data provide the reference data for development of the models. Investigations have shown that the models based on the Tully data provide an acceptable level of accuracy for EM% cane and billet length. The investigations need to be extended to include datasets from other mill districts to determine if universal models can be developed for implementation by the industry.

Di Bella, et al.

Comparing RSD screening methods for sugarcane and the real costs of diagnosis

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Ratoon stunting disease (RSD) is caused by the bacterium *Leifsonia xyli* subsp. *xyli*. The disease causes significant yield losses in sugarcane crops (*Saccharum* hybrids) throughout the world. We assessed three diagnostic techniques for detecting RSD in fields in the Herbert sugarcane region in 2022: qPCR on leaf sheath biopsy samples (LSB-qPCR); qPCR on expressed xylem sap; and phase-contrast microscopy (PCM) on expressed xylem sap. The LSB-qPCR leaf sheath biopsy is taken from the lowest green leaf sheath of the plant. Differences among techniques were compared for confirmation of the presence or lack of RSD detected, the time required to collect and process samples, the fee to undertake the sampling, safety considerations and transport costs. Differences were identified among the three sampling methods concerning RSD detection, costs incurred associated with sample collection, processing, and some safety related issues. LSB-qPCR was the most efficient and cost-effective diagnostic platform for RSD.

DiBella, et al.

Learnings from the Hinchinbrook Community Feral Pig Management Program

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⁴Bob Stewart's Agricultural Consultancy

The damage caused by feral pigs (*Sus scrofa*) in Wet Tropics cane growing regions can be significant, with losses in cane proceeds exceeding \$1M in certain years within the Herbert sugarcane region. The management of feral pigs is difficult due to the landscape in which the animals are found, the varying success of hunting, baiting, and trapping activities and the overall intelligence of the pest being managed. In 2009, Hinchinbrook Shire (in which the Herbert sugarcane region is located) community partners came together through a coordinated regional approach, while utilising science and management interventions

to control the pest animal. Approaches adopted by the group and the various management strategies utilised to manage feral pigs in the landscape of the Hinchinbrook Shire area are outlined.

Douglas, et al.

Sugarcane bagasse pyrolysis for green energy production

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Modern life depends on fossil fuels, an unrenowned resource, continually being depleted. As a result, developing viable alternatives is necessary. Pyrolysis, a thermochemical process using high temperatures to decompose organic matter in the absence of oxygen, has been highlighted as a possible solution. This study aimed to evaluate the effect of particle size, peak temperature and the addition of the Cu-SrO/ZSM-5 catalyst, on the quality of bio-oil produced from sugarcane bagasse feedstock. The bagasse was sieve-separated into four size classes: <425 µm, <600 µm, <2.36 mm, and Raw (unseparated). Each size fraction was evaluated for baseline physical and chemical properties, along with its applicability to pyrolytic bio-oil generation. Thermal gravimetric analysis (TGA) and scanning electron microscopy was performed on the bagasse feedstock to better understand its physical and thermal properties. TGA was used to understand the thermal decomposition of the sugarcane bagasse with and without catalyst influence, as well as to study the bagasse kinetic properties. Pyrolysis-gas chromatography-mass spectrometry (Py-GC/MS) was performed on catalytic and non-catalytic samples to evaluate the chemical product distribution. The quality of the bio-oil is based on maximising hydrocarbons and minimising the concentration of oxygenated compounds in the yield. Fibrous rind presents better quality bio-oil, and the inclusion of a catalyst greatly increases the concentration of hydrocarbons. The calorific value of the bio-oil was approximately 34.15 MJ.kg⁻¹ compared to 14.8 ±0.4 MJ.kg⁻¹ of the feedstock bagasse. Therefore, the energy density of the sugarcane bagasse was increased through application of pyrolytic decomposition. This study presents valuable implications on the Australian sugar industry, as a way to both increase the potential profit from bagasse assets, as well as to increase the domestic availability of liquid fuels.

Gilberd, et al.

Performance of the SRI Radial Design Evaporator in the final-effect position at Victoria Mill

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Victoria Mill installed a 4000 m² SRI-designed Robert evaporator in the final-effect position for the 2021 season. This evaporator is the first installation of this design in the final effect of the set. The design differs from the conventional Robert evaporators in the industry as it provides radial flow of both vapour and juice and has a large central downtake for the outflow of juice/syrup. Previous installations of the design have been in early evaporation stages, and these have provided improved separation of the inlet and outlet juice, and increased heat-transfer efficiency. Evaluation trials demonstrated favourable heat-transfer performance with the temperature difference across the evaporator being 3 to 4°C lower than that typically required by the conventional Robert evaporators, for the same heat-transfer rate. Modelling has shown that a conventional Robert evaporator would require one of the following changes in order to maintain the same crushing rate: (1) a 7% increase in installed heating surface area for the set; (2) an increase in exhaust pressure of 13 to 15 kPa and an increase in the process steam/cane by 0.6%; or (3) a reduction in added water to the milling train and to the mud filters of 19%. Increased pol losses in bagasse and mud cake would result, causing a reduction in sugar yield from the cane supply for the factory. The test program has determined that minor modifications to the juice outlet arrangements should be incorporated in future installations of the design.

Kent, Atkins

Feed forward control of mill chute level

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Mossman #5 mill suffers from highly variable feeding rate. The bagasse from #2 mill is transported by three intermediate carriers and two mill overflow chutes over the decommissioned #3 and #4 mills before getting to #5 mill. Although the #5 mill chute is relatively large, the chute level varies from 0% to 100% quite quickly, causing large variations in torque. The challenge of smoothing the bagasse flow into the mill is substantial and so efforts have been taken to improve mill control through a feed forward action. It has been observed that the preceding intermediate carrier motor current provides advance notice of chute level changes. When the motor current increases, the chute level subsequently rises, and vice versa. This characteristic has now been implemented into the Mossman #5 mill control system so that the mill speed starts to rise after the intermediate carrier motor current increases and before the chute level rises. This feed forward action provides a much more consistent chute level and more consistent mill torque.

Larsen, et al.

Use of mill by-products in the fallow in sugarcane production in Australia

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Mill by-products such as mud, ash and Mud/Ash mixtures are known to increase cane yields and sugar yields. Traditionally, Australian growers broadcast these by-products in the fallow at rates greater than 150 t/ha. However, growers are now banding by-products at less than 100 t/ha, with few guidelines on how to maximise their returns from this practice. Eight commercial size replicated, randomised strip trials were established in bare fallows between Ingham and Proserpine to investigate the impact of by-products banded between 35-100 t/ha and broadcast between 140-200 t/ha on cane yield, CCS and grower net revenue compared to standard grower fallow practices. The trials were harvested each year over the crop cycle using a commercial harvester. Tonnes of cane harvested and mill CCS provided by the receiving sugar mill were used to calculate tonnes cane per hectare and grower net revenue per hectare using the Australian cane payment method for each plot in a trial. The application of mud, Mud/Ash and ash increased cane yield with ash >= Mud/Ash >> mud. The greater the quantity of by-product applied, the greater the cane yield. Conversely, CCS decreased linearly with the quantity of mud, Mud/Ash, or ash applied. CCS was lowest in mud << Mud/Ash <= ash. Cumulative grower net revenue at the end of the crop cycle was greatest in ash > Mud/Ash >> mud and was greatest at application rates of 35-50 t/ha > 70-100 t/ha > 140-200 t/ha. Broadcasting mud at 200 t/ha resulted in the growers not recovering the cost of application. Banding by-products containing Mud/Ash and ash at 100 t/ha or less resulted in the grower recovering the cost of the product by the second or third ratoon. By-products applied at rates as low as 50 t/ha reduced CCS, and further research is needed to improve guidelines on nutrient and water management so that growers using these by-products can maximise their profitability.

Lavarack

Diversification done differently: feedback from the ISSCT Co-products Commission

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This paper reports on various learnings from the ISSCT Co-products papers presented at the 31st congress of ISSCT held in Hyderabad, India as well as the Co-products webinar held in July 2022. The webinar was held to replace the ISSCT Co-product workshop which was cancelled due to the COVID-19 pandemic. The focus of the presentations was on the optimal use of resources, including bagasse and sugarcane

agricultural residues (cane trash). The continued move to full-scale bioethanol production from biomass (second-generation ethanol) was noted in both the Brazilian and Indian industries. The adoption of first-generation ethanol for biofuel production in India is accelerating, with 9.8% blending achieved in 2022 and an ambitious target of 20% set for 2025. Innovations that are assisting in the development of the ethanol industries in India are discussed. The use of sugarcane agricultural residues (cane trash, SAR) is advancing, but high ash levels in SAR is limiting its use in boilers. Interesting developments in food products and the development of advanced fuels are reviewed.

Magarey, et al.

Local Expert Analysis (LEA): an objective approach to identifying constraints and opportunities

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Science is based on the objective analysis of data where conclusions need to be supported by the prevailing evidence. Scientists are thus trained to consider the facts and to draw sound conclusions. Those trained in specific disciplines use their skills-based experience to bring understanding to the issues being investigated. Some regions in the Australian sugarcane industry are suffering lower than expected productivity and profitability. A Local Expert Analysis (LEA) engaged SRA scientists from different disciplines and industry staff to analyse industry data in order to determine the reasons for the lower-than-expected productivity. Local industry organisations, farmers and millers, have contributed to the process by working collaboratively to identify both constraints and opportunities to improve both farm and Mill viability. The South Johnstone LEA has highlighted that several diseases, crop nutrition and other agronomic factors have been limiting yield. Opportunities identified include refined harvesting operations/sterilisation, optimised variety selection at the farm level and better data collection and analyses. Economic analyses and modelling will provide guidance on how both farmers and the miller can ensure future economic viability.

Magarey, et al.

A step-change in disease diagnosis: pathogen detection in cane delivered to the sugar factory

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Detection technologies for biological entities have been improving rapidly and this has introduced the possibility of pathogen detection beyond previous methods. Research shows that the ratoon stunting disease (RSD) bacterium (*Leifsonia xyli* subsp. *xyli*) can be detected in first-expressed juice at the sugar factory using a dipstick-mediated LAMP assay. This outcome provides the potential for mapping RSD in every harvested crop in a mill area on an annual basis – something never possible before. A summary of the research is provided and where the technology could lead with broader pathogen and pest detection is outlined.

Mann

When it is not so hot in a boiler

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In most cases sugar factories are energy self-sufficient even when they are not particularly energy efficient because combustion of the bagasse residue provides more than enough energy to support factory operations. This energy self-sufficiency during normal operations, made possible by the combustion of bagasse, is a significant competitive advantage for sugarcane factories. However, there are times when bagasse combustion does not occur under ideal conditions and there is a risk of incomplete combustion and the build-up of combustible gases that can lead to furnace gas pressure excursions and explosions. This paper reviews previous studies in this area and summarises calculations to predict what conditions are most likely to lead to adverse events.

Millbank, et al.

Upgrading the Farm Economic Analysis Tool (FEAT): a decision-support tool to assess farming options

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The sugarcane industry contributes \$4 billion in direct and indirect value to the Australian economy annually. Farm profitability is paramount to the sustainability of this industry, with individual farm businesses needing to adapt to changing market, environmental and regulatory conditions. Sugarcane growers have had limited access to user-friendly economic tools that can be tailored to their farm business and increase farm profit. The Farm Economic Analysis Tool (FEAT) was developed by the Department of Agriculture and Fisheries (DAF) in 2005 to assist sugarcane growers with decision making for improved farm profitability. This innovative tool was developed in Microsoft Excel® with the primary aim to compare the economic performance of different cane-farming systems by calculating gross margins, farm operating return and return on investment. Although this version was a powerful tool, major issues started to emerge with software compatibility, the ability to provide technical support and usability. A 2018 industry survey identified numerous issues relating to usability, accessibility and functionality of FEAT. A comprehensive review was undertaken, and a project was instigated to remedy the issues and reinvigorate the tool. The FEAT Online project was a 2-year collaboration led by DAF between 2018 to 2020. Key elements of project included the development of an online version, a collaborative research team, project reference group and training workshops. Major improvements included the ability to easily compare scenarios, streamlined data entry, an enhanced irrigation module, automated registration and live updates. Since the release of FEAT Online, 450 users have registered and 297 stakeholders have attended webinars and workshops across Queensland. Surveys were conducted on 78 workshop attendees and 93% rated the tool as very useful, with the majority planning to use the tool within a year for analysing farm profitability and production costs. Further extension of the tool is planned with the development of user support materials, peer-to-peer focus groups and updated regional example FEAT files.

Moller

At-line purity measurement system

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A prototype purity measurement system that can process syrup, and A, B and C molasses (all of the factory high-brix liquid streams) was developed, providing a purity estimation for a stream in less than 4 minutes per sample. This system can operate independently with a minimum of supervision or maintenance. The

system uses the previously published conductivity purity measurement system in an automated process. Trials of the system were undertaken at both Rocky Point and Millaquin Mills during the 2021 and 2022 crushing seasons. The results indicated that this system provides timely feedback to the operators to assist in the factory process control and fault finding, when used in conjunction with the analytical results from the laboratory.

Natarajan, et al.

Negligible interplot competition of cane yield in four-row plots

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Interplot competition confounds genotype performance and bias selections in small single-row plots. In the final stage of sugarcane selection, four-row wide by ten-meter-long plots are used on the basis that larger plots experience less interplot competition. However, only the middle two rows are evaluated in these trials and using borderless plots would be more resource efficient. The extent of interplot competition for cane yield in four-row plots was investigated in experiments in the Burdekin and Herbert regions under irrigated and rainfed conditions, respectively, with each experiment containing two replicates of 90 genotypes. Differences in cane yield between the middle two rows (TCH_m), representing non-competitive cane yield, and the outer two rows (TCH_o), subject to competition from nearby plots, were investigated. Competition was modelled using autoregressive models including genetic competition (GC) and genetic-residual competition models (GEC). Goodness of fit relative to a reference spatial model (AR1) and the correlation between estimated BLUPs were used to assess the effectiveness of the competition models. In both experiments, the interaction between genotype and weigh row had no effect on cane yield. There was a strong correlation between BLUPs of TCH_m and TCH_o in Burdekin ($r = 0.74$) and Herbert ($r = 0.87$). Genetic correlation between TCH_m and TCH_o was high ($r_g = 0.99$) in both experiments. Relative to TCH_m , TCH_o had inflated genetic and error variances; however, TCH_o had higher broad-sense heritability than TCH_m . The GC and GEC models did not improve accuracy when compared to the AR1 model. These indicate that interplot competition was modest for cane yield in four-row plots, even for TCH_o . Relative selection efficiency of TCH_o was equal to or greater than 1 in both experiments suggesting that unguarded plots are worth considering.

Nothard, et al.

Development of the decision-support tool 'Harvest Mate': economic calculations

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Improvements in sugarcane-harvesting practices remain critically important for productivity, profitability and sustainability gains in the Australian industry. The development of a decision-support tool to guide economically optimum harvester settings has the potential to add \$44 million to grower revenue. The online 'Harvest Mate' (HMate) tool was developed to reduce green sugarcane-harvesting losses and improve economic returns for growers. The 'Harvest Mate' tool includes the ability to set-up an online user profile for initial data capture that enables users to assess the most profitable harvester settings (e.g., flow rate and extractor fan speeds) infield. HMate can estimate harvesting cost changes and guide pre-season contract rate negotiations between the contractor and grower. The economic component of HMate incorporates both variable and fixed cost inputs, allowing the overall net benefit/loss to be determined for the grower. The highest net benefit output is defined as the most economically optimal harvester setting, accounting for the cost of harvesting and revenue achieved. HMate economic estimates show a high level of predictive accuracy for the cost/ha, cost/t and net benefit obtained when compared to actual detailed harvesting group costings. Slight differences were identified in the predicted cost/h results for HMate due to improvements in labour and fuel calculations. Information entered by users allows selection of the most profitable harvester settings for each unique situation that accounts for yield, CCS, and harvesting costs.

Patane, et al.

Development of the decision-support tool 'Harvest Mate': agronomic algorithms

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Changing cane-harvester primary-extractor fan speed and flow rate impacts tonnes of cane and sugar delivered to the mill and the cost of harvesting. Although past research shows a negative impact from high harvester flow rates and fan speeds on delivered cane yield, adoption rates of harvesting best practice (HBP) remain low. This despite the potential of HBP substantially increasing overall harvested sugarcane to the Australian industry without an increase in cane area. A key barrier to adoption is the challenge for growers and contractors to confidently determine the economic benefit or cost from adopting alternative harvesting practices over standard practices. One practical solution initiated and supported by industry is the development of a decision-support tool to assist harvesting groups in estimating both grower revenue and harvesting cost impacts. However, to determine revenue outputs, estimates of both yield and CCS are required. Given the extensive production data collected during the 2017-18 harvesting trials from project 'Adoption of practices to mitigate harvest losses', various algorithms were developed for a harvesting decision-support tool. These included estimates of yield, extraneous matter (utilised in CCS calculations) and billet diameter. There were also algorithms required to estimate changes in harvesting costs due to differences in fuel utilisation and bulk density. This paper examines the development of these algorithms and the functionality of Harvest Mate, a new tool that incorporates both agronomic and economic considerations to determine the most economically optimal harvester settings.

Piperidis, et al.

Highlights from the new varieties

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The SRA breeding program contributes to a more profitable and sustainable sugar industry through the continuous development of more productive and disease-resistant varieties. New varieties have been critical in reducing yield losses due to diseases and to help overcome the many disease outbreaks that have plagued the sugarcane industry. For a new variety to be released for commercial production, it must be better than the current commercial varieties for one or more productivity traits, have an acceptable level of resistance to the major diseases, and have no significant milling issues. Growers and millers expect on-going delivery of new varieties to make a significant contribution to increasing productivity and profitability and reduce the impacts of disease incursions. New varieties released during the decade after the smut incursion in 2006 have not been readily adopted by growers and failed to make a significant impact to the industry. However, some of the varieties released recently are being rapidly adopted by growers and show promise for becoming important varieties for the industry in the near future. We highlight the seed sales, early commercial results, productivity, and disease characteristics of some of the recently released varieties and compare them to the current suite of commercially grown varieties.

Piperidis

Decrypting the sugarcane genome architecture for pre-breeding applications

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Advances in sugarcane DNA sequence analysis and assembly have been major assets for the development of new methods in cytogenetics. An Oligo-FISH technique using whole-chromosome probes was developed to decrypt the genome architecture of pure species and cultivars of sugarcane. Results are described from whole-chromosome painting (WCP) combined with the use of three new oligo probes

designed to test our capacity to detect and track probes of different sizes and frequencies. The goal is to improve the efficiency and outcomes from cytogenetics research that support the SRA introgression breeding program. A set of retrotransposons (RT) repetitive-sequences that generate *S. spontaneum*-specific signals were converted into an oligo *S. spontaneum*-specific probe (RT-oligo) to characterise the species composition of SRA cultivars more accurately than with the previously used GISH method. Two gene-specific oligo probes for the alcohol dehydrogenase gene (*ADH*) and the gene responsible for brown rust resistance (*Bru1*) in sugarcane were designed. Whole-chromosome mapping, oligo-gene mapping and RT-oligo mapping were used to characterise the genomes of SRA elite/current varieties as well as introgression derivatives to establish a baseline database classifying chromosomal structure variations/chromosome patterns/genes inheritance across SRA cultivar germplasm. The next step is to characterise elite introgression clones and successive generations of introgression clones derived from the nematode-resistance research program. The characterisation of the genome structure of clones of multiple generations allows the study of chromosome transmission behaviour, to follow introgression regions/traits of interest, and to study transmission patterns. The aim is to improve fundamental understanding of trait transmission through generations which would maximise the chance to introgress required traits in preferred parents and make targeting breeding a closer reality.

Plaza, et al.

Modelling the harvester's front end to reduce billet and stool damage

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Increased harvesting speed has been carried out to provide the large increases in productivity required by the harvesting fleet to manage sugarcane-industry cost pressures. Whilst the power and processing throughput of the harvesters has been able to easily meet this requirement, the design of the 'front end' of the harvesters has undergone relatively little functional change since their initial development over 50 years ago. The harvesting interactions between the harvester's "front end" components and the cane plant and the resulting damage are seen to contribute to cane loss during harvesting, as well as being a contributor to poor ratoon performance often seen through the industry, impacting on ratoon cycle economics. Previous experimental investigations dated more than 25 years and recent experimental work have shown that there is a great deal of damage caused to the stalk and the stool by the current designs and operation of sugar cane harvesters. Due to the relatively small size of the Australian sugarcane industry, the manufacture of most new harvesters moved overseas, for example Brazil, where damage caused during harvesting has received little attention, and therefore little focus. Recent attempts have been made to understand and improve the interactions between harvester front-end components and the cane plant with respect to damage caused by the gathering, knockdown and base-cutting operations. As part of this work, a modelling tool using the Finite Element Modelling (FEM) software LS-DYNA was developed to assist in visualizing what happens during the gathering, bending and cutting processes at the front end of the harvester. The task was to predict deformations, stresses and forces in order to improve the design of the front of cane harvesters, in order to reduce stalk and stool damage and improve feeding and throughput. To aid in the modelling, a large number of cane parameter values were extracted from previous experimental data and are reported. In summary, the current paper provides information on improved modelling of the interactions of sugarcane with the front end of harvesters, in order to add further capability to existing calculations, visualize and hopefully facilitate adoption of improved designs.

Power, et al.

Potential of sugarcane farming systems in the Lower Burdekin to sequester soil carbon

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Carbon farming is the process of changing farming management to sequester atmospheric carbon in soil or plants or reducing carbon emissions from agriculture. The Australian and Queensland Governments have carbon farming initiatives such as the Queensland Land Restoration Fund and the Australian Government's Emissions Reduction Fund that are designed, in part, to promote or incentivise changes in farming practices to increase carbon sequestered in soils. These initiatives represent an opportunity for farmers to earn additional income and for income diversification. In this study, simulation modelling is used to predict changes in soil carbon due to changes in sugarcane management for a typical farm in the Lower Burdekin. It uses the sugarcane modelling framework developed for the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (P2R) which uses the Agricultural Production System sIMulator (APSIM) with inputs including a soil parameterised from the Queensland Government's Soil and Land Information (SALI) database, historical climate data and, sugarcane management elicited from workshops with local experts and from aggregated survey data collected for P2R. For a modelled farm, we estimate a carbon sequestration rate of 1.3 kg/ha/year for 25 years, reaching a maximum of 127 kg/ha after 70 years, which are generally consistent with recent published experiments, and with no significant effect on cane production. Using the most recent spot price for a tonne of atmospheric carbon abatement, this rate of sequestration has an economic value of \$18.50/ha/year, which does not include any cost incurred from changes in management.

Ralph, et al.

Towards improving airheater design to minimise corrosion: modelling of a single tube

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Boiler air heater tube corrosion costs the industry several million dollars a year in repairs, reduced boiler steam output and reduced boiler efficiency. There have been many cases where the reduced boiler steam output caused by leaking air heater tubes has reduced factory crushing rates and electricity export. Air heater corrosion has previously been addressed through multiple options, including more expensive corrosion resistant materials, as well as using computational fluid dynamics to improve the gas and air flow distributions with turning vanes and ductwork redesign. Evolving hardware and software modelling capabilities provide more options to critically study the gas velocity and temperature profiles, and, hence, potentially achieve improved understanding of the wall interaction, deposition and corrosion processes. This paper presents the computational fluid modelling details and results for a single tube at the air inlet.

Rosettenstein, et al.

Development, analysis and testing of a dimple tube to improve vacuum-pan performance

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A frequent requirement in existing and expanding factories is an expansion of the crystallisation/vacuum pan capacity. Usually, these expansions are problematic due to the significant investment required in reallocation of the existing vessels and construction of new vessels including various ancillary services. An

innovative vacuum heating tube has been developed, tested and trialled resulting in an alternative to major changes to the factory or expensive modifications to vessels. Over 4 years, the new Dimple Tube technology has been developed from an initial concept through to commercialisation and has been through a series of analyses, alterations, tests and trials. Analyses included computational fluid dynamics (CFD) to predict flow and performance characteristics, finite element analyses (FEA) to analyse direct and fatigue stress, pressure testing, destructive and non-destructive testing, in-service trials and laboratory testing. In addition, and perhaps most importantly, reliable and repeatable mass-production equipment and systems have been designed, developed, and implemented – taking this new technology from a concept through to a commercially viable and value-adding product. The result is a new tube technology that increases the heating-surface area of the vessel by 16.5%. Process and mechanical analyses and tests have shown that the flow characteristics of the new technology improves performance and the longevity, serviceability, fouling rate and operation of the tubes and equipment are not compromised. The benefit of the additional heating-surface area is as expected, but the increased turbulence makes a significant additional difference to the heat-transfer coefficients in practice and resulting evaporation rates of between 50% and 20% improvement through a batch vacuum pan cycle have been demonstrated. Trial operation has shown no drawbacks or compromises to existing operations. The extensive development and testing has led to a new patent-pending tube technology that has a large impact on vacuum-pan performance, at a significantly lower cost than alternative technologies or options.

Salter, Kok

Effect of application timing of nitrogen fertiliser on sugarcane crop performance and NUE

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Sugarcane crop development is typically slow in the first few months after planting or ratooning. This results in a low nitrogen (N) requirement during the early stages of growth. SIX EASY STEPS® guidance for ratoon crops indicates fertilisation can be delayed up to 6 weeks after harvest, except for late-cut cane that should be fertilised straight after harvest. A trial was established to investigate whether there were benefits of either early or delayed N application on N uptake, NUE and crop performance in a supplementary irrigated farming system at Mackay. Treatments included early and delayed application of N as urea and four N application rates (0, 75, 150 and 200 kg N/ha). Early application was approximately 14 days after planting/harvesting and Late application was approximately 70 days after planting/harvesting. Leaf N %, crop N uptake over time, cane and sugar yield, and nitrogen use efficiency were monitored in the plant, first-ratoon and second-ratoon crops. Nitrogen application timing had no statistically significant effects on the measured crop factors, although sugarcane yield tended to favour early application in the ratoon crops. N application rate increased leaf N %, crop N content and cane and sugar yield. In most cases this was associated with N deficiency at 0N and 75N. There were few statistically significant differences between the 150N and 200N rates. NUE declined with N application rate, but should always be considered in association with crop productivity. The average nitrogen fertiliser uptake efficiency for the site was 0.32. Increasing uptake of fertiliser N is key to overcoming water quality issues associated with sugarcane farming in the catchments of the Great Barrier Reef. The outcome of the trial is consistent with guidance not to delay fertiliser application by more than 6 weeks after harvest.

Santarossa, Dutta

24–32 tonne Canefield locomotive final drive improvement

LG Santarossa¹ and B Dutta²

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Wilmar Sugar has 20 Baldwin B-B locomotives ranging in mass from 24 t to 32 t and the Australian sugar industry has an additional 25. The first to enter service was the 26 t KILRIE in June 1972. Since then, the loads being hauled by the Baldwin locomotives have increased, to ensure an adequate supply of cane to

the sugar mills, as their crushing rates have increased. This load increase has taken its toll, particularly on the drivelines which include the final drives. Each Baldwin B-B locomotive has two driving and two driven final drives. Current typical service life for the Baldwin locomotive final drives between rebuilds is not acceptable. Furthermore, the final drives have now been rebuilt many times and have surpassed their design service life. This is reflected in their increasing maintenance costs and in-service failures. An option for continuing to operate the range of Baldwin B-B locomotives, is to replace their current final drives. Following extensive global driveline specialist enquiries to identify a suitable commercially available solution, or part solution, it became apparent that it was necessary to undertake a first-principles approach to custom design the final drives for the specific duty. This process has prompted the reassessment of the current range of designs for the final drives. Evaluation of the driving and driven final drive duty requirement for the 24–32 t application against internationally recognised engineering standards determined that the current design final drives were not appropriate for the current duty. The design process for the revised final drives identified several reliability concerns for the current designs, with the expected duty requirement. One alternative to obtain an improved service life for the current designs is to reduce the load limits for the range of Baldwin locomotives in service. An alternative approach is to design final drives capable of sustaining the required service loads. A benefit that could be realised with this approach is that one driving and one driven final drive could be designed to fulfil the duty requirement of the 24–32 t application, minimising spares requirement and inventory cost. This paper presents the reliability concerns identified with the current final drives and the process adopted to revise the design to overcome cost and reliability concerns for the 24–32 t application. An additional outcome of this process, is that a driving and a driven final drive design has been realised that can be integrated into new locomotive designs to replace the current 0-6-0 locomotives.

Santarossa, Dutta

24–32 tonne Canefield locomotive reversing box improvement

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Wilmar Sugar has 20 Baldwin B-B locomotives ranging in mass from 24 t to 32 t. Of these, 19 have reversing boxes that are gear driven, similar in design and achieve forward/reverse shifting with a dog-clutch mechanism. The Australian sugar industry has an additional 25 Baldwin B-B locomotives. The first to enter service was the 26 t KILRIE in June 1972. Since then, the loads being hauled by the Baldwin locomotives have increased, to ensure an adequate supply of cane to the sugar mills, as their crushing rates have increased. This load increase has taken its toll, particularly on the drivelines and the current typical service life for the Baldwin locomotive reversing box between rebuilds is not acceptable. Furthermore, the reversing boxes have now been rebuilt many times and have surpassed their design service life. This is reflected in their increasing maintenance costs and in-service failures. To continue to operate the range of Baldwin locomotives, their reversing boxes must be replaced. Following extensive global driveline specialist enquiries, to identify a suitable commercially available solution, or part solution, it became apparent that it was necessary to undertake a first-principles approach to custom design and manufacture a reversing box for the specific duty. The evaluation of the reversing box duty requirement for the 24–32 t application with internationally recognised engineering standards found that the current reversing boxes were not appropriate for the expected duty. The design process for the revised reversing box identified several reliability concerns for the current design. One alternative to obtain an improved service life for the current design reversing boxes is to reduce the load limits for the range of Baldwin locomotives in service. An alternative approach was to design a reversing box capable of sustaining the required loads. A benefit that could be realised with this approach was that one reversing box could be designed to fulfil the duty requirement of the 24–32 t application, thus minimising spares requirement and inventory cost. This paper presents the reliability concerns identified with the current design reversing boxes and the design process adopted in realising a revised design for the 24–32 t application to overcome cost and reliability issues. An additional outcome is the development of a reversing box design that can be integrated into new locomotive designs that will replace the current 0-6-0 locomotives.

Santarossa, et al.

24–32 tonne Canefield locomotive design

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Wilmar Sugar processes about 50% of Australia's raw sugar and requires a reliable locomotive fleet for this operation. The locomotive fleet is aging, as the last new locomotive was introduced to the fleet in 1991. As the crushing rates of the sugar mills have increased, the duty on the locomotive fleet has also increased, to ensure an adequate supply of cane to the sugar mills. Maintenance and minor improvements have been ongoing in the interim, to maintain adequate reliability in the locomotive fleet, but some of the fleet assets are now approaching, or are beyond economic repair. This is the case particularly with most of the 0-6-0 locomotives. In looking to procure new locomotives to replace the aging fleet, an assessment was conducted on the most appropriate locomotive type for Wilmar's 1,600 km of track across four cane districts and eight sites. A locomotive of 24 to 32 t mass, based on a standardised chassis geometry and driveline, was the most appropriate whole-of-business decision, giving operational flexibility within the business. As Australia no longer manufactures locomotives suitable for the Australian sugar industry, a number of suppliers were approached globally for proposals. The proposals received were not considered practical in our remote environment, particularly with electrical, mechanical and control, maintenance and break-down support concerns. Wilmar Sugar has developed improvements for discrete elements of locomotives over time, using reliable components that are readily available. This knowledge has now been applied to manufacturing a locomotive from the sum of discrete elements already developed. This philosophy has the significant benefit that elements of locomotives are becoming the same or similar, which makes support for maintenance and break-downs less complex, as there is less variation and the technology is imbedded in the organisation. This reduces downtime and lifecycle ownership cost. This paper presents the development of the elements of the locomotive and the design process adopted in realising the 24–32 t locomotive to replace aging fleet assets.

Schembri, Fillols

Effects of farming practices on end-of-paddock run-off water quality in the Central region

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Results from end-of-paddock run-off water quality monitoring conducted in the Central region are presented. By measuring nutrient and pesticide concentrations in run-off leaving the paddocks, we aimed to identify farming practices with reduced environmental footprints. This knowledge can be used by growers and advisors to select farming practices that are beneficial for the environment, specifically local waterways and the Great Barrier Reef lagoon. Six trial sites were established between 2020 and 2022. Each trial was designed as a strip trial, with treatments replicated two to three times. At each site, nutrient and pesticide concentrations in run-off were monitored over one wet season. Run-off from liquid imidacloprid applied to the correct label depth (100–125 mm) was less than from liquid imidacloprid applied at half of the recommended depth. The concentration of imidacloprid in run-off across the trial sites where the imidacloprid had been applied to best practice varied considerably. There were no significant differences between the run-off losses for surface-applied dunder, sub-surface-applied granular fertiliser and a sub-surface-applied liquid fertiliser. Run-off losses of imidacloprid, isoxaflutole, metribuzin and DIN were not significantly different between treatments with and without inter-row cultivation using an aerator. Banded mill mud and mill mud/ash treatments increased amicarbazone, isoxaflutole and imidacloprid concentrations in surface run-off compared to where no mill mud products had been applied. Trial data also validated established knowledge on herbicide loss behaviour such as highest loss via run-off occurs in the first run-off event, and/or when run-off occurs in the first 48 h after application, and the benefits of low mobility active ingredients in high-risk periods.

Selby, et al.

On-line monitoring of C seed grainings using the ITECA Crystobserver to improve pan-stage performance

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A microscope system, the Crystobserver (supplied by ITECA, France), was installed on the C seed pan at Condong Mill to monitor the crystal development in real time. The system provides a high-quality image and measures important parameters such as average crystal size and number of crystals in the image. Analysis of data collected over two seasons confirms that the system is reliable in obtaining images with sufficient clarity to assist the operators in remotely monitoring the crystal development from shortly after slurry addition. The reliability of the measurements is satisfactory once the crystals are larger than 30 µm through to near the end of the C seed, when the crystal density in the screen is high. The pan operators have found the Crystobserver to be very beneficial and it has allowed them to take corrective actions such as changing the amount of slurry addition or the purity of the graining blend more quickly. The software in the system stores historical data from several strikes, including images and key parameters that can be accessed readily. The installation, microscope and software features, and potential benefit to a raw sugar mill are described.

Shiddiky, et al.

SugarPATH: a handheld device for advancing sugarcane disease diagnostics

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Broadacre cropping is plagued by a multitude of pathogenic organisms that require vigilant surveillance and monitoring to inform management practices and reduce the severity of impact on productivity and yield. Despite the tremendous efforts in developing elaborate systems towards on-farm biosecurity and best management practice, plant pathogens still cause significant yield reductions in the Australian sugarcane industry, partly due to the lack of early, rapid and low-cost pathogen detection methods. Sugarcane pathogens that remain latent for a long period of time or diseases that lack apparent symptoms are particularly problematic. Early and rapid pathogen diagnosis, together with an understanding of disease severity, is critical for the prevention of disease spread as well as for devising an effective management strategy. While bench-based tests for diagnosis of these diseases are routinely performed in centralised laboratories, on-farm diagnostic tools are lacking. Most critically, current laboratory tests usually take weeks to provide results to growers. No rapid test is available for early detection of major sugarcane diseases such as leaf scald and ratoon stunting disease in potentially infected crops. Thus, there remains a need for simple to use, low cost, fast, accurate and specific diagnostics methods. We have developed a novel handheld device: SugarPATH, for the detection of two major sugarcane diseases, leaf scald disease and ratoon stunting disease (RSD). The device comprises an Arduino microcontroller to govern its two central working units: (i) sample processing, and (ii) detection. The sample processing unit contains a microcentrifuge tube-like homemade microreactor for extracting DNA from sugarcane xylem sap extracts. The detection unit employs an RGB sensor for *in-situ* target (i.e., DNA) detection. The device can detect *Leifsonia xyli* subsp. *xyli* (Lxx) and *Xanthomonas albilineans* (X. *albilineans*) in samples collected from RSD and leaf scald disease screening trials, respectively. The SugarPATH device is semi-automated, simple to use, low-cost and provides rapid analysis. It takes only 20 minutes to complete a test and can be used in-field for DNA-based diagnosis of sugarcane diseases without needing specialist pathologists. The potential for application of the SugarPATH device across the sugarcane growing sector is obvious.

Skocaj

Reviewing the results of soil tests identifies opportunities to improve nutrient management in the Wet Tropics

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Collecting soil samples according to industry best practice guidelines, using a reputable laboratory to analyse samples, and interpreting soil-test results using the SIX EASY STEPS® nutrient-management guidelines allows soil-ameliorant and crop-nutritional requirements to be determined. Identifying soil-chemical constraints, effectively managing these constraints, and achieving balanced crop nutrition is important for productive, profitable and sustainable sugarcane production. Records of available soil-test results for the Tully, South Johnstone and Mulgrave sugarcane production districts were collated and reviewed. It is evident that soil acidity and nutrient deficiency, specifically calcium and magnesium, are impacting the productivity of older ratoon crops and are likely to be affecting the performance of legume cover-crops grown during the traditional fallow period. Opportunities to alleviate soil-chemical constraints, overcome nutrient deficiencies and refine on-farm nutrient management are discussed.

Skocaj, et al.

Tully growers trial the SIX EASY STEPS® Toolbox guidance for their late-season ratoons and a final-ratoon crop

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SIX EASY STEPS® is a comprehensive, science-based program, promoting the importance of balanced nutrition to optimize productivity, profitability and minimize off-site effects. STEPS 1-4 (Knowing and understanding soils; Understanding and managing nutrient processes and losses; Soil testing regularly; and Adopting soil specific nutrient management guidelines) have been generally well adopted. STEPS 5 (Checking on the adequacy of nutrient inputs) and 6 (Modifying nutrient inputs where and when necessary) provide the basis for continuous improvement. This allows the SIX EASY STEPS guidelines to be refined for specific circumstances and also allows new information to be incorporated as it becomes available. The concept of a SIX EASY STEPS Toolbox was first introduced in 2018 to support greater adoption of the full SIX EASY STEPS approach to sustainable on-farm nutrient management. The Toolbox is a repository of all the tools that support or add value to the SIX EASY STEPS nutrient management program. Guidance for refining nutrient inputs in specific circumstances is also provided in the Toolbox. Over the 2020/21 growing season, three growers in the Tully district evaluated the guidance for late-season ratoons and final ratoon crops. A small reduction in nutrient inputs in two late-season crops resulted in similar productivity but improved profitability. In a poor-performing final ratoon, reducing the N rate by 30% had very little impact on cane and sugar yield compared to the grower standard. Additional trials are required at this site before implementing the guidance for poor-performing final ratoons more broadly.

Thaval, Kent

An improved model of pol extraction for mills and diffusers

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Extraction models for mills and diffusers were developed to determine the brix (total dissolved solids) extraction of the process. Pol extraction was calculated from the brix extraction based on arbitrary constants or empirical relationships. The Australian sugar industry introduced a term “purity ratio” in the early 1980s and has since been using the term in extraction models to predict the pol extraction of the milling process.

Here, an improved model of pol extraction is presented which replaces the purity ratio concept. The new model can be used in two different approaches, based on which brix extraction model (imbibition coefficient or crushing factor-mixing efficiency) is used. When using imbibition coefficient, an analogous term “purity coefficient” is used to determine the pol extraction of the milling unit. When using the crushing factor-mixing efficiency model for the bagasse mills, the model equations have been extended to determine the pol in delivery bagasse. The model is presented and, using factory experimental data, the results of purity coefficient of individual milling units are given. The same data is used to compare, for the bagasse mills, the measured pol and predicted pol in delivery bagasse of individual milling units.

Wei, et al.

Validation of using EC mapping to account for site variability in the early stages of selection in the Sugar Research Australia breeding program

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Previously in a clonal assessment trial (CAT), four zones identified by EC mapping produced significantly different yields. If ignored, these differences would result in different and biased selection intensity in the different zones, that is, fewer clones would be selected from a low-yielding zone. However, these differences could be caused by different sets of clones in each zone (despite low possibility given the random distribution of clones over the trial) and the clones from a low-yielding zone could actually be poor in the next stage of selection, the final assessment trial (FAT, with higher precision). Here, the yields in different zones were confirmed to be significantly different when a single variety Q208^A was grown in the exact same site as the CAT. The clones selected from a low-yielding zone at the CAT stage did not produce significantly different yields to those from high-yielding zones in FATs. This reinforces our conclusion from the previous study that EC mapping is an effective tool in accounting for site variability in sugarcane selection programs.

West

Sugarcane-locomotive control-system upgrade - Safer, Cheaper, Simpler

Nina West

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In 2019, Wilmar Sugar initiated a sugarcane-locomotive control-system upgrade project. Whilst the initial driver for this project was to address equipment obsolescence, the charter for the project subsequently set goals to improve the safety, reliability, productivity, maintainability, usability and cost of the existing locomotive control-system design. The project focused on leveraging off Wilmar’s readily available end users, system maintainers and technical experts to inform the new solution. This approach heavily contributed to a very successful project. The project took a risk-centered approach to the review and solution and used Design Thinking principles throughout each project stage. Formal processes that formed part of the overall control system upgrade were: Facilitated HAZOP/CHAZOP processes; Functional requirements specification based on reviewed use cases; Safety requirements specification and verification to AS (IEC) 62061; Stakeholder engagement workshops and independent reviews on prioritized design elements; Failure Modes and Effects Analyses (FMEA) of critical systems; Fit for purpose assessments of all control system components. The upgrade project quantifiably achieved its objectives, achieving reductions to residual plant risks, making reliability-based improvements, increasing productivity, improving maintainability, simplifying operation and achieving significant overall system cost reductions. The key elements of the designed control system that contributed to this outcome include a reduction in equipment count, implementation of alternative technology including moving to a CANBus enabled controller, the implementation of a sophisticated hierarchical alarming and indication strategy, the introduction of a new Remote Shunting Unit (RSU) platform (pending user acceptance testing), adoption of operator-driven changes to the system’s functional specification and the development of detailed system documentation. In 2022, Wilmar Sugar built and commissioned the first prototype of a new-generation sugarcane-locomotive control system that implements this solution in full. This locomotive will be in operational use during the 2023 crushing season.

Characterising the potential association of invertebrates with Yellow Canopy Syndrome of sugarcane

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Yellow canopy syndrome (YCS) is a complex syndrome for which no definitive cause has been determined. Recent studies have focused on what role invertebrates may play in the expression of this syndrome. Modified sampling methods were used to capture dispersive stages of both crawling and flying invertebrates, which live either above or below ground. Tentative groups that may be associated with YCS expression were detected. At least two species, pasture mealybug and rice whitefly, have abundance peaks associated with the timing of YCS expression. However, further studies are required before any firm conclusion can be drawn as to if these species are causal agents or merely invertebrates attracted to sugarcane expressing YCS symptoms.

Posters

Comparing install methodologies for pans and evaporators

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Alkalinity generation from cation-exchange water softening for boiler feedwater at Wilmar's Inkerman Mill

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Milling-train performance dashboard

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Beyond the conventional method for nucleic acid isolation and quantification for detection of sugarcane pathogens

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i-RAT: a tool to facilitate discussion between irrigators and advisors on increasing profitability and sustainability

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Economic impacts of introducing rotational legume harvested crops into a sugarcane farming system: results from the Burdekin fallow-management trial

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Transition to site-produced panstage graining slurry

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Investigating diversion strategies for B molasses to improve sugar recovery

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Revisiting variety ratings for ratoon stunting disease

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Effect of liquid calcium application on sugarcane yield in a fifth-ratoon crop in the Herbert River district

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Seasonal population dynamics and comparative trapping of above-ground invertebrate pests in Australian sugarcane

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Exotic moth borers – preparing for any incursion

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Solving the mystery of yellow canopy syndrome in sugarcane - are invertebrates the missing link?

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Optimising bagasse diffuser juice application

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Impact of lime saccharate addition to mud filter feed on mud loss and station retention

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Adjusting plant-cane nitrogen rates following legume cover crops in the Murray district

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SugarPath: a novel handheld diagnostic device for on-farm spatial and temporal pathogen surveillance

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Marian Mill treatment ponds and wetland

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Supplier's presentation

An alternative evaporator technology for first and second effects

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Developments such as steam for by-products, co-generation, continuous pans that operate well on V2 and higher imbibition rates have required large first- and second-effect evaporators in many factories. Traditional Robert evaporators are not well suited to this because of sugar losses due to their long juice residence times, large space requirements and costly supporting structures. An innovative evaporator design has solved these problems. This paper covers the theory of sucrose destruction at high temperatures and describes a new type of long-tube climbing-film evaporator (LTE) that minimises these losses and offers other benefits. Performance details for some LTE installations are given.