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Assessment of new soft cane varieties: final report submitted to Sugar Research Australia 2015/081

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Assessment of new soft cane varieties

Final Report submitted to Sugar Research Australia

2015/081

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Queensland University of Technology
and
Sugar Research Australia

Dec 2016

SRA Research Project Final Report

SRA Project Code	**2015/081**
Project Title	Assessment of new soft cane varieties
Key Focus Area in SRA Strategic Plan	KFA 1: Optimally-adapted varieties, plant breeding and release
Research Organisation(s)	Queensland University of Technology
Chief Investigator(s)	Geoff Kent
Project Objectives	• To experimentally determine whether extraneous matter affects the fibre quality parameters measured by SRA • To experimentally determine whether the commercial cane preparation process affects the fibre quality parameters measured by SRA • To experimentally compare the handle-ability properties of SRA1 and QC04-1411 to the major variety in the central and southern regions: Q208.
Milestone Title	Final Report
Success in achieving the objectives	☒ Completely Achieved ☐ Partially Achieved ☐ Not Achieved
SRA measures of success for Key Focus Area (from SRA Strategic Plan)	This project does not address any of the four measures of success listed in the SRA Strategic Plan. Rather, it addresses a gap in the current Strategic Plan to ensure that the developed varieties are able to be processed at reasonable cost at the factory.

Section 1: Executive Summary

Provide a non-technical overview of the project, outlining achievements in a form that can be communicated to the industry and the media. It should cover the following:

a) *Issue: What was the industry and/or community issue, what was its relevance, and how did the project address the issue?*
b) *R&D Methodology: Succinctly explain the methodology, and indicate the extent of collaboration and/or partnerships, especially with end users.*
c) *The project deliverables i.e. outputs (knowledge, skills, processes, practices, products and technology)*
d) *The outcomes and impact of the project findings on the sugar industry and the Australian community. Identify the SRA key focus area(s) the project has addressed, how it has met key measures of success and the realised/expected net benefits in terms of social, environmental and economic impact, and the realised/expected adoption of outputs.*

In 2016, three new cane varieties, SRA1, SRA4 and QC04-1411, were either released or were proposed for release into the Bundaberg and Mackay districts. According to the pre-release fibre quality measurements undertaken by Sugar Research Australia, all three varieties were classified as a soft cane. This report documents a series of experiments undertaken to better define soft canes and to measure the effect that these three varieties had on factory operation and performance.

The experiments were undertaken collaboratively by QUT, SRA and field and factory staff in the Isis, Farleigh, Millaquin and Maryborough districts.

Trash has been shown to affect the fibre quality measurements, reducing the short fibre content by typically 12 units and most likely increasing the shear strength measurement by about 6 units. Comparing the cleaned stalks of cane usually used for fibre quality measurements to factory-prepared cane, it seems likely that shear strength is underestimated by about 7 units and short fibre content is underestimated by about 4 units (most likely shredder dependent).

SRA1 had a low fibre content of typically 10% and an impact resistance lower than the minimum criterion considered for normal canes. The other two varieties, SRA4 and QC04-1411 had relatively normal fibre content of about 14%. While their impact resistance was low, it was still within the normal range. Shear strength is the other fibre quality parameter with a defined normal range. The shear strength of all three varieties were within the normal range, with SRA1 having the lowest values. The final fibre quality parameter, short fibre content, does not have a defined normal range. It is noted, however, that of the 35 results examined, the two highest values were for QC04-1411 and the next two highest values were for SRA1 (Q240 was the fifth highest and also had a shear strength lower than QC04-1411).

The low fibre content of SRA1 is considered the biggest problem regarding the processing of the three varieties. With current major varieties having fibre contents of typically 12% to 15%, SRA1 is particularly different and will cause fuel balance issues. The fact it is different to the other varieties means that it is difficult to configure a factory to consistently achieve a fuel balance, with the likelihood that there will be periods when fuel will need to be purchased and other periods when fuel will need to be disposed of. The fact it is low means that a factory will need to be reconfigured at high capital cost to become much more energy efficient.

All three varieties exhibited the soft cane characteristic of generating low mill torques. While there is some hope that mills could be re-set to achieve their torque set point when processing soft cane, the wide variation in variety characteristics between the soft canes and the other varieties in the cane supply means that a much wider control range is required to be able to achieve their torque set points across the different varieties.

Associated with the inability to maintain torque set points, bagasse moisture contents from the soft canes were found to be higher than normal. This result was particularly pronounced with SRA1 where Isis and Millaquin recorded increases in final bagasse moisture content of between three and eight units. The available information from the processing of SRA4 and QC04-1411 also showed higher bagasse moisture content but the results are less conclusive, due to the limited nature of the trials of those varieties. Not all factory boilers can withstand significant increases in bagasse moisture content. The Millaquin experience processing SRA1 resulted in a rapid drop in steam pressure that only avoided a boiler shutdown because SRA1 was only processed for 15 minutes. Sustained factory operation when feeding boilers with high moisture bagasse is problematic.

There was a potential concern with the processing of QC04-1411 where the bagasse caused feeding and combustion issues. It is unknown if this problem is characteristic of the variety or simply a one-off incident.

Other problems such as poor mill feeding and frothing when processing the soft cane varieties were experienced but are believed to be able to be resolved with relatively small capital expenditure.

While the yield of some of the soft cane supplies was measured to be quite high, those yield benefits need to be weighed up against the additional factory processing costs that will be incurred in terms of capital upgrades and stops.

Section 2: Background

This includes the technical information and existing knowledge concerning the problem or research need addressed by the project.

The technical information and existing knowledge concerning the problem addressed by the project is described in section 1 of the report attached in Appendix C.

Section 3: Outputs and Achievement of Project Objectives

Project objectives, methodology, results and discussion

Provide sufficient evidence to substantiate the degree to which the project objectives have been achieved and/or the reasons why they have been modified or not achieved. Include an overview of data and other relevant results. The discussion must be structured according to the defined project objectives as set out in the Research Agreement. Clearly enunciate the project process and its links to the outputs. Identify new knowledge, skills, processes, practices, products, technology and capacity building developed during the course of the project

Three reports have been prepared to describe the objectives, methodology, results and discussion associated with this project. The first report attached in Appendix A describes in detail the first experiment undertaken at Isis Mill in August 2016 to examine the processing of SRA1. The second report attached in Appendix B describes in detail the experiment undertaken at Farleigh Mill in August 2016 to examine the processing of QC04-1411. The third report attached in Appendix C provides a full report of the entire project, with lesser information about the August 2016 Isis and Farleigh experiments detailed in the reports in Appendix A and Appendix B.

The first objective to experimentally determine whether extraneous matter affects the fibre quality parameters measured by SRA is reported in section 3 of the report in Appendix C. The results of this experimental work showed that the presence of trash reduces the short fibre content measurement by typically 12 units and may increase the shear strength measurement by around 6 units.

The second objective to experimentally determine whether the commercial cane preparation process affects the fibre quality parameters measured by SRA is reported in section 4 of the report in Appendix C. The results of this experimental work suggest that the use of cleaned stalks of cane in measuring the fibre quality parameters results in an underestimate of the shear strength by about seven units. While the overall results suggest the use of cleaned stalks of cane will provide an underestimate of the short fibre content by about four units, this result may be shredder dependent.

The third objective to experimentally compare the handle-ability properties of SRA1 and QC04-1411 to the major variety in the central and southern regions, Q208, is reported in section 5 of the report in Appendix C and is the subject of the reports in Appendix A and Appendix B. The processing of SRA1 was completed as expected. The processing of QC04-1411 could not be compared against that of variety Q208 due to the limited amount of Q208 available in August 2016. Instead it was compared against the processing of Q240. Further tests were also conducted on variety SRA4. SRA1 was clearly the softest variety of the three and had a low fibre content that will cause significant fuel supply issues. All three varieties exhibited soft cane characteristics, most notably low milling torques and high bagasse moisture contents.

Section 4: Outputs and Outcomes

List the Outputs (manuals, processes, technology, equipment, workshops) or knowledge (scientific or other - including skills) that was derived from this project.

List the Outcomes (use or application of outputs) and Benefits (effects of the outcomes on industries and society as a whole).

Include where appropriate, details of stakeholder participation, systems integration, implementation/adoption strategies and enhancement of human capacity.

The outputs of this project were primarily knowledge.

The project provided new knowledge of the applicability of SRA's fibre quality tests on clean stalks of cane to factory cane supplies. Both shear strength and short fibre content measurements are affected by the presence of trash and short fibre content may also be affected by the difference in preparation between the SRA shredder and factory shredders.

The project provided increased confidence in the value of the SRA fibre quality tests. The impact resistance test in particular seemed quite discriminating in identifying degrees of *softness* of the different varieties. The short fibre content test also identified the more extreme soft varieties.

The project provided new knowledge of the characteristics of varieties SRA1, SRA4 and QC04-1411 and their effects on the factory. SRA1 proved particularly challenging because of its low fibre content and extremely soft nature that resulted in high bagasse moisture contents. While SRA4 and QC04-1411 also exhibited soft cane characteristics, they were not as extreme as those of SRA1 and may not be particularly different to other varieties such as Q240 that are currently widely supplied.

The knowledge developed in this project will be of benefit to Variety Adoption Committees to help guide them in selecting varieties for release. The knowledge will help to define the processing cost of soft canes that can be balanced against yield benefits of new varieties.

The project has highlighted some deficiencies in the current variety development and selection criteria. It has identified a need for fibre quality parameters to be assessed at an earlier stage in variety development to filter out varieties with extreme processing characteristics. It has also identified that the current rEGV (relative Economic Genetic Value) weightings for fibre in some regions promote the development of low fibre canes. The choice of a weighting on fibre promotes either high or low fibre canes, rather than an acceptable range with upper and lower limits.

Section 5: Intellectual Property (IP) and Confidentiality

Detail any intellectual property considerations or discoveries made and if these are to be protected and how. Outline any publications produced. State what information, if any, is to be treated as confidential, to whom and for how long. Projects contracted from July 2014 onwards will also need to attach an updated INTELLECTUAL PROPERTY REGISTER detailing any IP considerations or discoveries made and whether these are to be protected and how this may occur. (Note: The INTELLECTUAL PROPERTY REGISTER was provided as part of the executed project agreement)

The intellectual property developed in this project is the copyright in the project reports. These reports contain new knowledge but no protectable intellectual property. The results are not considered confidential.

Section 6: Industry Communication and Adoption of Outputs

a) What key messages have come from the project to date, when and how they have been communicated and to whom? Has there been any communication with the relevant SRA Professional Extension and Communication (PEC) officer or unit?

This project has been conducted under the guidance of stakeholders consisting of representatives of ASMC, SRA, Isis Central Sugar Mill, Mackay Sugar, Bundaberg Sugar, MSF Sugar and Wilmar Sugar Australia. This group have received updates on project progress throughout the early stages of the project.

The project chief investigator attended a meeting of the Variety Adoption Committee in the southern region and presented a summary of results for the work undertaken in the Millaquin, Isis and Maryborough districts.

At this stage, the main information communicated has been regarding the testing of the three varieties SRA1, SRA4 and QC04-1411. The major concerns regarding the low fibre content and high bagasse moisture content of SRA1 have been highlighted.

b) *What new information, if any, is available on the adoption of project outputs?*

The knowledge generated in this project has been utilised in Variety Adoption Committee discussions.

c) *List any newsletters, fact sheets or any other media coverage.*

Nil.

d) *Identify any further opportunities to disseminate and promote project outputs at seminars, field days etc.*

A paper is being prepared for presentation at the 2017 ASSCT conference.

Section 7: Environmental Impact

Outline any new information on adverse/beneficial environmental impacts of conducting the project and/or implementing its findings.

Nil.

Section 8: Recommendations and Future Industry Needs

Include activities or other steps to further develop, disseminate, commercialise or exploit the Project Outputs and realise the industry benefits.

A preliminary research proposal has been submitted to SRA for funding in 2017/2018 to address two major shortcomings:

- The ability to measure fibre quality at an early stage of the variety adoption process.
- The ability to feed information about the processing characteristics of varieties back to plant breeders to help in the selection of appropriate varieties.

Section 9: Publications

Copies of substantive publications from the project should be included as Appendices. Where the project involves a student and the thesis is relevant to the project, this should be referred to in the report and an electronic copy of the thesis sent with the report or as soon as it is available.

The three project reports have been attached in Appendix A, Appendix B and Appendix C.

Appendix A: A first experiment to investigate the processing of cane variety SRA1 at Isis Mill

A first experiment to investigate the processing of cane variety SRA1 at Isis Mill

by

GA Kent, R Parfitt and DM Pike

October 2016

Project No. 4258

IMPORTANT NOTICE

The use of this report is governed by the Research Project Agreement dated 6 June 2016 between Sugar Research Australia Limited and Queensland University of Technology. Please refer to the intellectual property and confidentiality sections of that agreement. Those sections provide (amongst other things) that:

a. all intellectual property developed during this project belongs to Sugar Research Australia; and

b. the contents of this report must not be disclosed to others or used except in accordance with the agreement.

A first experiment to investigate the processing of cane variety SRA1 at Isis Mill

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A first experiment to investigate the processing of cane variety SRA1 at Isis Mill

Summary

In 2016, a new cane variety, *SRA1*, was released into the Bundaberg district. According to the pre-release fibre quality measurements undertaken by Sugar Research Australia, SRA1 was classified as a *soft* cane. Soft canes were extensively studied in the Australian industry in the 1980s and 1990s, due to the processing difficulties they caused and the poorer performance achieved. This report documents an experiment conducted at Isis Mill to measure the impact of SRA1 on the factory.

Approximately 600 t of SRA1 plant cane, about 11 months old, was available for the experiment from a single farm. To provide a comparison to SRA1, a similarly sized supply of Q208 was also sourced.

This first small series of tests at Isis has provided good quality data on the processing of SRA1 in the factory.

In terms of difficulties processing the cane, the main one with the potential to stop the factory was the foaming of the juice from #1 and #2 mills and the resulting spillage of the foam. It is expected that this problem can be overcome with a small amount of capital expenditure.

To maximise the performance of the milling train in processing SRA1, there will be a need to modify mill settings to maintain torque over a wider range of operating conditions, since SRA1 is substantially different to the other varieties being processed. In addition, modification to the juice screen will be required to improve its efficiency.

If SRA1 is to become a large proportion of the crop, there is expected to be capital expenditure of about $20 million required to increase factory capacity and/or reduce steam consumption to maintain a fuel balance. While there are expected to be benefits in sugar production from the higher pol content in the cane and lower power consumption in the milling train, those benefits have to be offset by the capital expenditure, change in operating costs and loss in cogeneration income.

The further tests planned processing SRA1 this season and consideration of the impacts on the factory will help to identify whether SRA1 has positive or negative benefits to the industry.

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A first experiment to investigate the processing of cane variety SRA1 at Isis Mill

1. Introduction

In 2016, a new cane variety, *SRA1*, was released into the Bundaberg district. According to the pre-release fibre quality measurements undertaken by Sugar Research Australia (Kent et al. 2014), SRA1 was classified as a *soft* cane.

Soft canes were extensively studied in the Australian industry in the 1980s and 1990s, due to the processing difficulties they caused and the poorer performance achieved (Mason et al. 1983; Edwards & McGinn 1985; Edwards 1992, 1993; Edwards & Kent 1995). This work ultimately led to the development of the fibre quality tests that identified SRA1 as a soft cane (Mason & Loughran 1982; Brotherton 1984; Loughran & Murry 1984, 1985, Brotherton et al. 1986; Loughran & Murry 1987; Garson & McGinn 1991).

This report documents an experiment conducted at Isis Mill to measure the impact of SRA1 on the factory.

1.1 Methodology

Approximately 600 t of SRA1 plant cane, about 11 months old, was available for the experiment from a single farm (Webbs). This cane supply was split into two so that a measure of variability could be obtained. To provide a comparison to SRA1, a similarly sized supply of Q208 was also sourced. The Q208 supply could not be sourced from a single farm. A small supply of Q208 (100 t) was available of similar age but first ratoon on an adjacent field on Webb's farm. This supply was utilised in one test. The remainder of the Q208 supply (400 t) came from Emdex and was also plant cane of similar age.

The experiment was conducted as a blocked factorial experiment, with the two cane varieties being the single factor assessed and the two blocks being the days of testing. For the first day, the Q208 cane was only sourced from Emdex. For the second day, the Emdex cane was processed first but not sampled. The Q208 from Webbs was processed immediately after the Emdex cane and the second test sampling was done throughout the processing of this cane. Four tests in total were conducted. The details of the tests are provided in Table 1.1.

Table 1.1 The test program

Test	Block	Variety	Date	Start tipping	End tipping	Start sampling	End sampling
1	1	Q208	9 Aug 2016	09:35	10:17	09:54	10:17
2		SRA1	9 Aug 2016	10:17	10:46	10:30	10:47
3	2	Q208	10 Aug 2016	09:29	10:07	09:53	10:08
4		SRA1	10 Aug 2016	10:07	10:34	10:22	10:35

The tests in the first block were harvested using normal operating parameters. For the second block, there was an attempt to produce cleaner cane.

During each test, no sampling of milling train products was conducted during the first 10 minutes so that each milling unit and imbibition stream was full of product from the desired cane supply before data recording occurred (billet cane sampling commenced earlier). During the test period, samples of billet cane, prepared cane, bagasse from each mill, first expressed juice, juice from each mill and mixed juice were sampled. Many other parameters were available from routine analysis (such as weighbridge records and DCS data).

2. Results

2.1 Cane supply

The details of the cane supply for each test are provided in Table 2.1. The results are summarised in Table 2.2. Unlike the difference in bin weights, the difference in cane rates between the two varieties was statistically significant at the 5% level.

Table 2.1 Cane supply details

Test	Rake	Bins	Total mass (t)	Average bin weight (t)	Tip start	Tip end	Lost time (min)	Cane rate (t/h)
1	5907	18	95.3	5.3	9:35:17	9:51:29	2	403
	5908	17	95.9	5.6	9:51:29	10:04:30		442
	5909	17	91.4	5.4	10:04:30	10:17:05		436
	Total	52	282.5	5.4	9:35:17	10:17:05	2	426
2	5910	20	122.4	6.1	10:17:05	10:31:38		505
	5911	20	120.8	6.0	10:31:38	10:46:16		495
	Total	40	243.2	6.1	10:17:05	10:46:16		500
3	6072	12	75.7	6.3	9:29:17	9:39:24		449
	6073	13	79.4	6.1	9:39:24	9:50:27		431
	6074	22	123.5	5.6	9:50:27	10:06:30		462
	Total	47	278.6	5.9	9:29:17	10:06:30		449
4	6075	20	120.9	6.0	10:06:30	10:20:45		509
	6076	20	122.1	6.1	10:20:45	10:34:52		519
	Total	40	243.0	6.1	10:06:30	10:34:52		514

Table 2.2 Cane supply results

Test	Block	Variety	Bin weight (t)	Cane rate (t/h)
1	1	Q208	5.4	426
2	1	SRA1	6.1	500
3	2	Q208	5.9	449
4	2	SRA1	6.1	514
Mean		Q208	5.7	438
Mean		SRA1	6.1	507

2.2 Cane analysis

2.2.1 Routine analysis

For each test, cane analysis by NIR and first expressed juice analysis was conducted for each rake and can fibre analysis was conducted on two independent samples collected across the entire cane supply for the test. The detailed results are shown in Table 2.3. A summary is shown in Table 2.4. Table 2.4 also shows the results of trash analysis conducted at SRA. Although the SRA1 results consistently showed lower fibre content, higher pol content and higher purity, the differences from the Q208 results were not statistically significant at the 5% level. It is expected that a larger experimental program would have shown statistical significance.

Table 2.3 Cane analysis details

Test	Rake/sample	First expressed juice		Cane					
				NIR			Laboratory		
		Brix (%)	Pol (%)	Fibre (%)	Brix (%)	Pol (%)	Fibre (%)	Brix (%)	Pol (%)
1	5907	18.7	16.41	13.65	15.52	13.43			
	5908	19.2	17.08	13.45	16.16	13.94			
	5909	18.7	16.53	13.37	15.78	13.52			
	A						13.18		
	B						12.86		
	Total	18.9	16.68	13.49	15.82	13.63	13.02	15.85	13.67
2	5910	18.9	16.86	10.88	16.57	14.50			
	5911	19.2	17.27	11.21	16.82	14.86			
	A						9.18		
	B						9.87		
	Total	19.0	17.06	11.04	16.69	14.68	9.53	16.66	14.58
3	6072	18.9	16.69	14.22	15.86	13.38			
	6073	19.1	16.96	14.49	15.99	13.61			
	6074	18.0	15.22	12.87	15.11	12.57			
	A						11.83		
	B						11.63		
	Total	18.6	16.12	13.70	15.56	13.09	11.73	15.82	13.42
4	6075	19.0	17.09	11.84	16.74	14.27			
	6076	19.0	17.12	11.69	16.60	14.27			
	A						9.88		
	B						9.81		
	Total	19.0	17.10	11.76	16.67	14.27	9.85	16.56	14.56

Table 2.4 Cane analysis results

Test	Block	Variety	Fibre (%)	Pol (%)	Purity (%)	Trash (%)
1	1	Q208	13.02	13.67	86.27	15.2
2	1	SRA1	9.53	14.58	87.52	11.3
3	2	Q208	11.73	13.42	84.80	9.9
4	2	SRA1	9.85	14.56	87.95	11.1
Mean		Q208	12.38	13.55	85.54	12.6
Mean		SRA1	9.69	14.57	87.74	11.2

The NIR analysis results shown in Table 2.3 for fibre, brix and pol content were generally within 0.5 units of the laboratory-measured results. The NIR fibre content results for tests 2, 3 and 4, however, were over 1 unit higher than the laboratory-measured results. These three fibre contents were significantly lower than most measured results and are presumably not well represented in the NIR calibrations. These three tests include both SRA1 measurements.

The trash measurements show that the quality of the SRA1 cane supplies were quite similar while the quality of the Q208 cane supplies were substantially different (the first containing much more trash than the second).

2.2.2 Fibre quality analysis

Fibre quality measurements were made on billet samples, including and excluding the trash that was harvested with the cane, and on prepared cane samples. Shear strength and short fibre measurements were made on all three samples. Impact resistance (because of the nature of the test) could only be measured on the billets excluding trash (because they are made on a core sample of a billet). The results are shown in Table 2.5.

Table 2.5 Fibre quality results

Test	Block	Variety	Sample	Shear strength	Short fibre	Impact resistance
1	1	Q208	Billet clean	20	57%	0.51
			Billet	27	40%	
			Prepared	29	58%	
2	1	SRA1	Billet clean	12	64%	0.23
			Billet	20	49%	
			Prepared	12	66%	
3	2	Q208	Billet clean	24	49%	0.53
			Billet	24	36%	
			Prepared	21	55%	
4	2	SRA1	Billet clean	14	68%	0.23
			Billet	13	52%	
			Prepared	15	65%	
Mean		Q208		24	55%	0.52
Mean		SRA1		14	66%	0.23

The difference in all three fibre quality parameters for the two varieties was statistically significant, indicating that all three parameters were more successful in distinguishing between the two varieties than fibre, brix or pol contents.

For the shear strength parameter, the difference in results between the prepared cane from as-supplied and cleaned billets and the Isis-prepared cane was not statistically significant, supporting the SRA approach of using a cleaned billet sample to estimate the parameter. For the short fibre parameter, the as-supplied billets produced a statistically significant difference to both the cleaned billets and Isis-prepared cane. The difference in short fibre between the cleaned billets and Isis-prepared cane was not statistically significant, again supporting the current SRA approach of using a cleaned billet sample.

Figure 2.1 shows the two fibre quality parameters that are usually assessed against the quality criteria. While the Q208 results were quite central within the defined acceptable range, SRA1 had an impact resistance less than the defined criterion, and shear strength within the criteria but at the low end.

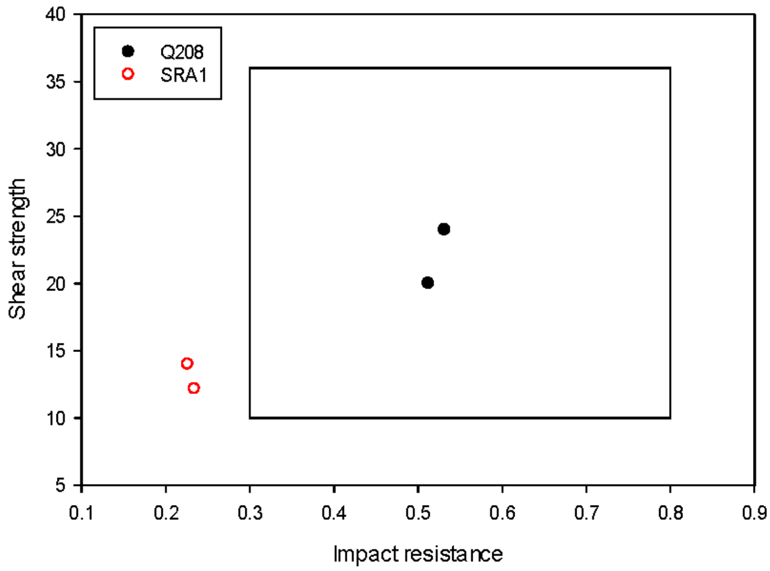

Figure 2.1 Average fibre quality results

2.3 Milling train performance

2.3.1 Milling train settings

To provide a comparison between processing Q208 and SRA1, an attempt was made to maintain constant #1 mill speed and constant added water % fibre. The achieved results are shown in Table 2.6. While the #1 mill speed was well controlled, the added water % fibre was not. The measured differences in both parameters were not statistically significant.

Table 2.6 Milling train settings

Test	Block	Variety	#1 mill drive speed (r/min)	Added water (% fibre)	Added water temperature (°C)
1	1	Q208	871	299	61
2	1	SRA1	871	347	63
3	2	Q208	864	294	90
4	2	SRA1	857	288	93
Mean		Q208	868	297	76
Mean		SRA1	864	318	78

One difference in settings between the first and second blocks is that the first block of tests was conducted under cool maceration conditions of typically 60 °C while the second block of tests was conducted under conventional hot maceration conditions.

2.3.2 Cane preparation

To provide a measure of preparation, pol in open cells analysis of the prepared cane samples was undertaken. In addition, the speed and chest pressure of the shredder turbines were recorded. The results are shown in Table 2.7. There was no evident trend in the results and no statistically significant differences.

Table 2.7 Cane preparation results

Test	Block	Variety	Pol in open cells (%)	Speed (r/min)	Chest pressure (kPa)	
					Turbine 1	Turbine 2
1	1	Q208	88.64	5411	990	928
2	1	SRA1	89.14	5406	1021	957
3	2	Q208	91.67	5403	1009	1007
4	2	SRA1	90.08	5407	1001	1005
Mean		Q208	90.15	5407	1000	967
Mean		SRA1	89.61	5407	1011	981

2.3.3 Milling

The overall milling train performance results in terms of total pol extraction and final bagasse moisture content are presented in Table 2.8. While the difference between cane varieties for neither parameter was statistically significant, the bagasse moisture difference was quite pronounced and suggests that the SRA1 moisture content was of the order of 3 units higher than the Q208 moisture content.

Table 2.8 Milling train performance

Test	Block	Variety	Total pol extraction (%)	Final bagasse moisture content (%)
1	1	Q208	97.16	50.09
2	1	SRA1	97.17	52.73
3	2	Q208	98.04	48.20
4	2	SRA1	97.46	52.93
Mean		Q208	97.60	49.15
Mean		SRA1	97.32	52.83

The milling train at Isis consists of five mills. The first and final mills have independent pressure feeders. All mills are driven by electric motors. The torque on the first and final mill pressure feeders and on the three intermediate mills is controlled using the feed chute flap (0% is fully open). The torque on the first and final mills is controlled using the pressure feeder to mill speed ratio. Torque is measured as a percentage of maximum current. The mean torques during each test are presented in Table 2.9. The mean values of the control parameters are shown in Table 2.10.

Table 2.9 Milling train torques

Test	Block	Variety	Torque (%)						
			#1 PF	#1 mill	#2 mill	#3 mill	#4 mill	#5 PF	#5 mill
1	1	Q208	71	63	65	65	60	71	90
2	1	SRA1	51	59	44	58	60	61	90
3	2	Q208	75	64	65	66	61	71	90
4	2	SRA1	56	63	45	57	60	59	85
Mean		Q208	73	64	65	66	61	71	90
Mean		SRA1	53	61	44	58	60	60	87

Table 2.10 Milling train torque control parameters

Test	Block	Variety	#1 mill		#2 mill	#3 mill	#4 mill	#5 mill	
			Flap (%)	PF/mill ratio	Flap (%)	Flap (%)	Flap (%)	Flap (%)	PF/mill ratio
1	1	Q208	1	1.47	65	29	72	65	1.16
2	1	SRA1	0	1.47	0	1	31	58	1.28
3	2	Q208	6	1.47	62	19	71	66	1.19
4	2	SRA1	0	1.47	1	1	25	57	1.31
Mean		Q208	4	1.47	63	24	71	66	1.18
Mean		SRA1	0	1.47	1	1	28	58	1.29

Statistically significant differences were identified in the #1 mill pressure feeder and #2 and #3 mill torques, the #2, #4 and #5 mill flap positions and the #5 mill pressure feeder to mill speed ratio. Although not statistically significant, there are indications of differences in the #1 mill and #5 mill pressure feeder torques and the #1 and #3 mill flap positions as well. The indications in all cases are that, either the torque reduced or that the control system acted to prevent the torque from reducing.

For #1 mill pressure feeder, #2 mill, #3 mill and #5 mill pressure feeder, the flap opened and the torque reduced. For all of these drives except the #5 mill pressure feeder, the flap opened to 1% or less, indicating that the control system ran out of control range before the torque set point could be achieved. Why the #5 mill pressure feeder didn't respond the same way has not been explored but is indicative of a control system problem. The pressure feeder to mill ratio on the first mill was at its maximum value (also out of control range) and so could not effectively control torque. Torque control could be achieved on #4 mill for all tests and on #5 mill during the first three tests. The maximum pressure feeder to mill ratio on #5 mill (1.31) was reached during test 4 and so the torque set point on this mill could not be maintained during that test. It is likely that the use of hot maceration is the reason for the inability to reach the #5 mill torque set point in test 4.

In addition to the torque control system, the top roll in each mill has the ability to lift. The only roll that did lift during the tests was the top roll of #1 mill that recorded 2 mm of lift with Q208 in both tests and 0 mm of lift with SRA1 in both tests.

In Table 2.11, Table 2.12 and Table 2.13, the performance of each mill has been defined in terms of the performance parameters delivery nip compaction, reabsorption factor multiplier and imbibition coefficient multiplier (Kent 2015).

Table 2.11 Delivery nip compactions

Test	Block	Variety	Delivery nip compaction (kg/m^3)				
			#1 mill	#2 mill	#3 mill	#4 mill	#5 mill
1	1	Q208	561	510	604	627	705
2	1	SRA1	496	389	536	591	669
3	2	Q208	540	498	583	626	698
4	2	SRA1	535	404	554	637	711
Mean		Q208	551	504	593	627	702
Mean		SRA1	515	396	545	614	690

Table 2.12 Reabsorption factor multipliers

Test	Block	Variety	Reabsorption factor multiplier				
			#1 mill	#2 mill	#3 mill	#4 mill	#5 mill
1	1	Q208	0.73	0.83	0.85	0.93	0.95
2	1	SRA1	0.79	1.01	1.01	1.07	1.02
3	2	Q208	0.76	0.83	0.86	0.92	0.90
4	2	SRA1	0.81	1.00	0.97	0.93	1.03
Mean		Q208	0.75	0.83	0.85	0.92	0.92
Mean		SRA1	0.80	1.00	0.99	1.00	1.02

Table 2.13 Imbibition coefficient multipliers

Test	Block	Variety	Imbibition coefficient multiplier				
			#1 mill	#2 mill	#3 mill	#4 mill	#5 mill
1	1	Q208	1.03	1.04	1.41	1.61	1.04
2	1	SRA1	1.00	0.46	1.33	1.56	1.64
3	2	Q208	1.01	1.07	1.47	1.53	1.74
4	2	SRA1	1.00	0.36	1.40	1.58	2.11
Mean		Q208	1.02	1.06	1.44	1.57	1.39
Mean		SRA1	1.00	0.41	1.36	1.57	1.87

Although the results were not statistically significant, Table 2.11 shows that the delivery nip compaction was consistently lower during the processing of SRA1 on #1, #2 and #3 mills but was not substantially different on #4 and #5 mills. These results are consistent with the torque results and provide an indication that, if torque can be maintained, delivery nip compaction can be maintained as well.

Table 2.12 shows that the reabsorption factor multiplier for all mills was consistently higher during the processing of SRA1 (the difference for #2 mill was statistically significant). These results provide an indication that higher bagasse moisture content can be expected on all mills when processing SRA1.

No consistent trends and no statistically significant differences were seen in the imbibition coefficient multiplier results in Table 2.13.

Table 2.14 presents the calculated power consumption of each mill (total of pressure feeder and mill drives for #1 and #5 mills). In all cases, less power was consumed during the processing of SRA1 (the difference for #5 mill was statistically significant). This result was expected for #1, #2 and #3 mills where the torque was lower, but not for #4 and #5 mills where the torque set point was largely maintained.

Table 2.14 Total mill power consumption

Test	Block	Variety	Power consumption (kW)				
			#1 mill	#2 mill	#3 mill	#4 mill	#5 mill
1	1	Q208	655	421	373	350	371
2	1	SRA1	552	317	320	320	333
3	2	Q208	668	410	371	338	360
4	2	SRA1	585	336	326	313	316
Mean		Q208	662	415	372	344	366
Mean		SRA1	569	327	323	317	324

Feed chute exit compactions (Kent 2015) were calculated to assess the effect of SRA1 on mill feeding. The results are shown in Table 2.15. While the differences were not statistically significant, the feed chute exit compaction for all mills was lower when processing SRA1, indicating that the milling train capacity in terms of cane fibre rate is lower.

Table 2.15 Feed chute exit compactions

Test	Block	Variety	Feed chute exit compaction (kg/m^3)				
			#1 mill	#2 mill	#3 mill	#4 mill	#5 mill
1	1	Q208	46	54	62	61	78
2	1	SRA1	39	40	55	57	67
3	2	Q208	44	53	60	61	75
4	2	SRA1	42	42	57	61	69
Mean		Q208	45	53	61	61	77
Mean		SRA1	41	41	56	59	68

2.3.4 Observations during the processing of SRA1

The SRA1 prepared cane and bagasse was able to be processed successfully through the shredder and all mills with no modification to operating parameters. There were, however, several issues that may have impeded sustained operation.

Probably the most significant operational issue was the frothing that occurred in the juice pit that receives #1 and #2 mill juice, prior to being pumped to the juice screen. When processing under normal conditions, the juice level in the pit is typically about 1 m below the grate. During both periods of just under 30 minutes that the SRA1 was being processed, froth built up and ultimately overflowed the pit and juice drains (Figure 2.2). It was expected that, if SRA1 had been processed for much longer, a factory stop would have resulted.

Figure 2.2 Froth overflowing the juice pit between #1 and #2 mills

During the sampling of juice from each of the mills, the samplers noted that there was considerably more cush in the juice from SRA1 than is normally the case. To quantify the amount, fibre analysis of the juice samples from each mill was undertaken. The results are shown in Table 2.16. None of the differences were statistically significant, but the #1, #2 and #3 mill juices showed higher fibre contents in the SRA1 samples of between 30% and 60%.

Table 2.16 Fibre content in juice streams

Test	Block	Variety	Fibre content (%)					
			#1 mill	#2 mill	#3 mill	#4 mill	#5 mill	Mixed juice
1	1	Q208	0.67	0.89	0.85	1.56	1.54	0.19
2	1	SRA1	0.85	1.42	1.24	1.17	1.18	0.22
3	2	Q208	0.53	0.94	1.02	1.66	1.82	0.16
4	2	SRA1	0.87	1.61	1.17	1.98	2.92	0.18
Mean		Q208	0.60	0.92	0.94	1.61	1.68	0.18
Mean		SRA1	0.86	1.51	1.21	1.58	2.05	0.20

It is considered likely that the higher fibre content in the #1 and #2 mill juices is responsible for the observed poorer performance of the rotary juice screen. It was noted that the juice screen was performing poorly when processing the Q208 variety, with a considerable amount of juice pouring out the end of the juice screen with the cush. When processing the SRA1, however, the juice quantity pouring out the end of the juice screen was considerably larger (Figure 2.3).

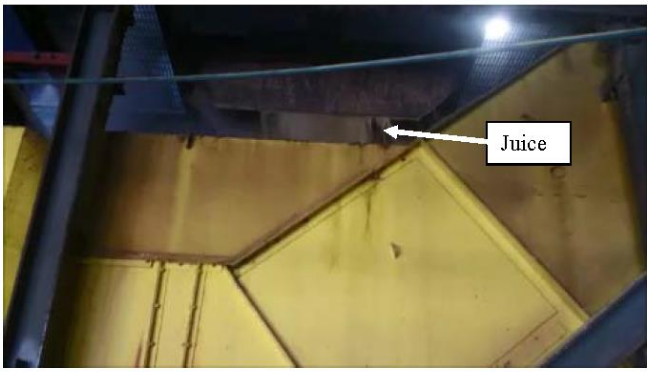

Figure 2.3 Juice flowing out the end of the juice screen

2.3.5 Other notes

Minimal differences in the behaviour of SRA1 were noted between the cool and hot maceration conditions.

The ash content of the bagasse was measured. The ash content of the Q208 bagasse was 4.73% dry fibre. The ash content of the SRA1 bagasse was higher at 7.22% dry fibre.

3. Implications

3.1 Overview

It is expected that the operational issues identified in section 2.3.4 will be able to be overcome so that continuous crushing of SRA1 can occur. One option to address the foaming proposed by industry staff is to reduce turbulence in the juice pit such as by not having the #1 and #2 mill juices entering the juice pit at opposite ends, causing the two flows to meet each other in the middle of the pit. While poor juice screen performance is not a hindrance to operation, it does represent lost extraction that could be presumably be overcome by increasing the screen aperture, increasing the rotational speed of the screen or by installing a second or larger screen.

The biggest issue identified in the experiment was simply the low fibre content of the SRA1. Lower fibre content results in lower bagasse production. Coupled with higher bagasse moisture and ash content that reduces the efficiency of bagasse utilisation, there is a likely shortfall in the bagasse supply that is needed for steam and electricity production.

One approach to maintaining the bagasse supply is to maintain crushing at the same cane fibre rate when processing SRA1. As discussed in section 2.3.3, the SRA1 did not feed as well as Q208, so some additional milling capacity is required to maintain the fibre rate. Even with the lower cane fibre rate achieved while processing SRA1 during the tests, the cane rate was substantially higher (Table 2.2). To achieve that higher rate, higher capacity in cane transport, receival and preparation is required. Higher cane rate also implies higher juice rate and, given the higher pol content of SRA1 (Table 2.4), higher pol rate that will require higher capacity through the back end of the factory as well.

The alternative approaches to maintaining cane fibre rate are to reduce factory steam consumption or to import fuel. Reducing factory steam consumption will require considerable capital investment while importing fuel adds to annual operating costs.

Further tests processing SRA1 are planned for October 2016 and smaller trials are also being undertaken at Millaquin and Maryborough in the 2016 season. These additional tests will help to confirm the main observations from this first test series.

3.2 Isis analysis

Isis have produced some process models to estimate the impact of reducing the cane fibre content on their bagasse surplus.

Figure 3.1 shows a model of the factory in its current configuration. Isis has a steam and electricity supply contract with AGL for the generation of export electricity. If the average cane fibre content drops below 13.4%, Isis cannot run the condensing steam turbine generator. If the average cane fibre content drops below 12.3%, Isis need to import fuel to run the factory. At an average cane fibre content of 10%, Isis would be 20 tonnes of bagasse short per hour to run the factory and 30 tonnes of bagasse short per hour for the operation of the condensing steam turbine generator.

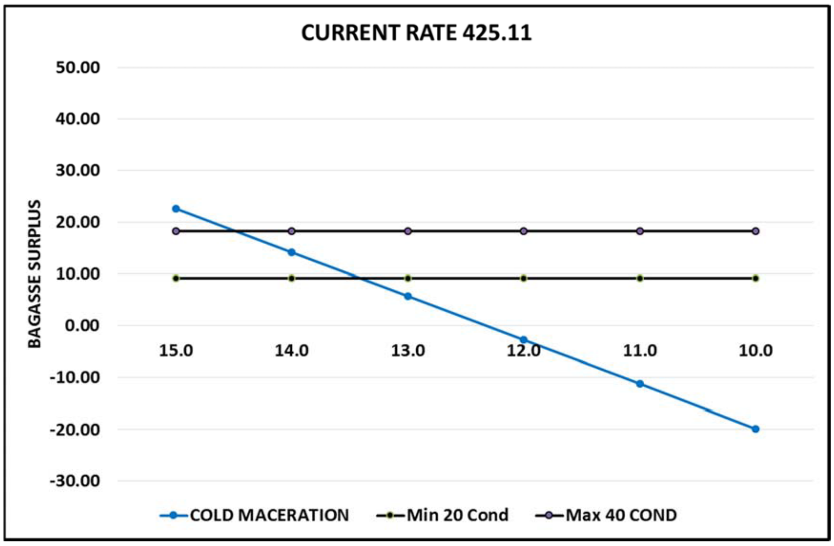

Figure 3.1 Bagasse surplus at Isis with the current factory configuration

Alternative configurations have been examined to modify the factory to allow processing of SRA1. An increase in cane rate to 470 t/h has been modelled, to partially offset the effects of the lower cane fibre rate. The "Steam on Cane" process modifications reduce factory steam consumption from 54% to 44%. A capital investment of about $20 million is required to achieve these changes. The changes allow the condensing steam turbine generator to operate down to a cane fibre content of 11.1 % and to eliminate the need to import fuel down to a cane fibre content of 10 % (Figure 3.2).

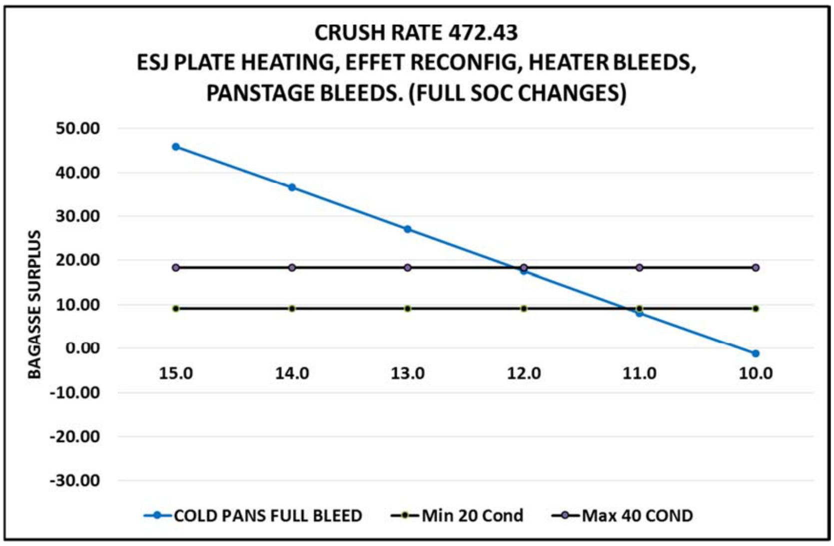

Figure 3.2 Bagasse surplus at Isis with the steam efficient configuration

4. Conclusions

This first small series of tests at Isis has provided good quality data on the processing of SRA1 in the factory.

In terms of difficulties processing the cane, the main one with the potential to stop the factory was the foaming of the juice from #1 and #2 mills and the resulting spillage of the foam. It is expected that this problem can be overcome with a small amount of capital expenditure.

To maximise the performance of the milling train in processing SRA1, there will be a need to modify mill settings to maintain torque over a wider range of operating conditions, since SRA1 is substantially different to the other varieties being processed. In addition, modification to the juice screen will be required to improve its efficiency.

If SRA1 is to become a large proportion of the crop, there is expected to be capital expenditure of about $20 million required to increase factory capacity and/or reduce steam consumption to maintain a fuel balance. While there are expected to be benefits in sugar production from the higher pol content in the cane and lower power consumption in the milling train, those benefits have to be offset by the capital expenditure, change in operating costs and loss in cogeneration income.

The further tests planned processing SRA1 this season and consideration of the impacts on the factory will help to identify whether SRA1 has positive or negative benefits to the industry.

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Appendix B: A first experiment to investigate the processing of cane variety QC04-1411 at Farleigh Mill

A first experiment to investigate the processing of cane variety QC04-1411 at Farleigh Mill

by

GA Kent, R Parfitt and PR Stuart

November 2016

Project No. 4258

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A first experiment to investigate the processing of cane variety QC04-1411 at Farleigh Mill

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A first experiment to investigate the processing of cane variety QC04-1411 at Farleigh Mill

Summary

A new cane variety, QC04-1411, is being evaluated in the Mackay district. According to the pre-release fibre quality measurements undertaken by Sugar Research Australia, QC04-1411 was classified as a *soft* cane. This report documents an experiment conducted at Farleigh Mill to measure the impact of QC04-1411 on the factory. This work follows a similar investigation of another new soft cane variety, SRA1 at Isis Mill.

166 t of QC04-1411 plant cane, about 11 months old, was available for the experiment from a single farm (3179A). To provide a comparison to QC04-1411, a similarly sized supply of Q240 was also sourced from the same farm. A further 156 t of QC04-1411 plant cane, also about 11 months old, was available from another farm. A similar comparison was planned for this second supply, but problems processing the first 166 t resulted in the plans to include this second supply in the experiment being abandoned.

This first small series of tests processing QC04-1411 at Farleigh has provided some data that suggests the constituents (brix, pol and fibre) of the cane are not significantly different to Q240. Analysis of billet cane and prepared cane for shear strength and impact strength did not identify significant differences between the two varieties, although the short fibre level tests and mill torque levels did identify significant differences between Q240 and QC04-1411.

It is expected that the problem feeding #1 mill can be overcome. The proposed solution of maintaining the profile of the pressure feeder juice grooves and external juice groove scrapers will require some additional annual maintenance costs.

The problem preventing blockages of juice drains due to excess cush levels is also expected to be overcome through the use of water sprays and adequate and well controlled emergency maceration. Use of water for this purpose is not ideal in terms of water use. It is best that this water use be controlled so that it is only used when necessary and accounted for in the entire water use to the milling train. Use of this water in the various juice drains rather than as imbibition before the final mill is also less efficient in terms of extraction so there will be a performance cost associated with this solution.

The problem of the knitting of bagasse fibres causing feeding and combustion problems in the boilers is more significant since it is less understood with no readily apparent solution. This issue needs further exploration if QC04-1411 is to become a regular component of the cane supply.

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A first experiment to investigate the processing of cane variety QC04-1411 at Farleigh Mill

1. Introduction

A new cane variety, QC04-1411, is being evaluated in the Mackay district. According to the pre-release fibre quality measurements undertaken by Sugar Research Australia (Kent et al. 2014), QC04-1411 was classified as a *soft* cane.

This report documents an experiment conducted at Farleigh Mill to measure the impact of QC04-1411 on the factory. This work follows a similar investigation of another new soft cane variety, SRA1 at Isis Mill (Kent *et al.* 2016).

2. Methodology

166 t of QC04-1411 plant cane, about 11 months old, was available for the experiment from a single farm (3179A). To provide a comparison to QC04-1411, a similarly sized supply of Q240 was also sourced from the same farm. A further 156 t of QC04-1411 plant cane, also about 11 months old, was available from another farm. A similar comparison was planned for this second supply, but problems processing the first 166 t resulted in the plans to include this second supply in the experiment being abandoned.

Details of the two tests that were completed are provided in Table 2.1. The large duration for test 2 includes significant factory stops that are discussed further in section 3.3.

Table 2.1 The test program

Test	Variety	Date	Start crushing	End crushing
1	Q240	24 Aug 2016	09:42	09:55
2	QC04-1411	24 Aug 2016	09:55	16:01

During the test period, an attempt was made to collect samples of billet cane, prepared cane, bagasse from each mill, first expressed juice, juice from each mill and mixed juice. Many other parameters were available from routine analysis (such as weighbridge records and DCS data). Because of the short duration of the tests, it was not possible to isolate a single period when the entire milling train was processing the variety for sample collection. Consequently, an attempt was made to stagger the sampling time at each sampling location and the period used for averaging DCS parameters.

3. Results

3.1 Cane supply

The details of the cane supply for each test are provided in Table 3.1.

Table 3.1 Cane supply details

Test	Sample	Bins	Total mass (t)	Average bin weight (t)	Crush start	Crush end	Lost time (min)	Cane rate (t/h)
1	368	22	123.0	5.6	9:42:23	9:55:46		552
2	369	18	107.8	6.0	9:55:46	15:43:56	336	510
	378	10	58.5	5.8	15:43:56	16:01:17	9	420
	Total	28	166.3	5.9	9:55:46	16:01:17	345	474

3.2 Cane analysis

3.2.1 Routine analysis

For each test, cane analysis by NIR and first expressed juice analysis was conducted for each rake and can fibre analysis was conducted on two independent samples collected across the entire cane supply for the test. The detailed results are shown in Table 3.2. Table 3.2 also shows the results of trash analysis conducted at SRA. The cane fibre, brix and pol contents of the two varieties were not substantially different.

Table 3.2 Cane analysis details

Test	Rake / sample	First expressed juice				Cane				Trash % cane
		Laboratory		NIR		NIR	Laboratory			
		Brix (%)	Pol (%)	Brix (%)	Pol (%)	Fibre (%)	Fibre (%)	Brix (%)	Pol (%)	
1	368	20.00	18.00	19.36	17.23	14.63				
	A						13.87			
	B						14.11			
	Total						13.99	16.60	14.58	16.0
2	369	20.10	17.70	19.07	16.83	13.75				
	378	19.60	16.90	19.31	16.99	13.75				
	A						13.76			
	B						13.95			
	Total						13.86	16.57	14.13	14.1

3.2.2 Fibre quality analysis

Fibre quality measurements were made on billet samples, including and excluding the trash that was harvested with the cane, and on factory-prepared cane samples. Shear strength and short fibre measurements were made on all three samples. Impact resistance (because of the nature of the test) could only be measured on the billets excluding trash (because they are made on a core sample of a billet). The results are shown in Table 3.3.

Table 3.3 Fibre quality results

Test	Variety	Sample	Shear strength	Short fibre	Impact resistance
1	Q240	Billet clean	15	72%	0.43
		Billet	23	46%	
		Prepared	34	62%	
2	QC04-1411	Billet clean	18	88%	0.38
		Billet	22	66%	
		Prepared	27	79%	
Mean	Q240		24	60%	0.43
Mean	QC04-1411		22	78%	0.38

The difference in the short fibre results between the two varieties was statistically significant. The difference in shear strength results was not statistically significant. Because only two tests were completed, it was not possible to determine statistically significant differences in the impact resistance results between the two varieties.

For the short fibre parameter, the differences between the as-supplied billets, the cleaned billets and the factory-prepared cane were all statistically significant. The as-supplied billets produced the lowest short fibre content while the cleaned billets produced the highest short fibre content. The results reported by Kent et al. (2016) also showed as-supplied billets having a lower short fibre content than cleaned billets.

Figure 3.1 shows the two fibre quality parameters that are usually assessed against the quality criteria. The Q240 and QC04-1411 results both fit in the lower corner of the defined acceptable range.

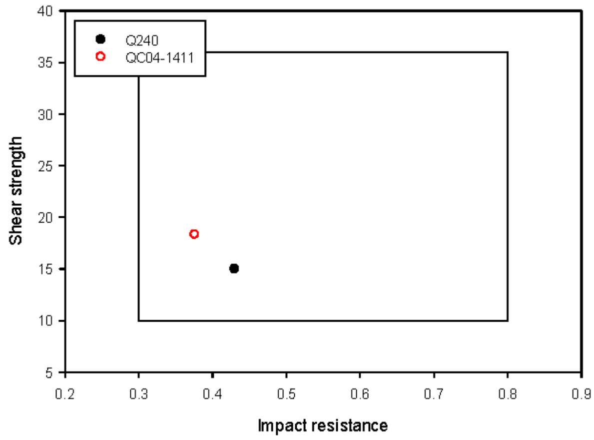

Figure 3.1 Average fibre quality results

3.2.3 Whole stick cane - fibre quality analysis and trash contribution

Cane was sampled whole stick from six identified paddocks for the mill trial, prior to the paddocks being harvested. This cane was analysed at SRA Bundaberg laboratory for fibre quality analysis. Cane was separated into trash and stalk for parallel tests to ascertain the contribution of the trash component to the fibre quality parameters shear strength and proportion of short fibre.

The QC04-1411 was *free trashing* so the proportion of trash with the whole stalk was low and varied from 0.3 to 0.9%. By comparison, trash proportion in the billets varied from 12 to 16%. A similar differential existed for Q240 billets and stalk samples.

The effect of the trash on the short fibre proportion is shown in Table 3.4, together with the prepared cane. Note that some SP80P samples were collected in the field and included in Table 3.4 but none of this variety was sampled at the factory.

Table 3.4 Short fibre – trash effect results

	Clean Stalk	Stalk + Trash	Clean Billets	Billets + Trash	Prepared Cane
Q240	60%	49%	72%	46%	62%
QC04-1411	88%	81%	88%	66%	79%
SP80P	58%	55%	NS	NS	NS

The data is not conclusive, but the comparisons above indicate that:

a. The Farleigh Mill shredder prepares the cane to produce more short fibre than the SRA hammer mill.

b. Trash added to the cane before hammer milling decreases the short fibre proportion as measured after the treatment.

c. QC04-1411 has a significantly higher proportion of short fibre than the two other varieties in the trial.

The effect of the trash on the shear strength measurement is shown in Table 3.5, together with the prepared cane.

Table 3.5 Shear strength - trash effect results

	Clean Stalk	Stalk + Trash	Clean Billets	Billets + Trash	Prepared Cane
Q240	25	32	15	23	34
QC04-1411	15	14	18	22	27
SP80P	24	28	NS	NS	NS

The comparisons above indicate that addition of trash increases the shear strength. Note that the QC04-1411 stalk plus trash samples included less than 1% trash.

The actual range of individual results behind the averages above varied considerably from 5 to 31 for QC04-1411, 15 to 43 for Q240, and 18 to 30 for SP80P. So in a factory environment, with some cane being very clean and other cane with higher trash levels, the shear strength will vary widely.

When the shear strength and short fibre data are checked for correlation (Figure 3.2), there does appear to be a loose correlation, which is expected. The more the shredder prepares the cane then the smaller the fibre particles and the lower the expected shear strength of a blanket of that cane.

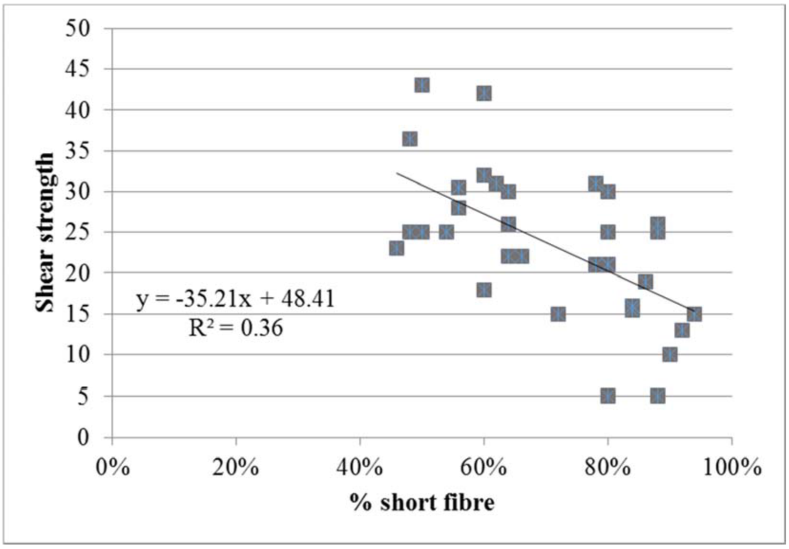

Figure 3.2 Correlation check of % short fibre versus shear strength

3.3 Milling train performance

3.3.1 Milling train settings

To provide a comparison between processing Q240 and QC04-1411, an attempt was made to maintain constant #1 mill speed and constant added water % fibre. The achieved results are shown in Table 3.6. The large stop during test 2 and the operational concerns discussed in section 3.3.4 resulted in a much lower #1 mill speed being adopted following the stop. The two stages of test 2 (cane tipped before and after the stop) are shown in Table 3.6. Note that period 2 ended after the cane tipped before the stop reached #1 mill and so the last of the period 2 cane was processed after the stop. As a result, the period 2 averages include some time at the lower mill speed after the stop.

Table 3.6 Milling train settings

Test	Period	Variety	#1 mill drive speed (r/min)	Cane rate (t/h)	Added water (% fibre)	Added water temperature (°C)
1	1	Q240	730	552	172	80
2	2	QC04-1411	734	525	215	81
	3	QC04-1411	614	442	118	57

3.3.2 *Cane preparation*

To provide a measure of preparation, the speed and chest pressure of the shredder turbine was recorded. The results are shown in Table 3.7. The chest pressure was considerably lower during the processing of QC04-1411 but much of the reduction was associated with the low speed operation following the large stop. In the period before the stop, the mean chest pressure when processing QC04-1411 was 769 kPa, higher than the 749 kPa shown in Table 3.7 for period 2 which includes some of the period after the stop, but much less than the period 1 mean chest pressure of 820 kPa.

Table 3.7 Cane preparation results

Test	Period	Variety	Shredder speed (r/min)	Shredder chest pressure (kPa)
1	1	Q240	6092	820
2	2	QC04-1411	6081	749
	3	QC04-1411	6063	607

When interpreting the shredder and mill chest pressure results, it was observed that the cane did slip in the cane carrier causing imperfect feed to the cane supply belts feeding the shredder and mills for all three test periods.

3.3.3 *Milling*

Because of the large stop in the middle of test 2, that split the already short processing time into smaller segments, steady state operation was not achieved and it is unlikely that meaningful analysis of the overall milling train performance can be made. There was some confidence in the analysis of the first mill results which are presented in Table 3.8. The extraction result for Q240 seems improbably high so the result is somewhat in doubt. The bagasse sample was not refrigerated before analysis so it is likely that degradation of the bagasse occurred, destroying some sucrose.

Table 3.8 Milling train performance

Test	Variety	#1 mill extraction (%)	#1 mill bagasse moisture content (%)
1	Q240	88.2[1]	50.2
2	QC04-1411	82.4	52.5

The milling train at Farleigh consists of six mills, but the #2 mill was bypassed during the tests, making it effectively a five-mill train. The first and final mills have independent pressure feeders. All mills are driven by steam turbines and both independently driven pressure feeders are driven by hydraulic motors. The hydraulic pressure on the first and final mill pressure feeders and chest pressure on the three intermediate mills is controlled using

[1] Probably due to degradation of bagasse sample.

the feed chute flap (100% is fully open). The chest pressure on the first and final mills is controlled using the pressure feeder to mill speed ratio.

Because of the short duration of the tests and stops during test 2, the period in which there was confidence which sample was being processed through each mill was quite short. The parameter that gave the best indication of which sample was being processed was chest pressure. There was a noticeable reduction in chest pressure during test 2, where steady state conditions were not achieved until the very end of the rake. Three periods were identified in the DCS data:

1. Test 1
2. Test 2 until the large stop
3. Test 3 when steady state conditions were more or less achieved.

For periods 2 and 3, the periods were between 0 and 6 minutes in duration with the longest duration at #1 mill and the shortest duration at #6 mill. The mean chest pressures during each period are presented in Table 3.9. Chest pressure was clearly lower during the processing of QC04-1411. For the two periods processing QC04-1411, the latter period at minimum #1 mill speed (600 r/min turbine speed) had lower chest pressures throughout the milling train than the former period.

Table 3.9 Milling train torques

Test	Period	Variety	Chest pressure (kPa)				
			#1 mill	#3 mill	#4 mill	#5 mill	#6 mill
1	1	Q240	850	776	881	922	673
2	2	QC04-1411	604	591	603	599	628
	3	QC04-1411	467	516	500	574	435

3.3.4 Observations during the processing of QC04-1411

Difficulties were experienced feeding #1 mill while processing QC04-1411. These difficulties manifested as the #1 mill feed chute filling up, causing the prepared cane elevator to slow down. At lower speed, the prepared cane elevator motor tripped due to high current (it was thought that the prepared cane was denser than usual, giving a higher mass for a similar volume). Attempting to restart the elevator initiated a trip of the 3 MW alternator, which in turn initiated a series of additional failures that resulted in the 336 minute stop (Table 3.1).

Upon restarting at minimum #1 mill speed, a large pool of juice was observed flowing over the top of the top pressure feeder roll. Although this roll had juice grooves, the grooves were worn to about half their usual depth. The juice groove scrapers were fitted to the nose plates which would have helped to reduce the size of the juice drainage space under the roll. It is considered likely that the pressures associated with this build-up of juice above the top pressure feeder roll were responsible for the poor feeding of the #1 mill.

Some frothing of the juice above the top pressure feeder roll of #1 mill was observed. This frothing may well be a similar phenomenon to the frothing that was observed in the juice pit between #1 and #2 mills at Isis when processing SRA1 (Kent et al. 2016). There were no pumping problems resulting from this froth in these short tests.

The second stop during the processing of QC04-1411 was caused by the juice tray under #5 mill filling up and overflowing. The cause of the incident was cush in the juice blocking the drains. It is possible that this blockage was related to the previous stop. It is also possible that the cause may have been insufficient emergency maceration water being applied. Farleigh have had many issues in 2016 with choked juice pipes and pumps on the milling train due to inadequacies with emergency maceration. Cush levels in maceration juice from QC04-1411 were not able to be measured except at #1 mill, which was at a normal level.

In addition to the issues experienced during test 2, the bagasse appeared to have short spikey fibres that knitted together and caused feeding and combustion issues in the boilers. Due to the clumping effect, the bagasse fell to the grate rather than burning in suspension. While no reliable bagasse moisture content measurements were made, it was not evident that the bagasse moisture content was high (a potential source of clumping), so the mechanism responsible for this behaviour is unknown. It was noted that the shredder chest pressure was slightly lower during the period 2 processing of QC04-1411 but it is not obvious if that lower chest pressure is related to lower preparation that may have contributed to the problem. Lower chest pressure could have been related to the lower rate being processed, to the softer cane, or both.

The two rotary juice screens at Farleigh seemed to cope with the cush flows during the single occasion they were observed. It is noted that the observation was made under the low #1 mill speed condition in period 3 (section 3.3.3).

4. Other experience processing QC04-1411

As discussed in section 2, a second block of QC04-1411 was harvested and planned to be processed as part of the factory test on the same day as the rake reported in section 3. After the first rake went through with associated factory stoppages, the precautionary decision was made to protect the factory operations and split the 28 bin rake into smaller rakes of five and four bins each. These smaller rakes were not subject to any special analysis, but were routinely analysed through the weighbridge and NIR systems. Table 4.1 presents the collected results. The four bin rakes were too small for payment analysis.

Table 4.1 Small rake analysis – variety QC04-1411

Rake	Weight	NIR	
		Fibre (%)	Ash (% dry fibre)
423	29.13	NA	NA
429	29.14	13.38	1.03
434	28.31	13.58	1.65
465	27.53	13.62	1.70
483	21.35	NA	NA
498	20.96	NA	NA

Instructions were passed to the shift that, while processing QC04-1411, the operators were to reduce #1 mill speed to 600 r/min to ensure that the cane could be processed through the milling train without stopping. These instructions achieved their purpose of ensuring no further lost time.

For each rake, the milling train experienced temporary depressions in each mill chest pressure below the normal range of variations (Figure 4.1, Figure 4.2 and Figure 4.3). The extent of the depression was not as severe as a gap passing through the milling train. The effect was comparable to the effect of a large drop in milling train speed.

There were no recorded effects on the boiler feed speeds or boilers.

With the benefit of hindsight, the drop in #1 mill speed to its minimum value was probably greater than necessary and there may not be a requirement to reduce the mill speed at all for small rakes such as the four and five bin rakes processed here.

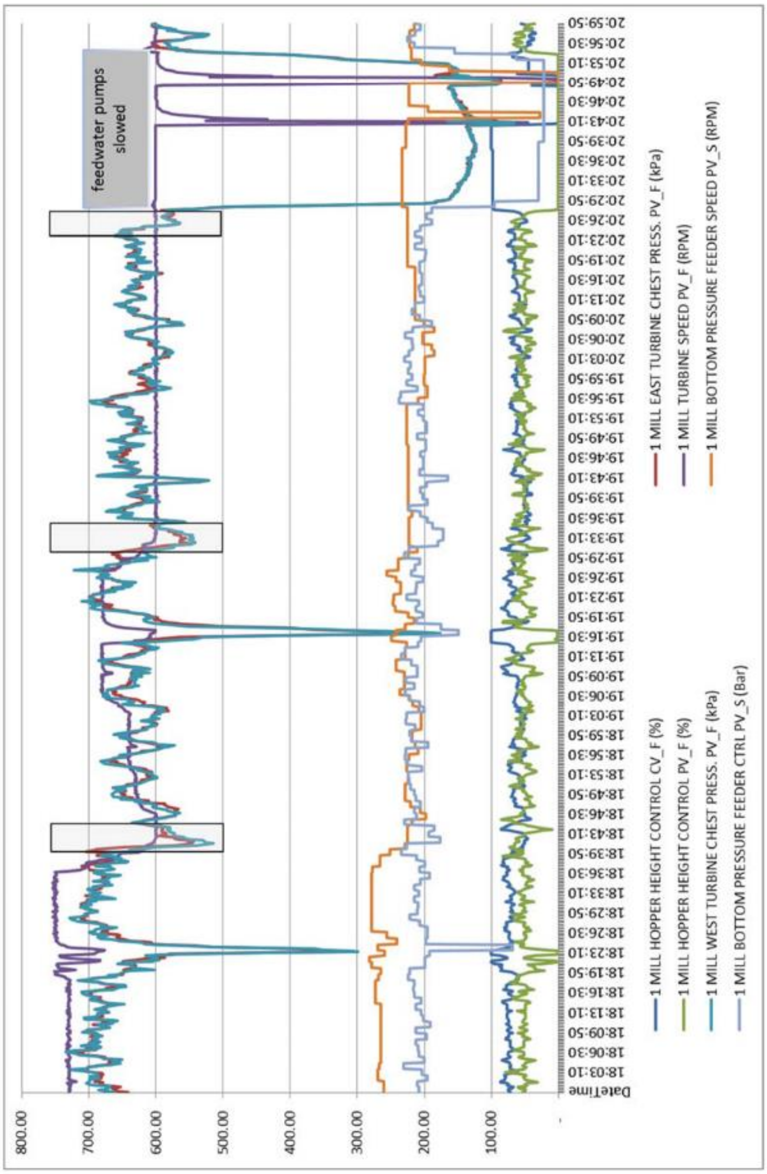

Figure 4.1 **#1 mill trend data when processing the first three small rakes**

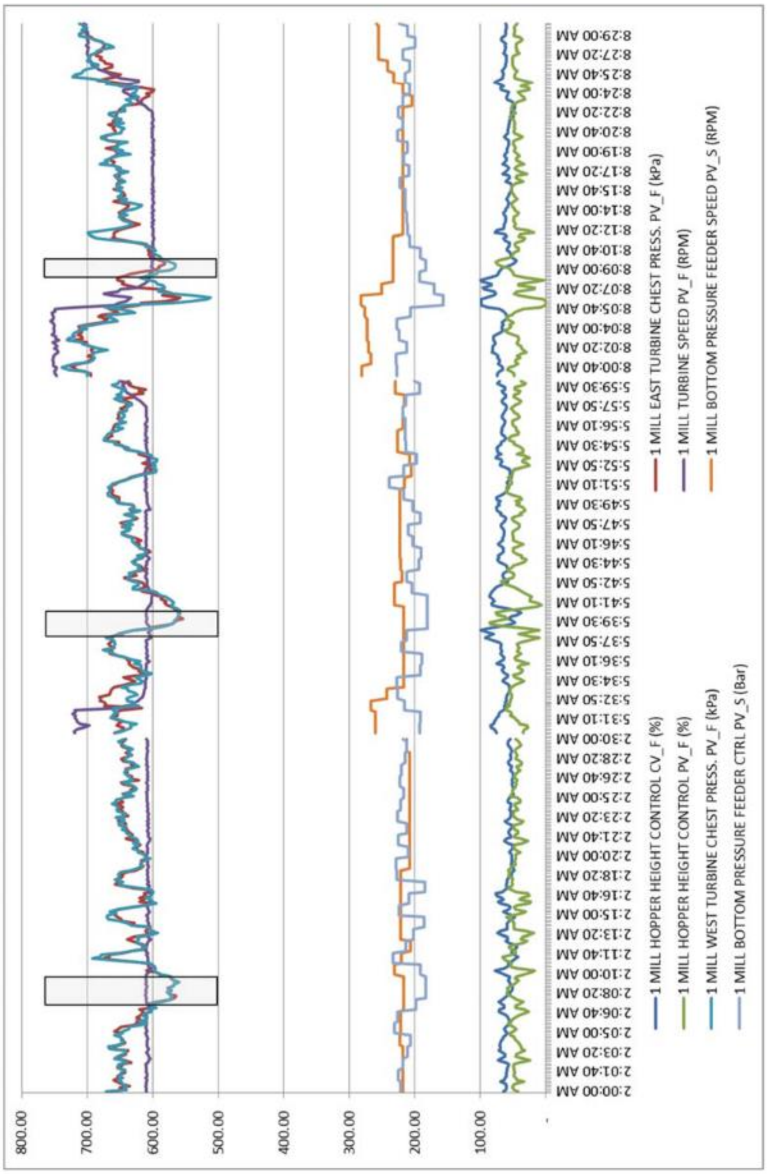

Figure 4.2 **#1 mill trend data when processing the last three small rakes**

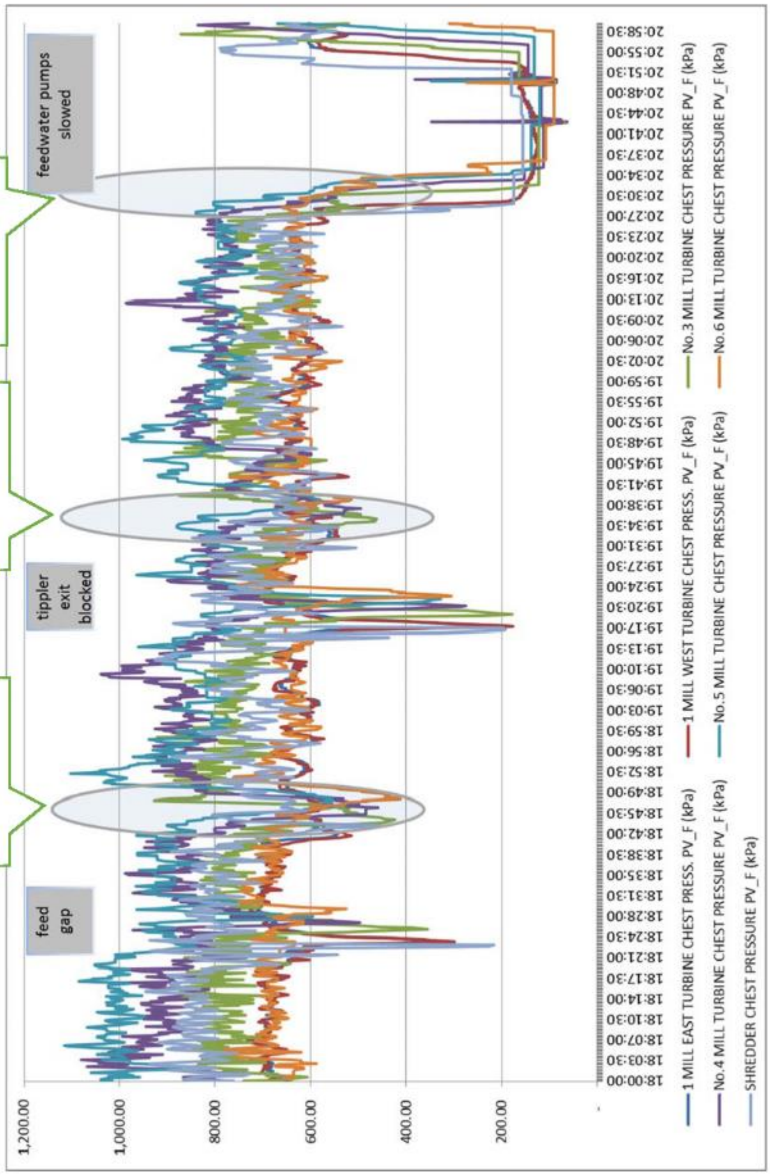

Figure 4.3 **Chest pressure trend data when processing the first three small rakes**

5. Implications

Cane constituents (brix, pol, fibre) were all measured to be in a similar range to those of Q240 from the same farm.

To process QC04-1411 through Farleigh without disruption, some changes are required. Most notably, juice drainage from the pressure feeder rolls needs to be improved. Maintaining juice grooves in good condition and utilising external juice groove scrapers that do not impede the flow of juice under the top pressure feeder roll may well be sufficient to address this problem.

While far from ideal, water sprays can be located in strategic locations to prevent the build-up of cush along juice drainage paths. Ideally these water flows should be measured and treated as part of the overall water addition to the milling train.

The cause of the knitting of the bagasse fibres that caused combustion problems is not obvious and needs further study if QC04-1411 is to become a regular component of the cane supply.

Unlike the low fibre content SRA1, QC04-1411 does not appear to be sufficiently different to Q240 to require significant changes to the factory. It is not expected to cause significant changes in rate or steam consumption.

6. Conclusions

This first small series of tests processing QC04-1411 at Farleigh has provided some data that suggests the constituents (brix, pol and fibre) of the cane are not significantly different to Q240. Analysis of billet cane and prepared cane for shear strength and impact strength did not identify significant differences between the two varieties, although the short fibre level tests and mill torque levels did identify significant differences between Q240 and QC04-1411.

It is expected that the problem feeding #1 mill can be overcome. The proposed solution of maintaining the profile of the pressure feeder juice grooves and external juice groove scrapers will require some additional annual maintenance costs.

The problem preventing blockages of juice drains due to excess cush levels is also expected to be overcome through the use of water sprays and adequate and well controlled emergency maceration. Use of water for this purpose is not ideal in terms of water use. It is best that this water use be controlled so that it is only used when necessary and accounted for in the entire water use to the milling train. Use of this water in the various juice drains rather than as imbibition before the final mill is also less efficient in terms of extraction so there will be a performance cost associated with this solution.

The problem of the knitting of bagasse fibres causing feeding and combustion problems in the boilers is more significant since it is less understood with no readily apparent solution.

This issue needs further exploration if QC04-1411 is to become a regular component of the cane supply.

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Appendix C: Assessment of new soft cane varieties

Assessment of new soft cane varieties

by

GA Kent and R Parfitt

November 2016

Project No. 4258

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a. all intellectual property developed during this project belongs to Sugar Research Australia; and

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Assessment of new soft cane varieties

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Assessment of new soft cane varieties

Summary

In 2016, three new cane varieties, SRA1, SRA4 and QC04-1411, were either released or were proposed for release into the Bundaberg and Mackay districts. According to the pre-release fibre quality measurements undertaken by Sugar Research Australia, all three varieties were classified as *soft* canes. This report documents a series of experiments undertaken to better define soft canes and to measure the effect that these three varieties had on factory operation and performance.

The experiments were undertaken collaboratively by QUT, SRA and field and factory staff in the Isis, Farleigh, Millaquin and Maryborough districts.

Trash has been shown to affect the fibre quality measurements, reducing the short fibre content by typically 12 units and most likely increasing the shear strength measurement by about 6 units. Comparing the cleaned stalks of cane usually used for fibre quality measurements to factory-prepared cane, it seems likely that shear strength is underestimated by about 7 units and short fibre content is underestimated by about 4 units (most likely shredder dependent).

SRA1 had a low fibre content of typically 10% and an impact resistance lower than the minimum criterion considered for normal canes. The other two varieties, SRA4 and QC04-1411 had relatively normal fibre contents of about 14%. While their impact resistance was low, it was still within the normal range. Shear strength is the other fibre quality parameter with a defined normal range. The shear strength of all three varieties were within the normal range, with SRA1 having the lowest values. The final fibre quality parameter, short fibre content does not have a defined normal range. It is noted, however, that of the 35 results examined, the two highest values were for QC04-1411 and the next two highest values were for SRA1 (Q240 was the fifth highest with a shear strength lower than QC04-1411).

The low fibre content of SRA1 is considered the biggest problem regarding the processing of the three varieties. With current major varieties having fibre contents of typically 12% to 15%, SRA1 is particularly different and will cause fuel balance issues. The fact it is different to the other varieties means that it is difficult to configure a factory to consistently achieve a fuel balance, with the likelihood that there will be periods when fuel will need to be purchased and other periods when fuel will need to be disposed of. The fact it is low means that a factory will need to be reconfigured at high capital cost to become much more energy efficient.

All three varieties exhibited the soft cane characteristic of generating low mill torques. While there is some hope that mills could be re-set to achieve their torque set point when processing soft cane, the wide variation in variety characteristics between the soft canes and the other

varieties in the cane supply means that a much wider control range is required to be able to achieve their torque set points across the different varieties.

Associated with the inability to maintain torque set points, bagasse moisture contents from the soft canes were found to be higher than normal. This result was particularly pronounced with SRA1 where Isis and Millaquin recorded increases in final bagasse moisture content of between three and eight units. The available information from the processing of SRA4 and QC04-1411 also showed higher bagasse moisture content but the results are less conclusive, due to the limited nature of the trials of those varieties. Not all factory boilers can withstand significant increases in bagasse moisture content. The Millaquin experience processing SRA1 resulted in a rapid drop in steam pressure that only avoided a boiler shutdown because SRA1 was only processed for 15 minutes. Sustained factory operation when feeding boilers with high moisture bagasse is problematic.

There was a potential concern with the processing of QC04-1411 where the bagasse caused feeding and combustion issues. It is unknown if this problem is characteristic of the variety or simply a one-off incident.

Other problems such as poor mill feeding and frothing when processing the soft cane varieties were experienced but are believed to resolvable with relatively small capital expenditure.

While the yield of some of the soft cane supplies was measured to be quite high, those yield benefits need to be weighed up against the additional factory processing costs that will be incurred in terms of capital upgrades and stops.

Assessment of new soft cane varieties

1. Introduction

In 2016, three new cane varieties, SRA1, SRA4 and QC04-1411, were either released or were proposed for release into the Bundaberg and Mackay districts. According to the pre-release fibre quality measurements undertaken by Sugar Research Australia (Kent et al. 2014), all three varieties were classified as *soft* canes.

Soft canes were extensively studied in the Australian industry in the 1980s and 1990s, due to the processing difficulties they caused and the poorer performance achieved (Mason et al. 1983; Edwards & McGinn 1985; Edwards 1992, 1993; Edwards & Kent 1995). This work ultimately led to the development of the fibre quality tests that identified these varieties as soft canes (Mason & Loughran 1982; Brotherton 1984; Loughran & Murry 1984, 1985, Brotherton et al. 1986; Loughran & Murry 1987; Garson & McGinn 1991).

This report documents a series of experiments undertaken to better define soft canes and to measure the effect that these three varieties had on factory operation and performance.

2. Fibre quality measurements

As reported by Brotherton et al. (1986) and Kent et al. (2014), there are three main tests conducted to assess fibre quality:

1. Shear strength, based on the force required to shear a block of cane compressed between two nailed boards.
2. Impact resistance, based on the energy absorbed by a core sample of cane during shear fracture by impact.
3. Short fibre content, based on the results of a sieve analysis.

3. Effect of extraneous matter on fibre quality measurements

3.1 Introductory remarks

As part of the breeding program, fibre quality measurements are conventionally conducted on clean samples of cane stalks. In contrast, the factory cane supply contains a significant amount of extraneous matter, particularly trash. This experiment was designed to determine if extraneous matter has a significant impact on the fibre quality measurements. Because the impact resistance test is conducted on a core sample of cane, it is by definition unaffected by extraneous matter and therefore was not included in this experiment.

3.2 Methodology

Samples of cane were collected from the field as whole stalks including trash. The samples were divided into two subsamples. One of the samples was cleaned to remove extraneous matter and the other was not.

The original intention was to compare the clean samples to samples with 10% trash content. This approach was achieved with the samples from Isis. For the samples from Mackay, the trash content was considerably below 10% and so the samples were simply processed with the entire trash content.

The varieties supplied from Mackay, Q240, SP80P and QC04-1411, all appeared to have shed most of their leaves so that the trash content attached to the stalk was low. The shed trash was evidently picked up by the harvester in order to result in cane supplies with the high trash levels typically recorded.

3.3 Results

The collected samples are identified in Table 3.1. No trash contents were recorded for the Isis or Millaquin samples since the trash content was set at 10% for tests using those samples.

Table 3.1 Samples collected for experiment 1

Block	Region	Variety	Trash content (%)
1	Isis	SRA1	
2	Isis	SRA1	
3	Isis	Q208	
4	Isis	Q208	
5	Mackay	QC04-1411	0.4
6	Mackay	Q240	0.7
7	Mackay	SP80P	1.9
8	Mackay	Q240	2.7
9	Mackay	QC04-1411	0.4
10	Isis	Q208	
11	Isis	Q208	
12	Isis	SRA4	
13	Isis	SRA4	
14	Isis	SRA1	
15	Isis	SRA1	
16	Millaquin	SRA1	
17	Millaquin	SRA1	
18	Millaquin	SRA1	
19	Millaquin	SRA1	

The shear strength and short fibre content results for each sample, with and without trash are presented in Table 3.2. The difference in short fibre content between the clean and trashy samples was statistically significant at the 0.0008% level. As shown in Table 3.2, trash reduces the short fibre content by typically 12 units. The results show that the shear strength was generally higher with trash and this result was statistically significant at the 8% level, more than the 5% level that is often considered the limit of statistical significance.

Table 3.2 Fibre quality results for experiment 1

Block	Trash	Shear strength	Short fibre content (%)
1	Clean	6	68
1	Trash	29	48
2	Clean	18	66
2	Trash	25	44
3	Clean	17	42
3	Trash	21	32
4	Clean	28	50
4	Trash	23	44
5	Clean	10	86
5	Trash	11	82
6	Clean	27	55
6	Trash	25	49
7	Clean	24	58
7	Trash	28	55
8	Clean	24	64
8	Trash	40	49
9	Clean	21	86
9	Trash	21	78
10	Clean	23	68
10	Trash	35	48
11	Clean	25	78
11	Trash	31	58
12	Clean	22	73
12	Trash	22	68
13	Clean	17	69
13	Trash	32	64
14	Clean	15	79
14	Trash	25	56
15	Clean	17	71
15	Trash	25	64
16	Clean	17	63
16	Trash	20	47
17	Clean	18	72
17	Trash	13	50
18	Clean	16	60
18	Trash	21	54
19	Clean	21	72
19	Trash	22	57
Mean	Clean	19	67
Mean	Trash	25	55

3.4 Concluding remarks

The results of this experiment show that the presence of trash reduces the short fibre content measurement by typically 12 units and may increase the shear strength measurement by around 6 units.

4. Effect of preparation on fibre quality measurements

4.1 Introductory remarks

While the impact resistance test is conducted on a core sample of cane, the shear strength and short fibre content tests are conducted on samples of prepared cane. As a result, the first step in analysing for shear strength and short fibre content is to prepare the cane sample in SRA's shredder. This small batch hammer mill obviously does not provide identical preparation to factory shredders, just as each factory shredder prepares cane differently. This experiment was designed to determine if the preparation process has a significant impact on the fibre quality measurements of shear strength and short fibre content.

4.2 Methodology

Samples of billet cane before the shredder and samples of prepared cane after the shredder from the same rake of cane were collected. The billet cane samples were divided into two subsamples. One of the subsamples was cleaned to remove extraneous matter and the other was not.

Fibre quality measurements were made on the clean billet cane samples, the complete billet cane samples and the prepared cane samples.

4.3 Results

The collected samples are identified in Table 4.1.

Table 4.1 Samples collected for experiment 2

Block	Region	Variety	Trash content (%)
1	Isis	Q208	15.2
2	Isis	SRA1	11.3
3	Isis	Q208	9.9
4	Isis	SRA1	11.1
5	Farleigh	Q240	16.7
6	Farleigh	QC04-1411	13.8
7	Isis	Q245	17.0
8	Isis	KQ228	15.2
9	Isis	Q238	11.6
10	Isis	Q208	10.0
11	Isis	SRA1	10.4
12	Isis	SRA1	9.2
13	Isis	SRA4	12.2
14	Isis	Q208	11.4
15	Millaquin	SRA1	9.5

The shear strength and short fibre content results for each sample, prepared at SRA from cleaned billets, prepared at SRA without removing trash and factory prepared, are presented in Table 4.2. The difference in shear strength between the cleaned billets prepared at SRA and the other two samples was statistically significant at the 0.02% level. No such difference was identified between the samples prepared at SRA without removing trash and the factory prepared samples. The difference in short fibre content between the samples prepared at SRA without removing trash and the remaining two samples was statistically significant at the 0.00004% level. The difference between the cleaned samples prepared at SRA and the factory prepared samples was significant at the 7% level (generally considered not statistically significant).

The cleaned SRA samples recorded shear strength measurements typically seven units less than the factory prepared samples and short fibre content measurements typically four units less than the factory prepared samples. This latter result may be shredder dependent. Looking closer at the data, the Farleigh results (blocks 5 and 6) both show the cleaned stalks giving a higher short fibre content than the prepared cane while the Isis and Millaquin results (the other 13 blocks) show the opposite trend. There is not enough information here to be confident that all factory shredders will achieve short fibre content results higher than the cleaned SRA samples.

Table 4.2 Fibre quality results for experiment 2

Block	Preparation	Shear strength	Short fibre content (%)
1	Clean billets	20	57
1	Trashy billets	27	40
1	Prepared cane	29	58
2	Clean billets	12	64
2	Trashy billets	20	49
2	Prepared cane	12	66
3	Clean billets	24	49
3	Trashy billets	24	36
3	Prepared cane	21	55
4	Clean billets	14	68
4	Trashy billets	13	52
4	Prepared cane	15	65
5	Clean billets	15	72
5	Trashy billets	23	46
5	Prepared cane	34	62
6	Clean billets	18	88
6	Trashy billets	22	67
6	Prepared cane	27	79
7	Clean billets	20	54
7	Trashy billets	32	41
7	Prepared cane	28	65
8	Clean billets	18	62
8	Trashy billets	28	41
8	Prepared cane	25	67
9	Clean billets	14	64
9	Trashy billets	16	54
9	Prepared cane	19	70
10	Clean billets	28	58
10	Trashy billets	33	50
10	Prepared cane	26	69
11	Clean billets	19	66
11	Trashy billets	20	60
11	Prepared cane	13	75
12	Clean billets	14	68
12	Trashy billets	16	58
12	Prepared cane	13	75
13	Clean billets	15	72
13	Trashy billets	25	46
13	Prepared cane	25	75
14	Clean billets	15	59
14	Trashy billets	24	47
14	Prepared cane	27	70
15	Clean billets	12	66
15	Trashy billets	18	49
15	Prepared cane	18	70
Mean	Clean billets	15	64
Mean	Trashy billets	23	49
Mean	Prepared cane	22	68

4.4 Concluding remarks

The difference in results between the cleaned samples and the samples with trash measured in this experiment were quite consistent with those measured for experiment 1, providing increased confidence in the results.

The results suggest that the use of cleaned stalks of cane in measuring the fibre quality parameters results in an underestimate of the shear strength by about seven units. While the overall results suggest the use of cleaned stalks of cane will provide an underestimate of the short fibre content by about four units, this result may be shredder dependent.

5. Effect of new soft cane varieties on the factory

5.1 Introductory remarks

Within the scope of this project, information was collected on the processing of three cane varieties (QC04-1411, SRA1 and SRA4) that had been identified from pre-release fibre quality measurements as soft canes. The full scope of the testing program is presented in Table 5.1.

Table 5.1 Summary of soft cane processed during the project

Date	Variety	Factory	Tonnes processed
9 August 2016	SRA1	Isis	243.2
10 August 2016	SRA1	Isis	243.0
24 August 2016	QC04-1411	Farleigh	166.3
29 August 2016	SRA1	Maryborough	78.6
18 October 2016	SRA1	Isis	173.2
19 October 2016	SRA4	Isis	127.4
20 October 2016	SRA1	Millaquin	100.2

This component of the project was originally planned to include only the processing of SRA1 at Isis and the processing of QC04-1411 at Mackay Sugar. The plan was to compare the processing of rakes of these canes against the processing of major variety Q208. This plan was achieved at Isis. For the Mackay Sugar experiment, Q208 was not readily available at the desired harvest time and so Q240 was utilised in its place. Problems associated with the processing of QC04-1411 caused the Mackay Sugar program to be reduced in scope.

Opportunities arose during the project to also study the processing of SRA1 at Maryborough and Millaquin factories and the processing of SRA4 at Isis. The SRA4 trial at Isis followed the same procedure as the SRA1 trials. At Maryborough and Millaquin, no comparison rake was processed but weekly average results were provided for comparison.

Detailed reports were prepared on the August experiments at Isis and Farleigh (Kent et al. 2016a; b). This report provides the most detailed documentation on the remaining trials.

5.2 Methodology

During the processing of each test at Isis, samples of billet cane, prepared cane, bagasse from each mill, first expressed juice, juice from each mill and mixed juice were taken. Billet cane, prepared cane, #1 mill bagasse and first expressed juice samples were taken throughout the processing period. A delay of 10 minutes after the commencement of prepared cane sampling was imposed before sampling of the remaining streams commenced, to allow time for the bagasse to reach the end of the milling train and for the expressed juice from the final mill to return as imbibition at #2 mill. All sampling ceased once the sample tracker identified the end of the rake at #1 mill (except for billet cane which ceased earlier).

The approach at Millaquin was similar except that no sampling of intermediate mill bagasse or juice or mixed juice was undertaken.

A similar sampling regime was attempted at Farleigh except that, because of the longer milling train and higher cane rate, there was no period when the entire milling train was processing bagasse and imbibition of the target rake. An attempt was made to stagger the sampling times but was not particularly successful.

No sampling was undertaken at Maryborough.

In addition to the sampling program, weighbridge, NIR cane analysis data and DCS data were collected for analysis. Observations by factory staff were also collected.

5.3 SRA1 effects

5.3.1 Introductory remarks

As discussed in section 5.1, SRA1 was processed on three occasions at Isis. Results from the first two occasions were reported in detail by Kent et al. (2016a). During the 18 October 2016 trial at Isis, the SRA1 was sourced from two separate farms.

Some of the fibre quality measurements from these cane supplies are presented in Table 4.2 (blocks 2, 4, 11, 12 and 15). Since no samples were collected from Maryborough, no fibre quality results are available for that trial. Figure 5.1 presents the fibre quality results for the SRA1 trials at Isis and Millaquin. The Q208 results, against which the Isis results were compared, are also shown. Figure 5.1 contains a box that represents the fibre quality bounds defined by Brotherton et al. (1986) as *normal*. While the Q208 results sit in the middle of the box, the SRA1 results all have lower impact resistance than the lower bound of the box, identifying all of the SRA1 cane supplies as *soft*.

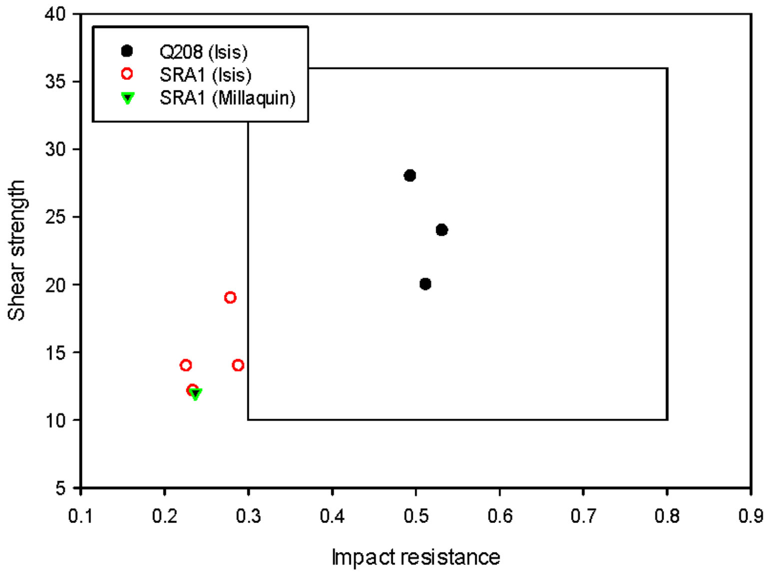

Figure 5.1 Fibre quality results for the SRA1 trials

5.3.2 Isis results

As discussed in section 5.1, the SRA1 tests at Isis were compared to similar tests processing Q208. The tests were conducted as a blocked factorial experiment, with the two cane varieties being the single factor assessed and the three blocks being the days of testing. Six tests in total were conducted. The details of the tests are provided in Table 5.2. Note that the block numbers in this section do not correspond to the block numbers listed in section 4.

While no difference in bin weight or trash content could be attributed to the varieties, the difference in cane rate of typically 60 t/h between the two varieties was statistically significant at the 2% level. The difference in yield was not statistically significant at the 5% level (it was significant at the 6% level), but the SRA1 yield exceeded the Q208 yield in each block.

Table 5.2 The test program and cane supply details for the Isis SRA1 experiment

Test	Block	Variety	Date	Bin weight (t)	Cane rate (t/h)	Trash (%)	Yield (t/h)
1	1	Q208	9 Aug 2016	5.4	426	15.2	98
2		SRA1	9 Aug 2016	6.1	500	11.3	134
3	2	Q208	10 Aug 2016	5.9	449	9.9	103
4		SRA1	10 Aug 2016	6.1	514	11.1	134
5	3	Q208	18 Oct 2016	6.4	396	10.0	70
6		SRA1	18 Oct 2016	5.8	439	9.8	83
Mean		Q208		5.9	424	11.7	90
Mean		SRA1		6.0	484	10.7	117

For each test, cane analysis by NIR and first expressed juice analysis was conducted for each rake and can fibre analysis was conducted on two independent samples collected across the entire cane supply for the test. A summary of the results from first expressed juice and can fibre analysis is shown in Table 5.3. Table 5.3 shows that the fibre content of SRA1 averaged 3.0 units lower than that of Q208, a statistically significant result at the 3% level. Although the SRA1 results consistently showed higher pol content, purity and CCS, the differences from the Q208 results were not statistically significant at the 5% level (pol and CCS significant at the 6% level and purity significant at the 12% level). It is expected that a larger experimental program would have shown statistical significance.

Table 5.3 Cane analysis results for the Isis SRA1 experiment

Test	Block	Variety	Fibre (%)	Pol (%)	Purity (%)	CCS (%)
1	1	Q208	13.02	13.67	86.27	12.58
2	1	SRA1	9.53	14.58	87.52	13.54
3	2	Q208	11.73	13.42	84.80	12.22
4	2	SRA1	9.85	14.56	87.95	13.57
5	3	Q208	14.53	16.25	87.39	15.07
6	3	SRA1	10.89	16.69	88.38	15.60
Mean		Q208	13.09	14.45	86.15	13.29
Mean		SRA1	10.09	15.28	87.95	14.24

To provide a comparison between processing Q208 and SRA1, an attempt was made to maintain constant #1 mill speed and constant added water % fibre. The achieved results are shown in Table 5.4. While the #1 mill speed was well controlled, the added water % fibre was not. The measured differences in both parameters were not statistically significant.

Table 5.4 Milling train settings for the Isis SRA1 experiment

Test	Block	Variety	#1 mill drive speed (r/min)	Added water (% fibre)	Added water temperature (°C)
1	1	Q208	871	299	61
2	1	SRA1	871	347	63
3	2	Q208	864	294	90
4	2	SRA1	857	288	93
5	3	Q208	846	293	99
6	3	SRA1	835	365	96
Mean		Q208	860	295	83
Mean		SRA1	855	334	84

One difference in settings between the first and subsequent blocks is that the first block of tests was conducted under cool maceration conditions of typically 60 °C while the second block of tests was conducted under conventional hot maceration conditions.

To provide a measure of preparation, pol in open cells analysis of the prepared cane samples was undertaken. In addition, the speed and chest pressure of the shredder turbines were recorded. The results are shown in Table 5.5. There was no evident trend in the results and no statistically significant differences.

Table 5.5 Cane preparation results for the Isis SRA1 experiment

Test	Block	Variety	Pol in open cells (%)	Speed (r/min)	Chest pressure (kPa)	
					Turbine 1	Turbine 2
1	1	Q208	88.64	5411	990	928
2	1	SRA1	89.14	5406	1021	957
3	2	Q208	91.67	5403	1009	1007
4	2	SRA1	90.08	5407	1001	1005
5	3	Q208	87.65	5413	920	914
6	3	SRA1	91.19	5418	909	894
Mean		Q208	89.32	5409	973	950
Mean		SRA1	90.14	5411	977	952

The overall milling train performance results in terms of total pol extraction and final bagasse moisture content are presented in Table 5.6. While the difference between cane varieties for neither parameter was statistically significant at the 5% level, the bagasse moisture difference was quite pronounced (significant at the 9% level) and suggests that the SRA1 moisture content was of the order of 5 units higher than the Q208 moisture content.

Table 5.6 Milling train performance for the Isis SRA1 experiment

Test	Block	Variety	Total pol extraction (%)	Final bagasse moisture content (%)
1	1	Q208	97.16	50.09
2	1	SRA1	97.17	52.73
3	2	Q208	98.04	48.20
4	2	SRA1	97.46	52.93
5	3	Q208	97.79	47.96
6	3	SRA1	96.72	56.27
Mean		Q208	97.66	48.75
Mean		SRA1	97.12	53.98

The milling train at Isis consists of five mills. The first and final mills have independent pressure feeders. All mills are driven by electric motors. The torque on the first and final mill pressure feeders and on the three intermediate mills is controlled using the feed chute flap (0% is fully open). The torque on the first and final mills is controlled using the pressure feeder to mill speed ratio. Torque is measured as a percentage of maximum current. The mean torques during each test are presented in Table 5.7. The mean values of the control parameters are shown in Table 5.8.

Table 5.7 Milling train torques for the Isis SRA1 experiment

Test	Block	Variety	Torque (%)						
			#1 PF	#1 mill	#2 mill	#3 mill	#4 mill	#5 PF	#5 mill
1	1	Q208	71	63	65	65	60	71	90
2	1	SRA1	51	59	44	58	60	61	90
3	2	Q208	75	64	65	66	61	71	90
4	2	SRA1	56	63	45	57	60	59	85
5	3	Q208	64	62	65	65	57	66	89
6	3	SRA1	43	50	46	41	30	36	41
Mean		Q208	70	63	65	66	59	69	90
Mean		SRA1	50	57	45	52	50	52	72

Table 5.8 Milling train torque control parameters for the Isis SRA1 experiment

Test	Block	Variety	#1 mill		#2 mill	#3 mill	#4 mill	#5 mill	
			Flap (%)	PF/mill ratio	Flap (%)	Flap (%)	Flap (%)	Flap (%)	PF/mill ratio
1	1	Q208	1	1.47	65	29	72	65	1.16
2	1	SRA1	0	1.47	0	1	31	58	1.28
3	2	Q208	6	1.47	62	19	71	66	1.19
4	2	SRA1	0	1.47	1	1	25	57	1.31
5	3	Q208	0	1.48	54	13	11	65	1.32
6	3	SRA1	6	1.46	1	0	10	43	1.29
Mean		Q208	4	1.47	60	20	51	66	1.22
Mean		SRA1	0	1.47	1	1	22	53	1.29

Statistically significant differences at the 5% level were identified in the #1 mill pressure feeder and #2 mill torques and the #2 mill flap position. Although not statistically significant, torque dropped consistently when processing SRA1 for #1 and #3 mills and #5 mill pressure feeder. Similarly, the #3 and #4 mill flaps consistently opened further when processing SRA1. The indications in virtually all cases are that, either the torque reduced or the control system acted to prevent the torque from reducing.

In Table 5.9, Table 5.10 and Table 5.11, the performance of each mill has been defined in terms of the performance parameters delivery nip compaction, reabsorption factor multiplier and imbibition coefficient multiplier (Kent 2015).

Table 5.9 Delivery nip compactions for the Isis SRA1 experiment

Test	Block	Variety	Delivery nip compaction (kg/m^3)				
			#1 mill	#2 mill	#3 mill	#4 mill	#5 mill
1	1	Q208	561	510	604	627	705
2	1	SRA1	496	389	536	591	669
3	2	Q208	540	498	583	626	698
4	2	SRA1	535	404	554	637	711
5	3	Q208	610	535	646	722	819
6	3	SRA1	519	436	531	596	675
Mean		Q208	570	515	611	658	741
Mean		SRA1	517	409	540	608	685

Table 5.10 Reabsorption factor multipliers for the Isis SRA1 experiment

Test	Block	Variety	Reabsorption factor multiplier				
			#1 mill	#2 mill	#3 mill	#4 mill	#5 mill
1	1	Q208	0.73	0.83	0.85	0.93	0.95
2	1	SRA1	0.79	1.01	1.01	1.07	1.02
3	2	Q208	0.76	0.83	0.86	0.92	0.90
4	2	SRA1	0.81	1.00	0.97	0.93	1.03
5	3	Q208	0.71	0.77	0.88	1.08	0.93
6	3	SRA1	0.79	1.08	1.07	1.12	1.12
Mean		Q208	0.73	0.81	0.86	0.98	0.92
Mean		SRA1	0.80	1.03	1.02	1.04	1.06

Table 5.11 Imbibition coefficient multipliers for the Isis SRA1 experiment

Test	Block	Variety	Imbibition coefficient multiplier				
			#1 mill	#2 mill	#3 mill	#4 mill	#5 mill
1	1	Q208	1.03	1.04	1.41	1.61	1.04
2	1	SRA1	1.00	0.46	1.33	1.56	1.64
3	2	Q208	1.01	1.07	1.47	1.53	1.74
4	2	SRA1	1.00	0.36	1.40	1.58	2.11
5	3	Q208	1.03	0.74	1.03	1.21	2.26
6	3	SRA1	1.01	0.09	1.25	1.34	1.80
Mean		Q208	1.02	0.95	1.31	1.45	1.68
Mean		SRA1	1.00	0.30	1.32	1.47	1.61

The results showed that the reduction in delivery nip compaction on #2 mill with SRA1 was statistically significant at the 5% level. Although the difference in delivery nip compaction for the other mills was not statistically significant at the 5% level, Table 5.9 shows that the delivery nip compaction was consistently lower during the processing of SRA1 on #1, and #3 mills but mostly followed the same trend on #4 and #5 mills. These results are consistent with the torque results and provide an indication that, if torque can be maintained, delivery nip compaction can be maintained as well.

Table 5.10 shows that the reabsorption factor multiplier for all mills was consistently higher during the processing of SRA1 (the difference for #1, #2 and #3 mills was statistically significant at the 5% level). These results provide an indication that higher bagasse moisture content can be expected on all mills when processing SRA1.

Lower imbibition coefficient multipliers were measured on #1 and #2 mill when processing SRA1. These differences were statistically significant at the 5% level. No consistent trends and no statistically significant differences were seen in the imbibition coefficient multipliers for the other mills in Table 5.11.

Table 5.12 presents the calculated power consumption of each mill (total of pressure feeder and mill drives for #1 and #5 mills). In all cases, less power was consumed during the processing of SRA1 (the difference for ##1 and #2 mills was statistically significant).

Table 5.12 Total mill power consumption for the Isis SRA1 experiment

Test	Block	Variety	Power consumption (kW)				
			#1 mill	#2 mill	#3 mill	#4 mill	#5 mill
1	1	Q208	655	421	373	350	371
2	1	SRA1	552	317	320	320	333
3	2	Q208	668	410	371	338	360
4	2	SRA1	585	336	326	313	316
5	3	Q208	600	415	362	298	336
6	3	SRA1	451	300	230	160	163
Mean		Q208	641	415	369	329	356
Mean		SRA1	529	318	292	264	271

Feed chute exit compactions (Kent 2015) were calculated to assess the effect of SRA1 on mill feeding. The results are shown in Table 5.13. While statistically significant differences at the 5% level were only identified for #2 and #5 mills, the feed chute exit compaction for all mills was lower when processing SRA1, indicating that the milling train capacity in terms of cane fibre rate is lower.

Table 5.13 Feed chute exit compactions for the Isis SRA1 experiment

Test	Block	Variety	Feed chute exit compaction (kg/m^3)				
			#1 mill	#2 mill	#3 mill	#4 mill	#5 mill
1	1	Q208	46	54	62	61	78
2	1	SRA1	39	40	55	57	67
3	2	Q208	44	53	60	61	75
4	2	SRA1	42	42	57	61	69
5	3	Q208	49	56	66	69	79
6	3	SRA1	41	45	54	57	66
Mean		Q208	46	54	63	64	77
Mean		SRA1	41	43	55	58	68

The SRA1 prepared cane and bagasse was able to be processed successfully through the shredder and all mills with no modification to operating parameters. There were, however, several issues that may have impeded sustained operation.

Probably the most significant operational issue was the frothing that occurred in the juice pit that receives #1 and #2 mill juice, prior to being pumped to the juice screen. When processing under normal conditions, the juice level in the pit is typically about 1 m below the grate. During both periods of just under 30 minutes that the SRA1 was being processed in August, froth built up and ultimately overflowed the pit and juice drains (Figure 5.2). It was expected that, if SRA1 had been processed for much longer, a factory stop would have resulted. Frothing during the processing of SRA1 in October was much less pronounced.

Figure 5.2 Froth overflowing the juice pit between #1 and #2 mills

During the sampling of juice from each of the mills, the samplers noted that there was considerably more cush in the juice from SRA1 than is normally the case. To quantify the amount, fibre analysis of the juice samples from each mill was undertaken in association with the first two blocks. The results are shown in Table 5.14. None of the differences were statistically significant, but the #1, #2 and #3 mill juices showed higher fibre contents in the SRA1 samples of between 30% and 60%.

Table 5.14 Fibre content in juice streams for the Isis SRA1 experiment

Test	Block	Variety	Fibre content (%)					
			#1 mill	#2 mill	#3 mill	#4 mill	#5 mill	Mixed juice
1	1	Q208	0.67	0.89	0.85	1.56	1.54	0.19
2	1	SRA1	0.85	1.42	1.24	1.17	1.18	0.22
3	2	Q208	0.53	0.94	1.02	1.66	1.82	0.16
4	2	SRA1	0.87	1.61	1.17	1.98	2.92	0.18
Mean		Q208	0.60	0.92	0.94	1.61	1.68	0.18
Mean		SRA1	0.86	1.51	1.21	1.58	2.05	0.20

It is considered likely that the higher fibre content in the #1 and #2 mill juices is responsible for the observed poorer performance of the rotary juice screen. It was noted that the juice screen was performing poorly when processing the Q208 variety, with a considerable amount of juice pouring out the end of the juice screen with the cush. When processing the SRA1, however, the juice quantity pouring out the end of the juice screen was considerably larger (Figure 5.3). The juice screen performance and the consequent large amount of wet cush feeding into #2 mill is considered to be the most likely reason for the pronounced reduction in torque, delivery nip compaction and feed chute exit compaction identified above.

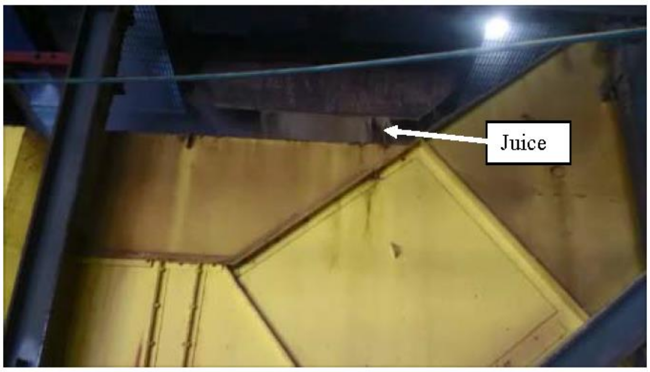

Figure 5.3 Juice flowing out the end of the juice screen

5.3.3 Maryborough results

A continuous supply of 78.6 t of SRA1 was processed through Maryborough factory. No special arrangements were made for the processing of this cane. The results were compared against the average results for that crushing week. The details of the test are provided in Table 5.15. Similar to the Isis tests, a higher cane rate than average was achieved when processing SRA1.

Table 5.15 The test program and cane supply details for the Maryborough trial

Test	Variety	Date	Cane rate (t/h)	Yield (t/ha)
1	SRA1	29 Aug 2016	329	102
2	Mixed	Full week	305	-

As shown in Table 5.15, the yield of the SRA1 was 102 t/ha. While the average yield for the previous week could not easily be determined, the average yield of the remainder of the block into which the SRA1 was planted (consisting of Q208) was the same as that of the SRA1.

NIR cane analysis was utilised. A summary of the results is shown in Table 5.16. Table 5.16 shows that the fibre content of SRA1 was two units less than the weekly average. The pol, purity and CCS of the SRA1 was similar to the weekly average.

Table 5.16 Cane analysis results for the Maryborough trial

Test	Variety	Fibre (%)	Pol (%)	Purity (%)	CCS (%)
1	SRA1	11.8	14.9	87.1	13.8
2	Mixed	13.9	14.9	87.5	13.9

Table 5.17 shows that the #1 mill turbine speed when processing SRA1 was 2% lower than the weekly average, while the added water rate % fibre was 6% higher.

Table 5.17 Milling train settings for the Maryborough trial

Test	Variety	#1 mill drive speed (r/min)	Added water (% fibre)
1	SRA1	2800	275
2	Mixed	2869	258

The milling train at Maryborough consists of five mills. The first mill has an independent pressure feeder drive. All mills are driven by turbines. The torque on the first mill pressure feeder and on the other four mills is controlled using the feed chute flap (0% is fully open). The torque on the first mill is controlled using the pressure feeder to mill speed ratio. Torque on the pressure feeder drive is measured as a hydraulic pressure. Torque on the mill drives is measured as a chest pressure.

The mean torques during each test are presented in Table 5.18. The mean values of the control parameters are shown in Table 5.19. Like the Isis results shown in Table 5.7, consistently lower torques were measured on all drives when processing SRA1. The pressure feeder to mill ratio on #1 mill was higher when processing SRA1, as expected in an attempt to maintain the torque set point. Little change was observed in the flap positions.

Table 5.18 Milling train torques for the Maryborough trial

Test	Variety	Hydraulic pressure (bar)	Chest pressure (kPa)				
		#1 PF	#1 mill	#2 mill	#3 mill	#4 mill	#5 mill
1	SRA1	136	718	718	487	394	427
2	Mixed	141	746	803	507	427	493

Table 5.19 Milling train torque control parameters for the Maryborough trial

Test	Variety	#1 mill		#2 mill	#3 mill	#4 mill	#5 mill
		Flap (%)	PF/mill ratio	Flap (%)	Flap (%)	Flap (%)	Flap (%)
1	SRA1	15	1.61	20	30	0	0
2	Mixed	16	1.56	21	31	1	2

The SRA1 was processed through the Maryborough extraction station without incident. The only note made by shift personnel was the reduction in chest pressure on the mill drives.

5.3.4 Millaquin results

A continuous supply of 100.2 t of SRA1 was processed through Millaquin factory. As discussed in section 5.2, samples were collected to enable the performance of #1 mill and the entire milling train to be measured. The results were compared against the average results for the previous crushing week. The details of the test are provided in Table 5.20. Similar to the Isis and Maryborough tests, a higher cane rate than average was achieved when processing SRA1.

Table 5.20 The test program and cane supply details for the Millaquin trial

Test	Variety	Date	Cane rate (t/h)	Yield (t/ha)
1	SRA1	20 Oct 2016	401	143
2	Mixed	Full week	339	-

As shown in Table 5.20, the yield of the SRA1 was 143 t/ha. While the average yield for the previous week could not easily be determined, the average yield of the whole block into which the SRA1 was planted was 119 t/ha. The average yield of the spring fallow plant cane (like the SRA1) for the major varieties in the district ranged from 96 t/ha for Q208 to 117 t/ha for Q238.

For each test, cane analysis by NIR and first expressed juice and can fibre analysis were conducted on the SRA1 rake. A summary of the results from first expressed juice and can fibre analysis for SRA1 and NIR analysis for the weekly average is shown in Table 5.21. Table 5.21 shows that the fibre content of SRA1 was four units less than the weekly average. The pol, purity and CCS of the SRA1 were below the weekly average.

Table 5.21 Cane analysis results for the Millaquin trial

Test	Variety	Fibre (%)	Pol (%)	Purity (%)	CCS (%)
1	SRA1	10.1	15.3	84.5	13.9
2	Mixed	14.1	16.1	87.8	15.0

Table 5.22 shows that the #1 mill turbine speed when processing SRA1 was 7% higher than the weekly average, while the added water rate % fibre was 31% higher.

Table 5.22 Milling train settings for the Millaquin trial

Test	Variety	#1 mill drive speed (r/min)	Added water (% fibre)
1	SRA1	3010	239
2	Mixed	2815	183

To provide a measure of preparation, the chest pressure of the shredder turbine was recorded. The results are shown in Table 5.23 The chest pressure was not substantially different when processing SRA1 than the weekly average.

Table 5.23 Cane preparation results for the Millaquin trial

Test	Variety	Chest pressure (kPa)
1	SRA1	1043
2	Mixed	1006

The overall milling train performance results in terms of total pol extraction and final bagasse moisture content are presented in Table 5.24. The results show no change in extraction but support the moisture content results obtained at Isis where a much higher bagasse moisture content results from SRA1 bagasse. In this case, SRA1 bagasse moisture content was measured to be over eight units higher than the average moisture content of the Millaquin bagasse supply.

Table 5.24 Milling train performance for the Millaquin trial

Test	Variety	Total pol extraction (%)	Final bagasse moisture content (%)
1	SRA1	97.3	54.3
2	Mixed	97.3	45.8

The milling train at Millaquin consists of five mills. The final mill is a BHEM with a pressure feeder. The first mill is driven by a turbine while the other mills are driven by electric motors. The torque on the first mill is controlled using the feed chute flap (0% is fully open). The torque on the final mill is controlled using the pressure feeder to mill speed ratio. Torque on the intermediate mills is not controlled (top roll lift provides load control). Torque on the first mill is measured as chest pressure. Torque on intermediate mills is measured as motor current. Torque on the final mill is measured as a percentage of maximum motor current. The mean torques during each test are presented in Table 5.25. The mean values of the control parameters are shown in Table 5.26.

Table 5.25 Milling train torques for the Millaquin trial

Test	Variety	Chest pressure (kPa)	Motor current (A)			Torque (%)	
		#1 mill	#2 mill	#3 mill	#4 mill	#5 PF	#5 mill
1	SRA1	896	462	476	358	21	51
2	Mixed	1021	647	553	525	27	78

Table 5.26 Milling train torque control parameters for the Millaquin trial

Test	Variety	#1 mill		#2 mill	#3 mill	#4 mill	#5 mill
		Flap (%)	Lift (mm)	Lift (mm)	Lift (mm)	Lift (mm)	PF/mill ratio
1	SRA1	0	6	3	3	1	1.30
2	Mixed	1	14	14	7	4	1.18

As for the Isis and Maryborough trials, the processing of SRA1 was characterised by lower torques on all drives. Roll lift on the top rolls of the first four mills also reduced, a further indication of lower torque. Similarly, the pressure feeder to mill ratio on the final mill increased when processing SRA1 in an unsuccessful attempt to maintain the torque set point.

The SRA1 was processed through the Millaquin extraction station without incident. It is believed, however, that sustained boiler operation for much longer than the 15 minute processing time would have been unlikely. The boiler steam pressure dropped rapidly at the time that the SRA1 bagasse was expected to reach the boiler. Figure 5.4 shows the reduction in steam pressure that occurred when processing SRA1. As a reference, the #5 mill torque is also shown. The boiler pressure reduction is offset due to the time delay between bagasse at the final mill and the boiler, including feeding into and out of the bagasse bin. Millaquin's experience is that when the boiler pressure drops much below 1400 kPa, the shredder is likely to trip on underspeed and there is increased risk of a factory blackout.

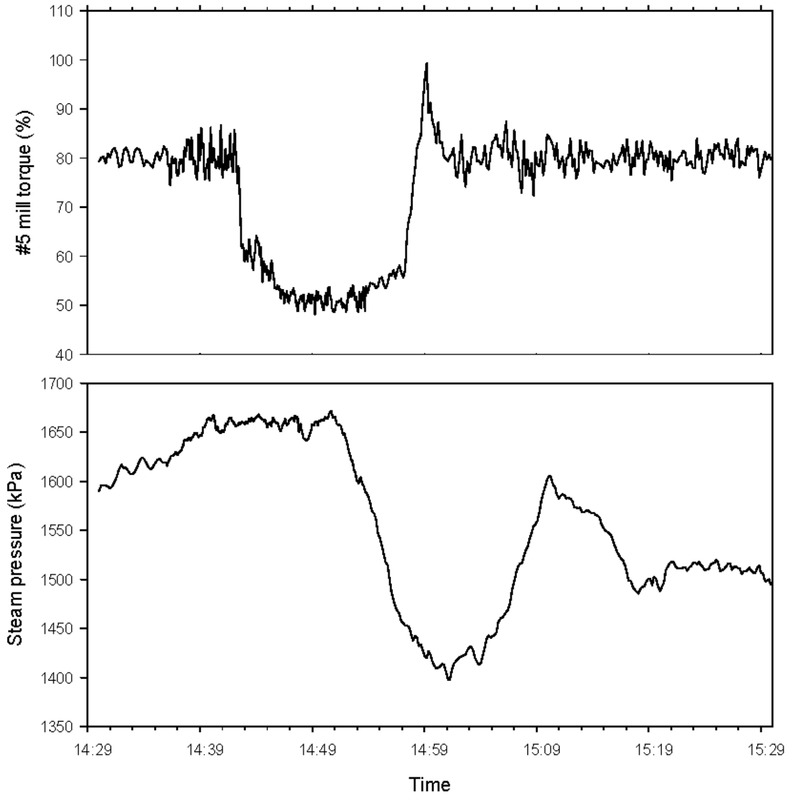

Figure 5.4 Boiler steam pressure effect when processing SRA1 at Millaquin

5.3.5 Concluding remarks

The processing of SRA1 at Isis, Maryborough and Millaquin has provided considerable data to evaluate SRA1.

The low fibre content of SRA1 is of particular concern. It is highly unlikely that any factory could afford to improve the efficiency of their factory sufficiently to operate with a cane supply with a fibre content of around 10%. Isis have estimated a capital cost of approximately $20 million to modify their factory to achieve a fuel balance with an average cane fibre content of 10% (Kent et al. 2016a). There is an added concern if the average cane fibre content varies considerably over the season, since a highly energy efficient factory able to operate with an average cane fibre content of 10% would have a considerable bagasse storage and possible disposal problem if the average fibre content was significantly higher than 10% for an extended period.

The results at both Isis and Millaquin were consistent in determining that SRA1 bagasse will have considerably higher moisture content than bagasse currently being produced from other varieties. The higher moisture content reduces the efficiency of steam generation, accentuating the problem of low cane fibre content. Not all boilers are capable of sustained operation at higher bagasse moisture content. The Millaquin experience showed that boiler steam pressure can drop quickly when high moisture content bagasse is processed, with the likelihood of disruption to operations.

There were minimal problems processing SRA1 through the extraction stations. The most notable concern was the low torque achieved on all mills. The low torque exacerbated the high bagasse moisture content problem. It is likely that mill settings and mill control parameters could be modified so that the torque set point could be achieved when processing SRA1 but it would be challenging to then control torque when processing the other varieties that are so different in milling characteristics.

5.4 SRA4 effects

5.4.1 Introductory remarks

As discussed in section 5.1, SRA4 was processed on one occasion at Isis. Some of the fibre quality measurements from this cane supply is presented as block 13 in Table 4.2. Figure 5.5 presents the fibre quality results for the SRA4 trial. The Q208 results, against which the Isis results were compared, are also shown. Unlike the SRA1 results, the SRA4 results lie within the box. The SRA4 and Q208 samples had similar shear strength but the SRA4 had lower impact resistance.

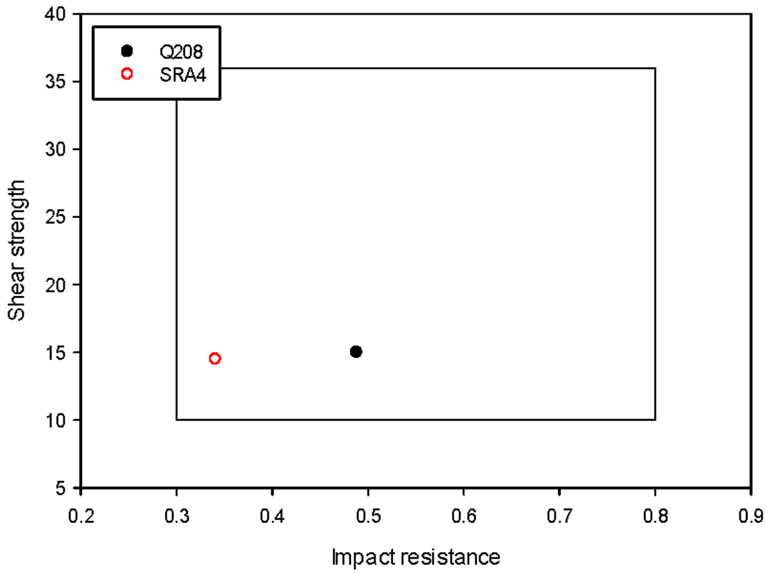

Figure 5.5 Fibre quality results for the SRA4 trial

5.4.2 Isis results

As discussed in section 5.2, the SRA4 test at Isis was compared to a similar test processing Q208. The details of the tests are provided in Table 5.27. It is difficult to draw conclusions from a single comparison.

Table 5.27 The test program and cane supply details for the Isis SRA4 tests

Test	Variety	Date	Bin weight (t)	Cane rate (t/h)	Trash (%)	Yield (t/h)
1	Q208	19 Oct 2016	6.6	402	11.4	75
2	SRA4	19 Oct 2016	5.3	382	12.2	100

For each test, cane analysis by NIR and first expressed juice analysis was conducted for each rake and can fibre analysis was conducted on two independent samples collected across the entire cane supply for the test. A summary of the results from first expressed juice and can fibre analysis is shown in Table 5.28. Table 5.28 shows that the cane quality of the SRA4 cane supply was similar to that of Q208. Unlike SRA1, the fibre content of SRA4 is similar to the other varieties.

Table 5.28 Cane analysis results for the Isis SRA4 tests

Test	Variety	Fibre (%)	Pol (%)	Purity (%)	CCS (%)
1	Q208	14.67	16.14	87.11	14.94
2	SRA4	13.96	16.86	87.91	15.70

To provide a comparison between processing Q208 and SRA1, an attempt was made to maintain constant #1 mill speed and constant added water % fibre. The achieved results are shown in Table 5.29. While the #1 mill speed was well controlled, the added water % fibre was not.

Table 5.29 Milling train settings for the Isis SRA4 tests

Test	Variety	#1 mill drive speed (r/min)	Added water (% fibre)	Added water temperature (°C)
1	Q208	846	280	96
2	SRA4	846	340	97

To provide a measure of preparation, pol in open cells analysis of the prepared cane samples was undertaken. In addition, the speed and chest pressure of the shredder turbines were recorded. The results are shown in Table 5.30. The results show that cane preparation during both tests was similar.

Table 5.30 Cane preparation results for the Isis SRA4 tests

Test	Variety	Pol in open cells (%)	Speed (r/min)	Chest pressure (kPa)	
				Turbine 1	Turbine 2
1	Q208	88.04	5410	939	937
2	SRA4	87.57	5411	919	917

The overall milling train performance results in terms of total pol extraction and final bagasse moisture content are presented in Table 5.31. Similar to SRA1, the SRA4 produced bagasse moisture content four units higher than Q208.

Table 5.31 Milling train performance for the Isis SRA4 tests

Test	Variety	Total pol extraction (%)	Final bagasse moisture content (%)
1	Q208	97.38	48.19
2	SRA4	96.63	52.65

The mean torques during each test are presented in Table 5.32. The mean values of the control parameters are shown in Table 5.33. The results show reduced torque in the last three mills and wider feed chute settings in the last four mills when processing SRA4. These results are consistent with soft cane behaviour but not to the extent exhibited by SRA1 (Table 5.7).

Table 5.32 Milling train torques for the Isis SRA4 tests

Test	Variety	Torque (%)						
		#1 PF	#1 mill	#2 mill	#3 mill	#4 mill	#5 PF	#5 mill
1	Q208	74	61	65	66	59	67	88
2	SRA4	67	61	67	57	46	46	68

Table 5.33 Milling train torque control parameters for the Isis SRA4 tests

Test	Variety	#1 mill		#2 mill	#3 mill	#4 mill	#5 mill	
		Flap (%)	PF/mill ratio	Flap (%)	Flap (%)	Flap (%)	Flap (%)	PF/mill ratio
1	Q208	3	1.47	47	56	12	66	1.33
2	SRA4	1	1.48	26	1	10	57	1.35

The SRA4 was processed through the Isis extraction station with one stop caused by poor feeding at #2 mill. While it is likely the soft nature of the SRA4 caused the stop, there was another stop caused by a similar issue later in the shift. It is believed that the problem could be resolved by improving the performance of the rotary juice screen.

5.4.3 Concluding remarks

The trial at Isis has provided a first look at the processing characteristics of SRA4. While the SRA4 cane supply was classified within the normal range according to the fibre quality tests, it did exhibit some soft cane behaviour, causing lower torques on most mills and higher bagasse moisture content. The behaviour was not as extreme as the SRA1 behaviour. The results suggest that the impact resistance parameter, in particular, is providing a reasonable indication of the comparative soft cane effects.

5.5 QC04-1411 effects

5.5.1 Introductory remarks

As discussed in section 5.1, QC04-1411 was processed on one occasion at Farleigh (although some smaller rakes were processed as discussed in section 5.5.2). Some of the fibre quality measurements from this cane supply is presented as block 6 in Table 4.2. Figure 5.6 presents the fibre quality results for the QC04-1411 trial. The Q240 results, against which the Farleigh results were compared, are also shown. Like the SRA4 results, the QC04-1411 results lie within the box. The QC04-1411 had slightly lower impact resistance and slightly higher shear strength than the Q240. It is also noted from Table 4.2 that the short fibre contents of the clean billets and prepared cane QC04-1411 samples were the highest of the 45 results shown in the table.

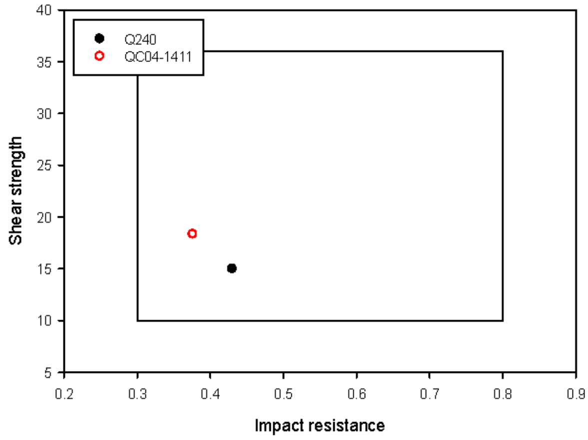

Figure 5.6 Fibre quality results for the QC04-1411 trial

5.5.2 Farleigh results

As discussed in section 5.1, the QC04-1411 tests at Farleigh were compared to similar tests processing Q240. Results from these tests were reported in detail by Kent et al. (2016b). The details of the cane supply for each test are provided in Table 5.34.

Table 5.34 The test program and cane supply details for the Farleigh QC04-1411 tests

Test	Variety	Date	Bin weight (t)	Cane rate (t/h)	Trash (%)	Yield (t/h)
1	Q240	24 Aug 2016	5.6	552	16.0	97
2	QC04-1411	24 Aug 2016	5.9	474	14.1	135

For each test, cane analysis by NIR and first expressed juice analysis was conducted for each rake and can fibre analysis was conducted on two independent samples collected across the entire cane supply for the test. A summary of the results from first expressed juice and can fibre analysis is shown in Table 5.35. Table 5.35 shows that the fibre content of QC04-1411 was similar to that of Q240 but that the pol, purity and CCS were lower.

Table 5.35 **Cane analysis results for the Farleigh QC04-1411 tests**

Test	Variety	Fibre (%)	Pol (%)	Purity (%)	CCS (%)
1	Q240	13.99	14.58	87.83	13.57
2	QC04-1411	13.86	14.13	85.32	12.92

To provide the comparison between processing Q240 and QC04-1411, an attempt was made to maintain constant #1 mill speed and constant added water % fibre. The achieved results are shown in Table 5.36. A large stop during test 2 and the operational concerns discussed later in this section resulted in a much lower #1 mill speed being adopted following the stop. The two stages of test 2 (cane tipped before and after the stop) are shown in Table 5.36. Note that period 2 ended after the cane tipped before the stop reached #1 mill and so the last of the period 2 cane was processed after the stop. As a result, the period 2 averages include some time at the lower mill speed after the stop.

Table 5.36 **Milling train settings for the Farleigh QC04-1411 tests**

Test	Period	Variety	#1 mill drive speed (r/min)	Cane rate (t/h)	Added water (% fibre)	Added water temperature (°C)
1	1	Q240	730	552	172	80
2	2	QC04-1411	734	525	215	81
	3	QC04-1411	614	442	118	57

To provide a measure of preparation, the speed and chest pressure of the shredder turbine was recorded. The results are shown in Table 5.37. The chest pressure was considerably lower during the processing of QC04-1411 but much of the reduction was associated with the low speed operation following the large stop. In the period before the stop, the mean chest pressure was 769 kPa, higher than the 749 kPa shown in Table 5.37 for period 2 which includes some of the period after the stop, but much less than the period 1 mean chest pressure of 820 kPa.

Inspection of the shredder and mill chest pressure results suggested that the cane did slip in the cane carrier causing imperfect feed to the cane supply belts feeding the shredder and mills for all three test periods.

Table 5.37 **Cane preparation results for the Farleigh QC04-1411 tests**

Test	Period	Variety	Shredder speed (r/min)	Shredder chest pressure (kPa)
1	1	Q240	6092	820
2	2	QC04-1411	6081	749
	3	QC04-1411	6063	607

Because of the large stop in the middle of test 2, that split the already short processing time into smaller segments, steady state operation was not achieved and it is unlikely that meaningful analysis of the overall milling train performance can be made. There was some confidence in the analysis of the first mill results which are presented in Table 5.38. The extraction result for Q240 seems improbably high so the result is somewhat in doubt. The bagasse sample was not refrigerated before analysis so it is likely that degradation of the bagasse occurred, destroying some sucrose.

Table 5.38 Milling train performance for the Farleigh QC04-1411 tests

Test	Variety	#1 mill extraction (%)	#1 mill bagasse moisture content (%)
1	Q240	88.2[1]	50.2
2	QC04-1411	82.4	52.5

The milling train at Farleigh consists of six mills, but the #2 mill was bypassed during the tests, making it effectively a five-mill train. The first and final mills have independent pressure feeders. All mills are driven by steam turbines and both independently driven pressure feeders are driven by hydraulic motors. The hydraulic pressure on the first and final mill pressure feeders and chest pressure on the three intermediate mills is controlled using the feed chute flap (100% is fully open). The chest pressure on the first and final mills is controlled using the pressure feeder to mill speed ratio.

Because of the short duration of the tests and stops during test 2, the period in which there was confidence which sample was being processed through each mill was quite short. The parameter that gave the best indication of which sample was being processed was chest pressure. There was a noticeable reduction in chest pressure during test 2, where steady state conditions were not achieved until the very end of the rake. Three periods were identified in the DCS data:

1. Test 1
2. Test 2 until the large stop
3. Test 3 when steady state conditions were more or less achieved.

For periods 2 and 3, the periods were between 0 and 6 minutes in duration with the longest duration at #1 mill and the shortest duration at #6 mill. The mean chest pressures during each period are presented in Table 5.39. Chest pressure was clearly lower during the processing of QC04-1411. For the two periods processing QC04-1411, the latter period at minimum #1 mill speed (600 r/min turbine speed) had lower chest pressures throughout the milling train than the former period.

[1] Probably due to degradation of bagasse sample.

Table 5.39 Milling train torques for the Farleigh QC04-1411 tests

Test	Period	Variety	Chest pressure (kPa)				
			#1 mill	#3 mill	#4 mill	#5 mill	#6 mill
1	1	Q240	850	776	881	922	673
2	2	QC04-1411	604	591	603	599	628
	3	QC04-1411	467	516	500	574	435

Difficulties were experienced feeding #1 mill while processing QC04-1411. These difficulties manifested as the #1 mill feed chute filling up, causing the prepared cane elevator to slow down. At lower speed, the prepared cane elevator motor tripped due to high current (it was thought that the prepared cane was denser than usual, giving a higher mass for a similar volume). Attempting to restart the elevator initiated a trip of the 3 MW alternator, which in turn initiated a series of additional failures that resulted in a 336 minute stop.

Upon restarting at minimum #1 mill speed, a large pool of juice was observed flowing over the top of the top pressure feeder roll. Although this roll had juice grooves, the grooves were worn to about half their usual depth. The juice groove scrapers were fitted to the nose plates which would have helped to reduce the size of the juice drainage space under the roll. It is considered likely that the pressures associated with this build-up of juice above the top pressure feeder roll were responsible for the poor feeding of the #1 mill.

Some frothing of the juice above the top pressure feeder roll of #1 mill was observed. This frothing may well be a similar phenomenon to the frothing that was observed in the juice pit between #1 and #2 mills at Isis when processing SRA1 (section 5.3.2). There were no pumping problems resulting from this froth in these short tests.

The second stop during the processing of QC04-1411 was caused by the juice tray under #5 mill filling up and overflowing. The cause of the incident was cush in the juice blocking the drains. It is possible that this blockage was related to the previous stop. It is also possible that the cause may have been insufficient emergency maceration water being applied. Farleigh have had many issues in 2016 with choked juice pipes and pumps on the milling train due to inadequacies with emergency maceration. Cush levels in maceration juice from QC04-1411 were not able to be measured except at #1 mill, which was at a normal level.

In addition to the issues experienced during test 2, the bagasse appeared to have short spikey fibres that knitted together and caused feeding and combustion issues in the boilers. Due to the clumping effect, the bagasse fell to the grate rather than burning in suspension. While no reliable bagasse moisture content measurements were made, it was not evident that the bagasse moisture content was high, so the mechanism responsible for this behaviour is unknown. It was noted that the shredder chest pressure was slightly lower during the period 2 processing of QC04-1411 but it is not obvious if that lower chest pressure is related to lower preparation that may have contributed to the problem. Lower chest pressure could have been related to the lower rate being processed, to the softer cane, or both.

The two rotary juice screens at Farleigh seemed to cope with the cush flows during the single occasion they were observed. It is noted that the observation was made under the low #1 mill speed condition in period 3.

5.5.3 Additional Farleigh results

A second block of QC04-1411 was harvested and planned to be processed as part of the factory test on the same day as the rake reported in section 5.5.2. After the first rake went through with associated factory stoppages, the precautionary decision was made to protect the factory operations and split the 28 bin rake into smaller rakes of five and four bins each. These smaller rakes were not subject to any special analysis, but were routinely analysed through the weighbridge and NIR systems. Table 5.40 presents the collected results. The four bin rakes were too small for payment analysis.

Table 5.40 Small rake analysis – variety QC04-1411

Rake	Weight	NIR	
		Fibre (%)	Ash (%)
423	29.13	NA	NA
429	29.14	13.38	1.03
434	28.31	13.58	1.65
465	27.53	13.62	1.70
483	21.35	NA	NA
498	20.96	NA	NA

Instructions were passed to the shift that, while processing QC04-1411, the operators were to reduce #1 mill speed to 600 r/min to ensure that the cane could be processed through the milling train without stopping. These instructions achieved their purpose of ensuring no further lost time.

For each rake, the milling train experienced temporary depressions in each mill chest pressure below the normal range of variations (Figure 5.7, Figure 5.8 and Figure 5.9). The extent of the depression was not as severe as a gap passing through the milling train. The effect was comparable to the effect of a large drop in milling train speed.

There were no recorded effects on the boiler feed speeds or boilers.

With the benefit of hindsight, the drop in #1 mill speed to its minimum value was probably greater than necessary and there may not be a requirement to reduce the mill speed at all for small rakes such as the four and five bin rakes processed here.

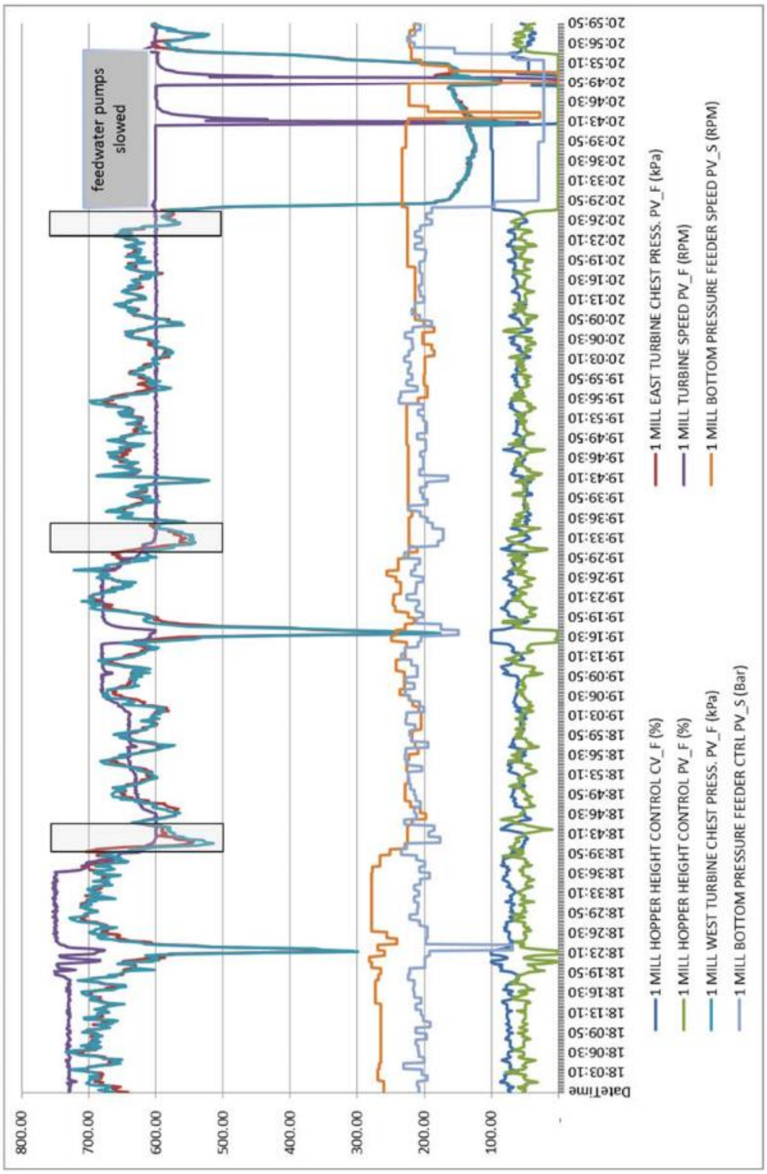

Figure 5.7 **#1 mill trend data when processing the first three small rakes**

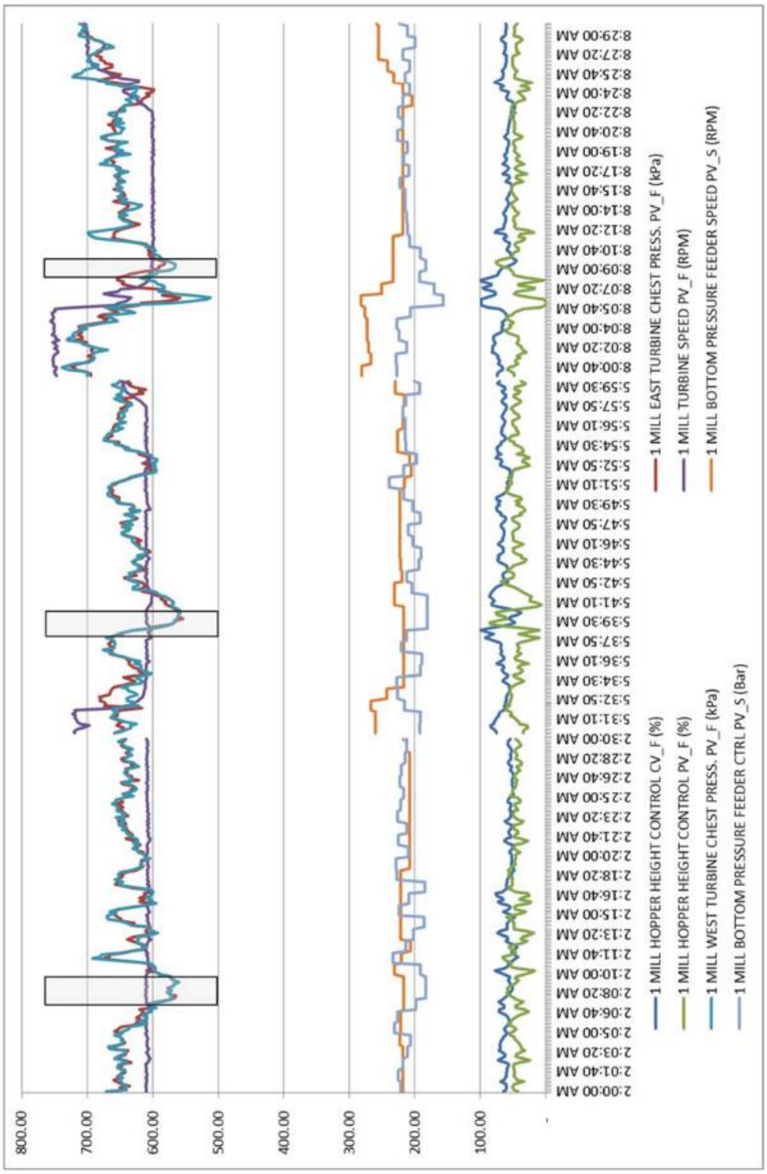

Figure 5.8 #1 mill trend data when processing the last three small rakes

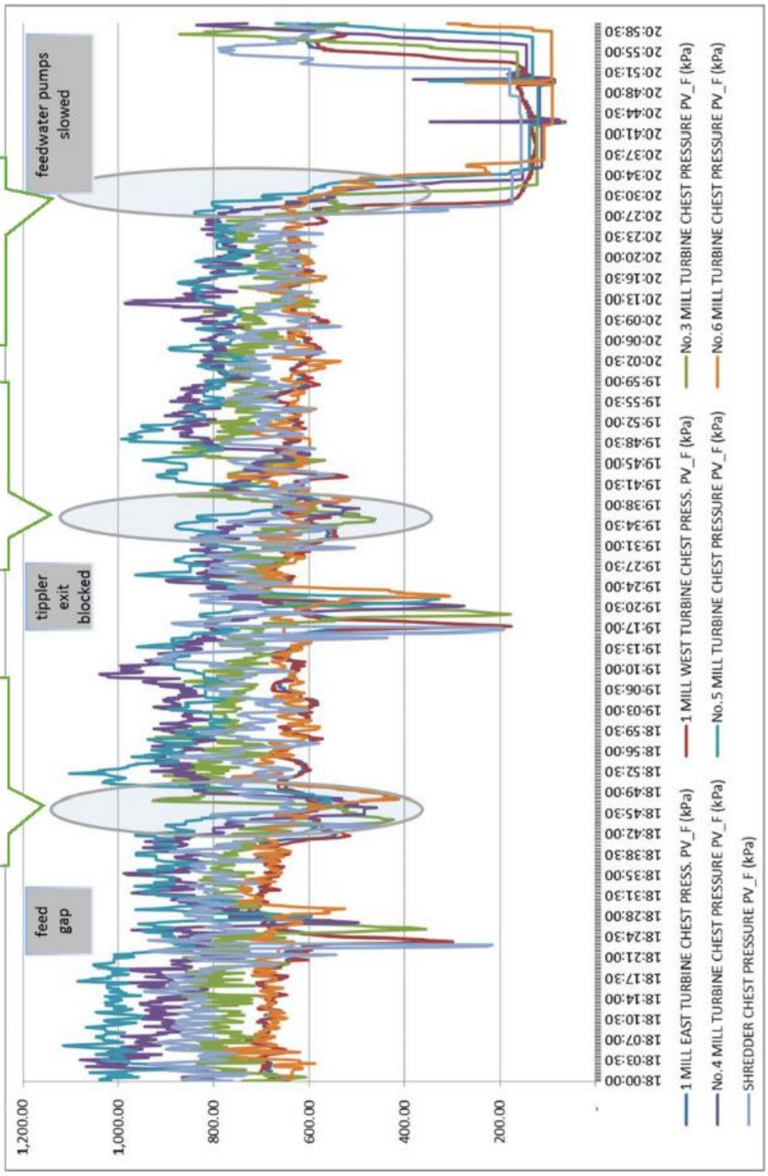

Figure 5.9 Chest pressure trend data when processing the first three small rakes

5.5.4 *Concluding remarks*

The trial at Farleigh has provided a first look at the processing characteristics of QC04-1411. While the QC04-1411 cane supply was classified within the normal range according to the fibre quality tests (like SRA4), it did have a high short fibre content and it did exhibit some soft cane behaviour, causing lower torques on most mills. As for SRA4, the behaviour was not as extreme as the SRA1 behaviour.

To process QC04-1411 through Farleigh without disruption, some changes are required. Most notably, juice drainage from the pressure feeder rolls needs to be improved. Maintaining juice grooves in good condition and utilising external juice groove scrapers that do not impede the flow of juice under the top pressure feeder roll may well be sufficient to address this problem.

While far from ideal, water sprays can be located in strategic locations to prevent the build-up of cush along juice drainage paths. Ideally these water flows should be measured and treated as part of the overall water addition to the milling train.

The cause of the knitting of the bagasse fibres that caused combustion problems is not obvious and needs further study if QC04-1411 is to become a regular component of the cane supply.

6. Conclusions

Trash has been shown to affect the fibre quality measurements, reducing the short fibre content by typically 12 units and most likely increasing the shear strength measurement by about 6 units. Comparing the cleaned stalks of cane usually used for fibre quality measurements to factory-prepared cane, it seems likely that shear strength is underestimated by about 7 units and short fibre content is underestimated by about 4 units (most likely shredder dependent).

This project has provided an opportunity to examine the processing characteristics of three cane varieties that were identified during the variety release process as being soft canes. SRA1 had a low fibre content of typically 10% and an impact resistance lower than the minimum criterion considered for normal canes. The other two varieties, SRA4 and QC04-1411 had relatively normal fibre contents of about 14%. While their impact resistance was low, it was still within the normal range. Shear strength is the other fibre quality parameter with a defined normal range. The shear strength of all three varieties were within the normal range, with SRA1 having the lowest values. The final fibre quality parameter, short fibre content does not have a defined normal range. It is noted, however, that of the 35 results shown in Table 4.2, the two highest values were for QC04-1411 and the next two highest values were for SRA1 (Q240 was the fifth highest with a shear strength lower than QC04-1411).

The low fibre content of SRA1 is considered the biggest problem regarding the processing of the three varieties. With current major varieties having fibre contents of typically 12% to 15%, SRA1 is particularly different and will cause fuel balance issues. The fact it is different to the other varieties means that it is difficult to configure a factory to consistently achieve a fuel balance, with the likelihood that there will be periods when fuel will need to be purchased and other periods when fuel will need to be disposed of. The fact it is low means that a factory will need to be reconfigured at high capital cost to become much more energy efficient.

All three varieties exhibited the soft cane characteristic of generating low mill torques. While there is some hope that mills could be re-set to achieve their torque set point when processing soft cane, the wide variation in variety characteristics between the soft canes and the other varieties in the cane supply means that a much wider control range is required to be able to achieve their torque set points across the different varieties.

Associated with the inability to maintain torque set points, bagasse moisture contents from the soft canes were found to be higher than normal. This result was particularly pronounced with SRA1 where Isis and Millaquin recorded increases in final bagasse moisture content of between three and eight units. The available information from the processing of SRA4 and QC04-1411 also showed higher bagasse moisture content but the results are less conclusive, due to the limited nature of the trials of those varieties. Not all factory boilers can withstand significant increases in bagasse moisture content. The Millaquin experience processing SRA1 resulted in a rapid drop in steam pressure that only avoided a boiler shutdown because SRA1 was only processed for 15 minutes. Sustained factory operation when feeding boilers with high moisture bagasse is problematic.

There was a potential concern with the processing of QC04-1411 where the bagasse caused feeding and combustion issues. It is unknown if this problem is characteristic of the variety or simply a one-off incident.

Other problems such as poor mill feeding and frothing when processing the soft cane varieties were experienced but are believed to be resolvable with relatively small capital expenditure.

While the yield of some of the soft cane supplies was measured to be quite high, those yield benefits need to be weighed up against the additional factory processing costs that will be incurred in terms of capital upgrades and stops.

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