

**Proceedings  
of the  
Australian  
Society  
of  
Sugar Cane  
Technologists**

**2021**

**BUNDABERG**

**42<sup>nd</sup> Conference**

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# AUSTRALIAN SOCIETY OF SUGAR CANE TECHNOLOGISTS LTD

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All papers published in these Conference Proceedings are peer-reviewed by at least two referees.

1530-1600	Norris, Whiteing, Norris - Machine-cane interactions: what is the impact of ‘front-end’ design and harvester operation on product quality and crop ratooning?	Young, Knight -RSD resistance and the resistance to change	Zhang, Hassanpour, Cai, O’Hara - An update on QUT’s acid-catalysed glycerol pretreatment technology for biorefining of sugarcane bagasse	
1600-1630	Kent, Ginns, Panitz, Robotham -Effect of post-harvest cleaning on cane yield	Magarey et al - Incidence and economic effects of ratoon stunting disease on the Queensland sugarcane industry	Zhang, Khatun, O’Hara - Production of fructo-oligosaccharide as valuable feed prebiotics from low-value molasses – a review	
1630-1700	Ginns, Kent, Johnston, Panitz, Robotham - Economic evaluation of post-harvest cane cleaning	Bhuiyan, Eglinton, Magarey - Prospects for a genetic solution to the management of ratoon stunting disease	Lavarack, Steggles - Technical Index: a measure of factory performance for over 20 years at Mackay Sugar	
1700-1730			Stobie, Broadfoot - Understanding the cause of high-colour sugar – intrinsic cane colour, extraneous matter or factory practices?	
1730-1830	Happy hour			

Thursday	Auditorium	Exhibition hall	Sugar 1	Sugar 2
0800-0830	Theobald, Henderson, Johnson, Halpin - Introduction of the sugarcane nitrogen and phosphorus budget	Bakir, Drury, Kent - A factory experiment to assess different shredder-hammer configurations	Bhuiyan, Deomano, Stringer, Magarey, Eglinton, Wei, Piperidis - Development of a new variety-rating system for sugarcane smut using improved statistical methods	
0830-0900	Janke, Fujinuma, Moody, Bell - Distribution and chemical speciation of nitrogen from band-applied enhanced-efficiency fertilisers	Nel, Wallace, Brouckaert, Stockham - Optimising bagasse diffuser performance using percolation velocities	Piperidis, Piperidis, D'Hont - Genomic organization of sugarcane cultivars revealed by chromosome specific oligonucleotide probes	
0900-0930	Panitz, Schroeder - Effect of temporal nitrogen-management strategies on sugarcane production in sub-tropical Queensland – a complete crop cycle	Shi, Rackemann, Bakir, Doherty - Assessment of microbial degradation in factory mixed juice and filtrate	Zhao, Bolton, Piperidis, Eglinton - Seed-based <i>in vitro</i> propagation to accelerate variety development	
0930-1000	Skocaj, Schroeder, Wood - Are responses to nitrogen fertiliser predictable under similar conditions?	Plaza, Mann - Improving bagasse-furnace combustion and modelling	Natarajan, Deutschenbaur, Basnayake, Lakshmanan - Predicting sugarcane physiological traits using hyperspectral reflectance	

## PROGRAM

Tuesday

1700-1900	Welcome drinks
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Wednesday	Auditorium	Exhibition hall	Sugar 1	Sugar 2
0900-1030	Opening ceremony Guest speaker			
1030-1100	Break			
1100-1130	Kealley, Peter, Aley - Creating a blockchain platform to show sustainability credentials and provenance of Queensland sugar			
1130-1200	Renouf, Schroeder - The Australian sugar industry can be a positive force for reducing greenhouse-gas emissions for climate stabilisation			
1200-1230	Moore, Jenner, McIntosh, Markey-Towler, Pickering - Utilising behavioural science to create practice change in agriculture: a case study with the Queensland sugarcane industry			
1230-1330	Lunch			
1330-1400	Patane, Landers, Thompson, Nothard, Norris, Olayemi - Investigating losses from green and burnt cane harvesting conditions	Broadfoot, Ashtiani Abdi, Lowrey, Mitchell - Performance of the SRI fixed-element cooling crystalliser at Broadwater Mill	Mann - Boiler simulation for improved operator training	Graduate meeting
1400-1430	Patane, Nothard, Norris, Douglas, Pfumayaramba, Stringer, Olayemi - Improving yield and cane quality through implementation of harvesting best practice - 2019 Herbert demonstration	Broadfoot, Ashtiani Abdi - Implications of crystal-size distributions in product massecuites from horizontal and vertical continuous pans	West - Management of the technical skillset required to support automation in the sugar industry	
1430-1500	Norris, Norris - SCHLOT Live: changing the harvesting game with real-time cane-loss monitoring	Collen - Online methods for the detection of sugar contamination in condensate systems	Moller, King - The Australian Sugar Industry Training (ASIT) Learning Management System (LMS)	
1500-1530	Break			

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1530-1600	Norris, Whiteing, Norris - Machine-cane interactions: what is the impact of ‘front-end’ design and harvester operation on product quality and crop ratooning?	Young, Knight -RSD resistance and the resistance to change	Zhang, Hassanpour, Cai, O’Hara - An update on QUT's acid-catalysed glycerol pretreatment technology for biorefining of sugarcane bagasse	
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1000-1030	Arioli, Hepworth, Farnsworth, Kasinadhuni, Nouné, Mattner - Effect of applications of seaweed extract on sugarcane yield in Australia	Chantasiriwan - Comparison of two methods of retrofitting a bagasse boiler: increasing the heating-surface areas and installing a flue-gas dryer	Aitken, McNeil, Bhuiyan, Li, Piperidis, Joyce, Eglinton - Genetic analysis and marker delivery for sugarcane breeding McNeil, Bhuiyan, Stiller, Li, Drenth, Aitken - Identification of SNP markers linked to resistance to root-knot nematode, <i>Meloidogyne javanica</i> , using transcriptome analysis Metcalf, Li, Piperidis, Aitken - Using flow sorting to select high-value <i>Erianthus</i> chromosomes from a <i>Saccharum-Erianthus</i> hybrid	
1030-1100	Break			
1100-1130	Graduate group report-back			
1130-1200	Han, Filippi, Bishop - Using data-driven forecasts of sugarcane yield to optimise variable N-fertiliser application Sockhill, Aird, Simmons, Barry, Van, Jeaffreson - Towards accessible crop-yield estimation Steer, Cavallaro - Stoller Australia: local solutions – international approach	Manufacturing Exhibitors Abdel-Latif - Engineering optimisations and troubleshooting enhancement with the ABB Sugar library Murphy, Wong - Process control and sugar crystallization Schofield - Benefits of using wedge-wire screens in a continuous centrifuge		
1200-1230	Ag section meeting	Manufacturing section meeting	Administration section meeting	
1230-1330	Lunch			
1330-1400	Thompson, Wilson - Effective quarantine: Interception of sugarcane diseases in the last 20 years has protected the industry from exotic threats	Marasinghe, Rackemann, Doherty - Impacts of superheated steam on juice degradation and evaporator performance	Adhikari, Bhuiyan - Identification and determination of the impact on sett germination of fungal isolates associated with sugarcane plants	
1400-1430	Fillols, Davis - Impact of application depth and slot closure on runoff losses of imidacloprid	Lehnberger - IIoT for batch centrifugals – initial results	Bhuiyan, Garlick, Di Bella, McVeigh, Sefton - Survey of nematodes in the Herbert region to develop a nematode-hazard index and evaluate soil health	

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1430-1500	<p>Umer, Bhuiyan, Shiddiky - A simple and inexpensive device for detection and quantification of sugarcane leaf scald disease caused by <i>Xanthomonas albilineans</i></p> <p>Padayachi, Rounds - Sugarcane grubs in the Lautoka and Rarawai Mill areas, Fiji</p> <p>Padayachi, Prasad, Rounds - Status of Asian subterranean termites in the sugarcane belt of Fiji</p>	Santarossa, Anderson, Poppi - Axle improvements for 40-tonne locomotives	Young, Wilson, Thomson, Fitzgerald, Fitzgerald, Baldock, Stirling, Stirling - Towards a molecular toolkit to assess biological health of soil	
1500-1530	Break			
1530-1600	Lenancker, Powell - Giving it our best shot in the war against soldier flies – future research directions	Rozis - High-vibration incidents at the Proserpine, Victoria and Plane Creek shredders – actions and response planning	Haines, Davis - Adapting solar energy to irrigated sugarcane production at Bundaberg, Queensland	Tyson - Secondary-juice flow-control strategy at Rocky Point Sugar Mill
1600-1630	Etebari, Lindsay, Ward, Furlong - Australian sugarcane soldier fly's salivary gland transcriptome in response to starvation and feeding on sugarcane crops	Pickering, Flinders - Preventing a major in-service failure of Pioneer Mill STG 3 stator core and winding	Schroeder, Jensen, Panitz, Wood - Prioritising R&D needs for mechatronic and data-dependent applications in Australian sugarcane	Thaval - Assessing the heat-transfer performance, operational strategies and sucrose losses of falling-film and rising-film evaporators
1800	Gala dinner			

Friday				
0800-0830	Williams, Hall, Isis Sugar Partnership - Grower-first approach delivers that extra 20% in the Isis	Lavarack, Iturbe, Giannangelo - Pan No.9 incident – Farleigh Mill 2020	Fillols, Davis - Soil-binding adjuvants can reduce herbicide loss via runoff AND Fillols, Davis - Effect of the soil-binding adjuvant Grounded® on herbicide efficacy and runoff losses in bare soil in ratoons (45 min)	Ashtiani Abdi, Zahn, Kumar, Sichtler, Broadfoot - Performance of the falling-film tube evaporator at Bingera Mill
0830-0900	<p>Greenway, Taylor - Digital farm maps in your pocket</p> <p>Greenway, Taylor - Your Farm, Your Way - Smartcane BMP Isis customised digital record keeping</p> <p>Bahadori, Pirpour, Madsen - Effect of organic additives on the development</p>	Camp, Favale - Response plan for a significant incident	Blair, Robertson, Gonzalez - Sugarcane boom spray diagnostics using a portable patternator (15 min)	Rashid, Shehryar, Arif - Falling-film evaporators - role in steam saving (a perspective of Almoiz Industries, Pakistan)

	and extension of roots in sugarcane variety CP48-103		
0900-1000	AGM		
1000-1030	Morning Tea and get on bus		
1030-1400	Field tours		



## **Creating a blockchain platform to show sustainability credentials and provenance of Queensland sugar**

**MJ Kealley<sup>1</sup>, L Peter<sup>2</sup> and G Aley<sup>2</sup>**

<sup>1</sup>CANEGROWERS, Brisbane, Qld 4000; Matt\_Kealley@canegrowers.com.au

<sup>2</sup>KPMG Australia, Sydney, NSW 2000

The application of blockchain technology in the Queensland sugar industry offers improved traceability and a platform to show validated provenance of sugar produced in Queensland. By using Smartcane BMP and blockchain technology, CANEGROWERS is seeking to provide provenance for sugar, increase market access and provide greater value to growers and the market. CANEGROWERS worked with KPMG Australia to prototype the application of a blockchain platform to prove the amount (on mass balance) of sustainable sugar entering the supply chain from Australia. Industry stakeholders were consulted to develop a Queensland sugar-industry supply-chain map to show how sugar could be digitally represented and traded across the supply chain. A data taxonomy was created to define and identify data so linkages could be created for traceability from the grower to the end-user. The data taxonomy was used to build the blockchain prototype on the KPMG Origins blockchain platform. The research showed that developing a digital supply-chain platform using blockchain technology was possible and can improve the visibility of Queensland's sustainably produced sugar. This has the potential to leverage market access for sugar, strengthen the industry against global competition, identify means of improving value for growers, and ensure shifting regulatory and consumer changes are addressed. This was the first time blockchain has been developed for the Queensland sugar industry. Future work has been scoped to test end-to-end traceability of Smartcane BMP-accredited sugar through the supply chain using the KPMG Origins platform.

**Renouf MA, Schroeder BL**

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## **The Australian sugar industry can be a positive force for reducing greenhouse-gas emissions for climate stabilisation**

**MA Renouf<sup>1</sup> and BL Schroeder<sup>2</sup>**

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<sup>2</sup>University of Southern Queensland, Toowoomba, Qld 4350

As the effects of climate change due to greenhouse gas (GHG) emissions are being felt more strongly, the need for emission reductions has become more pronounced. This paper aims to show that the Australian sugar industry can be a positive force in climate stabilisation through GHG 'mitigation' at the farm and GHG 'abatement' at mills/bio-refineries. This was done by compiling findings from previous environmental life-cycle assessment studies that have quantified the GHG emissions and savings for different Australian sugarcane systems. GHG 'mitigation' at the farm can occur through best-practice cane growing (in particular the efficient use of nitrogen, pesticide and fuel), and energy-efficient irrigation. It was interesting to observe that mitigation has been a by-product of other environmental stewardship initiatives aimed at protecting water quality and soil health. More significant scales of GHG 'abatement' can be achieved at sugar mills/bio-refineries by producing bio-electricity, bio-fuels and bio-materials that displace products derived from fossil fuels. An important condition for future dedicated bio-production is the avoidance of an up-front 'GHG debt' due to land-use change. The estimated scales of GHG reductions show that both mitigation and abatement are important, and that the industry is already on a good trajectory of emissions reduction.

## Utilising behavioural science to create practice change in agriculture: a case study with the Queensland sugarcane industry

S Moore, A Jenner, T McIntosh, B Markey-Towler and J Pickering

*Evidn Pty Ltd, 315 Brunswick St, Fortitude Valley, Qld 4006; sam@evidn.com*

Many disciplines in agriculture, particularly agricultural extension, are currently tasked with the challenge of increasing the adoption of more innovative, sustainable and productive methods of farming. However, it is often difficult to achieve widespread practice change given the complex nature of the industry, stakeholders, and geographic regions. This paper outlines a behavioural science approach to enabling widespread agricultural practice change through targeting key groups and their leaders. Drawing on these insights, a four-step methodology for disseminating new practices within a complex population is provided. The final section outlines a case study for how the four-step methodology was utilised throughout Project Cane Changer – an evidence-based behavioural change program for the Queensland sugarcane industry. It is intended for this methodology to be applicable for practitioners concerned with increasing the adoption of new and innovative practices throughout agricultural sectors, such as extension staff.

## Investigating losses from green and burnt cane harvesting conditions

P Patane<sup>1</sup>, G Landers<sup>2</sup>, M Thompson<sup>3</sup>, B Nothard<sup>4</sup>, CA Norris<sup>5</sup> and M Olayemi<sup>2</sup>

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<sup>3</sup>*Queensland Department of Agriculture and Fisheries, Townsville, Qld 4810*

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<sup>5</sup>*Sugar Research Australia Limited, Mackay Qld 4740*

Despite much research into the impact of high harvester pour rates and fan speeds on harvested cane yields, there has been low adoption of HBP (harvesting best practice) across the industry. Full adoption across the Australian sugarcane industry could increase industry revenue with no necessity for horizontal expansion (increase in cane land). In order to inform industry of the potential for significant gains, 95 replicated harvesting trials and workshops were undertaken during 2017 and 2018 across 12 sugarcane regions in Queensland and New South Wales. The performance of settings recommended by HBP was compared with each harvesting operation's standard practice by assessing yield, CCS, bin mass, extraneous matter (EM), fibre, sugar loss and revenue. To highlight the strong relationship between cane loss and excessive pour rates and fan speeds, treatments with higher pour rates and fan speeds and lower pour rates and fan speeds were also trialled. Cane loss, production and revenue data from the fully replicated and randomised trials were analysed to identify differences between industry standard harvesting practices and those recommended by HBP. Harvesters typically operate at ground and fan speeds at on average of 0.9 km/h and 95 rpm above those recommended under HBP parameters. The higher ground speed overloads the cleaning capacity of the harvester in delivering an average 21 t/h more cane through the machine. Consequently, fan speeds are increased to remove the additional EM (extraneous matter) entering the machine, which then removes additional cane via the extractor. This cane often disintegrated in the process, making much invisible. Trials indicated the average sugar loss out of the extractor increased by 0.15 t/ha over the HBP settings. However, there was no significant improvement in EM or bin mass. Preliminary results of "good" burn trials indicate an improvement of \$207/ha in grower gross revenue with lower fuel. but this does not account for additional milling or transport costs.

## Improving yield and cane quality through implementation of harvesting best practice - 2019 Herbert demonstration

P Patane<sup>1</sup>, B Nothard<sup>2</sup>, CA Norris<sup>3</sup>, A Douglas<sup>4</sup>, T Pfumayaramba<sup>5</sup>, J Stringer<sup>6</sup> and M Olayemi<sup>6</sup>

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<sup>4</sup>*Wilmar Sugar Australia, Ingham, Qld 4850*

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<sup>6</sup>*Sugar Research Australia Limited, Indooroopilly, Qld 4068*

In 2019, the Australian sugarcane industry conducted a month-long demonstration with 12 trials to determine the commercial viability of harvesting best practice. Initiated by a small group of innovative growers and contractors from the Herbert region, the concept of a commercial demonstration sought to determine both agronomic and economic impacts of adopting HBP, including the assessment of possible yield gains without having a detrimental impact on extraneous matter, and economic implication for growers and harvesting contractors arising from revenue and harvesting cost changes. Two Herbert harvesting contractors participated in the demonstration comparing their standard harvesting practices to Sugar Research Australia Harvesting Best Practice (HBP or recommended practice). The results identified an average 4.8 t/ha increase in yield with no additional increase in extraneous matter for the recommended setting. A comprehensive economic analysis was conducted on each of the trials. Detailed harvesting costs and operational information, including machinery, labour, and fuel data, were collected from the respective harvesting operations. Harvesting costs and levies were \$37/ha (\$0.07/t) higher for the recommended setting due to higher yields, reduced harvester ground speeds and lower extractor fan speeds. Despite the higher harvesting costs, recommended settings obtained significantly higher total revenue (\$151/ha, +4.7%). This resulted in an overall net benefit of \$114/ha in the adoption of recommended settings (based on a 4.4% higher net revenue calculated as total grower revenue minus harvesting costs and levies). The Herbert demonstrations have proven instrumental in the acceptance of harvesting best practice for the region. The results again confirm that adapting and aligning commercial-scale harvesting practices to crop and paddock conditions have positive impacts on both yield and economic outcomes.

Norris CP, Norris SC

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## SCHLOT *Live*: changing the harvesting game with real-time cane-loss monitoring

Chris P Norris and Stuart C Norris

*NorrisECT, Brisbane, Qld; Chris@NorrisECT.com*

SCHLOT *Live* is a real-time cane-loss quantification system for sugarcane harvesters, making this information available to both the operator and other value-chain stakeholders. SCHLOT *Live* measures the net power consumption of the extractor fans as they “process” the extracted trash and billets and utilises embedded algorithms, other measured parameters and relevant operator inputs to derive a commercially viable estimate of cane loss under widely varying harvesting and field conditions. SCHLOT *Live* is a major development as, despite the significant cost to industry of harvesting cane losses, there was no way of quantifying these within a useable timeframe, and, therefore, no way to properly manage these losses. While harvesting cane-loss generally increases with harvester extractor speed, the influence of the actual operating and environmental factors can be of equal or greater magnitude. These losses typically range from 5-15% of the harvested crop, although losses can be much higher than this, particularly under difficult harvesting conditions or where delivery of clean cane is considered a priority. Importantly, most of the loss is “invisible” as the sugarcane billets that are drawn through the extractor fans are effectively disintegrated into juice and particles near-invisible to the naked eye. For this reason, assessing visible losses in the extracted trash is not a competent methodology by which to assess actual harvesting losses, despite still being widely used both commercially and by researchers. SCHLOT *Live* allows the operator to fine-tune the harvesting settings to reduce cane losses, usually with little change in extraneous matter levels in the delivered product. Experience has been that the total value of the reductions in cane loss will often recoup the cost of the unit in < 100 hours of harvesting, with indications also of the changed operating practices resulting in improved quality of the product delivered to the mill.

## Machine-cane interactions: what is the impact of 'front-end' design and harvester operation on product quality and crop ratooning?

Chris P Norris, Cam Whiteing and Stuart C Norris

NorrisECT, Brisbane, Qld; Chris@NorrisECT.com

Increasing of harvesting speed has been necessary to facilitate 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. No attempt has been made to improve the interactions between harvester front-end components and the cane plant with respect to damage caused by the gathering, knockdown or bascutting operations. This is seen as a contributor to poor ratoon performance often seen through the industry. Linking rotational speeds of bascutters and gathering/forward feed components to groundspeed was hypothesised to optimise machine performance and minimise damage over a much wider operating speed range than with current machines. Five harvesters were modified to achieve this outcome. In the subsequent field trials, positive impacts on evenness of machine feed in large crops were noted. However, the differences in stool damage observed in replicated trials were small, with high to very high levels of severe damage typically being observed at all settings. Yield responses were low, but lower harvesting speeds in conjunction with matched component speeds had lower damage and gave marginally higher yields in the subsequent crop. To quantify the primary causes of the high levels of stool damage observed, sections in each trial treatment were hand-cut at 20–25 cm height prior to the 2018 harvest, and these sections were then included in the stool damage analysis. Very significant reductions in stool damage were noted in all hand-cut treatments (irrespective of final harvesting-speed parameters), indicating that the gathering/knockdown functions of the harvester are primary contributors to damage. At the subsequent harvest, yield increase of the 'pre-cut' sections of the plots at each trial averaged between 8% and 25% higher than the paired full machine-cut sections, with the average yield increase across the 72 plot pairs being 16%. This data indicates that very significant gains can be made by reducing the damage associated with the gathering and knockdown functions of harvesters, and the magnitude of the potential gains warrants significant research focus.

Kent *et al.*

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## Effect of post-harvest cleaning on cane yield

GA Kent<sup>1</sup>, SP Ginns<sup>2</sup>, JH Panitz<sup>3</sup> and BG Robotham<sup>4</sup>

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In-field cane loss is well recognised as a major source of sucrose loss. Strategies to reduce that cane loss typically involve reducing the harvester forward speed and the extractor-fan speed. Reducing harvester forward speed generally increases the cost of harvesting, while reducing extractor-fan speed generally increases the extraneous matter content of the cane supply. Efforts are being made to promote this lower speed strategy. An alternative strategy to reducing harvester forward speed is to introduce a post-harvest cane cleaning operation. Post-harvest cleaning has the potential to address the problem of increased extraneous matter content in the cane supply while maintaining the benefits of lower harvesting cost and lower cane loss. This paper reports on experiments conducted to test the strategy of post-harvest cleaning as a means of simultaneously achieving reduced in-field cane loss, low extraneous matter content in the cane supply and low harvesting cost. The experiments were conducted using Tableland cane supplies. Cane, billet and CCS yields were measured under cane-supply strategies with and without post-harvest cleaning. While the experiments confirmed that reduced harvester extractor-fan speed reduced cane loss and increased extraneous matter content, post-harvest cane cleaning did not achieve the desired objective of maintaining that reduced cane loss.

## Economic evaluation of post-harvest cane cleaning

SP Ginns<sup>1</sup>, GA Kent<sup>2</sup>, W Johnston<sup>1</sup>, JH Panitz<sup>3</sup> and BG Robotham<sup>4</sup>

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This paper examines three cane supply treatments, Commercial Harvesting, Low-Loss Harvesting and Low-Loss Harvesting plus Cane Cleaning, to determine if post-harvest cane cleaning offers economic benefits over current harvesting strategies. The project involved field and factory measurements of different harvesting and cane-supply strategies in an effort to identify strategies that maximise the total industry benefit, considering, in particular, the cost of the harvesting and cane-supply strategy, the resulting cane loss and the impacts of the resulting extraneous matter in the cane supply. The economic analysis quantified harvesting costs and the resulting product income. The economic analysis was undertaken on three large Tableland experiments to assess the most economical harvesting and cane-cleaning option of the three strategies tested. The analysis considered costs associated with harvest and haulouts, transport, trash and cane-cleaner operation, along with gross income based on tonnes of cane and CCS at the factory. The results did support the expectation of higher CCS yield with lower extractor fan speed, but much of the higher yield measured by low-loss harvesting was lost during post-harvest cane cleaning. In one experiment, the treatment with post-harvest cane cleaning was less economic than the normal harvesting treatment, even after allowing for the lower transport cost to the Mossman Mill, a distance of 81 km away. These trials and subsequent analysis did not measure an increase in CCS yield from the low-loss harvesting plus cane-cleaning treatment compared to the commercial harvesting treatment and, therefore, showed no improvement to sugar income.

Young AJ, Knight NL

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## RSD resistance and the resistance to change

Anthony J Young and Noel L Knight

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Management of ratoon stunting disease (RSD) in Australia has been a topic of intense debate for many years. Despite recent calls to examine the utility of incorporating RSD-resistance in the plant-improvement program, this has apparently not been seriously considered. Among the reasons for this is the cost of producing resistant cultivars, both in direct terms, as well as the loss of variety output and retardation of genetic gain. This argument has been further entrenched by the widely reported very low incidence of RSD claimed by Sugar Research Australia: why incur these costs when RSD is costing the industry so very little? The counterarguments, that RSD-resistance is itself a practical genetic gain, and that the industry as a whole can have no realistic comprehension of the productivity losses caused by the disease because it does not seriously test for it, do not appear to have had any traction. This paper presents epidemiological data from LSB-qPCR diagnoses of seedbeds in northern NSW and far north Queensland and uses sensitivity analyses that estimate the costs of RSD to Australia. It further provides an avenue by which RSD-resistance can be deployed in the plant-improvement program.

## Incidence and economic effects of ratoon stunting disease on the Queensland sugarcane industry

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Ratoon stunting disease (RSD) has had a significant influence on productivity and profitability in the Australian sugarcane industry for at least the last 76 years. There have been few attempts to objectively quantify the incidence and economic influence of the disease across the industry. Most Cane Productivity Service (CPS) groups routinely monitor RSD in plant sources and, in some cases, in commercial crops. Surveys by 12 Queensland CPSs were conducted in 2017-2020 with sampling of different proportions of commercial crops (5-25% of farms) in each region. The latest molecular technology was adopted to assay samples. RSD incidence varied between 0 and 60% in commercial crops and 0 and 41% in plant source inspections. The data suggest that implementation of the three pillars of RSD management (disease-free seed-cane, equipment sanitation and planting into fallow ground devoid of volunteers) were essential to minimise RSD incidence. Failure to adequately address any one of these pillars often compromised RSD management. An economic analysis suggested that RSD led to an annual loss of \$25m in the study areas in the 2019 crop. This is significant, but it is unlikely to be the largest single disease constraint on productivity.

Bhuiyan SA, Eglinton J, Magarey RC

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## Prospects for a genetic solution to the management of ratoon stunting disease

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Ratoon stunting disease (RSD,) caused by a bacterium (*Leifsonia xyli* subsp. *xyli*), is one of the most important diseases of sugarcane in Australia. RSD is an inconspicuous and highly infectious disease and can spread unnoticed causing significant yield loss across entire regions and industries. Developing varieties with resistance to RSD has been proposed at different times as a possible solution. This paper provides a review of the resistance status of the sugarcane germplasm, the effective range in reactions to the disease, and the efficacy of current practices used for RSD management. Examination of the Australian germplasm and historical resistance records show that material with effective RSD resistance has never been identified. Published literature has occasionally suggested that there are resistant varieties/clones, but these putative sources of resistance have failed to demonstrate commercially-effective disease control. Currently, there are no validated sources of resistance available to be used as parents in the breeding program. Evidence from overseas and Australia demonstrates that RSD can be successfully managed through disease-free planting material and farm hygiene. A genetic solution for RSD may only be considered if an effective source of resistance can be identified and validated.

## Introduction of the sugarcane nitrogen and phosphorus budget

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Regulation of nutrient use on farms is not exclusive to Australia. Eutrophication of surface waters due to diffuse nutrient run-off from agriculture is a widespread and longstanding problem. Growing concern about water quality issues in the United States resulted in the introduction of nutrient-management plans in three states to help optimise yields and minimise environmental losses. In New Zealand, diffuse nutrient run-off has been managed through regulations that set nutrient caps within catchments and identification of nutrient targets.

The Reef regulations aim to bring those who are still using outdated practices and operating below industry standard up to a minimum practice standard. Queensland's sugarcane industry has been regulated since 2009 in the Wet Tropics, Burdekin and Mackay Whitsunday regions. The new regulations will apply to these and the Fitzroy and Burnett-Mary regions. They require soil testing and use of a regulated method to calculate nitrogen and phosphorus rates based on the industry standard SIX EASY STEPS program developed through Sugar Research Australia Limited.

The N&P Budget complements the nutrient-management plans already completed by growers with the support of several industry organisations and funded through industry and government programs (e.g. the RP161 project). The requirements for an N&P Budget are intended to further help sugarcane growers in Reef regions better manage and refine nutrient rates across their farms. Based on extensive field trials, research and one-on-one extension projects carried out across many sugarcane-growing regions over more than a decade, this approach has been shown to maintain or increase farm productivity and profitability, while reducing the amount of surplus nutrients that could be lost to the environment and improving Reef water quality.

Janke CK *et al.*

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## Distribution and chemical speciation of nitrogen from band-applied enhanced-efficiency fertilisers

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Enhanced-efficiency fertilisers (EEFs) are promoted as tools for improving nitrogen (N) use efficiency (NUE) in agricultural systems, but more information is needed on their behaviour when they are band applied in tropical environments. Incubation studies using banded, urea-based EEFs with nitrification inhibitor (NI), urease inhibitor (UI) and polymer-coating (PCU) technologies have identified how soil physico-chemical characteristics impact on urea dissolution, hydrolysis, volatilisation and microbial nitrification processes that determine the effectiveness of these products. The extent of the affected zone was dependent on the soil type; mineral N species typically diffused further than the inhibitors, resulting in key N transformations often occurring outside the zone of inhibitor influence. The effects of banded UI were transient (ca. 5–9 days) in the two studied soils. More consistent co-location of the NI and nitrifying activity occurred in a clay-textured soil where diffusion was limited by soil properties, and some benefit of the NI was observed late in the incubation. In contrast, PCU slowed the rate of release of N from granules to the surrounding soil solution, and delayed N release from granules in concentrated bands was consistent with poorly developed concentration gradients due to the close proximity of PCU granules to each other. Understanding the N dynamics and subsequent transformations of EEFs in soils with different physico-chemical characteristics, and with different fertiliser application methods, will be the key to developing management practices that allow EEFs to have the greatest impact on fertiliser NUE.

## Effect of temporal nitrogen-management strategies on sugarcane production in sub-tropical Queensland – a complete crop cycle

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Although the nitrogen (N) guidelines within the SIX EASY STEPS program are robust and applicable for most soils and circumstances, opportunities exist for fine-tuning the N application rates using temporal management strategies. These include split applications and use of enhanced-efficiency fertilisers (EEFs). This paper reports on the overall outcomes of a temporal-N trial conducted over a crop-cycle in southern region of the Australian sugar industry. Reports have indicated that EEFs have the best chance of contributing to improved productivity, profitability and NUE in sugarcane, when soils are subject to extended wet periods. Although the trial described here was located on an usually well-drained site, different seasonal climatic conditions enabled assessments under different conditions. Sugarcane yield responses to the different temporal-N strategies compared to the use of standard urea applied as single applications each season were essentially absent across the crop cycle on this relatively high-fertility-status soil. However, no single temporal N strategy was superior to the others. Mean partial net return (PNR) values for the crop cycle showed that the best return on applied N was associated with a standard urea applied at a rate of 120 kg N/ha in a single application in each season (standard treatment). Losses in mean partial net returns (\$/ha/year) of each treatment relative to the standard treatment showed that similar mean PNR values resulted from standard urea applied at 160 kg N/ha and DMPP-urea applied at both rates (120 and 160 kg N/ha). Split applications of urea generally resulted in lower PNRs compared to the standard treatment. Application of PC-urea (both rates) was the least profitable at the trial site. Further results from EEF evaluations being undertaken by others may shed light on the advantages of temporal management strategies on sugarcane production on soils that are normally found in imperfectly drained conditions in bottomland positions.

Skocaj DM, Schroeder BL, Wood AW

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## Are responses to nitrogen fertiliser predictable under similar conditions?

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Much attention in nutrient-management research, development and extension (RD&E) has recently focused on improving nitrogen-use efficiency (NUE) in sugarcane production in Australia. Although these activities provide potential solutions to nitrogen (N) management issues facing the Australian industry, they appear to have resulted in perceptions that yield responses to applied N on particular soils and in particular circumstances are precise and highly predictable. This paper reports on an investigation aimed at questioning the validity of these perceptions using the results of two trials with different rates of N conducted on similar soils in the same region during the same seasons and covering the same ratoon crops. The trial results indicated that, although sugarcane yields may be similar across sites and crops, differences in optimum N rates occurred due to differences in soil properties and seasonal rainfall patterns. Although the SIX EASY STEPS N guidelines for the two trial sites remain appropriate, actual N rates determined for the sites were variable. This suggests that, although the SIX EASY STEPS N guidelines remain appropriate for circumstances in general, the inherent and associated variability needs to be recognised. The N guidelines are therefore neither precise nor highly predictable for specific circumstances. This is particularly important, if growers and/or their advisors were to consider reducing N rates below the SIX EASY STEPS guidelines.



**Effect of applications of seaweed extract on sugarcane yield in Australia****Tony Arioli<sup>1,2</sup>, Graham Hepworth<sup>3</sup>, Bill Farnsworth<sup>4</sup>, Naga Kasinadhuni<sup>5</sup>, Christopher Nouné<sup>6</sup> and Scott Mattner<sup>7,8</sup>**<sup>1</sup>Seasol R&D Department, Bayswater, Victoria, Australia; tonyarioli@seasol.com.au<sup>2</sup>Department of School of Life & Environmental Sciences, Deakin University, Geelong, Victoria, Australia<sup>3</sup>Statistical Consulting Centre, School of Mathematics and Statistics, The University of Melbourne, Victoria, Australia<sup>4</sup>Farmsnorth Research, Innisfail, Queensland, Australia<sup>5</sup>Australian Genome Research Facility, Queensland, Australia<sup>6</sup>Australian Genome Research Facility, Victoria, Australia<sup>7</sup>VSICA Research, Toolangi, Victoria, Australia,<sup>8</sup>School of Life Sciences, La Trobe University, Bundoora, Victoria, Australia

Sugarcane growers are seeking innovations that will increase their productivity and profitability and enable sustainable farming practices. The aim of this research was to evaluate the effect of applying seaweed extract on sugarcane production and economics in Australia under commercial conditions and over an extended time frame (2014 to 2019). Seaweed extract significantly improved sugarcane productivity by an average of 17% (cane yield, sugar yield), and increased grower returns by 18% or AU\$1,158/ha. This is the first publication to demonstrate the efficacy of seaweed extracts applied by sub-surface drip irrigation across such an extended number of cropping seasons.

**Development of a new variety-rating system for sugarcane smut using improved statistical methods****Shamsul A Bhuiyan<sup>1</sup>, E Deomano<sup>2</sup>, J Stringer<sup>2</sup>, R Magarey<sup>3</sup>, J Eglinton<sup>4</sup>, X Wei<sup>5</sup> and G Piperidis<sup>6</sup>***Sugar Research Australia Limited, <sup>1</sup>Woodford, <sup>2</sup>Indooroopilly, <sup>3</sup>Tully, <sup>4</sup>Meringa, <sup>5</sup>Burdekin and <sup>6</sup>Mackay, Qld; sbhuiyan@sugarresearch.com.au*

Sugar Research Australia has helped the Australian sugarcane industry to manage diseases through the development of disease-resistant varieties. Candidate varieties are screened for resistance to major diseases, before release to the industry, and data collected from screening trials are used to predict the disease rating of each variety. A linear mixed model is fitted to the combined historical and most recent trial and predictions of the average disease ratings for each standard, and candidate varieties are obtained from the model. Using the predicted ratings from current data, both standard and candidate varieties are assigned to one of three resistance groups, i.e. resistant, intermediate, or susceptible. Varieties in each resistance group are presented in a tabular form, but problems have been identified in the two-stage analysis and the tabular report. To rectify the problems, this study aimed to (a) account for trial data variation associated with environmental and biological parameters, (b) replace the resistance groups with a confidence interval, and (c) develop an easily grasped visual illustration that indicates the predicted resistance of a variety plus variation in trial data. The 10-year historical data used in the study consisted of 10 top commercial varieties, nine standard varieties and a combination of six newly released varieties and advanced clones. A Box-Cox transformation was applied to the ratings and then a weighted linear mixed model was fitted to the data. Several combinations of parameters in the model were used, such as trial name or trial year as a random effect and trial confidence as a weight variable. Predicted average ratings and the 95% confidence interval (CI) for the predicted average ratings were calculated from the models. As a visual representation of the predictions from the best model, a scatter plot with the confidence interval (as error bars) was used. The visual reports were presented at the 2019 industry meetings following support by the Regional Variety Committees.

## Genomic organization of sugarcane cultivars revealed by chromosome-specific oligonucleotide probes

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Sugarcane (*Saccharum* spp.) is probably the crop with the most complex genome. Modern cultivars (2n=100-120) are derived from interspecific hybridization between the noble cane *S. officinarum* (2n=80) and the wild cane *S. spontaneum* (2n=40-128). We investigated the genome organization of important sugarcane cultivars and their parental species using chromosome-specific probes combined with genomic *in situ* hybridization (GISH). This allowed the genomic and genetic characterisation of Australian sugarcane cultivars and one of the major contributing parental clones, Mandalay. The *S. spontaneum* clone Mandalay follows the classical organization of *S. spontaneum* clones with x=8 with a major discrepancy related to an extra six chromosomes compared to the previously reported 2n=96 for Mandalay's clone. Our previous results reported the rearrangements between the *S. officinarum* (x=10) and *S. spontaneum* (x=8) chromosomes, with a most likely scenario of a two-step process leading to x= 9 and then x=8, where each step involved three chromosomes that were rearranged into two. Further polyploidization led to the wide geographical dispersion of *S. spontaneum* clones with x= 8. In modern cultivars, the 13-20% of the *S. spontaneum* contribution originated from cytotypes with x=8. Modern cultivars have mainly 12 copies of each of the first four basic chromosomes and a more variable number for those basic chromosomes whose structure differs between the two parental species. These new insights and cytogenetic tools substantially improve our understanding of the extreme level of complexity of modern sugarcane cultivar genomes and could lead to guiding breeding strategies in the development of new improved varieties for the Australian industry.

Zhao L *et al.*

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## Seed-based *in vitro* propagation to accelerate variety development

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To shorten the current lengthy selection process in sugarcane breeding and to accelerate genetic gain, Sugar Research Australia is implementing a range of novel breeding strategies and selection tactics. One strategy is to rapidly evaluate the progeny of elite crosses in replicated trials without passing through the traditional Stage 1 trials. However, insufficient planting material hinders its adoption. A seed-based *in vitro* propagation system has been developed for sugarcane in which sodium hypochlorite (bleach) and plant preservative mixture (PPM<sup>TM</sup>) were used in the sterilisation of seeds and seedlings, as well as in the treatment of infected seedlings. The system had been successfully implemented to propagate over 1000 clones of the elite cross Q208<sup>®</sup> x CP74-2005, for a Stage 2 selection trial. The new system, a first for sugarcane, is more cost efficient, providing three times the number of clones as in the seedling-based micropropagation system with the same input of resources. This innovation will shorten the selection cycle of proven elite crosses by up to 3 years, accelerating the delivery of new varieties.

## Predicting sugarcane physiological traits using hyperspectral reflectance

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Physiological traits have the potential to accelerate genetic improvement for adaptation to abiotic stresses, resource-use efficiency and yield in general. However, using these traits as selection targets in breeding programs is constrained by current phenotyping approaches that involve destructive, time-consuming and labour-intensive measurements. There is growing interest in developing high-throughput tools and prediction models for precise phenotyping of important physiological traits under field conditions. The aim of this study was to explore the potential of remotely piloted aircraft (RPA)-based canopy hyperspectral reflectance in predicting physiological and biochemical traits in sugarcane. Partial least square regression (PLSR) models for predicting physiological, biochemical and yield traits from hyperspectral data had varying degree of accuracy. The prediction accuracy was good for cane yield and sugar yield ( $R^2 = \sim 0.5$ ), moderate for leaf sucrose, leaf starch content and gas exchange attributes ( $R^2 = \sim 0.2$ ), while, poor for the other traits. It appears that a larger spectral and traits dataset from measurements made under different environmental conditions and crop growth stages is needed to improve the PLS prediction model. Results from this initial proof-of-concept study suggests the effectiveness of hyperspectral sensing for characterising and predicting certain physiological and yield attributes. Validation of these results across seasons and under distinct environmental conditions using diverse genotypes is needed before delivering prediction models for phenotyping sugarcane physiological traits using hyperspectral reflectance.

## Poster

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## Genetic analysis and marker delivery for sugarcane breeding

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The use of molecular markers in variety development gives breeders the ability to increase selection pressure for key traits by applying selection at stages of the breeding cycle when it is not possible or practical to use phenotyping. Sugarcane's large heterozygous genome has resulted in the proven parent breeding method where high-combining ability parents are repeatedly crossed, and the progeny screened in the breeding program to identify new genetic combinations generated from these high-value parents. The move in the sugarcane breeding program to larger populations sizes has provided the opportunity to harness the non-additive genetic effects or epistasis and given the ability to conduct higher precision genetic analysis using the high-density SNP markers that has not been possible before.

Using a novel propagation method designed to speed up the time from generation of the seed to field planting, a population of over 300 progeny from Q208<sup>♂</sup> x Q209<sup>♂</sup> were planted in a replicated field trial. At the same time, replicates of each progeny were sent to Woodford to propagate material to screen for red rot and smut resistance. Leaf tissue from all the progeny was collected for DNA extraction and SNP-marker analysis.

Three methods of marker generation will be tested to determine the most cost-effective generation of single-dose markers needed to identify quantitative trait loci for all agronomic traits of interest. All data will be captured in the Sugarcane Hub, an online web-based data-management tool for genetic/genomic data. This will be a resource for development of high-throughput markers linked to both disease and agronomic traits for use in selection by the breeders.

## Identification of SNP markers linked to resistance to root-knot nematode *Meloidogyne javanica* using transcriptome analysis

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Root-knot nematodes (RKNs, *Meloidogyne javanica*) are widely distributed and are economically important parasites of sugarcane crops. Studies have shown that nematodes cause from 5 to 20% yield loss per year, which costs the sugarcane industry more than AU\$80 million. Screening of varieties and wild *Saccharum* germplasm has identified some accessions with resistance to RKNs. In order to identify genes that contribute to this resistance, we carried out an expression analysis study. One resistant (QBYN04-26030) and one susceptible (QBYN04-26137) sugarcane progeny from a BC1 *spontaneum* population were grown in a replicated glasshouse trial. The plants were grown for 10 weeks, then inoculated by injection into the soil with 5,000 eggs of *M. javanica*. After 1 week and 10 weeks post-inoculation, the roots were sampled and snap frozen for RNA extraction. The RNA was then sent for library preparation and sequencing. A combined total of 4.2 billion paired-end reads were generated and the trimmed reads were mapped against a *de novo* transcriptome assembled from the raw reads. To identify linked SNP markers the reads were also mapped against 81,000 contigs generated from the development of the Affymetrix® Axiom® Sugarcane 48K SNP array. Differential gene expression analysis showed numerous defence-related genes induced in plants infected with RKN and included genes such as receptor-like kinases (RLK), nucleotide-binding site-leucine-rich repeat (NBS-LRR) proteins, PR-proteins, and transcriptional regulators, as well as known anti-nematode proteins such as a jacalin-related lectin gene. SNP markers were identified from these differentially expressed genes and converted to Fluidigm SNPTYPE markers. These SNP markers were validated against a panel of sugarcane cultivars that had different levels of resistance to RKN. The results indicate that there is potential for SNP markers in candidate genes to be used for the selection of sugarcane plants resistant to RKN in the breeding program.

## Using flow sorting to select high-value *Erianthus* chromosomes from a *Saccharum-Erianthus* hybrid

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The complex polyploid nature of the sugarcane genome and the high representation of repetitive and transposable elements it shares with other plant genomes has hindered progress in our understanding of the genome. This complexity means genome assembly is highly challenging and there is still no high-quality sequence available. One approach that has been successfully used in many plants is to break down the complexity of the genome by using flow cytogenetics and examining individual chromosomes or groups of chromosomes. We have successfully modified the approach that was developed in wheat to flow-sort chromosomes from seven sugarcane plants, three modern sugarcane varieties, two *Saccharum-Erianthus* BC4 hybrids and two *S. officinarum* accessions, the parental species which contributes ~ 80% to the modern sugarcane cultivar genome. This has led to a greater understanding of the sugarcane genome structure. We used a *Saccharum-Erianthus* BC4 hybrid, to demonstrate that single chromosome sorting can be carried out in sugarcane. The BC4 hybrid was derived from an initial *Saccharum-Erianthus* F1 hybrid, then backcrossed to *Saccharum* to recover the high-sucrose phenotype, resulting in reduced numbers of *Erianthus* chromosomes. This BC4 plant has only three *Erianthus* chromosomes in a background of *Saccharum* chromosomes. *Erianthus* is of value to sugarcane breeding as it is resistant to nematodes and pachymetra root rot. To identify the genes responsible for its resistance we have flow-sorted and sequenced a single *Erianthus* chromosome. This sequence was then used to identify genes and develop markers to determine if markers could be used to introgress resistance genes from *Erianthus* into sugarcane varieties. This would fast track the development of new varieties that retain high-value *Saccharum* traits such as cane yield and high CCS but remain resistant to nematodes and pachymetra root rot.

**Using data-driven forecasts of sugarcane yield to optimise variable N-fertiliser application****Si Yang Han, Patrick Filippi and Thomas Bishop**

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The Australian sugar industry is under international scrutiny due to nutrient-rich runoff that flows into the Great Barrier Reef. In response, there have been industry-wide efforts to introduce precision agriculture (PA) into sugarcane (*Saccharum* spp.) production. The overall aim of PA is to variably apply agricultural inputs according to crop needs in space and time, which are reflected by the potential yield and sugar content of the crop. Current methods to digitally forecast sugarcane yield incorporate a range of data; from crop simulation models (such as APSIM-sugar) to satellite imagery. However, simulation models require many strict inputs, and satellite imagery approaches are only able to accurately predict in-season yield well beyond the nutrient application and management intervention deadline for growers. Commercial cane sugar (CCS) is rarely modelled despite being a key factor in the price return for sugarcane. This project aimed to include a wider range of publicly available spatio-temporal data (e.g. satellite imagery, climate, terrain attributes and soil maps) in tandem with data collected by growers and mills (e.g. past yield, relative CCS, ratoon number, planting and harvest dates) to more closely represent the factors that drive yield and CCS.

Accurate early season forecasts of yield offer growers the opportunity to make better informed decisions regarding fertiliser rates, as well as the scheduling of harvest and management of operations by sugar mills. On the other hand, foreknowledge of relative CCS with yield offers the potential for growers to estimate future income and better manage farm budgets. Not only will more targeted and accurate applications of fertiliser improve profitability for growers, additionally, it will have positive environmental effects as less excess nutrients enter the Great Barrier Reef. Although this project was performed using data from a large sugarcane farm, the method developed is scalable. Future work will pool together data from many farms across a region, while still maintaining the predictions at a fine spatial resolution (block scale). A modelling approach such as this could have considerable benefits for the Australian sugar industry as a whole.

**Towards accessible crop-yield estimation****Luke Sockhill, Alex Aird, Anthony Simmons, Aki Barry, Jeff Van and Oliver Jeaffreson**

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This work attempts to meet the significant challenges posed in the agricultural industry around accessible crop-yield prediction. Not only should the designed system provide an accurate prediction of crop yields, but the technology should aim to minimise barriers to entry that may impact the user experience of key user demographics.

**Stoller Australia: local solutions – international approach****Cameron Steer and Domenic Cavallaro**

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Stoller Australia is a leader in the provision of liquid nutrients and crop empowerment products. These are nutrients and co-factors that make the plant healthier and more productive. The range includes a full complement of primary, secondary and micronutrients, as well as proprietary products designed to achieve specific crop-production outcomes.

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- Excellence: achieving the highest consistent quality and performance.

**Thompson N, Wilson E****Effective quarantine: Interception of sugarcane diseases in the last 20 years has protected the industry from exotic threats****Nicole Thompson<sup>1</sup> and Elizabeth Wilson<sup>2</sup>**

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Sugar Research Australia Indooroopilly has a post-entry quarantine facility that imports foreign clones per year. The imported clones are used for germplasm improvement in the SRA breeding program, with about 50% of released cultivars having at least one foreign clone as a parent. Quarantine of clones prior to their entry into the Australian sugarcane industry is important to keep out exotic pests and diseases. There have been many changes to quarantine since the industry began over 100 years ago: from no precautions at all, to the comprehensive system that we have today. This paper discusses the major milestones in quarantine, the evolution of the post-entry quarantine facility, the diseases tested for in post-entry quarantine, and the diseases that have been intercepted. We conclude with a summary of improvements that could be made to minimise the risk of importing diseases when achieving effective variety exchange.

## Impact of application depth and slot closure on runoff losses of imidacloprid

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Imidacloprid represents the Australian sugar industry's best canegrub-management tool, but it has been detected in many water bodies, including groundwater, creeks, rivers and marine environments, posing a potential risk to the health of the Great Barrier Reef. In ratoon cane, it is commonly applied in liquid form with coulters within the cane row. Imidacloprid product labels state that, when applied in ratoons, the product must be placed at 100–125 mm depth and the slot must be covered; however, it is not uncommon to observe application equipment that does not maintain the desired depth or fails to close the slot appropriately. To investigate the best application methods to reduce imidacloprid runoff, two rainfall-simulation trials were established in the Burdekin and in the Wet Tropics to assess the impact of depth and slot coverage on imidacloprid runoff when the liquid formulation is applied with a stool-splitter tine implement. An additional runoff trial under overhead irrigation was set up in the Wet Tropics to test the efficacy of the StoolZip™ to close the slot and reduce imidacloprid runoff losses when the product is applied at the correct depth of 100 mm. Results from the rainfall-simulation trials showed higher imidacloprid concentration in runoff from a shallow application at 50 mm compared to the recommended minimum 100 mm application depth. A press wheel reduced the imidacloprid concentration to nil when the product was applied at the correct depth of 100 mm; however, it slightly increased the concentration in the case of the shallow application. In the overhead-irrigation trial, the StoolZip™ increased the imidacloprid concentrations in runoff versus the slot left open, but these concentrations were still extremely low and not of environmental concern. These trials indicate that ensuring the product is consistently applied at 100 mm depth is the best way to reduce imidacloprid loss via runoff when the product is applied with a stool-splitter tine implement. As trials were only conducted in loam soils at two locations, further trials are recommended over a range of soil types and geographic locations.

## Poster

## A simple and inexpensive device for the detection and quantification of leaf scald disease of sugarcane caused by *Xanthomonas albilineans*

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Exotic and endemic diseases are major threats to sugarcane production in Australia and worldwide. Most of the approaches for diagnosis of sugarcane diseases are at least 10 years old, and centralised laboratory-based tests are expensive and lengthy turnaround times. The aim of this pilot project was to develop a novel nanotechnology-based reliable and highly sensitive detection method for plant diseases.

Leaf scald disease, caused by the bacterium *Xanthomonas albilineans*, was selected as model disease for this purpose because the infected plant can remain asymptomatic for months making visual detection impossible. We developed a platform device that provides multilevel diagnostic capacity of leaf scald disease: naked-eye evaluation, and highly sensitive electrochemical detection (Figure 1). We demonstrated the functionality of this proof-of-concept device platform using *X. albilineans* grown on plates, and from inoculated sugarcane clones of various degrees of resistance. Overall, per sample cost of the assay was estimated to be <AUD\$10. Results were highly correlated with standard qPCR assay, as well as resistance rating of the test clones.

We aim to develop a prototype device based on this novel assay for on-farm diagnosis of leaf scald disease. This device platform can then be adapted for early detection of various other exotic and endemic diseases of sugarcane in Australia.

**Sugarcane grubs in the Lautoka and Rarawai Mill areas, Fiji****BV Padayachi and PNB Rounds***Sugar Research Institute of Fiji, Drasa, Lautoka, Fiji; binitap@srif.org.fj*

Sugarcane grubs (larvae of Scarabaeidae) have been long-standing but non-significant pests in the Fijian sugar industry with limited research done in the past, the last being nearly a century ago. A preliminary survey was conducted in the two mill regions in Fiji, Lautoka and Rarawai, to investigate the incidence of the pest. Fifteen farms were randomly selected from every sugar-producing district in the larger island of Fiji (Viti Levu). Only a few farms had significant infestations. Species encountered were the melolonthines *Xenotrogus subnitida* (Arrow) and *X. vestita* (Arrow) and the ruteline *Adoretus versutus* Harold.

**Status of Asian subterranean termites in the sugarcane belt of Fiji****BV Padayachi, NS Prasad and PNB Rounds***Sugar Research Institute of Fiji, Drasa, Lautoka, Fiji; binitap@srif.org.fj*

Asian subterranean termite, *Coptotermes gestroi* (Wasmann) (AST), has invaded Viti Levu and in late 2009 and early 2010 there was an outbreak mainly in the Lautoka area that caused massive damage to homes and schools. AST is affecting the sugarcane belt areas in Lautoka sectors; Lovu, Lautoka and Drasa. This paper highlights the results of an ongoing survey which is being done through SRIF's routine roguing inspection to provide status and margins of the termite zone. Every farm within the affected sectors is being inspected for the presence of AST. All communities from Drasa to Saru including Lautoka City have been declared as biosecurity emergency areas under the *Biosecurity Emergency Promulgation 2010*. The survey result will enable SRIF to closely monitor and modify the certifications of exchange of seed cane within the close localities.



## Identification and determination of the impact on sett germination of fungal isolates associated with sugarcane plants

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Nine fungi were isolated from the sugarcane setts from locations in Queensland and New South Wales cane-growing areas. The fungal isolates were grown on potato dextrose agar (PDA), indexed and maintained at Sugar Research Australia Woodford for further study. Growth characteristics and sporulation of the fungal isolates were recorded. A glasshouse experiment was conducted to determine the pathogenicity of the fungal isolates. The experiment was established at the end of July 2019 with nine isolates, one un-inoculated and one known fungal species (*Athelia rolfsii*, WF001). The fungal isolates in PDA were cut into small pieces and mixed with moist vermiculite. Sugarcane variety Q208<sup>®</sup> was collected from the Woodford propagation plots, cut into one-eye-setts (OES) and hot-water treated at 50.5°C for 30 minutes to eliminate internal systemic infection. The setts were then left on a bench inside a shed for 1 hour to dry before they were planted into the inoculated vermiculate trays, and maintained in a germination chamber at 30°C. Three vermiculite trays of each isolate with 10 OES in each tray were planted in a randomised complete-block design and, germination data were collected at the first, second, third and fourth weeks after planting. Morphological study showed that five isolates (WF 006, WF 008, WF 009, WF 011 and WF 012) were *Colletotrichum* spp., two isolates were *Athelia rolfsii* (WF 005 and WF 010) and two isolates (WF 007 and WF 013) yet to be identified. None of the isolates produced fruiting bodies or structure under ambient condition. Germination of setts were reduced in the trays inoculated with WF 010, WF 012, WF 007 and WF 001 when compared with the un-inoculated control. Other fungal isolates did not affect the sett germination. Further research is underway to identify more isolates and to determine their impact on sett germination.

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## Survey of nematodes in the Herbert region to develop a nematode-hazard index and evaluate soil health

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Soil nematodes are microscopic worm-like organisms and are important members of the soil ecosystem. Some nematodes are either plant or animal parasites, and some are 'free-living' feeding on bacteria, fungi or on other nematodes. Plant-parasitic nematodes can cause significant yield loss in sugarcane. Free-living nematodes are vital contributors to soil health through their involvement in mobilisation of nitrogen and carbon and are important indicators of soil health. The objectives of this study were to determine the extent of plant-parasitic nematodes and their potential impact on sugarcane production in the Herbert region, and the use of nematode community analysis to determine the soil health of the surveyed sugarcane farms. Soil samples were collected from 56 locations from six sugarcane productivity zones, Central Herbert, Lower Herbert, Ingham Line, Stone River, Abergowrie and Wet Belt from one-year plant crops. Most of the sugarcane fields surveyed had medium (484 nematodes/200g soil) to high (1137 nematodes/200 g soil) numbers of root-lesion nematodes. Other nematodes, including root-knot nematodes, were relatively low in number. A nematode-hazard index (HI) was developed by adding the weighted number of parasitic nematodes determined from a hazard factor derived from the damage caused relative to damage caused by root-knot nematodes. Approximately 73% of surveyed farms had medium to high HI values, an indication of moderate to high potential impact on yield. As an indicator of soil health, soil food-web maturity indices (MI) were determined on the basis of nematode community. Analysis of nematode community showed low maturity indices (MI and MI2-5) (<3.5) in all farms, an indication of low soil food-web maturity and persistent use of chemical fertilisers. Soil food-web indices and metabolic footprints indices also indicated perturbation of sugarcane soil and a farming system dominated by herbivorous nematodes. Our study demonstrated that nematodes community analysis can be used as indicators of soil health for the sugar industry as well as a monitoring tool to determine the effects of management practices.

## Towards a molecular toolkit to assess biological health of soil

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Sugarcane farmers are becoming increasingly aware of the importance of soil health. However, there are limited tools by which the health of soils can be measured. Nematodes are known to be an excellent indicator of soil health, but their identification and enumeration is laborious and requires the expertise of a diminishing pool of trained scientists. Molecular methods are being used to detect specific nematode targets and estimate their numbers, but in the sugar industry this work has focused on two key pests: root-lesion nematode (*Pratylenchus zeae*) and root knot nematode (*Meloidogyne* spp.). However, such methods are not useful against the huge range of free-living nematodes that are present in sugarcane soils and are arguably more informative with regards to soil health. Advances in DNA sequencing technology have facilitated the development of metabarcoding tools which can effectively identify as well as enumerate soil micro-organisms such as bacteria and fungi. We describe how we aim to apply this technology to the identification and enumeration of soil nematodes, and how the molecular tests that are developed could be used by farmers to assess the effectiveness or otherwise of soil health interventions.

**Lenancker P, Powell K**

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## Giving it our best shot in the war against soldier flies – future research directions

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Soldier flies are economically damaging pests of sugarcane, particularly in central and southern Queensland. Despite decades of research on soldier fly control, the search for an effective management approach, except for cultural control, remains elusive. Trials were conducted from 2015 to 2017 to identify potential management solutions for soldier flies by assessing insecticide efficacy and varietal tolerance in field conditions. Five field trials were established to determine whether applying insecticide at plant cane would reduce the build-up in soldier fly larvae in subsequent ratoons. Ten products, comprising seven active ingredients, were field tested at high application rates. Overall, as in most previous studies, none of the insecticides tested reduced the number of larvae in field-trial conditions. The inefficacy of insecticide treatments could be due to products failing to come into contact with soldier fly larvae or simply lack of an effective active. In addition, three field trials, using up to 14 varieties, were conducted, to assess varietal tolerance. Some varieties tended to host fewer larvae than others, suggesting some resistance, in two trials established in southern Queensland. Any future insecticide and varietal screening trials will need to be conducted in both controlled laboratory and field conditions. However, before such trials can be undertaken, a standardised laboratory rearing method and improved field sampling strategy for soldier flies needs to be developed. Soldier fly outbreaks are also unpredictable and developing methods to forecast them (e.g. using climatic data or identifying preferential soil properties) will also be highly beneficial to inform growers of the potential risk of soldier fly establishment in their paddocks and for selecting field-trial sites. Additionally, recent DNA barcoding and morphological studies have revealed that at least six species of soldier flies are found in sugarcane, not two as previously identified. That finding highlights that the distribution of soldier fly species in Australia and the relative damage to sugarcane varieties needs to be resolved to enable the development of targeted species-specific management approaches.

## Australian sugarcane soldier fly's salivary gland transcriptome in response to starvation and feeding on sugarcane crops

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The soldier flies *Inopus rubriceps* (Macquart) (Diptera: Stratiomyidae) and *Inopus flavus* (James) are endemic to Australia where they are economically important insect pests of sugarcane. Small numbers of larvae can cause significant damage to roots and reduce the crop yields. Soldier fly pest management is difficult in sugarcane crops as insecticides are ineffective and no crop cultivars are tolerant to larval feeding. The development of improved pest-management strategies requires a better understanding of the relationship between soldier fly and its sugarcane host plants, but little is known about the composition and function of the soldier fly salivary gland or its secretions, and the role that these products play in insect-plant interactions.

We performed transcriptome analysis of the salivary glands of starved and sugarcane root-fed soldier fly larvae. Soldier fly (*I. flavus*) larvae were collected from an infested sugarcane field near Hay Point, Queensland. To examine direct interactions between larvae and plant roots, individual sugarcane seedlings (cultivar Q208<sup>®</sup>) were transplanted into six 50 mL Falcon tubes filled with 70% peat and 30% sand and grown in sunlight for 3 weeks to develop a root system. Ten mature larvae (~10 mm long) were then introduced to the surface of the soil in each tube and allowed to move down towards the roots. Larval activity and feeding behaviour were monitored under a binocular microscope each day for 2 weeks before larvae were carefully removed and prepared for RNA extraction from salivary glands.

In our study, a transcriptomic approach was developed to characterize the composition of salivary glands in soldier fly larvae. This cutting-edge approach improved our understanding of the insect-plant interaction as it enabled us to produce the first gene expression profile in soldier fly salivary glands. Although we identified noticeable differential gene expression in the salivary glands of starved and fed soldier fly larvae, further comprehensive investigations to characterise the proteins that these genes code for are required, followed by functional studies in sugarcane plants. There are many other sequences in the soldier fly transcriptome which have completely unknown functions.

Haines MG, Davis G

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## Adapting solar energy to irrigated sugarcane production at Bundaberg, Queensland

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The concept of renewable and Hybrid Energy systems (HESs) are highlighting opportunities for electrification of isolated or energy-deficient areas, and where grid-supplied electricity costs exceed these alternatives. The concept of utilising solar photovoltaic (PV) as an energy source for irrigation in sugarcane production has been promoted by grower representatives and governments as a solution to the energy trilemma, particularly the escalating cost of grid-supplied electricity. However, there is a deficit of independent, publicly available data on the true value proposition of solar in this context. The critical issue is whether such a system is capable of maintaining the peak irrigation requirement for the daytime energy demands of current sugarcane production; and whether solar powered systems could change irrigation management practice leading to increased farm productivity. Adoption of new technology is limited by knowledge around capability and viability, particularly where the technology is to be deployed to meet a specific crop demand, such as irrigated sugarcane production, and where significant capital investment will be required. A demonstration and evaluation trial of new energy technologies on-farm was installed at Bundaberg to overcome barriers to adoption, such as attaining proof-of-concept and to provide financiers with confidence to support the capital expenditure required. This paper outlines the design specifications and crop considerations associated with the adoption of HES across a range of irrigation methods utilised in the Australian sugar industry. The hypothesis posed is, can a solar system provide a stand-alone energy supply for sugarcane farming operations that have high seasonal demand for irrigation and, if not, what combinations of solar and grid or other energy are the most efficient. This project has demonstrated that when optimally designed, HESs prove to be more reliable and economical than single energy source systems for irrigation and can lead to productivity gains.

## Prioritising R&D needs for mechatronic and data-dependent applications in Australian sugarcane

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Sugarcane-production systems in Australia continue to evolve as on-farm practices and management strategies are tested and adopted. Mechatronic and data-dependent (MADD) applications offer novel ways of contributing to this process. Here we provide a summary of a paper delivered at the M2VIP Conference held at the University of Southern Queensland in December 2019. We indicated where MADD-related R&D opportunities exist within the different stages of a typical semi-irrigated one-year production system. These were ranked from currently available/being adopted to requiring R&D effort. They were classified according to complexity and estimated timeframe for successful outcomes. Several potential MADD applications were recognised as being possible in the shorter term using existing knowledge and technologies. Others were identified as being more complex and needing longer timeframes to produce workable outputs. The latter included (i) automated and robust sugar sensors to determine commercial cane sugar (CCS) at appropriate heights in the crop at harvest, and (ii) automated/semi-automated in-field robotic soil-test equipment. Irrespective of the level of complexity, comprehensive evaluation of MADD applications for use in sugarcane-production systems is needed to ensure that they are appropriate, reliable and robust.

## Grower-first approach delivers that extra 20% in the Isis

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A grower-centred, continuous-improvement profitability and productivity strategy, Isis 20:20, was initiated in the Isis District to work on the unique 20% gains for each grower. A grower or person-centred, extension approach was trialled to explore the effect on practice change with results tracked using action-research methodology. Extension personnel were purposefully integrated and coordinated to implement priority, targeted activity as identified by growers. Results included: (a) using a 'grower-centred' extension approach enabled extension personnel to know and understand growers' individual and unique productivity goals that supported increased practice change; (b) there was a higher chance of extension and support personnel knowing about growers implementing practice improvements when there was a working relationship in place; (c) change appeared to occur more often in incremental steps than a major step change and there seemed to be a pattern to these steps; and (d) a grower's incremental practice improvements could be systematically recorded, measured and reported by extension and support personnel live in the paddock. Results provide support for further exploration of both the relationship between the farming family and extension personnel and the effect on practice change using the continuous practice-improvement continuum.

## Digital farm maps in your pocket

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The age of the smart phone and tablet is well and truly upon us with many people having one in their pocket, vehicle, office or shed. Farming in the Isis district is fast paced and ever evolving with many businesses being multi-faceted. Business managers are seeking efficiencies and innovation to access their information readily. Google Earth Pro is a free program that allows the viewing, sharing, editing and customisation of Global Information System (GIS) data. The Keyhole Markup Language files (KML file extension) from GIS programs can be sent to and imported into another users' program. As part of the Nutrient Management Planning in the Isis project funded by the Queensland Government Reef Water Quality Program, growers have been receiving one-on-one Google Earth Training from Isis Productivity Limited (IPL) staff. Over 40 Isis district growers have been given their 2019 farm maps as a KML file. The growers have installed the Google Earth App on their phone/tablet and/or Google Earth Pro on their computer to utilise the map layer/s. Map layers provided have included;

- Farm map, which shows farm number, block description, area in hectares, current year, variety, and crop class (created annually);
- Soil type by map code, which utilises soil types determined by medium intensity across the Isis and Bundaberg districts;
- Soil type by SRA productivity group;
- Plant Available Water Capacity and Readily Available Water;
- Soil sampling history with live hyperlinks to soils test organised by year and labelled by farm and block number;
- Nutrient management zones and associated product recommendations.

Layers can be viewed individually or with multiple layers selected at the same time displaying related information simultaneously. Some growers are using images from the app on mobile devices to show service providers locations on their farm. For example, where they would like soil samples collected or pests, weeds or disease inspections conducted. Others are linking their mobile record keeping tools such as farm area calculators to their Google Earth layers.

Growers have given Isis Productivity Limited positive feedback on the ability to easily access farm details in the field from the phone or tablet without a physical map. This integration of smart technology allows for instant access to information, potentially assisting in more efficient decision making. This along with further grower innovations will rapidly build a readily accessible mobile, digital and spatial, farm data library and history.

## Your Farm, Your Way – Smartcane BMP Isis customised digital record keeping

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Smartcane BMP Isis is customising record-keeping tools with end-use capacity for growers. There are many growers who are operating at best practice although may not have all the necessary records. While best management practice is about so much more than record keeping, having useable records is essential for effective business management and economic decision making. Each farming business is unique and so too are their record-keeping requirements. The records collected on-farm need to yield a return on time invested just like any other farming activity. The first step in selecting a record-keeping strategy is to understand the available options. In their facilitation roles the Smartcane BMP Isis team have been working with growers to discuss and demonstrate the available options. The 2019/20 season has seen growers in the Isis district take on the innovative practice of building their own digital record keeping tools. These fillable forms can be used in the field on any mobile device to record the information growers need or want to capture. This free, customisable record-keeping tool is being trialled by more than 20 sugarcane businesses throughout the district in its first season and has unlimited potential for more businesses in the future. Growers have found that this innovative tool reduces the need for repetitive and excessive data entry associated with other record-keeping methods. Growers are keeping records on everything from herbicide application to irrigation, energy, nutrition, planting and cultivation. Records generated from these forms are assisting growers benchmark their production systems by providing useable data for analysis and decision making "on the go", as well as reflection at the end of the season. This tool enables growers to collect the specific data that they require, inclusive of time saving calculations. The ability to pre-fill multiple categories in a form also results in time efficiencies. For example, the irrigation record tool has customised built-in calculators for area watered and megalitres applied, ultimately displaying and recording a value of millimetres of water applied per hectare. This enables decision making in the field on allocation of limited and costly resources such as nutrients, pesticides, water and energy. The Smartcane BMP Isis team will continue to work with new and existing growers on this exciting record keeping opportunity to help growers with the "Your Farm, Your Way" integrated approach.

## Effect of organic additives on the development and extension of roots in sugarcane variety CP48-103

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Iran's domestic sugar production comes from both sugarcane and sugar beet industries with sugar output in recent years split very roughly 50/50 between the two crops. The sugarcane industry is concentrated in Khuzestan Province in the south-west of Iran. A pot trial was undertaken to examine the effect of various organic amendments, readily available in the industry, on root growth of sugarcane variety CP48-103. The treatments involved different combinations of a trash blanket, molasses, vinasse and buffalo manure. In addition, the effect of the addition of two microbial solutions, with good hydrolysis and composting properties, was also examined. The first microbial solution contained bacteria of the Bacillaceae family (*Bacillus licheniformis*, *B. subtilis*, *Geobacillus thermodenitrificans* and *Brevibacillus agri*) plus the fungus *Thermoascus*, whereas the second microbial solution tested contained the fungi *Aspergillus niger*, *Trichoderma fumigatus* and *Trichoderma harzianum*. The pots were placed outdoors near sugarcane fields to simulate a realistic growth environment. Plants were harvested 5 months after planting, and root weights and lengths measured.

No significant differences in root length were observed between the two microbial solutions applied. The largest root length was obtained when pots were treated with a trash blanket, buffalo manure and microbial solution 1. For the five treatments involving amendments, the smallest root length was recorded when a trash blanket, vinasse, molasses and buffalo manure was added to the pots.

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## Soil-binding adjuvants can reduce herbicide loss via runoff

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Concentrations of a range of pesticides exceed water-quality guidelines throughout the year in many fresh and estuarine water bodies of the Great Barrier Reef catchment. To mitigate its impact and maintain its productivity, the Australian sugar industry is looking at innovative options to reduce the movement of herbicides off site. Three oil-based adjuvants (Grounded<sup>®</sup> applied at 3 L/ha, Atpolan<sup>®</sup> soil Maxx applied at 0.4 L/ha and Ad-Here<sup>™</sup> applied at 1L/ha according to their respective labels), a terpene-based adjuvant (Flexend<sup>®</sup> applied at 1.2 L/ha) and a polyol-based adjuvant (Watermaxx<sup>®</sup>2 applied at 9.35 L/ha), were tested on bare soil and on a trash blanket for their potential to reduce runoff losses as well as improving the weed control efficacy of four registered pre-emergent herbicides applied at full label rate: imazapic (96 g/ha), hexazinone (975 g/ha), isoxaflutole (150 g/ha) and amicarbazone (700 g/ha). Herbicide-efficacy trials were implemented as randomised complete-blocks with three replicates and adjacent untreated controls. Losses of the tested pre-emergent herbicides in runoff were monitored using replicated rainfall simulations, delivering 80 mm of simulated rain, 48 h or 3 weeks after herbicide application. On green-cane trash-blanket, all oil-based adjuvants significantly increased the runoff of the tested herbicides, Flexend did not affect herbicide runoff and Watermaxx<sup>®</sup>2 slightly reduced herbicide concentration in runoff by up to 25%. On bare soil, three of the tested adjuvants significantly reduced herbicide runoff losses. Grounded<sup>®</sup> achieved the best outcomes by reducing herbicide concentration in runoff by about 35% when runoff occurred 48 h after application. Most of the tested products slightly increased herbicide efficacy on weeds in the efficacy trials, but the differences were not significant. If validated in other soil types and in bare soil ratoon cane, the use of Grounded<sup>®</sup> could assist in improving the quality of runoff water leaving sugarcane paddocks and, therefore, reduce canegrowers' impact on freshwater water and marine ecosystems.

## Effect of the soil-binding adjuvant Grounded® on herbicide efficacy and runoff losses in bare soil in ratoons

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This paper presents additional research work carried out to assess the impact of Grounded® on pre-emergent herbicide efficacy and on runoff losses when applied to ratoon cane on bare soil. This scenario is typical of the Burdekin and New South Wales regions. Two trials were conducted in untilled ratoons after burning the trash blanket in far northern Queensland. Grounded® was added to six registered pre-emergent herbicides: imazapic (94.5 g/ha), hexazinone (472.5 g/ha), isoxaflutole (150 g/ha), amicarbazone (700 g/ha), atrazine (1350 g/ha) and pendimethalin (1001 g/ha). Herbicide efficacy trials were implemented as randomised complete blocks with three replicates and adjacent untreated controls. Losses of the tested pre-emergent herbicides in runoff were monitored using replicated rainfall simulations, delivering 80 mm of simulated rain, 48 h or 3 weeks after herbicide application. Both runoff trials generated similar herbicide concentrations in runoff. As expected, higher concentrations for all herbicides were found in runoff 48 h after spraying compared to 3 weeks after spraying. The adjuvant Grounded® added to the spray tank did not decrease herbicide loss via runoff in both trials. Topsoil samples taken before and after rainfall, generally showed higher percentage herbicide in topsoil after rainfall when Grounded® was added to the tank mix compared to no added adjuvant. However, this slight binding improvement to the soil did not result in lower herbicide loss in runoff. These runoff and soil results mirrored previous research results when Grounded® was applied on trash blanketed ratoons. In both efficacy trials, weed control varied at each site between herbicide treatments depending on the environmental conditions and the weed species. However, the addition of Grounded® to each herbicide treatment did not affect the efficacy of any herbicide treatment in both trials. These results show that the oil-based adjuvant Grounded® is unlikely to improve the quality of runoff water leaving sugarcane paddocks when applied to untilled ratoon cane on bare soil.

Blair A, Robertson J, Gonzalez D

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## Sugarcane boomspray diagnostics using a portable patternator

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Homogeneity of liquid distribution across the entire sprayer boom is one of the most important factors affecting the efficacy of chemical treatments for crop protection. However, this can be easily ignored and have serious repercussions, such as minimizing control and maximizing costs and environmental harm. With increasing pressure on sugarcane producers to remain economically viable and increase their environmental stewardship by improving their chemical application, correctly operating sprayers are essential. This paper highlights the use of a portable horizontal patternator as a tool for on farm testing of herbicide application and outflow consistency over boom width.

**Performance of the SRI fixed-element cooling crystalliser at Broadwater Mill****R Broadfoot<sup>1</sup>, I Ashtiani Abdi<sup>1</sup>, M Lowrey<sup>2</sup> and G Mitchell<sup>2</sup>**<sup>1</sup>*Queensland University of Technology, GPO Box 2434, Brisbane, Qld 4001; r.broadfoot@qut.edu.au*<sup>2</sup>*Sunshine Sugar, Broadwater Mill, Broadwater, NSW 2472*

The fixed-element design of a horizontal cooling crystalliser is relatively new to the Australian industry and the installation at Broadwater Mill for the 2017 season proved to be an economical solution to refurbish the mill's first unit in a continuous-flow station of three crystallisers. The crystalliser consists of 12 fixed cooling elements and 14 rotating paddles. A variable-speed drive was installed to allow a rotational speed of the paddles up to 1.45 r/min, depending on the massecuite viscosity and imposed torque. Apart from fabrication of the fixed elements, the mill's staff undertook the complete installation. During the 2019 season, trials were undertaken to determine the heat-transfer performance and massecuite-exhaustion performance for different conditions of inlet massecuite composition, rotational speed of the paddles and cooling rate. The residence-time distribution for massecuite flow through the crystalliser was also measured. The results of this test program are reported and recommendations provided for maximising the exhaustion performance. The installation costs for this type of refurbishment and the financial implications for Australian factories are discussed.

**Broadfoot R, Ashtiani Abdi I**

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**Implications of crystal-size distributions in product massecuites from horizontal and vertical continuous pans****R Broadfoot and I Ashtiani Abdi***Queensland University of Technology, GPO Box 2434, Brisbane, Qld 4001; r.broadfoot@qut.edu.au*

The crystal-size distribution of product massecuites from continuous pans has always been of major interest to designers of these pans. As several overseas cane factories seek to operate continuous pans with lower pressure vapour, e.g. vapour 3 or vapour 4 from the evaporators, and also to use seed with smaller crystal size in order to increase the extent of crystallisation conducted in continuous pans, a closer examination of the factors affecting the crystal size distributions of product massecuites is warranted. Both these changes tend to produce a broader spread of crystal sizes. This paper examines the influence of the seed crystal-size distribution, the residence time distribution, the number of cells in the continuous pan, and the dispersion of crystal growth rates on the product crystal-size distribution. The size distributions of both horizontal and vertical continuous pans are considered, as well as the implications for the future applications of both types of continuous pans. Measures to narrow the size distribution of the product crystals are examined.



## Online methods for the detection of sugar contamination in condensate systems

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Many sugar mills struggle with contamination in condensate given that sugar can cause major disruptions in the boiler(s) producing steam for production. The sugar decreases the surface tension of the boiler water, allowing a property called 'foaming' whereby the boiler water can move from a boiler drum into the steam space and, hence, into the production steam system. This phenomenon in turn causes contamination of product, safety risks to personnel, and damage to expensive production. The effect of the contamination is also typically a full plant shutdown, time loss from cleaning boilers, chemical cost, labour cost, product loss, and alike. Detecting sugar contaminant has typically been done using conductivity methods. This relies on detecting by-products of the sugar process, or by hydrolysis of the sugar-producing conductive species. Although it is simple, it relies on the factors outlined, and is typically insensitive and non-selective. Online methods have been developed with the aim of detecting sugar contamination. These methods involve multiple technologies, and each have their advantages and disadvantages. New methods using fluorescence detect low-level sugar 'thin juice', TOC (total organic carbon) measurement, refractive index, multiple oxidation reduction measurements, pH, and others are available. This paper investigates the methods but aims to clarify value for money, measurement range, and application suitability for sugar mills. The outcome of the paper is to ensure sugar mills are well informed to ensure the selection of technologies is based on suitability for process, rather than sales and marketing campaigns.

**Mann AP**

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## Boiler simulation for improved operator training

**AP Mann**

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Continuous, efficient and safe operation of a sugar factory depends on having competent and confident operators who can prioritise sometimes conflicting requirements and choose the best option under pressure. Most operators in sugar factories have another role during the maintenance season, and there is anecdotal evidence from factories that issues arising from operator error are more common early in the crushing season when operators are getting back up to speed. Operator training in the sugar industry, like in a lot of other industries, has been based on trainee operators working under the guidance of more experienced operators who act as mentors. In many cases, this approach works reasonably well, but in some cases it does not because some experienced operators may not be the best role models and/or the best trainers. Simulators are an ideal complement to the traditional modes of training because they allow trainee operators to learn by doing rather than learning just by observing other operators and following instructions. Trainee operators can learn from mistakes made on simulators rather than mistakes during actual boiler operation that can have serious consequences. This paper summarises the development of a boiler-simulator with a generic interface and a training program that can be used for operator training. Some of the components of the boiler-simulator can be incorporated into the distributed control systems used by factories. Use of the simulator will improve the skill level of operators and increase the effectiveness of operator training and operator refresher training. There will be a reduced risk of damage to boilers and lost production. With improved operator performance the number of incidents should be reduced. This will improve the financial performance of the industry, the public perception of the industry and in the long term, reduce insurance costs.

## Management of the technical skillset required to support automation in the sugar industry

Nina West

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As in many industries, the Australian sugar industry has seen change driven by advances in automation technology. The many advantages delivered by these technologies and the inevitable use across all industries are seemingly well researched and accepted. An element of the progression towards advanced automation technologies that appears to have been somewhat taken for granted, however, is the management of the technical skillset required to support them. This paper aims to highlight the challenges that have been observed in practice on this topic. By considering the context of these challenges through a high-level literature review, it has been concluded that the workforce or labour market does not seem to be naturally evolving to be one that supports the sugar industry's continued advancement towards increased automation. Comment is made about the opportunity to strategically address these issues by further quantifying them and subsequently pro-actively acting to address them.

Moller D, King B

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## The Australian Sugar Industry Training (ASIT) Learning Management System (LMS)

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Now that the Australian Sugar Industry Training (ASIT), Learning Management System (LMS) is operational, the common question asked is – “How can I use the system?”. This presentation outlines different ways in which the system can be used by the Australian sugar industry.

Different types of training courses within the ASIT LMS include: a) Reference courses based on past, paper-based, training material; b) Courses that assess the knowledge competency to the national standards; c) Videos explaining a single factory-unit operation.

Two of the reference courses introduce the unit operations and terminology used within the sugar industry. These courses are useful in providing background for all employees who have no previous sugar-industry experience after the maintenance season. The eight reference courses cover all unit operations within the raw-sugar factory. These courses are based on the SOTrain courses and include material from the Sugar Research Modules (SRM) training courses. These courses are structured so that they can be searched, enabling learners to go directly to course content that is related to the search. This enables learners to access information very quickly that may assist in fault-finding during factory operation.

Three training courses have been released that are mapped and examined to the national standards: High grade fugals and sugar drying; Low grade fugals; and Cooling crystallisers. These courses can be used to train and test their knowledge competence of operators at the start of each season. This may assist in the gaining of knowledge of a new operator or the transformation of the operator from maintenance-season mode to prepare for the start of the crushing season. Each milling company has its own separate training environment. This allows companies to add company or site-specific training modules in addition to the available industry content creating a one login solution for all training modules.

The ASIT LMS is an industry-developed tool that is available for use by all the Australian sugar industry. The authors can answer any further questions about the use of this resource.

## **An update on QUT's acid-catalysed glycerol pretreatment technology for biorefining of sugarcane bagasse**

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Sugarcane bagasse is one of the most abundant agricultural biomass in the world. As a lignocellulosic biomass, sugarcane bagasse consists of sugar polymers (cellulose and hemicellulose, ~65%) and aromatic polymers (lignin, ~28%). Fractionation of sugarcane bagasse to low-cost fermentable sugars for producing biofuels and bioproducts and high-quality lignins for synthesizing biopolymers and biocomposites is critical towards biorefining of sugarcane bagasse for value-adding. Previously, the research team at QUT developed a patented acid-catalysed glycerol pretreatment technology that can convert cellulose in sugarcane bagasse to glucose with a yield of over 90%. Our recent studies showed that this pretreatment technology was a promising platform technology towards biorefining of sugarcane bagasse. Based on this technology, sugarcane bagasse could be fractionated to fermentable sugars and reactive lignins. These fractions can be used to produce a number of valuable biomass-derived products, such as biofuels, biochemical, and biodegradable packaging materials. In this paper, our recent progress on this pretreatment technology towards development of biorefinery processes for sugarcane bagasse utilisation is summarised.

## **Production of fructo-oligosaccharide as valuable feed prebiotics from low-value molasses – a review**

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Sugarcane molasses is rich in sugars and widely used as a low-cost energy source for feeding animals in Australia. Meanwhile, the use of prebiotics as feed additives to improve animal health and meat quality has gained increasing interest worldwide. Oligosaccharides are the most studied prebiotics for food and feed applications and the health benefits of using many oligosaccharides have been well demonstrated, including improving gut health, mineral absorption and immunity. Fructo-oligosaccharides (FOS) are a type of oligosaccharides prebiotics and often produced from sucrose or sucrose-rich carbon sources, such as molasses. In this paper, FOS production from sucrose and molasses, as well as FOS application as feed additives are reviewed. In addition, the preliminary research achievements on FOS production from molasses at QUT are also introduced. Two novel *Aureobasidium pullulans* strains were identified for producing FOS enzymes and FOS production from both pure sucrose and molasses was tested. Currently, a new FOS production strategy is being developed with the aiming of improving FOS yield using molasses. It is expected that transformation of low-value molasses to high-value FOS feed additives can increase the revenue of the Australian sugarcane industry.

**Technical Index: a measure of factory performance for over 20 years at Mackay Sugar****BP Lavarack<sup>1</sup> and CC Steggles<sup>2</sup>**

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<sup>2</sup>*Mackay, Qld 4740*

Coefficient of Work or its more modern equivalent of Pool Sugar Index are essential to the commercial evaluation of sugar factories in Australia. Recent studies have suggested these benchmarks are lacking in some respects and that a complementary metric is required. This shortcoming was realised over 20 years ago and a measurement criterion called Technical Index developed and introduced into the weekly data reporting scheme for all factories at Mackay Sugar. The methodology behind the development of Technical Index and the equations for the calculation of Technical Index are given. Data for Technical Index and factory sugar losses are compared. In addition, Pool Sugar Index and Technical Index for four factories over a period of 12 years are reported and analysed. The meaning of Technical Index is discussed. Technical Index ranges between 90 and 100 with higher values indicating good performance. There appears to be a good correlation between Pool Sugar Index and Technical Index for the season average data, the correlation is less clear for data reported on a weekly basis. Technical Index is typically about 5 to 8 units less than Pool Sugar Index for Mackay Sugar factory operations. Technical Index is a key performance indicator that complements Pool Sugar Index and has been found to be a useful benchmark for factory operations.

**Stobie RM, Broadfoot R****Understanding the cause of high-colour sugar – intrinsic cane colour, extraneous matter or factory practices?****RM Stobie<sup>1</sup> and R Broadfoot<sup>2</sup>**

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In recent years the colour of Brand 1 sugar from mills processing green cane has fluctuated near the upper limits of Queensland sugar colour expectations. Cane supply to these mills has also contained higher levels of extraneous matter (EM), which is known to produce sugar of high colour. For these cane conditions, when highly coloured raw sugars are produced, the affined sugars also tended to be highly coloured. The colourants that tend to more strongly partition into the crystal lattice are known to be of higher molecular weight. These colourants originate from the plant pigments associated with polysaccharides in the incoming cane supply and are produced during the processing of cane to sugar, particularly during pan boiling. Investigations were conducted through sampling from three mills. Sampling of process streams from juice to liquor and from magma to final shipment sugar was performed at four stages across the 2018 season. Extraneous matter was measured at two mills where the infrastructure was available. Masseccuities were subjected to varying wash times at each high-grade fugal station to produce sugars of differing purity to examine the efficiency of colour and impurity removal. Colour partitioning into the crystal lattice at one mill was observed to be greater at different times through the season, suggesting that extraneous matter was a dominant contributor. Trials mainly focused on assessing the incorporation of colour and impurities in shipment sugar, but extensive sampling was also performed within the process to help identify where specific operations were contributing to colour development or incorporation into crystal. The combination of extraneous matter, sources of high-grade masseccuite foundation crystal and cycle times for shipment sugar masseccuities, all contribute to affined sugar colour intensity and require further investigation. Considerably more intense sampling and analysis is still required to identify and confirm which constituents in the cane supply and which aspects of factory operations most strongly influence the partitioning of colour into the crystal lattice.

## A factory experiment to assess different shredder-hammer configurations

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Shredding is critically important to maximising the amount of pol extracted from the supplied cane by the milling tandem or diffuser. Whilst modern shredders typically achieve high levels of preparation (greater than 85 POC), they also use considerable energy, have high maintenance costs and produce much noise. An experiment was undertaken at Rocky Point Mill during the 2016, 2017 and 2018 seasons to evaluate the effect of shredder-hammer configuration on shredder performance in terms of POC, windage, noise, hammer wear rates and hammer-tip wear rates. Two hammer configurations were tested: a conventional checkerboard configuration (114 hammers) and an 'Alternative 1' configuration (152 hammers). The results showed that, although there were 33% more hammers in the 'Alternative 1' configuration, the POC was surprisingly lower at 87 compared to 88 for the conventional configuration. Furthermore, the mean specific power, noise levels and windage were slightly higher for the 'Alternative 1' hammer configuration. The wear rate for the hammers and hammer tips were ~40% and ~68% higher in the 'Alternative 1' configuration, respectively.

Nel K *et al.*

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## Optimising bagasse diffuser performance using percolation velocities

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Invicta Mill at Giru, north Queensland, is a dual-train sugar mill that crushes about 3 Mt of cane each season. The factory has a traditional milling train on the A-side and a bagasse diffuser on the B-side installed in 1995. During the 2019 crushing season, Invicta Mill had several reliability issues with the bagasse diffuser. The root cause of these issues was difficult to identify and prompted an investigation to better understand how this unit operated. The objectives were to eliminate the diffuser-reliability issues experienced and improve the B-side bagasse loss for which the diffuser was a key contributor. The general principle of a bagasse diffuser relies on counter-current maceration/juice flow being passed through a slowly moving bed of fibre. This creates a washing action that extracts the sucrose from the fibre. Depending on the size of the diffuser, there are several intermediate juice cells that are situated below the diffuser bed and capture the intermediate juice. This juice is then pumped forward and applied upstream to continue with the washing process. The velocity at which this applied juice passes through the fibre bed is termed the percolation velocity and is a key parameter in optimizing diffuser performance. It is important to ensure that the application point of each intermediate juice stream is positioned correctly for the minimizing of by-passing and recycling of the juice as well as prevent flooding of the diffuser whilst allowing sufficient time for the washing mechanism to occur. Work at Invicta Mill during the 2020 crushing season was to determine the percolation velocities of the intermediate juice streams in order to optimise juice application positions and, hence, overall diffuser performance. The work comprised trials in which lime was injected into the juice stream and the juice pH was measured in each intermediate cell to identify where the juice was percolating and the velocity at which the percolation occurred. Using this data, recommendations and modifications were made to the intermediate juice-application points to optimise the diffuser performance. The outcome from this trial work was a final bagasse loss on B-side of 1.4–2.5% each week for the entire 2020 season.

**Assessment of microbial degradation in factory mixed juice and filtrate****C Shi, DW Rackemann, CH Bakir and WOS Doherty***Sugar Research and Innovation, Queensland University of Technology, Brisbane, Qld 4000; c.shi@qut.edu.au*

Undetermined sucrose loss is a serious problem in raw-sugar manufacturing. Laboratory deterioration experiments were conducted at ambient temperature using factory mixed juice (MJ) and filtrate (FIL). Well-known metabolic products, including mannitol, lactic acid, polysaccharides, oligosaccharides and organic acids, were detected. Unexpectedly, methanol was found in both the untreated and deteriorated juices and is suspected to be caused by the action of micro-organisms on the pectin present in sugarcane juice. The deterioration rate of filtrate was generally slower than that of mixed juice, but the formation of exocellular polysaccharides was significantly higher. The mannitol concentration was a good indicator to predict sucrose loss in MJ, but not in FIL. It is suggested that an evaluation of the use of biocides, particularly in the filter station to reduce the negative impact of polysaccharides due to filtrate recycling to mixed juice, should be undertaken.

**Plaza F, Mann AP**

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**Improving bagasse-furnace combustion and modelling****F Plaza and AP Mann***Queensland University of Technology, Brisbane, Qld 4000; f.plaza@qut.edu.au*

The control of bagasse combustion in the furnace is an important part of boiler operations for sugarcane factories. High bagasse moistures and/or high boiler steam loads can lead to furnace combustion issues. Significant effort has been carried out, for example, in improving boiler operating procedures and equipment interlocks to minimize the probability of such occurrences. This paper has considered options and designs to reduce the likelihood of bagasse deposition on furnace grates and resultant furnace instability. The literature described a modified conventional spreader design that resulted in improved combustion. The computational fluid dynamics (CFD) software code FURNACE, was used to determine the predicted steady-state behaviour of a furnace when fed by conventional spreaders and swirl spreaders, with the swirl spreaders using a significant quantity of the hot air previously going through the grate. The predictions and previous research were used to gain an improved understanding of how swirl spreaders modify the operation of the furnace. With improved combustion stability, a boiler could be operated at lower excess air levels and, therefore, higher efficiency. This should lead to a significant reduction in wear of boiler components such as convection banks, economisers, dust collectors and air heaters. Some current limitations of the FURNACE code are described. Addressing those limitations and subsequent application of the updated code will assist in evaluating improvements to boiler design for improved combustion performance.

## **Comparison of two methods of retrofitting a bagasse boiler: increasing the heating-surface areas and installing a flue-gas dryer**

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The efficiency of a bagasse boiler increases as the final flue-gas temperature decreases. High flue-gas temperatures may be used to reduce the moisture content of bagasse in a flue-gas dryer. Alternatively, increasing the surface areas of an economizer and air heater can also decrease the flue-gas temperature. In this paper, both methods of retrofitting a low-efficiency bagasse boiler, based on a boiler model and a flue-gas dryer model, are compared. The bagasse boiler in this model consists of a furnace, evaporator, steam drum, superheater, boiler bank, economizer, and air heater. Both models are used to demonstrate that, under the same controlled conditions, both methods of retrofitting can effectively reduce the fuel consumption and increase the boiler efficiency. It is also shown that the cost of the flue-gas dryer must be lower than an upper limit so that the total cost of installing a flue-gas dryer is not higher than the total cost of adding heating-surface areas.

**Abdel-Latif O**

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## **Engineering optimisations and troubleshooting enhancement with the ABB Sugar library**

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Advanced process control and real-time optimization are techniques that can improve a plant's profitability and efficiency by maintaining a process at desired operating conditions while taking process constraints into account.

Process control is designed to minimize variations in processes and keep them within specified boundaries. The main purpose of a process control is to maintain a process at desired operating conditions while taking process constraints into account.

Safety, environmental compliance, and process reliability must be maintained; optimal process controls help operations produce quality products, minimize costs, and respond to changing business conditions.

## Process control and sugar crystallization

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The process of always producing sugar crystals of a defined size in large volumes requires a robust process control strategy. With sustainability a key focus of most sugar producers, the challenges are to maintain consistency (reduce wastage, rework) and reduce dependence on human interaction as staffing levels in all operations are already stretched. Siemens is working with sugar manufacturers both in Australia and around the world to help with process control strategies whether in continuous vertical or horizontal pans, or in vacuum batch pans. This presentation aims to show through case studies and reference examples how Siemens has helped by implementing process control technologies to maximise the consistency of the crystallization process whilst at the same time delivering benefits around energy efficiency and overall plant reliability. We address topics including: crystallization with NAHMAT PCS7 Pan Control solution; Digitalisation tools; Energy efficiency monitoring with IoT Suite and drive application technology.

Schofield P

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## Benefits of using wedge-wire screens in a continuous centrifuge

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Wedge-wire screens that match the percentage open area of current foil technology used in continuous centrifuges have been available to the market for more than 10 years. I have become aware of the benefits that customers have observed when using the technology. Here, I share the identified benefits, to outline the suitability of the product for different processes.

The installed base comprises:

- 300+ screens running in North and South America in cane and beet factories.
- 4 Screens running at Al Khaleej Sugar refinery in the UAE.
- 17 screens running in South Africa, Swaziland, Zambia and Mozambique in cane factories.

Trials in Europe during the 2018/ 2019 seasons are with Nordzucker, Südzucker, Tereos, Agrana, Pfeiffer and Langen, Polski Cukiernik and British Sugar in beet sugar. Trials are booked for 2020 at PT Angels refinery in Indonesia. Individual trial details are confidential, but general observations are shared.

The wedge-shaped wires used in the construction of the screens increase the efficiency of molasses flowing through the screen. The percentage of open area on the surface of the screen matches the percentage of open area of the current foil technology, but the percentage of open area at the back of the screens, greater than 90%, ensures that there is a free-flowing runoff with little opportunity for screen blockage.

The primary reason for developing the wedge-wire screen was to overcome the issues of foil lifetime. Foils may need be replaced during the season for many reasons, causing reduction in capacity and loss of sugar crystal in the runoff. The wedge screen has overcome this issue and additional benefits have been identified.

The wedge-wire screen is a single piece construction that fits any make and model of continuous centrifuge without any modifications to the centrifuge. Open area can match current technology, but the efficiency of the slots enables smaller slot widths to be used without impacting on centrifuge capacity.

In summary, whilst wedge-wire screens are relatively expensive; the increase in sugar retention and long life of the screens more than recovers the cost of the screen.



## Impacts of superheated steam on juice degradation and evaporator performance

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Process steam used in juice evaporation is typically supplied from a turbine exhaust or from a pressure let-down station and so is usually superheated. Superheat raises the temperature difference between the heating surface and the temperature of the bulk juice in the first evaporator. There is anecdotal evidence that large amounts of superheat can reduce the heat-transfer coefficients of the first evaporator as the superheated vapour can blanket the heating surface, which impedes condensation, and this in turn raises the calandria pressures and increases the scaling rates of the evaporators. It is generally considered ideal that the amount of superheat is small (e.g. 5°C or lower) so that most of the heat transfer in the steam space occurs from saturated vapour. This study investigated the impact of high surface temperature on juice quality using a specially designed laboratory evaporator rig. Juice samples were boiled and analysed for sucrose loss, pH and colour formation under a range of operating conditions. Results were also compared against empirical correlations and kinetic models in order to allow predictions on the impact of surface temperature on sucrose loss. The results showed higher surface temperatures had limited impact on sucrose loss and colour formation reactions which was attributed to effective mixing within the vessel that allowed the bulk juice temperature to be adequately maintained. Juice pH was very influential on sucrose losses but had limited impact on colour formation. The heat transfer and operational impacts on evaporation performance due to superheated steam are also discussed and modelling showed minimal overall impact to the evaporator station occurs for a reduction of 10% in heat transfer performance (used to simulate impact of superheated steam) in the first effect.

Lehnberger A

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## IIoT for batch centrifugals – initial results

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Nowadays, the use of digital products has become an integral part of the private and business environment, be it in the form of ubiquitous smartphones or the convenience and safety functions found in the office, the home or vehicles. In manufacturing, these developments have been slower, but also taking different forms. While automation has become widely established at local production sites or at group level, digitalisation projects involving the use of cloud services are not very common in process industries. As part of the implementation of a development project for the sugar industry, the operating data of batch-type centrifugals were locally recorded and analysed in cloud-based applications. The information obtained can be classified into machine-related status data, separation-process-related key figures and advanced evaluation results for the massecuite processed and the sugar produced. The benefit of this IIoT ('Industrial Internet of Things') technology, applied for the first time in the world in Australia in separation technology, is the continued availability of the latest analyses. These analyses, which could previously be prepared only in limited quantities and by specialists with expert knowledge, will be available from any location and in any time zone. It is anticipated that plant operators will be able to further improve control of their processes as a result.

## Axle improvements for 40-tonne locomotives

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Wilmar Sugar has a population of 24 40-tonne locomotives, each having four axles. The combined axle population for the 40-t locomotives has various designs, material properties and age in service. Superimposed on these variables are manufacturing deficiencies, assembly and maintenance deficiencies and service conditions. These axles are currently at varying risk of developing crack-like defects. Over time, the axle design and material properties have improved, but the older design axles and axles that have been involved in a derailment, or other operational high loading case, are at a higher risk of failure. Railway axles are ranked as an important part of rolling stock, because their failure will result in certain derailment. Following the failure of axle No. 3 on locomotive Hodel on 5 August 2018 at Invicta Mill, TICS were commissioned to crack-test all Wilmar Group 40-t locomotive axles during 2018. The procedures for crack testing of locomotives axles at that time had a low probability of detection for cracks. In collaboration with Rockfield and Wilmar, TICS have since developed a specific procedure for near-end low angle ultrasonic scanning, to improve the probability of detection from around 20% to around 90% for 40-t locomotive axle defects. To date, 100 axles have undergone ultrasonic testing with the improved scanning procedure developed. The findings from the testing prompted the replacement of 27 axles during the 2019 maintenance program, with a further 33 axles identified for replacement during the 2020 maintenance program. The Hodel locomotive incident also triggered a re-evaluation of all processes associated with the axle life cycle, from initial procurement to final disposal. Improvements identified and developed through the 40-t locomotive axle replacement program, will significantly reduce the risk of a locomotive derailment caused by axle failure and will reduce locomotive wheel set whole of life cost.

**Rozis J**

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## High-vibration incidents at the Proserpine, Victoria and Plane Creek shredders – actions and response planning

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During the 2018 crushing season, Victoria Mill's B side Shredder developed reoccurring high levels of vibration with variability in the phase angle following the processing of low-quality cane. Over a course of weeks, the vibration levels trended upward until reaching unacceptable levels (>10 mm/s). Vibration analysis trends indicated an out-of-balance phase angle shift. This followed evidence of a phase-angle shift at the Proserpine Mill when the disc pack was found to be loose. With 10 weeks until the end of crush, attempts were made to reduce the vibrations at Victoria Mill to acceptable levels and manage the operational capacity of the shredder to the end of season by the reduction of load and speed to mitigate the risk of an extended stoppage. Multiple corrective strategies were undertaken over 4 weeks and were unsuccessful. Failed corrective attempts ultimately led to equipment shutdown with a focus on emergency repair. A decision was made to remove the rotor, transport it to the Burdekin and conduct repairs at the Pioneer Mill's Integrated Work Management (IWM) utilising its workforce and skill base. Operations recommenced 8 days following initial equipment shutdown and isolation, 2 days ahead of initially planned. This paper maps the response plan that was adopted to optimize the corrective actions to minimize the operational impact to the business. Learnings saw the creation of a Shredder Response Plan that was implemented during a similar incident at the Plane Creek Mill.

## Preventing a major in-service failure of Pioneer Mill STG 3 stator core and winding

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During a routine inspection of the Pioneer STG3 46 MVA Generator, serious issues with overheating of the inter-strand insulation on the transposition coils were identified. Due to the criticality of this generator to cogeneration operations, the complexity and time associated with either a rewind or a complete replacement of the generator, the decision was made to replace the stator core and winding only as a complete unit. Due to the unique design of this generator the removal of the old stator core and installation of the new stator core and winding could be undertaken in a relatively short period. This was important in this project, since the available time-window allowed by the production schedule to work on the generator was very restricted. A stator rewind and possible core re-stack in the conventional sense would not have been possible for this generator due to this limited time-window and available winding data. Total replacement of the stator core and winding was, therefore, the only feasible option to meet business needs. This replacement strategy would allow the generator to remain in service, after minor repairs, until April/May of 2019, where an optimal cogeneration window was identified for Siemens to install the newly manufactured stator core and winding. To meet the tight timelines required, the new stator core and winding were manufactured in Germany and air freighted to Australia. The project activities were all completed within the planned schedule and final commissioning and testing proved that the generator performance was as expected per design specifications.

Tyson B

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## Secondary-juice flow-control strategy at Rocky Point Sugar Mill

B Tyson

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An effective juice-flow control system is an essential component of juice clarification. It assists in maintaining other process variables at set point, makes use of the buffering capacity of the installed juice tanks including the incubator for starch reduction, and steadies the flow to the clarifier to enhance its performance. Consideration is given to potential sucrose losses through microbial activity and/or acidic inversion if excessive quantities of juice are held in the tanks. Major disturbance to the flow control system is caused by variations in the incoming juice flow rate due to variations in the instantaneous crushing rate and the juice/fibre ratio of the incoming cane. Rocky Point sugar mill is the smallest sugar factory in Australia. Over the last several years an increase in process automation has been implemented to maintain a low manning operation to keep the factory financially viable. As part of this factory efficiency program, a secondary-juice (SJ) flow-control strategy was implemented to meet the following requirements: maintain a practicable minimum of juice in process; prevent additional added water into the evaporator supply juice (ESJ) tank; smooth juice flow rate to enhance clarifier performance; control starch levels in sugar without the addition of amylase; minimise the required operator intervention to the control system. The adopted strategy is based on a calculated remote set-point for the secondary-juice flow rate using inputs derived from the mixed-juice (MJ) flow rate, the secondary-juice tank level and the ESJ tank level. This paper outlines the mill's installed equipment, control system and how the control strategy was able to meet the factory's processing objectives.

## Performance of the falling-film tube evaporator at Bingera Mill

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For the 2018 season Bundaberg Sugar installed a 4,000 m<sup>2</sup> falling-film tube evaporator (FFTE) of the BMA design at No 1 evaporator position at Bingera Mill. This was the first installation of a FFTE into the Australian industry. An evaluation program was undertaken during the 2019 season to assess the performance with respect to heat-transfer efficiency, effect of scaling rates on heat transfer, de-entrainment efficiency of the juice droplets from the vapour outflow stream and the general operational performance. In addition, tracer studies were undertaken to determine the distribution of residence times for juice in the evaporator. Measurements were also undertaken to determine the extent of sucrose degradation occurring within the evaporator. Overall, the evaporator has performed well with respect to the above test parameters. However, the effect of scaling on heat-transfer efficiency was only able to be evaluated for typically 120 hours of operation as the mill was restricted to five-day crushing operations each week due to the small drought-affected crop. A chemical clean of the evaporator was undertaken on shutdown each week. The results of the evaluation trials are presented and operational experiences during start-up, normal operation and shutdown phases are discussed.

Lavarack B, Iturbe R, Giannangelo M

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## Pan No.9 incident – Farleigh Mill 2020

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On 3 June 2020, pan No.9 at Farleigh Mill imploded, causing the top cone of the pan to collapse into the pan body and come to rest on the calandria. The incident occurred during steam trials when boiling water under vacuum conditions. Severe damage was caused to the entire pan above the calandria, including the vapour ducting, the vapour condenser, pan stirrer and ancillary equipment at the top of the pan. Some damage was caused to the calandria. Fortunately, no people were injured. Following the implosion, the factory was shut down and the area around pan No.9 made secure. Workplace Health and Safety Queensland were notified of the incident. A full incident investigation was undertaken, which resulted in root cause analysis workshop sessions and several reports being completed. The event took place in the week preceding crush and a recovery plan was instituted to bring the pan back to service in the shortest period to minimise the disruption to the 2020 season. The failure of the top cone was attributed to corrosion-induced thinning of the cone plate. The thinning of the steel plate compromised the structural integrity of the cone, causing it to fail (buckle) and then collapse into the body of the pan. The addition of more testing points, in the high corrosion areas, will provide advanced warning of metal thinning for vessels at risk of implosion.

## Response plan for a significant incident

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On Saturday 5 October 2019 at approximately 18:00, a fire initiated on bagasse conveyor 1 at Wilmar Sugar's Pioneer Mill. The fire quickly progressed throughout a significant section of the bagasse conveyor system. The fire caused extensive damage to the conveyor systems and control, communication and electrical infrastructure. The initial estimate placed the repair time at 21 days; it was accepted that the repair was unplanned and the work scope was not yet developed. It was important that the repair duration be reduced. The fire was investigated by Queensland Fire and Emergency Service (QFES) on Sunday and Wilmar initiated an Incident Cause Analysis Method (ICAM) investigation. An internal Wilmar project management team was tasked with planning and execution of the repair without compromising safety and quality and to reduce the duration of the processing interruption. A repair-response plan was developed with repair project and execution teams accelerating repair works. During the interruption, Pioneer region cane was processed at other Wilmar mills. Crushing resumed at the mill on Thursday 17 October, just 12 days after the fire. The impact on the mill crush finish date was limited to 7 days. The repair response plan was widely regarded as a success due to the planning, communication and co-operation between functional teams to safely repair and recommission the mill in the short timeframe. Due to the success of the project the business wanted to understand the process and extract the learnings, so if a similar type event occurred in the future, the steps could be replicated.

## Thaval OP

## Assessing the heat-transfer performance, operational strategies and sucrose losses of falling-film and rising-film evaporators

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Efficient operation of the evaporator station is the key to achieve high juice-processing rates and low steam consumption; however, the efficient design of the evaporator also plays important roles. An efficient design should provide a high heat-transfer coefficient (HTC) over an extended period, adequate mixing of the juice in the heating elements, and short residence time of juice in the evaporator. Falling-film and rising-film are the two evaporator types (both tubular and plate type) used in the sugar industry. This paper presents heat-transfer coefficients and operational strategies of falling-film tubular evaporators and compares them to the heat-transfer coefficients and operational strategies of Robert-type (rising-film tubular) evaporators available from other investigations. The assessment includes the heat-transfer performance, strategies for effective operation, residence times, and the extent of sucrose degradation in falling-film and rising-film tubular evaporators.

**Falling-film evaporators - role in steam saving (a perspective of Almoiz Industries, Pakistan)****Khalid Rashid<sup>1</sup>, Salman Shehryar<sup>2</sup> and Muhammad Arif<sup>1</sup>**<sup>1</sup>*Almoiz Industries Limited, Unit-II, 42 km MM Road, Mianwali, Pakistan; khalid.rashid@almoiz.com*<sup>2</sup>*Almoiz Industries Limited, Unit-II, 2D-1 Gulberg III, Lahore, Pakistan*

The energy efficiency of a sugar mill depends to a large extent on the performance of the evaporators. The conventional Robert evaporators used in most cane sugar factories work with high  $\Delta T$ , thus usually the 1st or 2nd vapours are required for juice heating and boiling of the massecuite. To operate the sugar plant with high efficiency, one of the pre-requisites is that the evaporators work on very low  $\Delta T$ , so that the lower stage vapours can be utilized for heating and boiling. Falling-film evaporators (FFEs) have the required characteristics to work on a narrow  $\Delta T$  to improve the steam economy. Currently, the Pakistani sugar cane industry is facing multiple challenges for its survival and those can only be addressed by improving efficiencies both in agriculture and processing. Therefore, Almoiz Industries set up a state-of-the-art project in Pakistan having high energy-efficient values either as steam % cane or in-house power consumption. These factors lead towards availability of extra electrical power, which can be used for any other diversified allied operation such as power export to the utility or using the surplus power for steel making etc. Similarly, it helped in saving bagasse, which can be used for different purposes during the off season. To reduce steam consumption, a complete set of seven FFEs was installed. All vapours from the 1st effect to 5th, including condensate, were used for heating juice and boiling massecuites to reduce steam consumption per tonne of cane. The operation of FFEs is based on small  $\Delta T$ , due to which the vapour temperature in each effect increases and allows the use all types of vapours. Although there were operational difficulties in the beginning, these were resolved over time. A minimum 35% steam on cane with a refinery and 33kW/t of cane electrical consumption is achieved at maximum rate of cane crushing. The operation of FFEs proved that all vapours from 1st effect to 5th can be used, which results in steam consumption reduction of the plant and saving of bagasse. Saved bagasse can be used for power export and other allied businesses.