FINAL REPORT 2013/022

Exploiting introgression for the development of productive and regionally adapted varieties for NSW

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1 ABSTRACT

This project aimed to explore sugar cane variety improvement opportunities available through introgression in relation to 2-year cropping, temperate cane growing conditions of NSW and frosting. It provided an opportunity to review the NSW selection program that has been operating since early 2000.

Traditionally, the top 25 performing clones from the NSW 1-year program would enter the NSW 2-year program for testing as a 2-year cane. In this project, selected introgression clones from project BSS344 plus varieties imported from the USA were directly included in the NSW 2-year selection program without first being tested in the 1-year program. These clones plus current commercial varieties were also included in frost observation plots for assessment for frost tolerance.

Saccharum spontaneum introgression clones were the most successful group to fast-track directly into the NSW 2-year program. One *S. spontaneum* introgression clone (SRAW18) was released to NSW growers in 2019/20 and it is highly likely that another *S. spontaneum* introgression clone will be released in 2020/21. *Erianthus arundinaceus* introgression clones and varieties from the USA generally did not perform well.

For the three years (2015-2017) the frost observation plots were monitored there were relatively few nights with temperatures below freezing (0°C), the coldest being -0.9°C on 9th August 2017. The light frost events resulted in no/little differentiation between clones and negatively impacted the selection of NSW clones for release and use as parents for the crossing program.

Based on results from this project, the NSW selection program was modified and will place further emphasis on introgression material for the 2-year program.

2 EXECUTIVE SUMMARY

The sugar industry in northern NSW includes three sugar mills: Condong, Broadwater and Harwood. Sugarcane is mostly grown on a 2-year cropping cycle in the Broadwater and Harwood mill areas, while most of the cane in the Condong mill area is grown on a 1-year cropping cycle. The average tonnes of cane crushed over all three mills for the last ten years is 1.68 million tonnes which is some way below existing crushing capacity of 2.4 million tonnes of cane per year. The industry needs to both improve production and expand the area under cane. Available land for expansion is further from the coast and more frost prone. To make this successful the industry requires productive frost tolerant varieties, in particular for Broadwater and Harwood mill areas.

This project aimed to explore sugar cane variety improvement opportunities available through introgression in relation to 2-year cropping, temperate cane growing conditions of NSW and frosting. The research consisted of three main activities: assessment of clones/varieties fast-tracked directly into the NSW 2-year selection program; assess fast-tracked clones and NSW commercial varieties in frost screening trials; determine the chromosome number and species composition of NSW 1- and 2-year commercial varieties using cytogenetic techniques.

Traditionally, the top 25 performing clones from the NSW 1-year program would enter the NSW 2-year program for testing as a 2-year cane. In this project, select introgression clones from project BSS344 plus varieties imported from the USA were directly included in the NSW 2-year selection program without first being tested in the 1-year program. This was achieved by increasing the number of clones in the 2014 and 2015 NSW core 2-year Agronomic Assessment Trials. Replicated Frost Observation Plots were established in 2014 and 2015 at a location known for frosting.

The research has identified *S. spontaneum* introgression clones as the most successful group to fast-track directly into the NSW 2-year program. One *S. spontaneum* clone (SRAW18) was released to NSW growers in 2019/20 and it is highly likely that another *S. spontaneum* clone will be released in 2020/21. *Erianthus arundinaceus* introgression clones and varieties from the USA generally did not perform well.

For the three years (2015-2017) the frost observation plots were monitored there were relatively few nights with temperatures below freezing (0°C), the coldest being -0.9°C on 9th August 2017. The light frost events resulted in no/little differentiation between clones, and this negatively impacted the selection of NSW clones for release and parents for the crossing program.

Chromosome counts in 36 NSW 1- and 2-year varieties indicates a slightly higher percentage S. *spontaneum* and recombinant chromosomes for varieties harvested on a 2-year cycle (35.4%) than varieties harvested annually (33.2%). The 2-year clones/varieties on average have a slightly lower number of *S. officinarum* chromosomes, slightly higher number of *S. spontaneum* chromosomes and slightly lower 2n chromosome number than the averages for the 1-year varieties. These results suggest that earlier generation *S. spontaneum* back-crosses could have good yield performance in NSW 2-year yield trials.

Fast-tracked clones will be released at least two years earlier than non-fast-tracked clones. It is expected that growers who adopt these new varieties will show improved production and result in a more sustainable NSW industry with flow on effects to the community. It is probably still another three to four years off to understand the extent and likely adoption of these varieties by NSW growers and the impacts on the industry.

Results from this project strongly indicate that fast-tracking introgression clones, particularly *S. spontaneum* back-crosses, into the NSW 2-year program is advantageous. The fast-tracking strategy has been implemented in the 2-year NSW selection program with the planting of 47 introgression clones from the SRA introgression program into propagation plots in NSW in 2019 for inclusion into future 2-year Agronomic Assessment Trials (AATs). The modified NSW selection program does not require additional resources to complete, speeds up the selection process and should lead to the release of further 2-year varieties to sustain/increase NSW production.

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1. BACKGROUND

1.1. Sugarcane industry in NSW

The sugar industry in northern NSW includes three sugar mills, Condong, Broadwater and Harwood. Sugarcane is mostly grown on a 2-year cropping cycle in the Broadwater and Harwood mill areas, while most of the cane in the Condong mill area is grown on a 1-year cropping cycle. The NSW industry is subject to similar challenges facing the Queensland industry; a relatively weak sugar price, droughts/flooding and alternative crops/urban expansion diminishing the total amount of cane planted and grown in the region. The NSW region is also the region most impacted by frost, particularly in the more inland country. The average cane crushed over all three mills for the last ten years is 1.68 million tonnes, varying from below a million tonnes in 2012 to close to 2.2 million tonnes in 2015. This is some way below existing crushing capacity of 2.4 million ton of cane per year.

The industry needs to expand the area under cane and available land for expansion is further from the coast and more frost prone. To make this successful the industry requires productive frost tolerant varieties. Current varieties vary in frost tolerance (Munro and Beattie 2010). Improved frost tolerant varieties will result in a steady and reliable cane production from these new farms in expansion areas.

1.2. Sugarcane breeding and selection in/for NSW

The current NSW plant breeding and selection program was implemented in the early 2000s (Chapman *et al.* 2002; Cox 1995). The basic strategy has remained unchanged although there have been some modifications to improve efficiencies and/or genetic gain. The strategy amalgamated the NSW and southern Queensland selection programs with the NSW program culminating early stage trial work totally and the southern early stage program supplying clones for both the southern and NSW late stage trials.

When the strategy was initially implemented, NSW late stage trials were planned to cater for both the 1-year and 2-year variety needs of the NSW industry. Trials in the same series were alternatively harvested as either 1-year plant crop and then 2-year first ratoon or 2-year plant crop and then 1-year first ratoon. This pattern of trial harvest proved practically difficult, particularly when it came to data analysis and a few years after implementing the strategy this was changed to separate trials for 1- and 2-year cropping. The 2-year cropping trials are smaller than the 1-year cropping trials, only including top clones from the NSW 1-year program (i.e. those clones to be repeated in 1-year trials). Two-year cropping trials are planted in the Broadwater (x2) and Harwood (x2) mill areas, with 1-year cropping trials planted in Condong (x1) and alternating between Broadwater/Harwood (x1).

With the formation of SRA in 2013, NSW industry representatives got together with the NSW plant breeding team to discuss the program. A big concern of the NSW industry was that the program did not place enough emphasis on selecting 2-year cropping varieties. Constraints, gaps and opportunities in the selection program were identified where additional research would be beneficial to objectively modify the program. This research would be conducted as an integrated component of the NSW breeding program with specific RFU funding. This funded project (2013/022) would build on previous research (BSS344 (Croft 2016) and GGP041 (Munro and Beattie 2010)) and would determine the efficacy of fast-tracking selected introgression and imported clones, directly into the 2-year program without first testing in the 1-year program, as well as frost screening of clones and parents. As results of this research have become available, both the NSW 1- and 2-year cropping programs have been modified to be more aligned and focused with industry needs.

2. PROJECT OBJECTIVES

This project aims to explore sugar cane variety improvement opportunities available through introgression in relation to:

- Two-year cropping
- Temperate cane growing conditions of NSW
- Frosting

Core project activities are to fast-track clones from project BSS344 “New germplasm to develop more productive varieties with enhanced resistance to nematodes, Pachymetra root rot and smut” into the NSW 2-year selection program. This will be achieved by increasing the number of clones in NSW 2-year final stage trials from 25 to 35. An additional project activity will be to plant these clones plus clones from the international variety exchange program into observation plots in a frost prone area and assess clones for frost tolerance. This will provide essential information on frost tolerance that will supplement the routine assessment for cane yield (TCH) and sugar content (CCS). This information will be used to select varieties for release as well as parents.

3. OUTPUTS, OUTCOMES AND IMPLICATIONS

3.1. Outputs

The major outputs of this project are:

- New productive 2-year cropping cycle varieties released to NSW growers. Clones fast-tracked into the 2-year program will be available to growers earlier than would otherwise be possible. One variety (SRAW18) was released in 2019 from set 1 and it is highly likely that a further variety(s) will be released in 2020 from set 2.
- Frost tolerant information (ratings) on NSW sugarcane clones in late stage 2-year trials and NSW parents for crossing.
- A faster increase in the frequency of cold-tolerant genes in the NSW parent population.
- Knowledge to aid a review of the breeding and selection strategy (incorporating introgression) for NSW.

The target adoption audience for new 2-year releases are growers in the Broadwater and Harwood mill areas. Release decisions are made by the Regional Variety Committee (RVC) on considering the trial performance data and other information (disease ratings, milling characteristics, etc.). Distribution and marketing the new releases are mostly done by NSW Agricultural Services staff either through distribution plots (whole stalk) or through tissue culture plantlets. It is still a few years off to understand the extent of adoption of these varieties by NSW growers.

Knowledge and information from this project have been used by the plant breeding team and NSW industry representatives in the review of the NSW program and modifications to the program have been made.

3.2. Outcomes and Implications

The main outcome will be the increase in production from varieties with good adaptation to NSW growing conditions. Variety SRAW18 was released in 2019/20 as a 2-year variety to NSW growers and it is highly likely that clone KQB07-24815 will be released in 2020/21. Clone KQB09-20047 is also a contender for release in 2020/21, but initial smut screening results indicate susceptibility which may result in the clone being discarded. KQB07-34350 (SRAW18), KQB09-20047 and KQB07-24815 are all *S. spontaneum* introgression clones fast-tracked into the NSW 2-year plant breeding selection program as part of this project. Fast-tracked clones will be released to the NSW industry at least two years earlier than non-fast-tracked clones first going through the 1-year program. SRAW18 would probably not have been released at all as it performed poorly in the 1-year program and was discarded. These three clones/releases have a relative Economic Genetic Value (rEGV) above 10 (average of standards = 10) with good TCH and average to above-average CCS when grown on a 2-year cropping cycle. It is expected that growers who adopt these new varieties will show improved production and result in a more sustainable NSW industry with flow on effects to the community. It is probably still another three to four years off to understand the extent and likely adoption of these varieties by NSW growers and the impacts on the industry.

Results from this project strongly indicate that fast-tracking introgression clones, particularly *S. spontaneum* back-crosses, into the NSW 2-year program is advantageous. The fast-tracking strategy has been implemented in the 2-year NSW selection program with the planting of 47 introgression clones from the SRA introgression program into propagation plots in NSW in 2019 for fast-tracking into future 2-year AATs. The modified NSW selection program does not require additional resources to complete, speeds up the selection process and should lead to the release of further 2-year varieties to sustain/increase NSW production.

4. INDUSTRY COMMUNICATION AND ENGAGEMENT

4.1. Industry engagement during course of project

NSW industry representatives have been involved in the project right from conception, particularly representatives on the NSW RVC that meet a minimum of once peryear and decide on clones progressing through the program and for release. The RVC have also been an integral part of the group involved in the NSW program review. The SRA Adoption Group Regional Coordinator – NSW & Rocky Point, as well as the Sunshine Sugar Ag services staff are all members of the NSW RVC. The project is managed by Rick Beattie, Agricultural Manager for Sunshine Sugar.

Discussion of the introgression project and varieties arising from this program have been presented to NSW farmers at shed meetings and variety field day walks.

Variety Data Files (VDFs) are reports (fact sheets) collating all the latest information/data regarding a specific clone and are generated from the SRA SPIDNet database. Variety Data Files of the top clones in 1- and 2-year late stage trials are distributed to members of the NSW RVC and are mostly the communication format of key data/messages from the selection program.

With the current COVID-19 situation, no project meetings are planned before the project ends in June 2020, or thereafter. This includes the annual April RVC meeting that has been cancelled and is taking an online consultation format.

4.2. Industry communication messages

- Results from this project strongly indicate that fast-tracking introgression clones, particularly *S. spontaneum* back-crosses, into the NSW 2-year program is advantageous.
- A modified NSW selection program that does not require additional resources to complete, speeds up the selection process and should lead to the release of further 2-year varieties has been implemented.
- SRAW18 was released as a 2-year cropping variety to NSW growers in 2019/20. It is a high tonnes cane, lower CCS variety with good disease resistance.

5. METHODOLOGY

5.1. Overall plan

The project research plan for the period 2013-2020 is summarised below:

- Propagate clones from project BSS344 for inclusion into the NSW 2-year cropping cycle selection program, bypassing the NSW 1-year selection program (fast-track).
- Increase the size of the NSW 2-year cropping final stage trials from 25 to 35 to include selected clones from BSS344 and other sources.
- Plant these clones plus clones from the international variety exchange program into observation plots in a frost prone area and assess clones for cold-tolerance.
- Characterize the introgression clones incorporated from BSS344, plus select NSW commercial varieties using Genomic In Situ Hybridization (GISH) to determine the number and source of chromosomes.

5.2. Year-by-Year plan

2013 - Select clones from BSS344 and other sources. Establish propagation plot of these clones for NSW 2-year late stage trials (trials also known as Agronomic Assessment Trials (AATs)). Establish propagation plot of 60 clones for Frost Observation Plot (FOP).

2014 - Plant introgression clones, together with routine clones, into four 2-year core plant breeding AATs (#1). Plant 50 clones in FOP (#1). Establish new propagation plots for the next series of AATs and FOP.

2015 - Plant introgression clones, together with routine clones, into four 2-year core plant breeding AATs (#2). Plant 50 clones in FOP (#2). Assess frost tolerance of clones/varieties in FOP (#1).

2016 – Sample, harvest and weigh plant crop AATs (#1). Assess frost tolerance of clones/varieties in FOPs (#1 and #2).

2017 – Sample, harvest and weigh plant crop AATs (#2). Assess frost tolerance of clones/varieties in FOP (#2). Accelerate promising clones from AATs (#1).

2018 – Sample, harvest and weigh 1st ratoon AATs (#1). Accelerate promising clones from AATs (#2). Maximum propagate clones from AATs (#1).

2019 – Sample, harvest and weigh 1st ratoon AATs (#2). Maximum propagate clones from AATs (#2). Release variety(s) to growers from AATs (#1).

2020 - Release variety(s) to growers from AATs (#2).

5.3. Experimental design and measurements

The experimental design used for AATs was a Randomized Complete Block (RCB) design with two replications and ~40 treatments. Four trials were planted for each series, two in Broadwater mill area and two in Harwood mill area. Treatment plot size was four rows by 10 metres each. Included in the ~40 treatments were 4-6 commercial varieties as standards.

The FOP experimental design was also an RCB with two replications and ~ 50 treatments (100 plots in total). Trial planted at a single location know for frosting. Treatment plot size was one row by 10 metres long.

A six stalk sample was taken from each AAT treatment plot (middle two rows) at harvest and processed through a roller mill to express the juice for determining brix and pol in a mobile juice laboratory. The two middle rows of each plot were then harvested and weighed using a commercial harvester and the SRA weighing unit.

Individual clone fibre values are not determined for NSW trials. Clones in NSW 2-year trials are assigned an industry fibre value based on the average of the mill area (BWR or HWD), harvest year, harvest month, crop cycle (2-year) and crop class (plant or first ratoon). This means that all clones within a trial will have the same fibre percentage, but each trial may have a different fibre value.

The raw data collected at the plant crop and first ratoon crop harvests were uploaded into the SRA SPIDNet database and checked for outliers and possible errors before analysis. A combined analysis including all four AATs in a series/set and both crops (P and 1R) was undertaken. The analysed data is also saved on the SRA SPIDNet database.

The SRA plant breeding program utilizes a selection index (relative Economic Genetic Value (rEGV)) to select clones for promotion in the selection program and for release (Wei *et al.* 2008). The rEGV is a single value which combines the traits: TCH, CCS, fibre% and disease resistance, with each of these traits weighted according to their economic value for maximising industry profitability. Trait economic weights are region specific and each region has a unique rEGV index. A rEGV of 10 is assigned to the mean of the standards for a given crop and trial and clones with a rEGV greater than 10 are superior to the average of the standards, and visa-versa.

Frost observation plots were commercially harvested at 1- or 2- years depending growth and frosting; no samples were taken for processing and plots were not weighed. A progressive system for scoring frost damage in the FOPs was based on:

- Scoring leaf damage/burn for light frosts with no stalk damage.
- Slicing tops of stalks to determine if the growing point was damaged/dead. Could follow up with inspection/scoring of side-shooting.
- Slicing upper portion of the stalk to determine if top buds damaged/dead. Could follow up with inspection/scoring of side-shooting.
- Slicing whole stalk to determine damage to buds down the stalk. Could follow up with inspection/scoring of side-shooting.
- Score ratooning if above ground killed from severe frost.

The progressive frost scoring system was never put into practice because of mild (no frost) years.

6. RESULTS AND DISCUSSION

6.1. Yield results from four 2-year AATs (Set 1)

Additional introgression and exchange clones fast-tracked directly into the 2014 NSW 2-year AATs as part of this project are listed in Table 1. These include three *E. arundinaceus* and seven *S. spontaneum* back-crosses, plus six clones imported from Houma, Lousiana, USA. The three *E. arundinaceus* back-cross three (BC3) clones all have QBYC06-30376 as the male parent. The clones from Houma were requested in 2010 as part of the SRA international variety exchange program. This exchange between Australia and USA was an exchange of commercial varieties, SRA selecting USA commercial varieties showing some cold tolerance. After two years in quarantine these clones were propagated in NSW for inclusion in these trials.

Table 1 List of introgression and exchange clones included in the 2014 AATs (set 1)

Clone	Female Parent	Male Parent	Type
Ho06-537	HoCP92-624	HOCP96-540	USA commercial
Ho07-612	HoCP01-558	TucCP77-42	USA commercial
Ho07-613	HoCP00-905	HOCP96-540	USA commercial
Ho08-706	HoCP02-625	HoCP02-642	USA commercial
Ho08-717	HoCP00-960	LCP85-384	USA commercial
HoCP04-838	HoCP85-845	LCP85-384	USA commercial
KQ08-1134	Q208	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-1201	QN80-3425	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-2664	Q208	QBYC06-30376	BC3 (*E.arundinaceus*)
KQB07-24524	Q171	QBYN04-10357	BC1 (*S.spontaneum*)
KQB07-33647	QN80-3425	QBYN04-26272	BC2 (*S.spontaneum*)
KQB07-34148	QC83-625	QBYC05-20720	BC2 (*S.spontaneum*)
KQB07-34350 (SRAW18)	Q208	QBYN04-26272	BC2 (*S.spontaneum*)
KQB09-20290	Q208	QBYC04-10865	BC1 (*S.spontaneum*)
KQB09-20328	KQ228	QBYN04-10472	BC1 (*S.spontaneum*)
KQB09-20485	KQ228	QBYC04-10577	BC1 (*S.spontaneum*)

The four NSW 2-year AATs planted in 2014 and sampled/harvested in 2016 as plant crop and again in 2018 as 1st ratoon crop are listed in Table 2. The two Harwood trials were harvested earlier in the season (August) while the two Broadwater trials later in the season (October/November). Few issues were experienced with harvesting the trials. The last AAT to be planted in this series has two clones less than the other three trials, missing Ho08-717 and KQB07-34350 (SRAW18).

Table 2 List of 2-year AATs (set 1) planted in 2014 with plant and first ratoon harvest dates

Mill area	Farm	Trial code	Introgression clones	USA clones	Standards	Total clones	Date planted	Plant crop harvest date	First ratoon harvest date
Broadwater	Mill farm, Broadwater	BWR14-41	9	5	6	40	07-Nov-14	03-Nov-16	23-Nov-18
Broadwater	Steve Boland, Sheehans Lane	BWR14-42	10	6	6	42	29-Oct-14	28-Oct-16	22-Nov-18
Harwood	Andrew Fischer, Chatsworth Island	HWD14-41	10	6	6	42	31-Oct-14	19-Aug-16	23-Aug-18
Harwood	Bob Ensbey, Lawrence	HWD14-42	10	6	6	42	05-Nov-14	17-Aug-16	13-Aug-18

The mean predicted TCH and CCS over all trials and crops for all clones in the NSW 2014 AATs (set 1) are presented in Figure 1 and Figure 2, respectively. Introgression clone KQB09-20290 is the top performer for TCH, as it was in the individual plant and first ratoon crops. All 10 introgression clones have cane TCH greater than the average of the trial (yellow bar), with *S. spontaneum* back-crosses (solid orange bars) having higher TCH than *E. arundinaceus* back-crosses (striped orange bars). The six clones imported from the Louisiana program are mostly amongst the poorer performers for TCH.

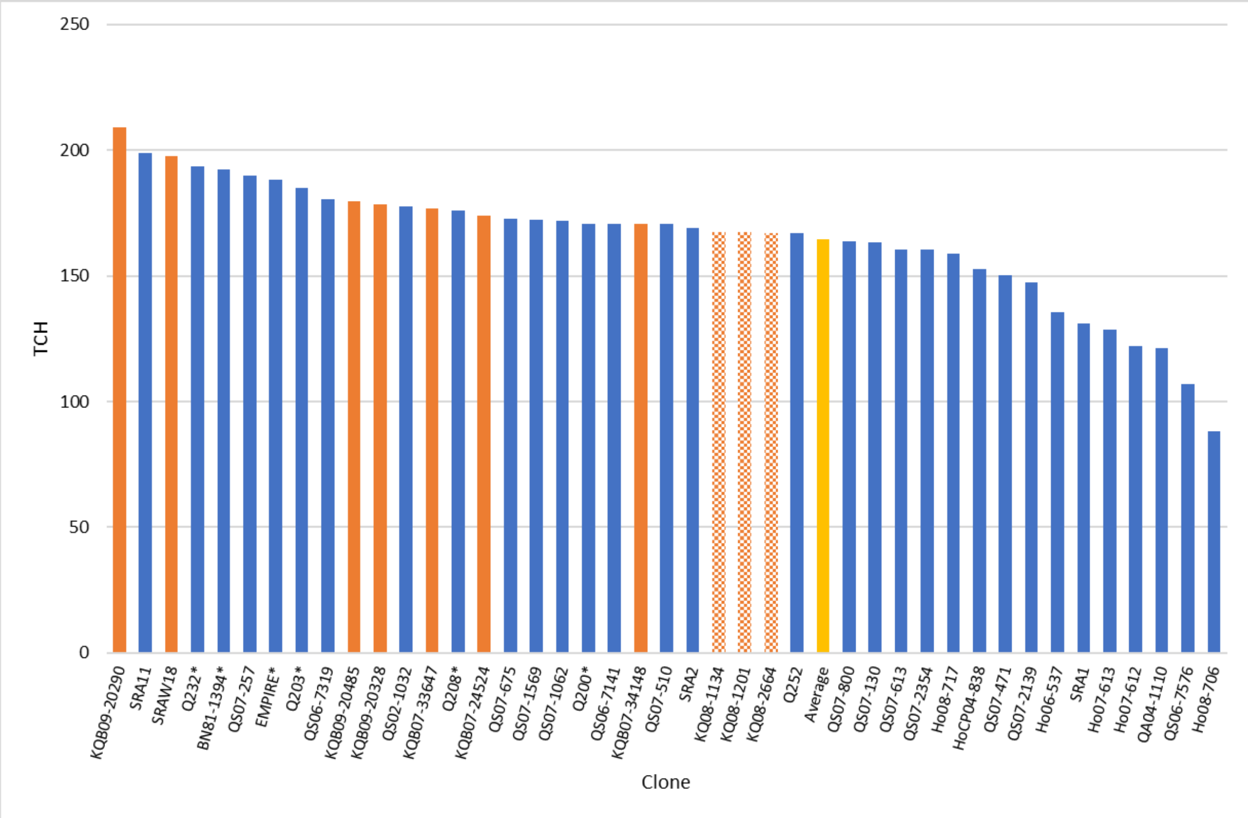

Figure 1 Mean predicted cane yield (TCH) for clones in the NSW 2014 AATs

For CCS, the reverse was observed to TCH with nine of the introgression clones having CCS values less than the trial average. Erianthus clone KQ08-2664 had the highest CCS of the introgression clones in the plant crop, first ratoon and ranked fourth over both harvests combined (Figure 2). The Louisiana clones were mostly poor for CCS and were scattered among the introgression clones below the trial average, except Ho08-706 which was just above average.

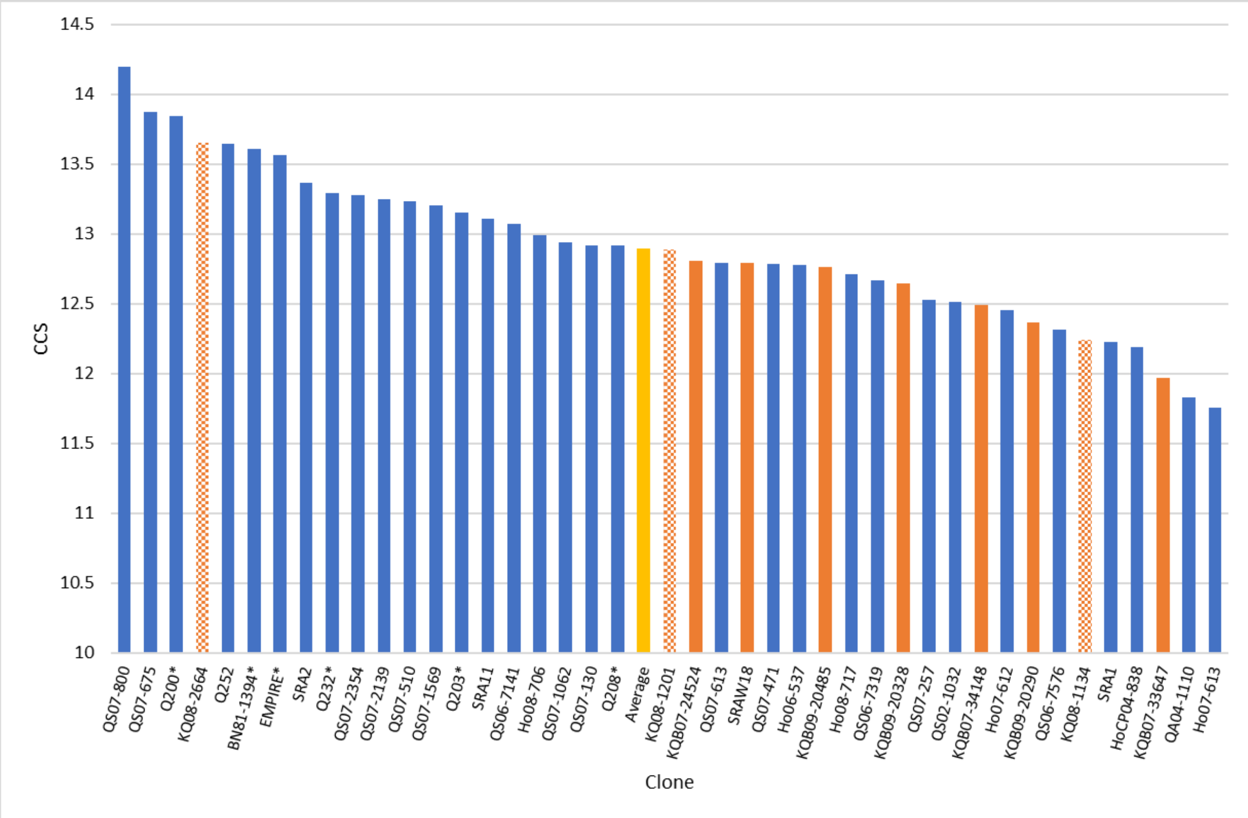

Figure 2 Mean predicted sugar content (CCS) for clones in the NSW 2014 AATs

Combining the TCH and CCS to give tonnes sugar per hectare (TSH); the mean TSH over all trials and crops for all clones are shown in Figure 3. Based on overall TSH, SRA11, KQB09-20290 and KQB07-34350 are the only three clones competing with the top performing standards. The two top *S. spontaneum* back-crosses have Q208 as the female parent. Clone QS02-1032, flagged as a good performing clone on the plant crop data, performed relatively poorly in the first ratoon crop and overall has moved down to an average performer. Interesting is the difference in overall rank position of SRA11 and SRA1, full sibling clones with the same parentage, with SRA11 doing well as a 1- and 2-year cane, but SRA1 only doing well as a 1-year cane. Also interesting is the good performance of stalwart variety BN81-1394, released in NSW in 1993.

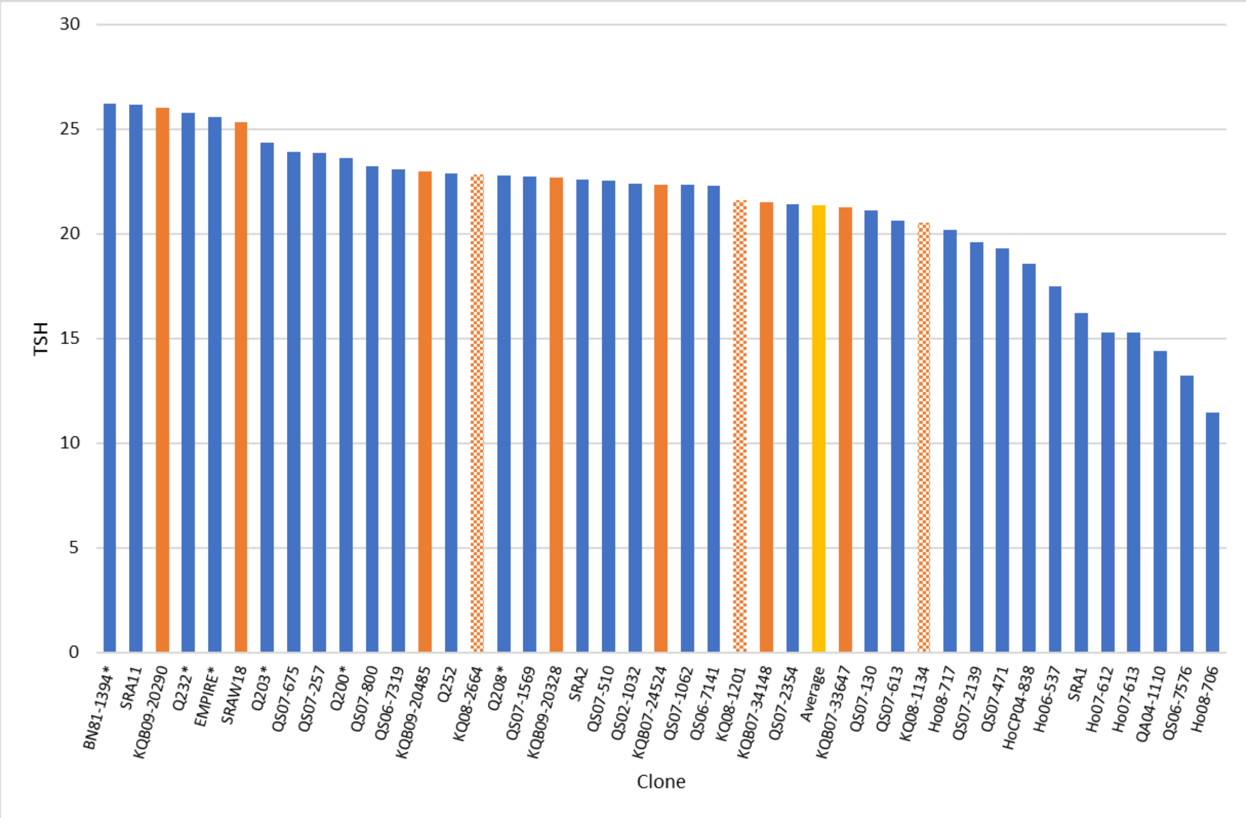

Figure 3 Mean tonnes sugar per hectare (TSH) for clones in the NSW 2014 AATs

Considering the rEGV, the SRA plant breeding selection index value, the top six clones in each trial plus overall are shown in Table 3. The top variety (SRA11) overall has come through the southern/NSW 1-year program, where it also performed very well. SRA11 was released in the southern region and as a 1-year variety in NSW in 2018. Overall ranks five and six are encouraging as these are introgression clones fast-tracked into the 2-year program. At the NSW RVC meeting held in April 2019, KQB07-34350 was selected, together with SRA11, to be released in NSW growers as 2-year canes. KQB07-34350 was given the commercial variety name SRAW18 according to convention with the breeding program where the clone was selected first (SRA) and the breeding program that made the cross second (W)(Wilmar). KQB07-34350 has slightly lower TCH than KQB09-20290, but a higher CCS. The Variety Data File (VDF) for SRAW18 and KQB09-20290 are included in Appendix 2 and the pedigree of these two clones are shown in Appendix 5.

KQB07-34350 and KQB09-20290 were included into the NSW 1-year program trials (FATs) in 2015 and 2014, respectively. Based on their performance in the 1-year trials, these two clones would not have been promoted routinely to be included in the 2-year program. The approach of fast-tracking select clones directly into the 2-year program has successfully identified a variety for 2-year commercial release and shortened the route to release by at least two years.

Table 3 Top six clones/varieties for rEGV in each of the four 2014 AATs and overall

Ranking	BWR14-41	BWR14-42	HWD14-41	HWD14-42	Overall AATs
1	BN81-1394* 10.50	Q232* 10.72	SRA11 10.66	EMPIRE* 10.32	SRA11 10.29
2	KQB09-20290 10.43	BN81-1394* 10.23	SRAW18 10.48	SRA11 10.23	Q232* 10.28
3	SRA11 10.40	QS07-675 10.19	KQB09-20290 10.37	Q203* 10.23	BN81-1394* 10.24
4	EMPIRE* 10.27	Q252 10.10	BN81-1394* 10.35	Q232* 10.12	EMPIRE* 10.18
5	QS07-800 10.14	Q200* 10.07	EMPIRE* 10.22	QS07-675 10.09	SRAW18 10.11
6	Q200* 10.13	QS07-800 10.07	Q232* 10.18	SRAW18 9.94	KQB09-20290 10.11

* Standard

6.2. Yield results from four 2-year AATs (Set 2)

Additional introgression clones fast-tracked directly into the 2015 NSW 2-year AATs (set 2) as part of this project are listed in Table 4. These include ten *E. arundinaceus* and four *S. spontaneum* back-cross clones. The *E. arundinaceus* clones are all back-cross three (BC3) compared to the *S. spontaneum* clones that are from earlier generation back-crosses (BC1 and BC2). The *E. arundinaceus* clones have either QN80-3425 or Q208 as the female parent and 5/10 have QBYC06-30376 as the male parent.

Table 4 List of introgression clones included in the 2015 AATs (set 2)

Clone	Female Parent	Male Parent	Type
KQ08-1046	QN80-3425	QBYC06-30138	BC3 (*E.arundinaceus*)
KQ08-1053	QN80-3425	QBYC06-30138	BC3 (*E.arundinaceus*)
KQ08-1076	Q208	QBYC06-30296	BC3 (*E.arundinaceus*)
KQ08-1144	Q208	QBYC06-30280	BC3 (*E.arundinaceus*)
KQ08-1231	QN80-3425	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-1306	QN80-3425	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-1329	Q208	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-1348	QN80-3425	QBYC06-30415	BC3 (*E.arundinaceus*)
KQ08-2408	Q208	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-2838	Q208	QBYC06-30376	BC3 (*E.arundinaceus*)
KQB07-23864	KQ228	MQB89-12554	BC2 (*S.spontaneum*)
KQB07-23990	Q208	MQB89-12212	BC2 (*S.spontaneum*)
KQB07-24815	QA89-3305	QBYC05-10199	BC1 (*S.spontaneum*)
KQB09-20047	KQ228	QBYC04-10577	BC1 (*S.spontaneum*)

Table 5 shows the detail of the four AATs planted during 2015 and harvested as 2-year plant crop in 2017 and 2-year first ratoon crop in 2019. Trial BWR15-42 was not sampled/harvested at first ratoon due to an uncontrolled fire very early in the 2019 season. Few issues were experienced with harvesting the trials.

Table 5 List of 2-year AATs (set 2) planted in 2015 with plant and first ratoon harvest dates

Mill area	Farm	Trial code	Introgression clones	USA clones	Standards	Total clones	Date planted	Plant crop harvest date	First ratoon harvest date
Broadwater	Phil Whitby, Wardell	BWR15-41	14	0	10	49	30-Oct-15	05-Aug-17	04-Sep-19
Broadwater	Keith Robinson, Kilgin Rd	BWR15-42	14	0	10	49	26-Oct-15	28-Aug-17	Not harvested
Harwood	Harwood Mill Farm, Harwood	HWD15-41	14	0	10	54	13-Oct-15	21-Aug-17	21-Aug-19
Harwood	Milton Lewis, Chatsworth Island	HWD15-42	14	0	10	50	08-Oct-15	06-Oct-17	26-Aug-19

The mean predicted TCH and CCS over both crops for all the clones in the NSW 2015 AATs are presented in Figure 4 and Figure 5, respectively. Introgression clone KQB07-24815 is the top performer for TCH, as it was in the individual plant and first ratoon crops. Only four of the 14 introgression clones have TCH greater than the average of the trial (yellow bar); three *S. spontaneum* back-crosses (solid orange bars) and one *E. arundinaceus* back-cross (striped orange bars). The five *E. arundinaceus* clones with QBYC06-30376 as male parent is amongst the poorer performers for TCH.

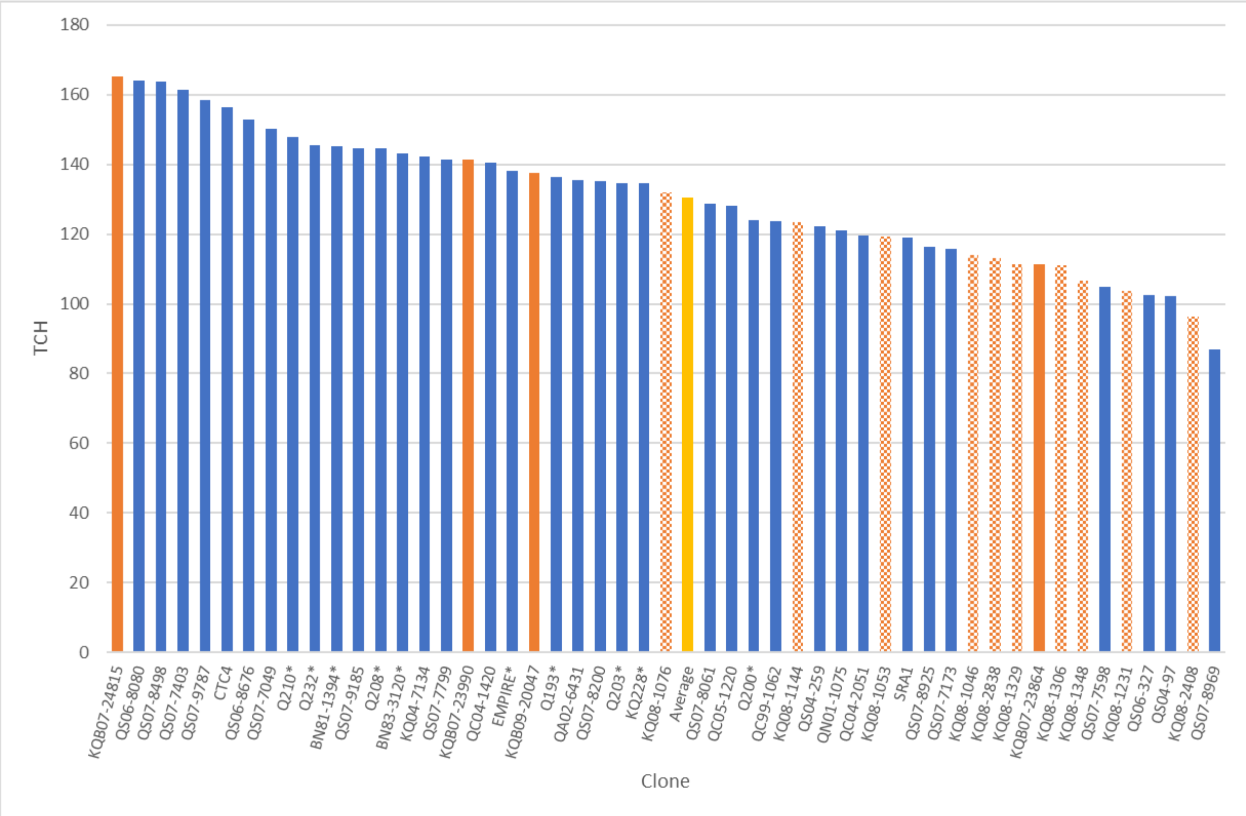

Figure 4 Mean predicted cane yield (TCH) for clones in the NSW 2015 AATs

For CCS, a similar trend was observed to TCH with most of the introgression clones having CCS values less than the trial average. It was encouraging to see that two of the *S. spontaneum* clones with above average TCH were also above average for CCS, often this is the reverse. Clones ranked two to six for TCH (QS06-8080, QS07-8498, QS07-7403, QS07-9787 and CTC4) (Figure 4) had below average CCS. KQB09-20047 had the highest CCS of the introgression clones as was the case in the plant crop and first ratoon crop harvests. The top-ranking CCS clone overall, and in both plant and first ratoon crops (QS04-259) is highly susceptible to smut but was selected/utilized as a parent for crossing in the past. It is interesting to see that the 10 standards included in these trials are average to above average for TCH, but spread over the whole range for CCS.

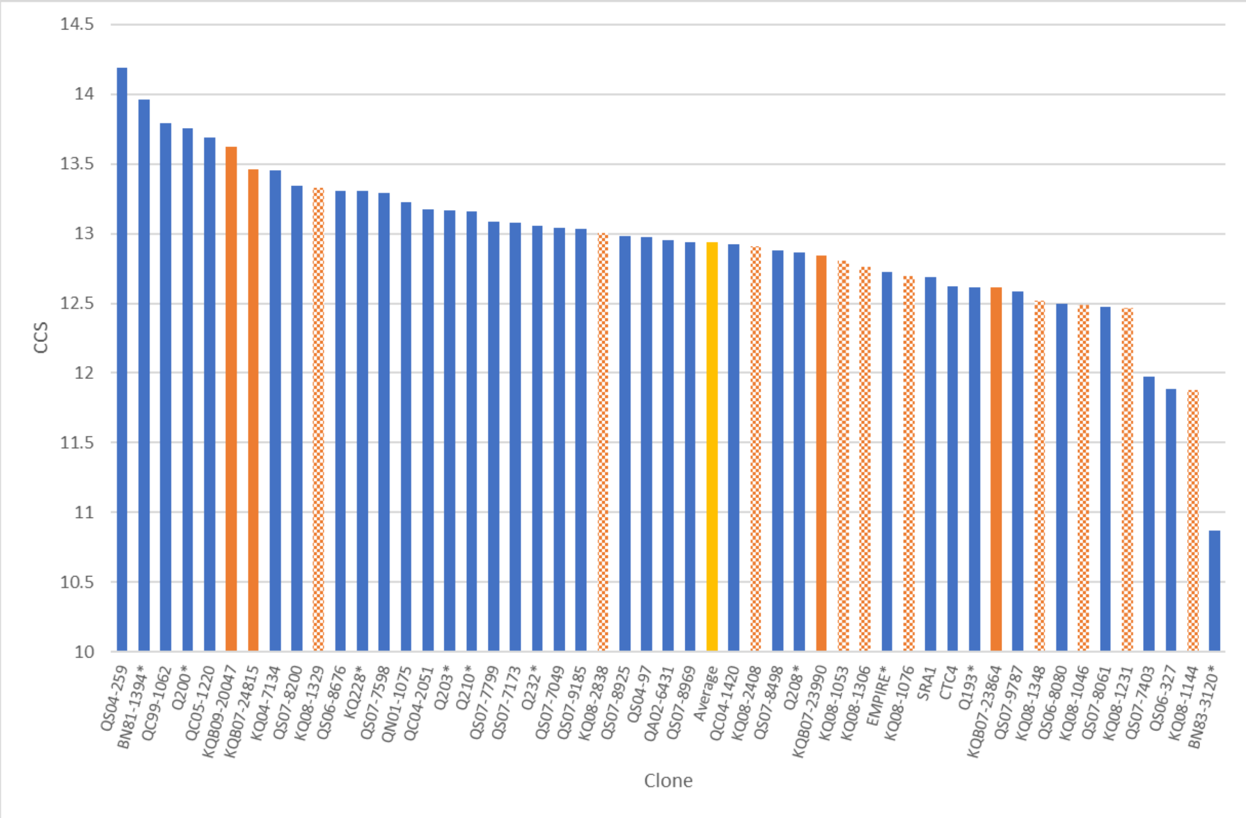

Figure 5 Mean predicted sugar content (CCS) for clones in the NSW 2015 AATs

Combining the TCH and CCS to give TSH; the mean TSH over both crops for all clones are shown in Figure 6. There are four clones with higher TSH than the top performing standard, stalwart variety BN81-1394. Introgression clone KQB07-24815, however, stands out with an impressive 22.3 TSH, over one tonne more than second place contender QS07-8498. SRA1 was included in two of the four trials as a comparator and below average results for TCH and CCS confirm previous trial results that it is not a good 2-year cane.

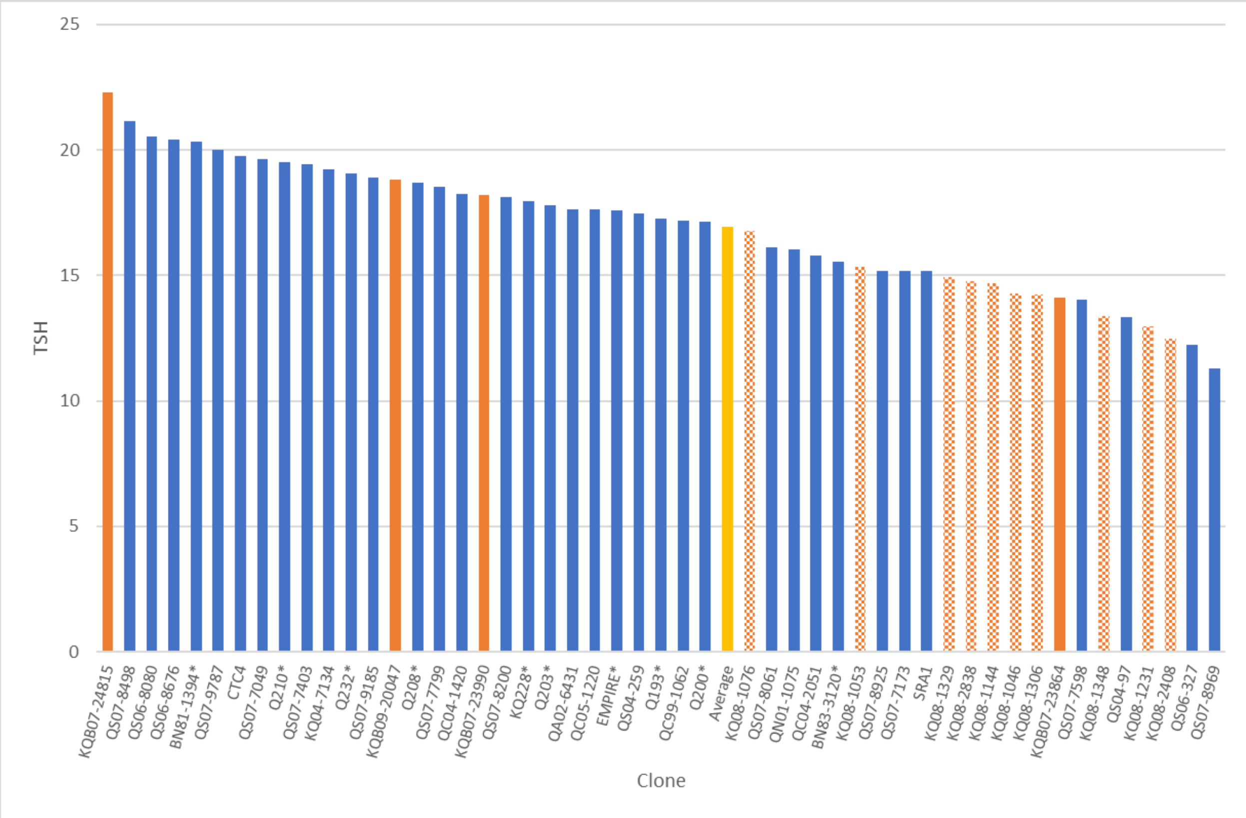

Figure 6 Mean tonnes sugar per hectare (TSH) for clones in the NSW 2015 AATs

The 2015 AAT series is an exciting series with seven clones (excluding standards) having a mean rEGV greater than 10.5 and 16 clones with a mean rEGV greater than 10. The top six clones/varieties based on the mean rEGV across both crops in each of the four 2015 AATs plus overall are shown in Table 6. *Saccharum spontaneum* introgression clones (KQB07-24815 and KQB09-20047) are ranked first and fourth overall trials, with KQB07-24815 having an impressive track record of 1st in each of the four trials. Looking at the individual harvest results, KQB07-24815 ranked 1st in five of the seven harvests and 2nd in two harvests. The average rEGV for KQB07-24815 and KQB09-20047 from these four AATs are 11.58 and 10.70, respectively.

In 2019, on the plant crop yield and disease screening results, these two introgression clones were selected to maximum propagate for possible release in 2020. Both these clones will be considered for release to growers in 2020/21 by the NSW RVC, although a shadow is hanging over KQB09-20047 as smut has been observed in the field. Variety Data Files (VDF) for these two introgression clones are included in Appendix 3 and the pedigree in Appendix 5.

Table 6 Top six clones/varieties for rEGV in each of the four 2015 AATs and overall

Ranking	BWR15-41	BWR15-42^	HWD15-41	HWD15-42	Overall AATs
1	KQB07-24815 11.65	KQB07-24815 11.45	KQB07-24815 11.53	KQB07-24815 11.62	KQB07-24815 11.58
2	BN81-1394* 11.06	BN81-1394* 11.31	BN81-1394* 11.05	BN81-1394* 11.06	BN81-1394* 11.09
3	QS06-8080 10.86	KQB09-20047 11.16	KQ04-7134 10.85	QS06-8080 10.80	KQ04-7134 10.72
4	QS07-7049 10.76	KQ228* 11.06	KQB09-20047 10.65	KQB09-20047 10.76	KQB09-20047 10.70
5	CTC4 10.71	QC05-1220 10.87	QS06-8080 10.63	QS07-9787 10.76	QS06-8080 10.68
6	QS07-9787 10.67	Q210* 10.74	Q232* 10.59	QS07-7049 10.72	QS07-7049 10.66

* Standard

^ Plant crop only

6.3. GISH analysis

Genomic *In Situ* Hybridization (GISH) is a powerful and unique technique that can reveal the number of chromosomes of *S. officinarum* and *S. spontaneum* of a clone, as well as show the recombined chromosomes between the two species (Piperidis 2013).

Thirty-six clones/varieties were selected from the NSW 1- and 2-year selection program for processing using this technique. The clones/varieties were processed in two batches; the first batch completed in 2014/15 and the second batch in 2015/16. Although the number of clones/varieties is not large, the aim of this component of the project was to determine if there was a difference in chromosome composition between clones/varieties performing well as a 1-year cane compared to clones/varieties performing well on a 2-year harvesting cycle. If such a difference occurred, the breeding and selection strategies for the NSW 1- and 2-year programs would need to be structured accordingly.

Counts of *S. officinarum*, *S. spontaneum* and recombinant chromosomes for the 36 NSW clones/varieties are shown in Table 7. Counts are mostly done on a number of metaphase cells on a microscope slide, with each cell re-counted a number of times. Photographs of a metaphase cell of representative varieties are included in Appendix 4 as examples. In all the pictures, *S. officinarum* chromosomes are represented in orange, *S. spontaneum* chromosomes are green and recombined chromosomes are showing different patterns of orange and green sections.

Some interesting observations from the results are, the high number of chromosomes in SRA1 (2n = 122), the low number of chromosomes in Triton (2n = 95) and an average 2n number of 113. The number of *S. officinarum* and *S. spontaneum* chromosomes in clones/varieties ranged from 65-86 and 15-25, respectively. The percent *S. spontaneum* plus recombinant chromosomes varied from 25.2% to 42.5%.

Table 7 List of NSW clones with chromosome numbers and origin as determined using GISH

Clone names	Female parent	Male parent	Crop cycle	No. of chromosomes				Percentage	
				S. officinarum	S. spontaneum	Recombined	2n cell	S. spontaneum	S. spontaneum + recombined
ARRIS	APOLLO	MQB72-15089	2	76	19	16	111	17.12	31.53
BN81-1394	NCo310	VESTA	1 & 2	69	21	16	106	19.81	34.91
Co740	P3247	P4775	1	70	23	24	117	19.66	40.17
Concord	CP65-357	LF47-2777	1	86	14	15	115	12.17	25.22
CP65-357	CP52-68	CP53-17	1	72	17	21	110	15.45	34.55
EMPIRE	Unknown	Unknown	2	74	19	19	112	16.96	33.93
KQ228	QN80-3425	CP74-2005	1	80	16	16	112	14.29	28.57
Q68	POJ2878	Co290	2	69	21	19	109	19.27	36.70
Q124	NCo310	QN54-7096	1 & 2	74	21	21	116	18.10	36.21
Q136	NCo310	QN54-7096	2	no results					
Q151	Q96	QC66-807	1	79	16	16	111	14.41	28.83
Q157	QN58-829	QN66-2008	2	71	22	19	112	19.64	36.61
Q159	NCo310	QN54-7096	2	82	25	15	122	20.49	32.79
Q183	Q124	H56-752	1	70	18	29	117	15.38	40.17
Q188	Q113	QS63-782	1	81	18	21	120	15.00	32.50
Q193	CP51-21	Q121	1 & 2	71	19	18	108	17.59	34.26
Q203	F146	CP28-11	2	73	21	18	112	18.75	34.82
Q205	Q121	H60-3802	2	85	17	15	117	14.53	27.35
Q208	QN61-1232	QA87-1413	1 & 2	80	16	11	107	14.95	25.23
Q210	QC64-386	Q121	1 & 2	82	18	18	118	15.25	30.51
Q211	Q138	H56-752	1	80	15	15	110	13.64	27.27
Q212	Q138	H56-752	2	81	16	16	113	14.16	28.32
Q232	QN80-3425	QS72-732	1	74	23	20	117	19.66	36.75
Q234	Q107	QN66-2008	1 & 2	78	15	14	107	14.02	27.10
Q235	QS83-2103	QC89-6015	1	79	18	23	120	15.00	34.17
Q242	Q170	Q150	1	75	22	16	113	19.47	33.63
Q243	QC83-631	SP78-3137	1	69	20	20	109	18.35	36.70
Q244	CP75-1322	Q170	1	79	22	19	120	18.33	34.17
QS01-206	QC83-700	QN77-676	2	69	23	28	120	19.17	42.50
QS02-598	QS77-1321	QC90-353	2	72	19	22	113	16.81	36.28
QS04-259	QC83-625	QC91-3511	1	74	15	26	115	13.04	35.65
RB72-454	CP53-76	Unknown	2	68	21	20	109	19.27	37.61
SRA1	QN86-2139	QC90-289	1	80	21	21	122	17.21	34.43
SRA2	QS92-206	QS87-7430	1	77	17	18	112	15.18	31.25
Triton	Co270	EROS	1 & 2	65	17	13	95	17.89	31.58
TS65-28	TS56-377	TS56-2668	2	69	16	26	111	14.41	37.84

The average counts for varieties grown predominantly as either a 1-year or 2-year cane are presented in Figure 7. The 2-year clones/varieties on average have a slightly lower number of *S. officinarum* chromosomes, slightly higher number of *S. spontaneum* chromosomes and slightly lower 2n chromosome number than the averages for the 1-year varieties. This equates to the 2-year clones/varieties having a slightly higher percentage (35.4% compared to 33.2%) *S. spontaneum* and recombinant chromosomes than the 1-year clones/varieties. There is aan opportunity to further investigate if this difference is real; is this difference because the 2-year program takes so much longer than the 1-year program and that the breeding generations of the two programs are not aligned, or is it that selection for different traits in the NSW 1-year and 2-year programs is favouring chromosomes of the one species?

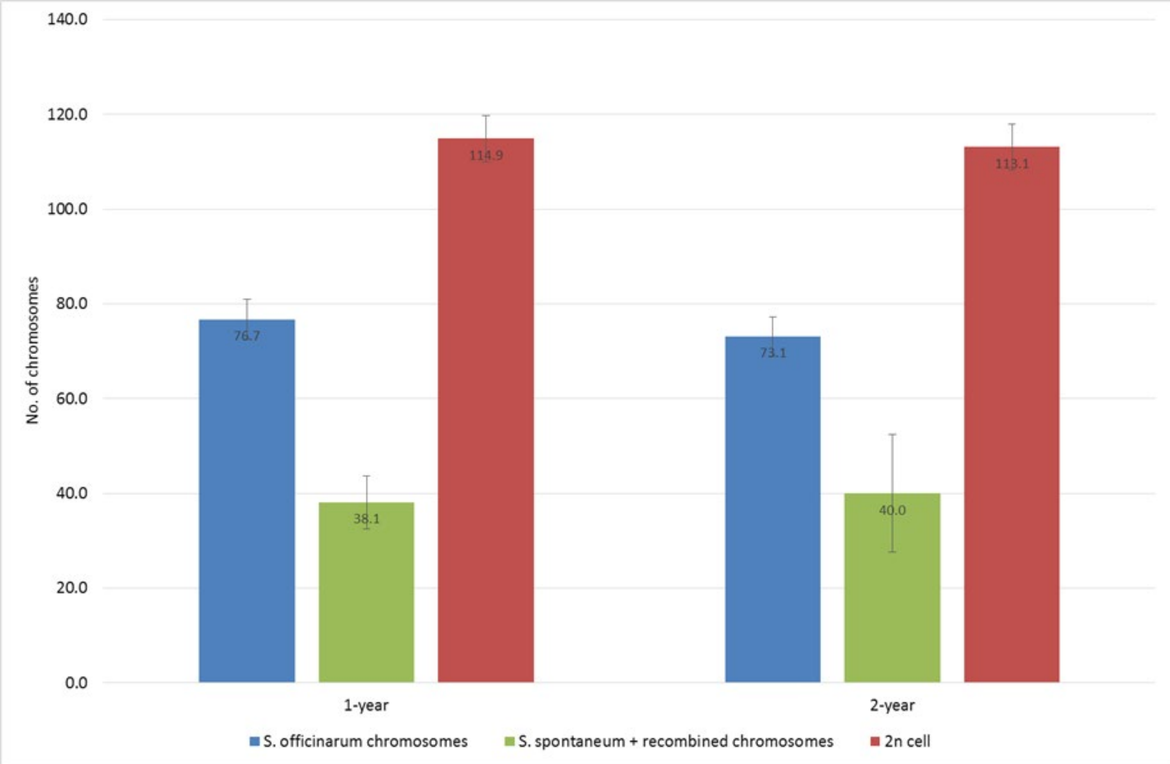

Figure 7 Average number of chromosomes in NSW 1-year and 2-year varieties

6.4. Screening results from the Frost Observation Plots (Set 1 and Set 2)

The FOPs were established at Main Camp, with the first set planted in October 2014 and the second set in October 2015 (Table 8). Fifty two clones were included in set 1 and 60 clones in set 2. Clones were sourced from the program from crosses with *E. arundinaceus* or *S. spontaneum*, foreign varieties, clones from the NSW core program plus standard varieties for comparison (see Appendix 6,7 and 8 for list of clones and location map).

Table 8 List of Frost Observation Plots planted with harvest dates

Mill area	Farm	Trial code	Type	Introgression clones	USA clones	Standards	Total clones	Date planted	Plant crop harvest date	First ratoon harvest date
Broadwater	Main Camp, Myrtle Creek	BWR14-FOP	FOP	25	9	12	52	09-Oct-14	Nov-16	Nov-17
Broadwater	Main Camp, Myrtle Creek	BWR15-FOP	FOP	33	1	12	60	07-Oct-15	Nov-16	Nov-17

The 2014 FOP went through three winters (2015 to 2017). After the mild winter of 2015, the cane in these plots was not harvested and entered the winter of 2016 as 2-year cane. The cane was harvested after the 2016 winter and allowed to ratoon for assessment during the 2017 winter as first ratoon 1-year old cane. The 2015 FOP (Set 2) was assessed during the winter of 2016 and 2017 as 1-year plant crop and first ratoon, respectively.

The 2015 to 2017 winters at Main Camp were mild with no to little frost damage occurring during these three years of assessment. Reports from field studies have characterised the range of temperatures (-1.7 - -5.5°C) that is needed to cause various levels of damage leading to reduced ratoonabiltiy and bud germination and deterioration in juice quality (McAleese 1964; Matthews 1966; Majid 2007; Sachdeva SK *et al.* 2008). Minimum temperatures for the winter months of 2015 to 2017 are shown in Figure 8. In 2015 there were six days with temperatures below 0°C; -0.8°C the lowest temperature which was recorded on the 18th July. In 2016 there were only two days with temperatures below 0°C, -0.6°C and -0.5°C on 26th June and 2nd July, respectively. In 2017 there were also only two days with temperatures below 0°C, -0.6°C and -0.9°C on 30th July and 9th August, respectively.

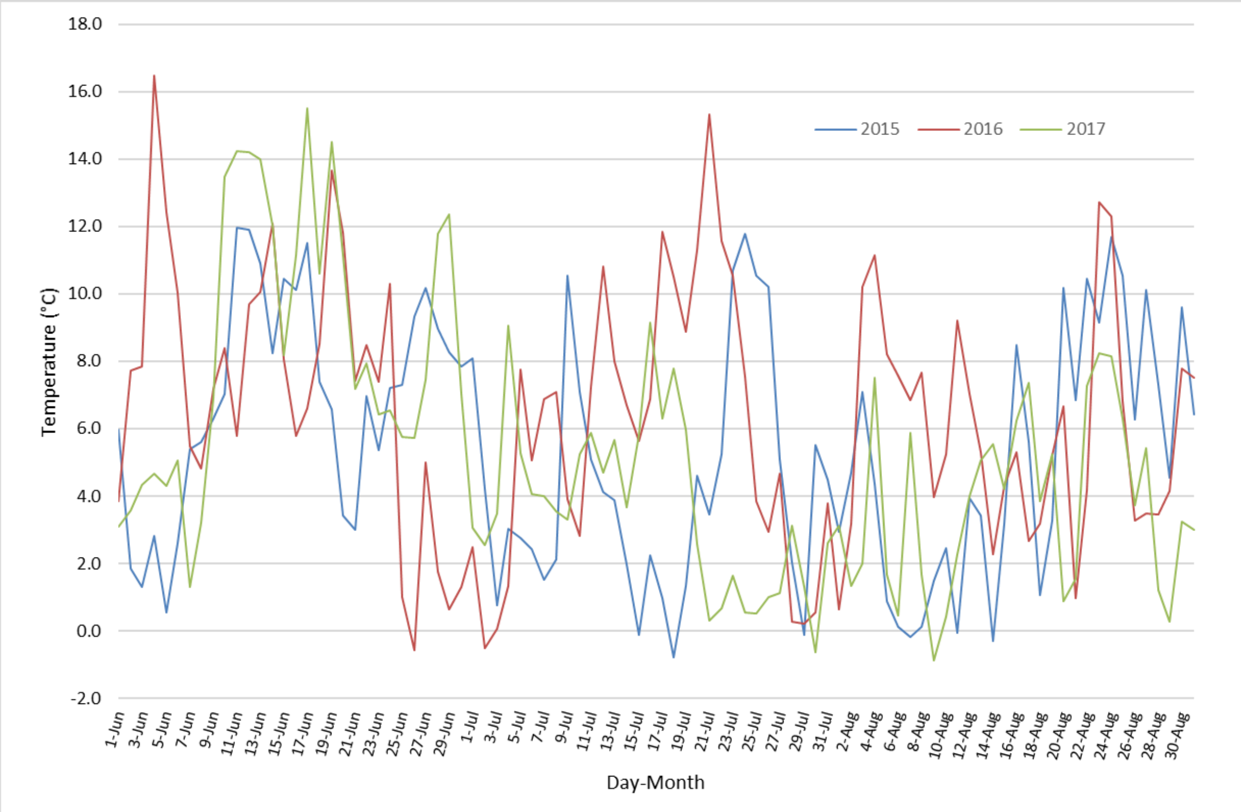

Figure 8 Minimum temperatures measured at Main Camp during the winter months of 2015 - 2017

A frost assessment was made in both FOPs (set 1 and 2) on 24 October 2017. No frost damage was noted in the 2015 FOPs (set 2), but some frost damage and side-shooting were recorded in the 2014 FOPs (set 1). Damage and side-shooting in the 2014 FOPs (set 1) was limited to the southern end of the FOPs (plots 5-8), with the northern side (plots 1-4) having no damage. Replication alignment of the FOPs (set 1) was also in the same direction as the frost damage; with no frost damage recorded in replication 1. Thirteen of the clones in replication 2 had no frost damage recorded, the majority (9) of these clones being introgression clones. Introgression clone, SRAW18 (KQB07-34350), released to NSW growers in 2019/20 had no frost damage in the 2014 FOPs (set 1). The top clones in the 2015 AATs were not represented in the 2014 FOP (set 1), so no frost observations are available for these clones.

7. CONCLUSIONS

Thirty clones were fast-tracked directly into the NSW 2-year selection program during 2014 and 2015 without first being tested in the 1-year program. This included 11 *S. spontaneum* introgression clones, 13 *E. arundinaceus* introgression clones and six exchange varieties from the USA. The *S. spontaneum* introgression clones were the most successful group to fast-track. One *S. spontaneum* clone (SRAW18) was released from the 2014 AAT series to NSW growers in 2019/20 and it is highly likely that another *S. spontaneum* clone will be released from the 2015 AAT series in 2020/21. Clones from the *E. arundinaceus* introgression and USA exchange groups did generally not perform well. The results from this project give a good indication on where future fast-track clones should be sourced. Forty-seven introgression clones (*S. spontaneum* and *E. arundinaceus* back-crosses) were sourced from the SRA introgression program and planted in NSW propagation plots in 2019 for initial screening and possible inclusion into future 2-year AATs.

Traditionally, the top 25 performing clones from the NSW 1-year program would enter the NSW 2-year program for testing as a 2-year cane. Seventeen of the 30 clones fast-tracked directly into the NSW 2-year program have since been included in the NSW 1-year program for assessment. Of these seventeen, 16 have been discarded due to poor performance and/or disease susceptibility and would have never entered the 2-year program; this includes SRAW18. One clone has no results, only having been included into 1-year FATs in 2019.

Chromosome counts in 36 NSW 1- and 2-year varieties indicates a slightly higher percentage (35.4% vs 33.2%) *S. spontaneum* and recombinant chromosomes for varieties harvested on a 2-year cycle than varieties harvested annually. The 2-year clones/varieties on average have a slightly lower number of *S. officinarum* chromosomes, slightly higher number of *S. spontaneum* chromosomes and slightly lower 2n chromosome number than the averages for the 1-year varieties. The exact meaning of these differences is not yet fully understood but, does seem to support the good yield performance of earlier generation *S. spontaneum* back-crosses fast-tracked into the NSW 2-year program. The high yielding *S. spontaneum* back-crosses in these AATs will be cytogenetically characterised as part of the core SRA Introgression program, but the results are not yet available. At this point no caryotype information is available on the *E. arundinaceus* introgression clones, or the USA exchange varieties.

The frost screening component of this project was not that successful with no data forthcoming that could be analysed statistically. The unpredictable occurrence of one or more frost events in a given year/location is a known risk in field frost tolerance screening trials/plots. The light frost events at Main Camp during 2015-2017 resulting in no/little differentiation between clones (no frost damage) did negatively impact on selection of clones and parents for the NSW program. The lack of frost results, however, did not delay the NSW 2-year breeding and selection program *per se*. A benefit of these FOPs not being frosted in 2016 was that they could serve as a seedcane source for a number of introgression clones for other projects.

8. RECOMMENDATIONS FOR FURTHER RD&A

The following recommendations are made for further research and development:

- There is a need to better understand how to best select 2-year canes while they are progressing through the early stages of the southern 1-year program based in Bundaberg. This not only includes research into the physiological and phenotypic differences between 1- and 2-year canes, but also selection strategy (e.g. PAT and CAT designs and assessments).
- Instead of continuing with FOPs at the NSW Main Camp location, in 2016 a FOP was planted at Gayndah in collaboration with Isis mill. There were three reasons for this; 1) larger pool of germplasm available from the southern program in Bundaberg, 2) low frost incidence at the NSW location and 3) possible expansion of sugarcane growing area around Gayndah. A early stage/seedling/family FOP was planted in autumn 2018 at a second location at Gayndah. The first location at Gayndah proved too harsh with severe frosts, while the second location had minimal frosts. Research in controlled environments for screening sugarcane clones for frost tolerance needs to be considered to counter the unpredictable occurrence and severity of frost events in a given year/location.
- SRA has implemented an introgression program as part of core plant breeding activities. This will ensure a steady flow of introgression clones for inclusion in the NSW 2-year selection program. This germplasm typically exhibits a wider range of fibre levels than conventional breeding material making the current practice of applying a single assumed fibre level to all clones in a trial even more problematic. SRA has planned for investment in a SpectraCane NIR system for the NSW program which will address this issue.
- There are further research opportunities to determine which wild species (*S. spontaneum, S. robustum etc.*), origin of wild species germplasm (taking into account elevation, latitude, temperature) and back-cross generation that will give the best results in the NSW 2-year program.
- The project has produced some initial evidence suggesting chromosome number and composition may be associated with the adaptation of varieties. This could form the basis for a new line of research into the genomic features important for variety performance.

9. PUBLICATIONS

At this stage, no publications have been prepared.

Several presentations on this project have been made to NSW industry groups:

- Distribution of VDFs and presentations on the performance of varieties in these two AAT series were made at the annual NSW RVC April meetings during the four years 2017-2020. These meetings are specific for discussing/selecting varieties for promotion in the NSW 1- and 2-year programs and for release to the NSW industry.

- Initial results from this project were presented at the NSW program review meeting held in June 2017 and it was agreed to place further emphasis on introgression material in the 2-year program rather than foreign and inter-station exchange (ISE) material.

10. ACKNOWLEDGEMENTS

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- Anthony Cattle (SRA) who organized and was involved in all the trial plantings, maintenance and harvests.
- Michael Grogan (SRA) who was involved in all trial plantings, maintenance and managed the mobile juice laboratory during sampling/harvesting.
- Nathalie Piperidis (SRA) who carried out the GISH analysis reported in section 6.3.

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- Growers in the Broadwater and Harwood mill areas on whose farms the trials were planted. See Tables 2, 5 and 8.
- Wayne and Craig Rodgers, long standing harvest contractors, for part played in harvesting the AATs.
- Emily Deamano (SRA) who carried out the statistical analysis of the AAT data reported on in section 6.1 and 6.2.

11. REFERENCES

Chapman SC, Rattey A & Jackson PA (2002) ‘Evaluation and re-structuring of regional selection programs to maximise efficiency and speed of cultivar release.’ SRDC project CTA028 final report.

Cox MC (1995) ‘Seasonal distribution of growth and sugar accumulation in sugarcane.’ SRDC project BS5S final report.

Croft B (2016) ‘New germplasm to develop more productive varieties with enhanced resistance to nematodes, pachymetra root rot and smut.’ SRDC project 2011/344 final report.

Majid MA (2007) ‘Freezing-frost damage to sugarcane crop and mill recovery in Pakistan.’ Pakistan Sugar Journal, 22, p 19-37.

Matthews AA (1966) ‘Assessing the extent of frost damage.’ The cane growers quarterly bulletin, 30, p 32-33.

McAleese CM (1964) ‘Some frost observations in the Carmila West Area, 1963.’ The cane growers quarterly bulletin, 28, p 34-36.

Munro A & Beattie R (2010) ‘Better frost tolerant varieties for NSW.’ SRDC project GGP041 final report.

Piperidis N (2013) GISH: resolving interspecific and intergeneric hybrids in: Methods in Molecular Biology (Ed) Pascale Besse, Vol. 1115. Humana Press.

Sachdeva SK, Singh K, Singh D & Singh N (2008) ‘Impact of suboptimal temperatures and frost on the productivity of sugarcane crop during crushing season 2007-08 at Saraswati sugar mill, Yamunanagar (Haryana).’ Proc. Ann. Conv. of STAI, 69, p 121-132.

Wei X, Jackson P, Stringer J, & Cox M (2008) ‘Relative economic genetic value (rEGV) - an improved selection index to replace net merit grade (NMG) in the Australian sugarcane variety improvement program.’ Proceedings of the Australian Society of Sugar Cane Technologists, 30, p 174-181.

12. APPENDIX

12.1. Appendix 1 METADATA DISCLOSURE

Table 9 Metadata disclosure 1

Data	AAT plant and first ratoon crops yield data, including TCH, Brix, Pol, CCS
Stored Location	SRA – SPIDNet database
Access	Restricted; SRA staff with access to SPIDNet database
Contact	Roy Parfitt – SRA plant breeder Anthony Cattle – SRA variety officer for NSW

Table 10 Metadata disclosure 2

Data	Caryotype information/pictures and frost observations
Stored Location	SRA – bdbsvr (G:)
Access	Restricted; SRA staff with access to bdbsvr (G:)
Contact	Roy Parfitt – SRA plant breeder Anthony Cattle – SRA variety officer for NSW

12.2. Appendix 2 Variety data files for SRAW18 and KQB09-20290

Sugar Research Australia

VARIETY DATA FILE

2019

(Trials included in this Variety Data File)

NSW 2 Year 2014 AAT

Page 1 Produced: 29/04/2020

2. SRAW18 (Q208 x QBYN04-26272)

Summary of Ratings

Pathology Testing *(Disease, Avg Rating, No. of Tests, Individual Results)*

Fiji Leaf Gall: 2 (2)	Leaf Scald: 2 (2)	Lesion Nematode: 8 (2)	Mosaic: 2 (2)
FIXED RATING	FIXED RATING	FIXED RATING	FIXED RATING
Pachymetra: 5 (3)	Red Rot: 2 (1)	Root Knot Nematode: 8 (1)	Smut: 4 (3)
FIXED RATING	FIXED RATING	FIXED RATING	FIXED RATING

Current Trials: Floc (RAC18-71, RAC18-72)

Summary of Performance - BLUPS (Diff to stds)

TCH 12.4 **CCS** -0.5 **Fibre**

Selection Status/Comments (by region)

S: FAT - 15FAT; Introgression; low rEGV
H: FAT - INTROGRESSION 2014 PROP 2015 TRIALS
A: FAT_D - .
C: FAT_D - 2015; trial only
W: FAT_D - D18;FAT15
2: Released - Rel19;AAT14 (RB_big_balls_2)

New Status/Comments? ________

Pending selection trial results (by region)

From Routine Trials	From Optional Trials	In Southern Plant Propagation?	In Southern Ratoon Propagation?
2(1)		No	No

Detailed Trial Results

2014 Series

Harvested	Crop	TCH		CCS		Fibre		rEGV	(rank)
BWR14-42	*Steve Boland*			*Sheehans Lane*				*Planted: 29/10/2014*	
						Trial Standards: (BN81-1394;EMPIRE;Q200;Q203;Q208;Q232)			
28/10/2016	P 2yr (n=42)	187 (173)*	(4)	13.5 (13.9)	(16)	15.1 (15.1)	(1)	10.20	(7)
22/11/2018	1R 2yr (n=42)	121 (125)	(6)	12.3 (12.8)	(20)	16.9 (16.9)	(1)	9.65	(11)
Trial Means Of	All Crops	154 (149)		12.9 (13.3)		16.0 (16.0)		9.93	
HWD14-41	*Andrew Fischer*			*Chatsworth Island*				*Planted: 31/10/2014*	
						Trial Standards: (BN81-1394;EMPIRE;Q200;Q203;Q208;Q232)			
19/08/2016	P 2yr (n=42)	255 (227)*	(1)	13.0 (13.3)	(20)	14.1 (14.1)	(1)	10.73	(2)
23/08/2018	1R 2yr (n=42)	188 (172)*	(3)	13.4 (13.9)	(27)	15.6 (15.6)	(1)	10.22	(6)
Trial Means Of	All Crops	222 (200)		13.2 (13.6)		14.8 (14.8)		10.48	
HWD14-42	*Bob Ensbey*			*Lawrence*				*Planted: 5/11/2014*	
						Trial Standards: (BN81-1394;EMPIRE;Q200;Q203;Q208;Q232)			
17/08/2016	P 2yr (n=42)	224 (192)*	(1)	12.8 (13.6)	(32)	14.1 (14.1)	(1)	10.48	(2)
13/08/2018	1R 2yr (n=42)	212 (223)	(17)	11.8 (12.6)	(36)	15.6 (15.6)	(1)	9.41	(26)
Trial Means Of	All Crops	218 (208)		12.3 (13.1)		14.8 (14.8)		9.94	

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2014 Series Crop Class Summary

3	Mean Of	P 2yr	222 (197)	13.1 (13.6)	14.4 (14.4)	10.47
3	Mean Of	1R 2yr	174 (173)	12.5 (13.1)	16.1 (16.1)	9.76
	Mean of	All	198 (185)	12.8 (13.3)	15.2 (15.2)	10.11

Significant x of y times: 4 / 6

End of 2014 Series

3. KQB09-20290 (Q208 x QBYC04-10865)

Summary of Ratings

Pathology Testing *(Disease, Avg Rating, No. of Tests, Individual Results)*

Fiji Leaf Gall: 2 (1) c(2)

HES-S: 4 (2) d(6, 1)

Lesion Nematode: 8 (2) b(8, 8)

Pachymetra: 2 (3) a(2, 2, 2)

Root Knot Nematode: 8 (1) b(8)

Smut: 5 (2) a(5, 5)

Current Trials: None

Summary of Performance - BLUPS (Diff to stds)

TCH 24.7 **CCS** -1.0 **Fibre**

Selection Status/Comments (by region)

S: FAT - 14FAT; Introgression;low rEGV

H: FAT - INTROGRESSION 2014 PROP 2015 TRIALS

W: FAT_D - D Sm 17; Smut found in trial

2: FAT_D - DSm17;Smut_found_in_trial;AAT14

C: FAT_D - Introgression FAT2015

A: Special

New Status/Comments? ______________________

Pending selection trial results (by region)

From Routine Trials	From Optional Trials	In Southern Plant Propagation?	In Southern Ratoon Propagation?
		No	No

Detailed Trial Results

2014 Series

Harvested	Crop	TCH	CCS	Fibre	rEGV (rank)
BWR14-41	*Bwr Mill Farm*	*Broadwater*		*Peaty Podzol: Sandy loam*	*Planted: 7/11/2014*
				Trial Standards: (BN81-1394;EMPIRE;Q200;Q203;Q208;Q232)	
3/11/2016	P 2yr (n=40)	261 (213)** [1]	12.9 (14.1) [34]	15.1 (15.1) [1]	10.52 [2]
23/11/2018	1R 2yr (n=40)	181 (150)** [1]	12.3 (13.2) [26]	16.9 (16.9) [1]	10.35 [4]
Trial Means Of	All Crops	221 (181)	12.6 (13.6)	16.0 (16.0)	10.43
BWR14-42	*Steve Boland*	*Sheehans Lane*			*Planted: 29/10/2014*
				Trial Standards: (BN81-1394;EMPIRE;Q200;Q203;Q208;Q232)	
28/10/2016	P 2yr (n=42)	197 (173)* [2]	12.9 (13.9) [29]	15.1 (15.1) [1]	10.14 [8]
22/11/2018	1R 2yr (n=42)	141 (125) [2]	10.9 (12.8) [40]	16.9 (16.9) [1]	9.38 [16]

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Trial Means Of	All Crops	169 (149)	11.9 (13.3)	16.0 (16.0)	9.76
HWD14-41	*Andrew Fischer*		*Chatsworth Island*		*Planted: 31/10/2014*
			Trial Standards: (BN81-1394;EMPIRE;Q200;Q203;Q208;Q232)		
19/08/2016	P 2yr (n=42)	250 (227)* [3]	12.9 (13.3) [30]	14.1 (14.1) [1]	10.51 [3]
23/08/2018	1R 2yr (n=42)	194 (172)** [1]	13.1 (13.9) [30]	15.6 (15.6) [1]	10.22 [6]
Trial Means Of	All Crops	222 (200)	13.0 (13.6)	14.8 (14.8)	10.37
HWD14-42	*Bob Ensbey*		*Lawrence*		*Planted: 5/11/2014*
			Trial Standards: (BN81-1394;EMPIRE;Q200;Q203;Q208;Q232)		
17/08/2016	P 2yr (n=42)	221 (192)* [2]	12.1 (13.6) [40]	14.1 (14.1) [1]	9.99 [10]
13/08/2018	1R 2yr (n=42)	227 (223) [6]	11.7 (12.6) [37]	15.6 (15.6) [1]	9.74 [11]
Trial Means Of	All Crops	224 (208)	11.9 (13.1)	14.8 (14.8)	9.86

2014 Series Crop Class Summary

4 Mean Of	P 2yr	232 (201)	12.7 (13.7)	14.6 (14.6)	10.29
4 Mean Of	1R 2yr	186 (168)	12.0 (13.1)	16.3 (16.3)	9.92
Mean of	All	209 (184)	12.4 (13.4)	15.4 (15.4)	10.11

Significant x of y times: 6 / 8

End of 2014 Series

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12.3. Appendix 3 Varaity data files for KQB07-24815 and KQB09-20047

Sugar Research Australia

VARIETY DATA FILE

2019

(Trials included in this Variety Data File)

NSW 2 Year 2015 AAT

Page 1 Produced: 29/04/2020

All

1. KQB07-24815 (QA89-3305 x QBYC05-10199)

Summary of Ratings

Pathology Testing *(Disease, Avg Rating, No. of Tests, Individual Results)*

Fiji Leaf Gall: 2 (3)	Leaf Scald: 1 (2)	Lesion Nematode: 8 (2)	Mosaic: 1 (2)
FIXED RATING	FIXED RATING	b(8, 8)	FIXED RATING
Pachymetra: 3 (3)	Red Rot: 5 (1)	Root Knot Nematode: 8 (1)	Smut: 3 (3)
FIXED RATING	FIXED RATING	b(8)	FIXED RATING

Current Trials: Red Rot (RR19-70) Leaf Scald (LS19-188) Floc (RAC19-71, RAC19-72)

Summary of Performance - BLUPS (Diff to stds)

TCH 25.8 **CCS** 0.5 **Fibre**

Selection Status/Comments (by region)

W: CAT_D - D16
H: FAT - INTROGRESSION 2014 PROP 2015 TRIALS
C: FATProp - Introgression FAT2015; Recover into 2020 Prop
2: Released - Rel20;AAT15
A: Special - Hu

New Status/Comments? ____________

Pending selection trial results (by region)

From Routine Trials	From Optional Trials	In Plant Propagation?	In Ratoon Propagation?
H(1) 2(1)		No	No

Detailed Trial Results

2015 Series

Harvested	Crop	TCH	CCS	Fibre	rEGV (rank)
BWR15-41	*Phil Whitby*	*Wardell*			*Planted: 30/10/2015*
		Trial Standards: (BN81-1394;BN83-3120;EMPIRE;Q193;Q200;Q203;Q208;Q210;KQ228;Q232)			
15/08/2017	P 2yr (n=49)	154 (127)** (1)	13.9 (13.4)** (8)	14.6 (14.6) (1)	11.62 (1)
4/09/2019	1R 2yr (n=49)	152 (123)** (1)	12.3 (11.8)* (6)	15.6 (15.6) (1)	11.68 (1)
Trial Means Of	All Crops	153 (125)	13.1 (12.6)	15.1 (15.1)	11.65
BWR15-42	*Keith Robinson*	*Kilgin Rd*			*Planted: 26/10/2015*
		Trial Standards: (BN81-1394;BN83-3120;EMPIRE;Q193;Q200;Q203;Q208;Q210;KQ228;Q232)			
28/08/2017	P 2yr (n=49)	155 (135)* (1)	13.4 (12.9)* (11)	14.6 (14.6) (1)	11.44 (2)
Trial Means Of	All Crops	155 (135)	13.4 (12.9)	14.6 (14.6)	11.44
HWD15-41	*Harwood Mill Farm*	*Harwood*			*Planted: 13/10/2015*
		Trial Standards: (BN81-1394;BN83-3120;EMPIRE;Q193;Q200;Q203;Q208;Q210;KQ228;Q232)			
21/08/2017	P 2yr (n=54)	151 (136)** (2)	14.0 (13.4)** (9)	14.8 (14.8) (1)	11.49 (2)
21/08/2019	1R 2yr (n=54)	172 (139)** (3)	13.4 (13.0) (9)	16.0 (16.0) (1)	11.57 (1)
Trial Means Of	All Crops	162 (138)	13.7 (13.2)	15.4 (15.4)	11.53

All Page 2

2015 Series *(continued)*

Harvested	Crop	TCH	CCS	Fibre	rEGV (rank)
HWD15-42	*Milton Lewis*		*Chatsworth Island*		*Planted: 8/10/2015*
			Trial Standards: (BN81-1394;BN83-3120;EMPIRE;Q193;Q200;Q203;Q208;Q210;KQ228;Q232)		
6/10/2017	P 2yr (n=50)	208 (175)** (2)	14.3 (13.6)* (7)	15.9 (15.9) (1)	11.68 (1)
26/08/2019	1R 2yr (n=50)	165 (141)** (1)	12.9 (12.4)** (9)	16.0 (16.0) (1)	11.55 (1)
Trial Means Of	All Crops	186 (158)	13.6 (13.0)	15.9 (15.9)	11.61

2015 Series Crop Class Summary

		TCH	CCS	Fibre	rEGV
4 Mean Of	P 2yr	167 (143)	13.9 (13.4)	15.0 (15.0)	11.56
3 Mean Of	1R 2yr	163 (134)	12.9 (12.4)	15.9 (15.9)	11.60
Mean of	All	165 (139)	13.5 (12.9)	15.3 (15.3)	11.58
Significant x of y times:		7 / 7	6 / 7		

End of 2015 Series

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3. KQB09-20047 (KQ228 x QBYC04-10577)

Summary of Ratings

Pathology Testing *(Disease, Avg Rating, No. of Tests, Individual Results)*

Fiji Leaf Gall: 1 (3) FIXED RATING	Leaf Scald: 3 (2) FIXED RATING	Lesion Nematode: 8 (1) b(8)	Mosaic: 1 (1) FIXED RATING
Pachymetra: 4 (2) FIXED RATING	Root Knot Nematode: 8 (1) b(8)	Smut: 3 (3) FIXED RATING	

Current Trials: Red Rot (RR19-70) Leaf Scald (LS19-188)

Summary of Performance - BLUPS (Diff to stds)

TCH -1.8 **CCS** 0.7 **Fibre**

Selection Status/Comments (by region)

W: CAT_D - Clones for BC #344 and NSW AAT
A: FATProp - Introgression
2: Released - Rel20;AAT15;pendingSm2020
New Status/Comments?

Pending selection trial results (by region)

From Routine Trials	From Optional Trials	In Southern Plant Propagation?	In Southern Ratoon Propagation?
2(1)		No	No

Detailed Trial Results

2015 Series

Harvested	Crop	TCH	CCS	Fibre	rEGV (rank)
BWR15-41	*Phil Whitby*	*Wardell*			*Planted: 30/10/2015*
		Trial Standards: (BN81-1394;BN83-3120;EMPIRE;Q193;Q200;Q203;Q208;Q210;KQ228;Q232)			
15/08/2017	P 2yr (n=49)	124 (127) (20)	14.1 (13.4)** (6)	14.6 (14.6) (1)	10.61 (11)
4/09/2019	1R 2yr (n=49)	121 (123) (21)	12.1 (11.8) (11)	15.6 (15.6) (1)	10.32 (17)
Trial Means Of	All Crops	123 (125)	13.1 (12.6)	15.1 (15.1)	10.46
BWR15-42	*Keith Robinson*	*Kilgin Rd*			*Planted: 26/10/2015*
		Trial Standards: (BN81-1394;BN83-3120;EMPIRE;Q193;Q200;Q203;Q208;Q210;KQ228;Q232)			
28/08/2017	P 2yr (n=49)	143 (135) (9)	13.6 (12.9)* (7)	14.6 (14.6) (1)	11.15 (3)
Trial Means Of	All Crops	143 (135)	13.6 (12.9)	14.6 (14.6)	11.15
HWD15-41	*Harwood Mill Farm*	*Harwood*			*Planted: 13/10/2015*
		Trial Standards: (BN81-1394;BN83-3120;EMPIRE;Q193;Q200;Q203;Q208;Q210;KQ228;Q232)			
21/08/2017	P 2yr (n=54)	135 (136) (24)	14.2 (13.4)** (7)	14.8 (14.8) (1)	11.00 (6)
21/08/2019	1R 2yr (n=54)	129 (139) (29)	13.7 (13.0)* (6)	16.0 (16.0) (1)	10.29 (16)
Trial Means Of	All Crops	132 (138)	14.0 (13.2)	15.4 (15.4)	10.65
HWD15-42	*Milton Lewis*	*Chatsworth Island*			*Planted: 8/10/2015*
		Trial Standards: (BN81-1394;BN83-3120;EMPIRE;Q193;Q200;Q203;Q208;Q210;KQ228;Q232)			
6/10/2017	P 2yr (n=50)	174 (175) (16)	14.5 (13.6)** (6)	15.9 (15.9) (1)	10.71 (10)

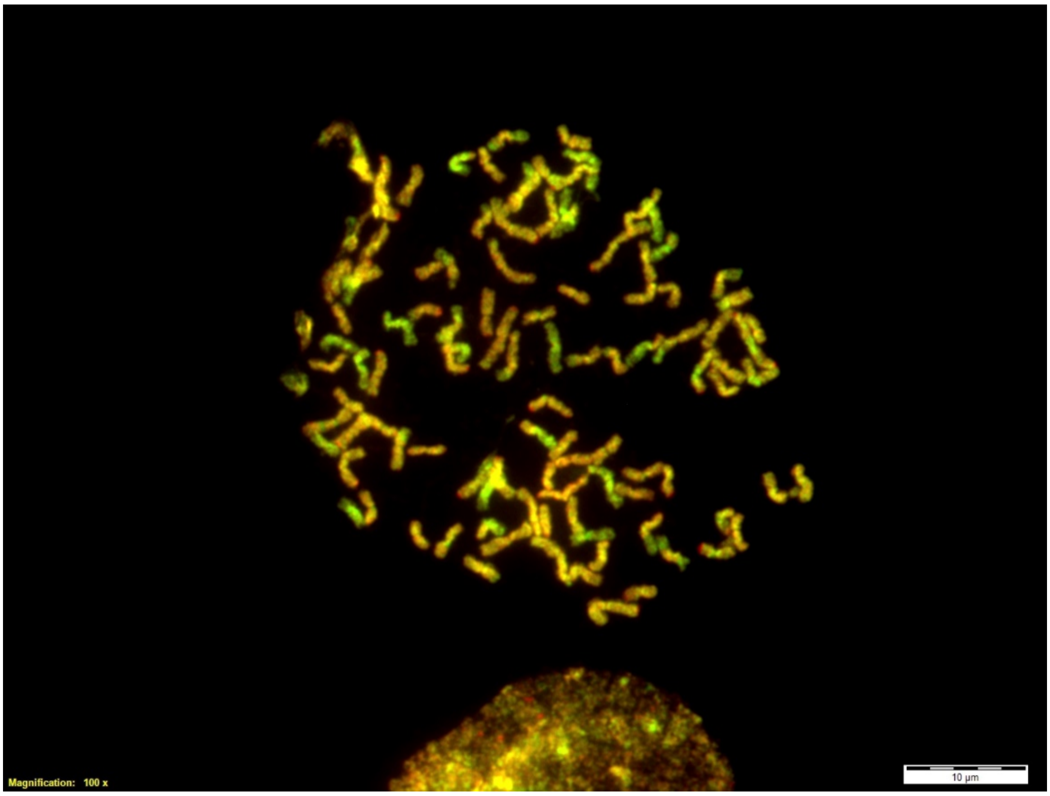
2015 Series *(continued)*

Harvested	Crop	TCH	CCS	Fibre	rEGV (rank)
26/08/2019	1R 2yr (n=50)	138 (141) (19)	13.2 (12.4)** (6)	16.0 (16.0) (1)	10.81 (5)
Trial Means Of	All Crops	156 (158)	13.8 (13.0)	15.9 (15.9)	10.76
2015 Series Crop Class Summary					
4 Mean Of	P 2yr	144 (143)	14.1 (13.4)	15.0 (15.0)	10.87
3 Mean Of	1R 2yr	129 (134)	13.0 (12.4)	15.9 (15.9)	10.47
Mean of	All	138 (139)	13.6 (12.9)	15.3 (15.3)	10.70
Significant x of y times:			6 / 7		

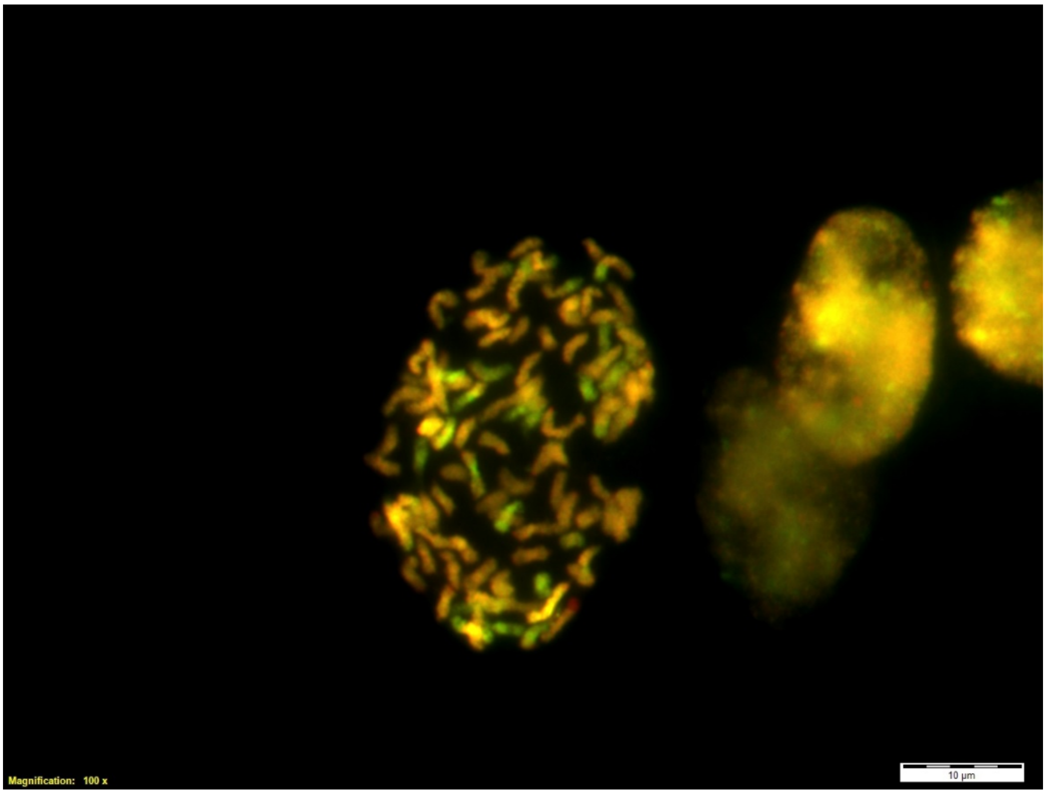
End of 2015 Series

12.4. Appendix 4 Examples of GISH metaphase cells

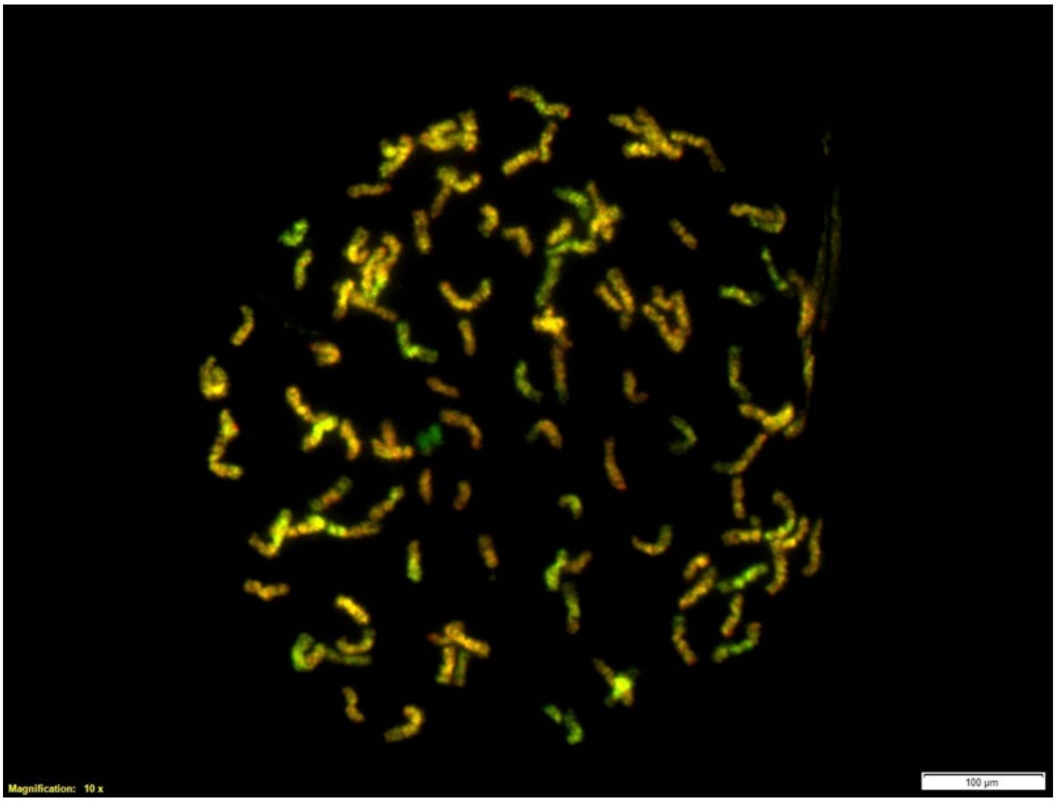
Co740



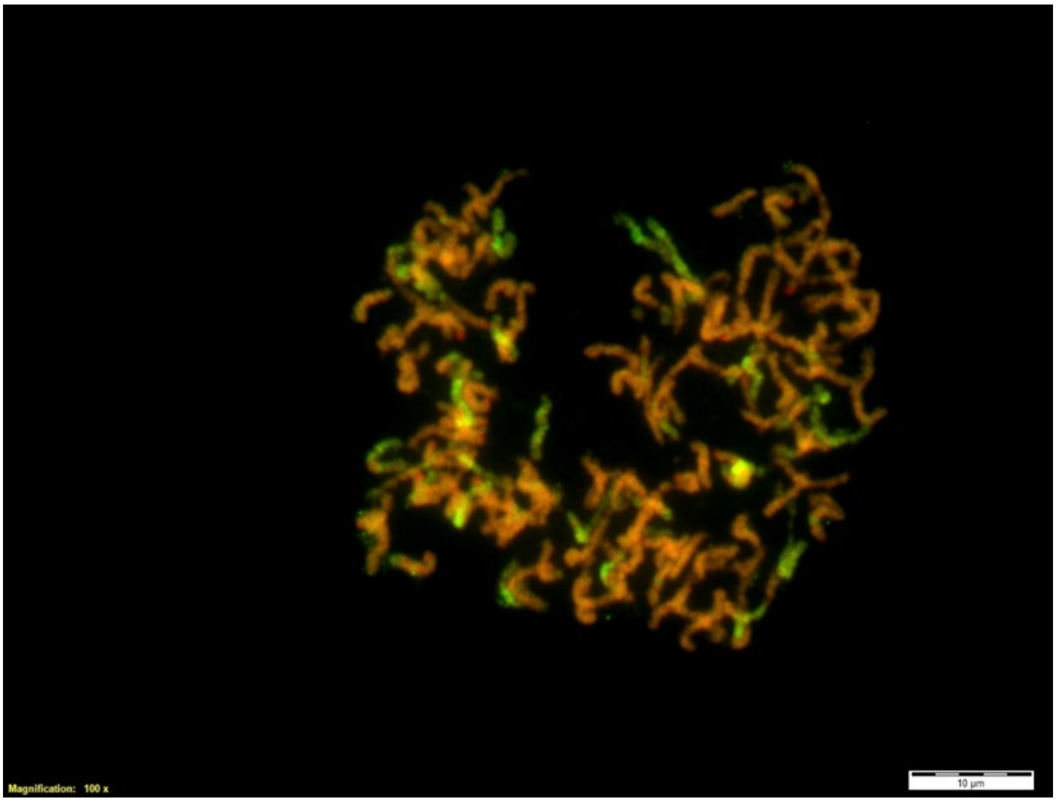
TRITON



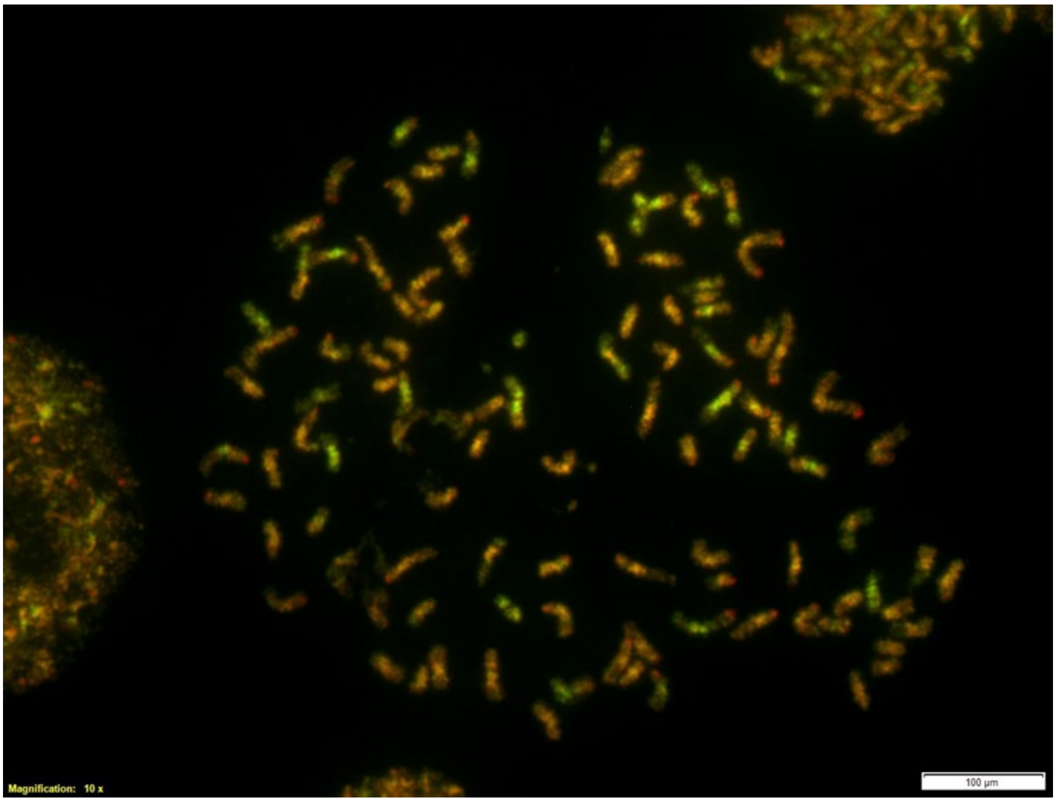
EMPIRE



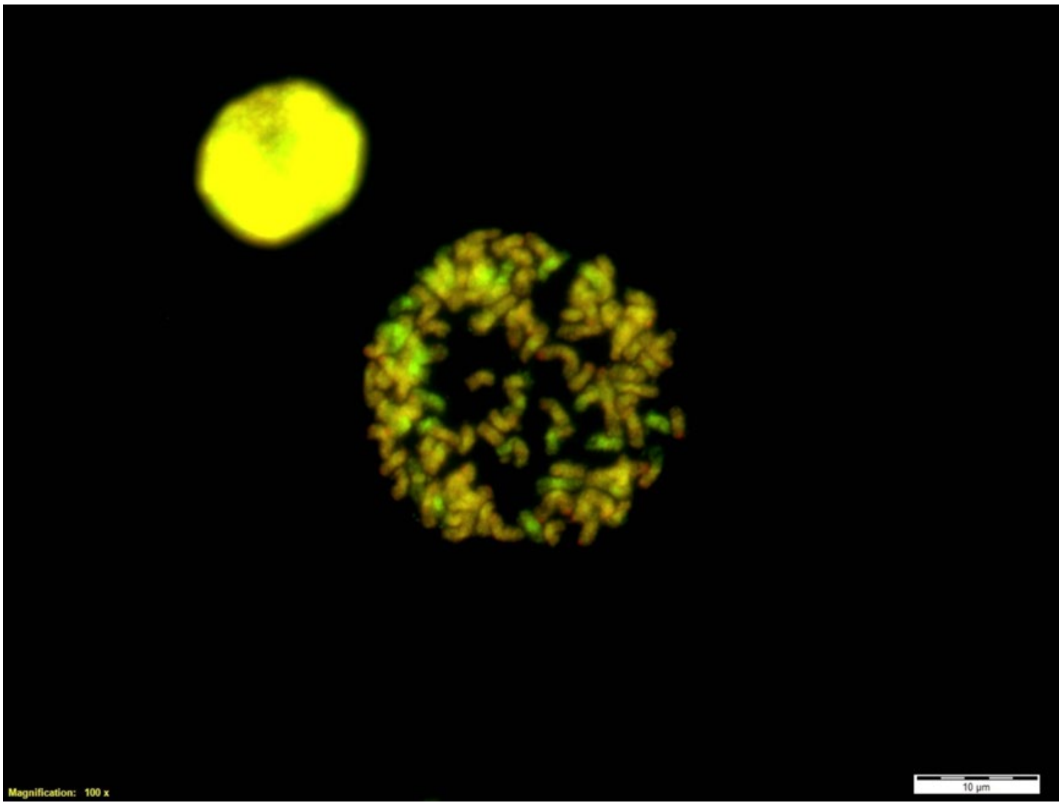
SRA1



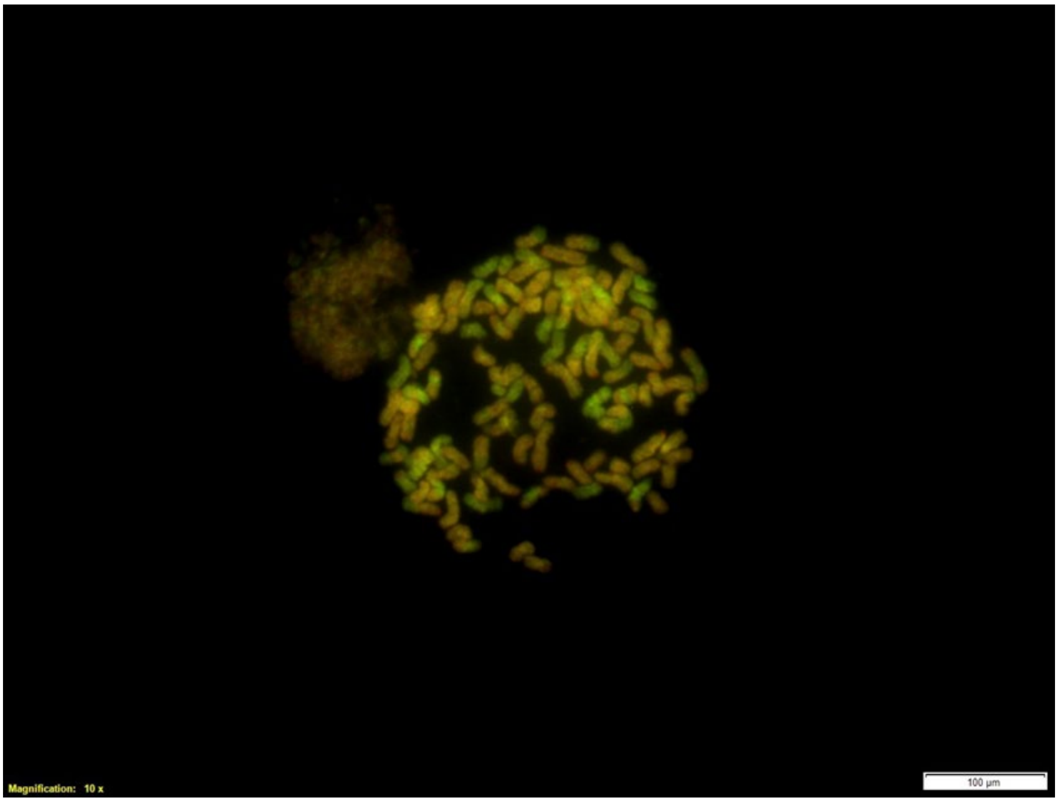
Q242



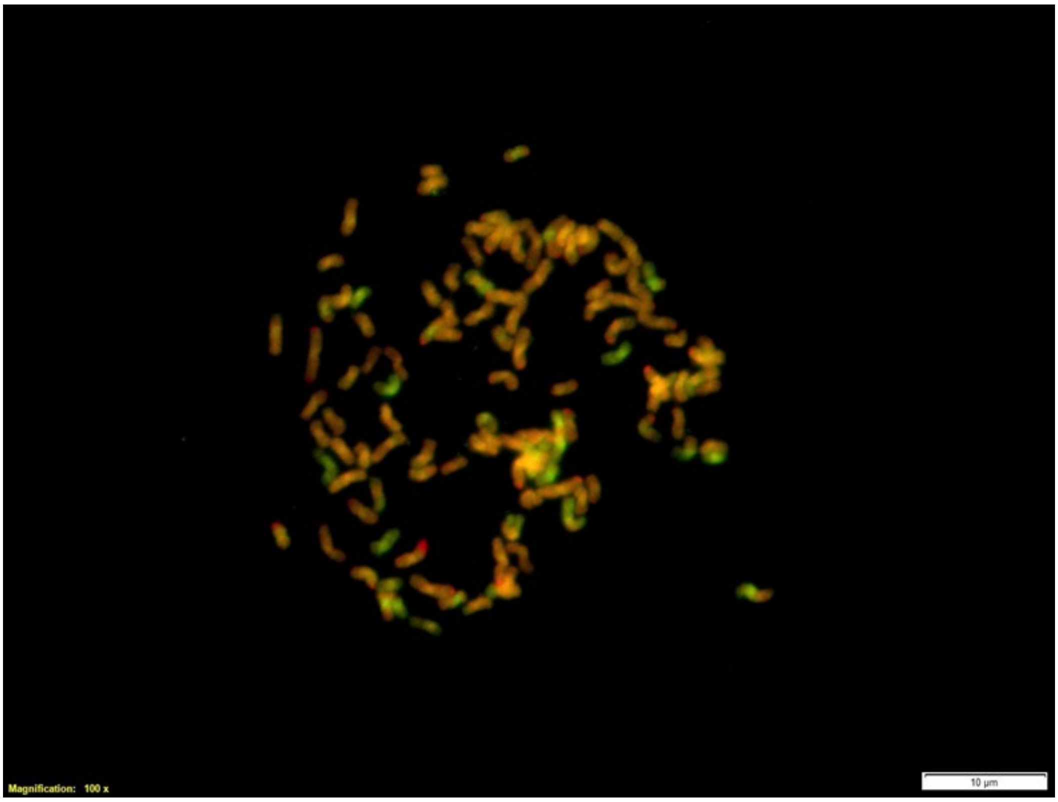
Q157



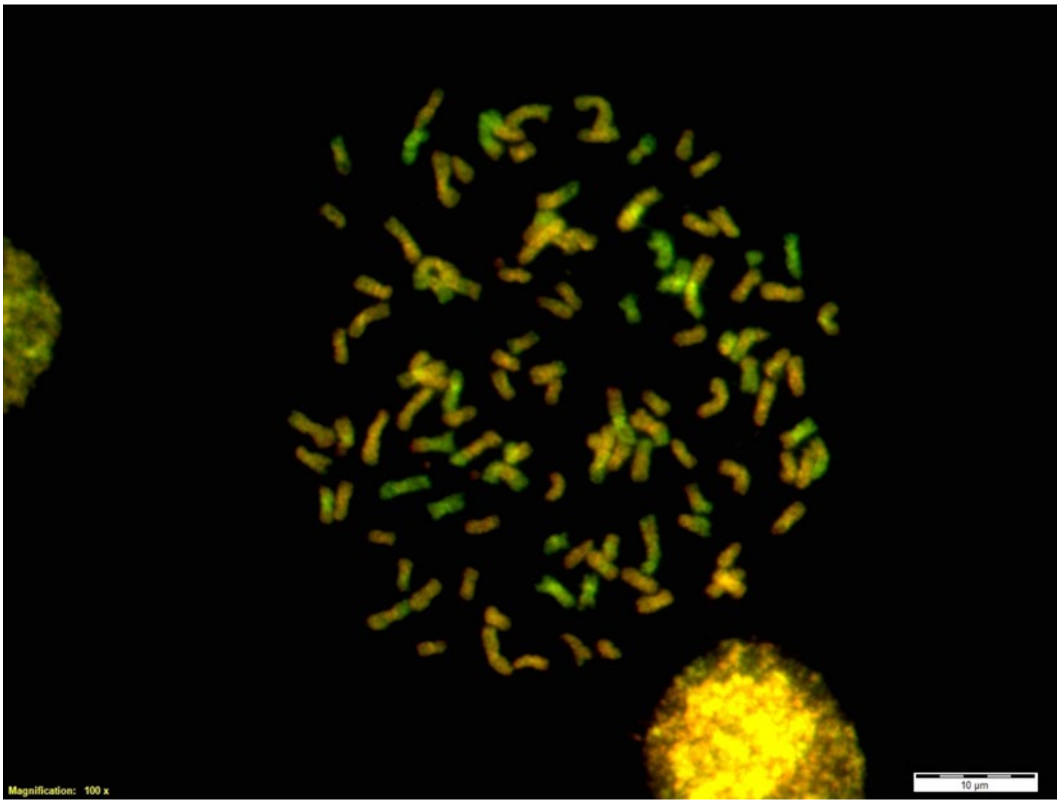
Q232



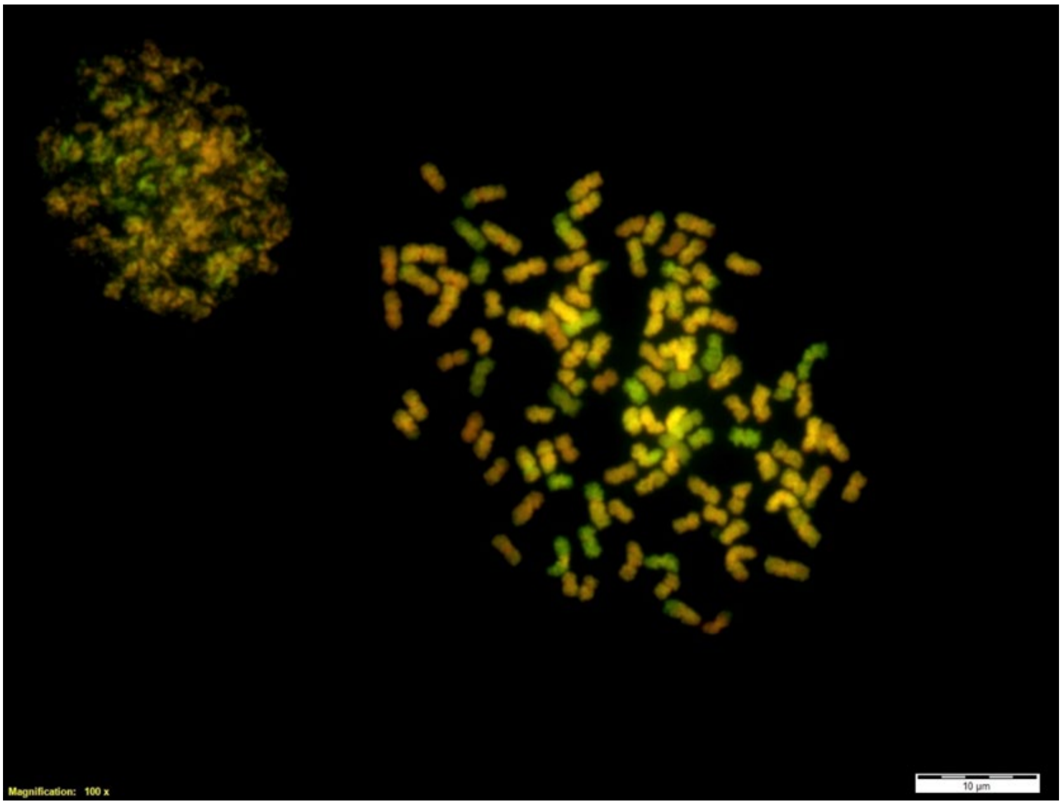
Q211



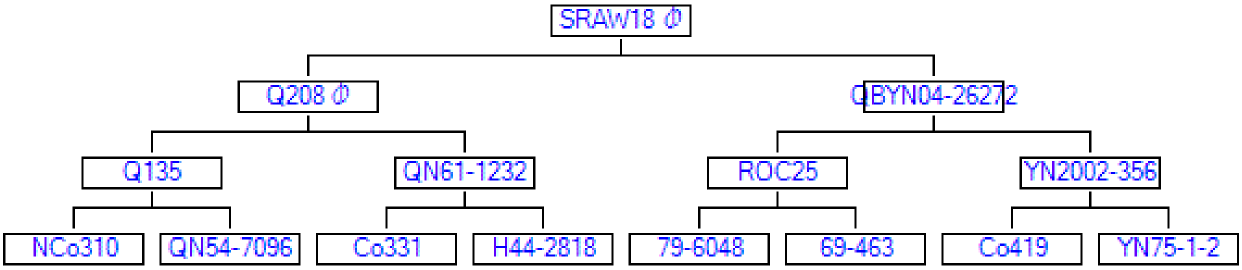
KQ228

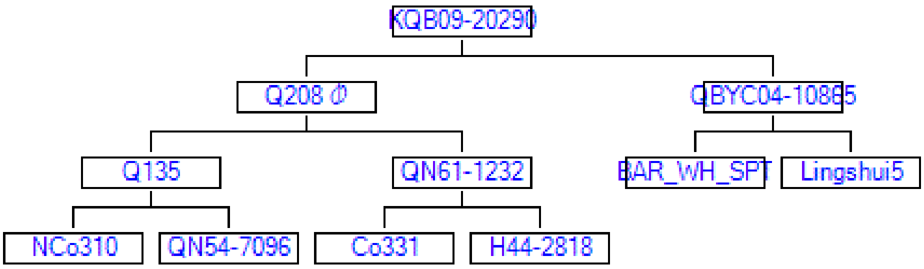


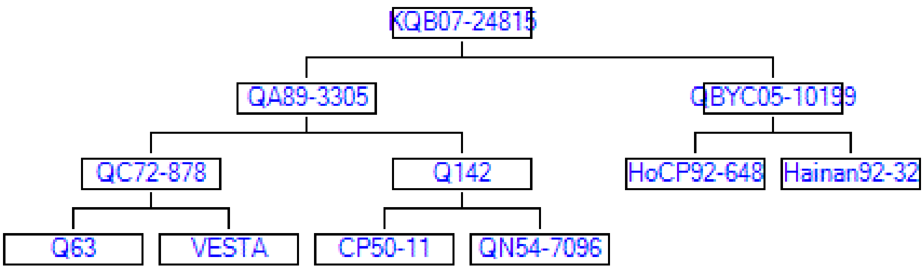
Q208

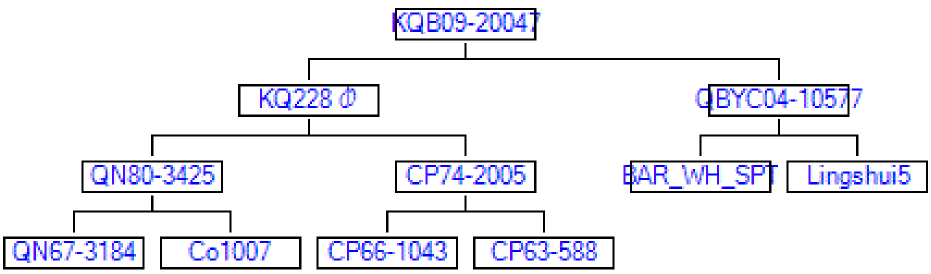


12.5. Appendix 5 Pedegree of SRAW18, KQB09-20290, KQB07-24815 and KQB09-20047

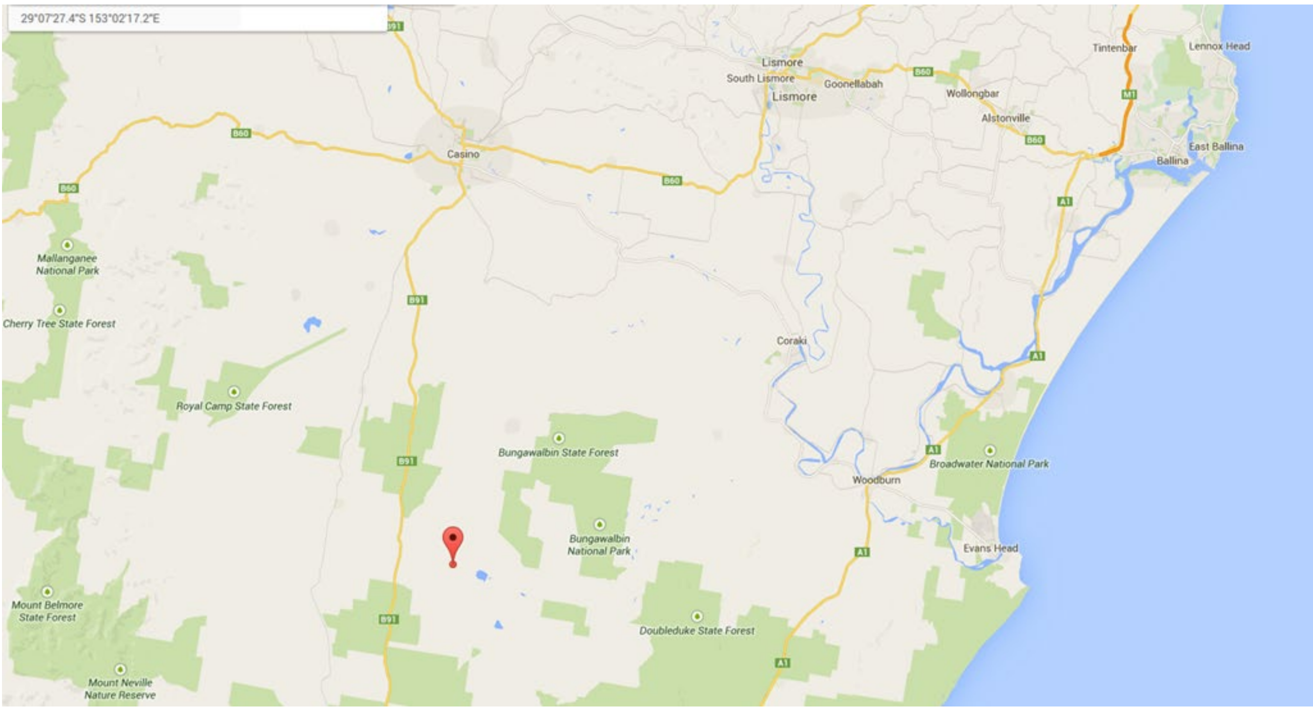








12.6. Appendix 6 Location map of the Frost Observation Plots established in 2014 and 2015 at Main Camp



12.7. Appendix 7 List of clones included in the 2014 NSW Frost Observation Plots

Clone	Female Parent	Male Parent	Type
BN81-1394	NCo310	VESTA	Standard
BN83-3120	NCo310	MQ76-752	Standard
EMPIRE	Unknown	Unknown	Standard
Ho06-537	HoCP92-624	HOCP96-540	USA variety
Ho06-563	TucCP77-42	HoCP01-553	USA variety
Ho07-612	HoCP01-558	TucCP77-42	USA variety
Ho07-613	HoCP00-905	HOCP96-540	USA variety
Ho08-706	HoCP02-625	HoCP02-642	USA variety
Ho08-717	HoCP00-960	LCP85-384	USA variety
HoCP04-838	HoCP85-845	LCP85-384	USA variety
HoCP05-902	HoCP95-950	HOCP96-540	USA variety
HoL08-723	HoCP89-846	HOCP96-540	USA variety
KQ08-1046	QN80-3425	QBYC06-30138	BC3 (*E.arundinaceus*)
KQ08-1134	Q208	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-1144	Q208	QBYC06-30280	BC3 (*E.arundinaceus*)
KQ08-1201	QN80-3425	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-1231	QN80-3425	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-1348	QN80-3425	QBYC06-30415	BC3 (*E.arundinaceus*)
KQ08-1391	QN80-3425	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-2408	Q208	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-2664	Q208	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-2838	Q208	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ228	QN80-3425	CP74-2005	Standard
KQB07-23864	KQ228	MQB89-12554	BC1 (*S.spontaneum*)
KQB07-23989	Q208	MQB89-12212	BC1 (*S.spontaneum*)
KQB07-23990	Q208	MQB89-12212	BC1 (*S.spontaneum*)
KQB07-24524	Q171	QBYN04-10357	BC2 (*S.spontaneum*)
KQB07-33647	QN80-3425	QBYN04-26272	BC2 (*S.spontaneum*)
KQB07-34148	QC83-625	QBYC05-20720	BC2 (*S.spontaneum*)
KQB07-34350	Q208	QBYN04-26272	BC1 (*S.spontaneum*)
KQB09-20048	KQ228	QBYC04-10577	BC1 (*S.spontaneum*)
KQB09-20290	Q208	QBYC04-10865	BC1 (*S.spontaneum*)
KQB09-20328	KQ228	QBYN04-10472	BC1 (*S.spontaneum*)
KQB09-20432	KQ228	QBYN05-10390	BC1 (*S.spontaneum*)
KQB09-20485	KQ228	QBYC04-10577	BC1 (*S.spontaneum*)
KQB09-20624	KQ228	QBYN05-10420	BC1 (*S.spontaneum*)
N12	NCo376	Co331	Sth African variety
Q193	CP51-21	Q121	Standard
Q200	QN63-1700	QN66-2008	Standard
Q203	F146	CP28-11	Standard
Q208	Q135	QN61-1232	Standard
Q211	Q138	H56-752	Standard
Q232	QN80-3425	QS72-732	Standard
Q240	QN81-289	SP78-3137	Standard
Q242	Q170	Q150	Standard
QBYC06-30376	ROC20	YCE01-102	BC2 (*E.arundinaceus*)
QBYN04-26066	ROC25	YN2002-356	BC1 (*S.spontaneum*)
QS00-256	QN80-440	QN89-1043	NSW core program
QS03-2717	QS92-206	QS87-7430	NSW core program
QS05-2595	QN86-2139	QC90-289	NSW core program
QS99-1315	QS83-1051	QS87-7427	NSW core program
QS99-2637	Q224	Q150	NSW core program

12.8. Appendix 8 List of clones included in the 2015 NSW Frost Observation Plots

Clone	Female Parent	Male Parent	Type
BN81-1394	NCo310	VESTA	Standard
BN83-3120	NCo310	MQ76-752	Standard
BR95-16	UCW5465	POLYCROSS	Foreign exchange (Dominican Republic)
CG01-27	Co270	POLYCROSS	Foreign exchange (Guatemala)
CR00-26	CR78-51	CR74-250	Foreign exchange (Dominican Republic)
CTC4	SP83-5073	POLYCROSS	Foreign exchange (Brazil)
EMPIRE	Unknown	Unknown	Standard
HoCP08-726	L97-128	HOCP96-540	Foreign exchange (USA)
KQ08-1073	Q208	QBYC06-30296	BC3 (*E.arundinaceus*)
KQ08-1076	Q208	QBYC06-30296	BC3 (*E.arundinaceus*)
KQ08-1158	QN80-3425	QBYC06-30296	BC3 (*E.arundinaceus*)
KQ08-1287	Q208	QBYC06-30296	BC3 (*E.arundinaceus*)
KQ08-1296	MQ239	QBYC06-30413	BC3 (*E.arundinaceus*)
KQ08-1306	QN80-3425	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-1329	Q208	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-1389	QN80-3425	QBYC06-30376	BC3 (*E.arundinaceus*)
KQ08-2552	Q208	QBYC06-30296	BC3 (*E.arundinaceus*)
KQ08-2744	QN80-3425	QBYC06-30296	BC3 (*E.arundinaceus*)
KQ08-2850	QBYC06-30101	MQ239	BC3 (*E.arundinaceus*)
KQ08-2859	Q208	QBYC06-30296	BC3 (*E.arundinaceus*)
KQ08-2915	QBYC06-30101	N29	BC3 (*E.arundinaceus*)
KQ08-3482	Q208	MQ239	BC3 (*E.arundinaceus*)
KQ228	QN80-3425	CP74-2005	Standard
KQB07-23930	Q171	QBYN04-10357	BC1 (*S.spontaneum*)
KQB07-23976	Q208	MQB88-10825	BC1 (*S.spontaneum*)
KQB07-23980	Q208	MQB88-10825	BC2 (*S.spontaneum*)
KQB07-23981	Q208	MQB88-10825	BC1 (*S.spontaneum*)
KQB07-24260	Q208	QBYN04-10357	BC1 (*S.spontaneum*)
KQB07-24644	KQ228	MQB89-12336	BC1 (*S.robustum*)
KQB07-24815	QA89-3305	QBYC05-10199	BC1 (*S.spontaneum*)
KQB07-33307	QN80-3425	QBYN04-20250	BC2 (*S.spontaneum*)
KQB07-34851	QBYN05-20830	KQ228	BC2 (*S.spontaneum*)
KQB07-34872	Q208	QBYC05-20681	BC2 (*S.spontaneum*)
KQB08-32673	QBYN04-26073	QC91-580	BC2 (*S.spontaneum*)
KQB09-20047	KQ228	QBYC04-10577	BC1 (*S.spontaneum*)
KQB09-20424	KQ228	QBYN05-10390	BC1 (*S.spontaneum*)
KQB09-20434	Q208	QBYN05-10420	BC1 (*S.spontaneum*)
KQB09-20481	KQ228	QBYC04-10577	BC1 (*S.spontaneum*)
KQB09-20497	KQ228	QBYC04-10577	BC1 (*S.spontaneum*)
KQB09-23126	QC90-353	MQB89-12216	BC1 (*S.spontaneum*)
KQB09-30026	QBYN05-20643	QBYN05-10383	BC2 (*S.spontaneum*)
KQB09-30110	QBYC05-20721	QC91-580	BC2 (*S.spontaneum*)
Q193	CP51-21	Q121	Standard
Q200	QN63-1700	QN66-2008	Standard
Q203	F146	CP28-11	Standard
Q208	Q135	QN61-1232	Standard
Q211	Q138	H56-752	Standard
Q232	QN80-3425	QS72-732	Standard
Q240	QN81-289	SP78-3137	Standard
Q242	Q170	Q150	Standard
Q252	Q208	Q96	NSW core program
QC02-6007	QC83-625	Q170	NSW core program
QC99-1062	QN81-289	QC75-139	NSW core program
QS04-259	QC83-625	QC91-3511	NSW core program
QS07-7665	QA92-1037	QA85-2234	NSW core program
QS07-7743	QA93-2768	QN90-6006	NSW core program
QS07-8183	QC93-1067	QN88-193	NSW core program
QS07-8545	QN83-434	QN88-650	NSW core program
QS07-9802	R580	QS84-1225	NSW core program
QS08-716	QC83-625	H84-778	NSW core program

PROGRAM MANAGER'S RECOMMENDATION

(To be completed by the SRA-RFU Program Manager)

Milestone Number			
Milestone Title	Final Report		
Final Report Due Date		**Date submitted**	
		Date of submission of revised version (if relevant)	
Date Reviewed		**Date of review of revised version (if relevant)**	
Reason for delay **(if relevant)**			
Milestone Payment			
Total Project Funding by SRA-RFU			
Project Objectives **(Contracted)**			
Success in achieving the objectives	☒ Completely Achieved ☐ Partially Achieved ☐ Not Achieved		

Program Manager's Comments:

Project Outputs (brief version)

Activities to further develop, disseminate, commercialise or exploit the Project Outputs (after discussion with CI)

Recommendation:

ABSTRACT

Body Copy here

<Delete these guidelines prior to submission. Please do not change font styles. Abstract should provide a non-confidential plain-English summary of the project findings and implications in a form that can be communicated to industry and the media. What is that take home message? Maximum of 250 words.>

EXECUTIVE SUMMARY

Body Copy here

<Delete these guidelines prior to submission. Please do not change font styles. Executive summary should provide a non-technical overview of the project, outlining achievements in a form that can be communicated to the industry. It should not be more than 800 words. It should cover the following:

a) *Issue and objectives: What is the industry/community issue, what is 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 outputs (i.e. knowledge, skills, processes, practices, products and/or technology).*
d) *The outcomes and implications of the project findings on the sugar industry and the Australian community. Identify the industry benefits that will arise from the work. If possible, identify or estimate the realised/expected net benefits in terms of social, environmental and economic impact, and the realised/expected adoption of outputs. Indicate who will benefit from this research and where they are located in Australia.>*

CONTENTS

TABLE OF TABLES

<Insert Table of Figures here if required. Use “References > Insert Table of Figures”. Delete if not required.>

TABLE OF FIGURES

1 BACKGROUND (Heading 1)

1.1 (Heading 2)

Body Copy here

1.1.1 *Sub heading (Heading 3)*

Body Copy

1.1.1.1 (Heading 4)

Body Copy

1.1.1.1.1 (Heading 5)

Body Copy here

- Body Bullets
- Bullets
-

<Delete these guidelines prior to submission. Please do not change font styles. The background includes technical information and existing knowledge concerning the problem or research need addressed by the project. This section should provide a background and context of the project including

a) Why it was undertaken?
b) Its significance to the industry.
c) How this project builds on previous research.>

2 PROJECT OBJECTIVES (Heading 1)

2.1 (Heading 2)

Body Copy here

2.1.1 *Subheading (Heading 3)*

<Delete these guidelines prior to submission. Please do not change font styles. This section must state the project objectives as worded in the research agreement.>

3 OUTPUTS, OUTCOMES AND IMPLICATIONS (Heading 1)

3.1 Outputs (Heading 2)

Body Copy here

3.1.1 *Heading 3*

<Delete these guidelines prior to submission. Please do not change font styles. This section should address the delivery of the project outputs identified at contracting and the adoption pathway of these outputs. Identify other outputs if applicable. Include the following:

a) Detail further development (if any) of the output(s) that is required prior to adoption (for example, another project).
b) Identify the target adoption audience of project outputs and detail how much adoption, if any, has taken place so far.
c) If a third party or commercial party has been identified or will be required, please detail.>

3.2 Outcomes and Implications

Body Copy here

<Delete these guidelines prior to submission. Please do not change font styles. Address the outcomes (use and application of project outputs) and benefits (impact) of the project. Detail the implications and/or estimate the potential impact quantitatively

and where, how and when these impacts have occurred or may occur. Address industry, environmental and social implications.>

4 INDUSTRY COMMUNICATION AND ENGAGEMENT

4.1 Industry engagement during course of project

Body Copy here

<Delete these guidelines prior to submission. Please do not change font styles. This section should answer the following:

a) What key messages have come from the project to date, when and how have they been communicated and to whom? List the communication activities thus far. Has there been any communication with the relevant SRA Adoption Officer or Unit?
b) What information, if any, is available on the adoption of project outputs?
c) List any upcoming meetings, seminars, field days etc. associated with the project with a description.>

4.2 Industry communication messages

Body Copy here

<Delete these guidelines prior to submission. Please do not change font styles. This section should explain the industry and/or community communication message as a result of the project findings.>

5 METHODOLOGY

5.1 Heading 2

Body Copy here

<Delete these guidelines prior to submission. Please do not change font styles. Describe succinctly the key activities, methodologies used and experiments conducted during the course of this project to deliver the research outputs and achieve project objectives. This section should provide a full description of how the project was conducted including experimental design(s), measurements and statistical analysis.>

6 RESULTS AND DISCUSSION

6.1 Heading 2

Body Copy here

<Delete these guidelines prior to submission. Please do not change font styles. The results and discussion should include an overview of data and other relevant results. This section should include datasets with appropriate analysis. Use of graphs and tables to summarise data is encouraged. Project data should be included as an appendix. Full consideration and interpretation of the results is required. Structure should be clear and concise.

The discussion must 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. The discussion should also include:

a) Inferences and insights from the data relative to previous research.
b) What didn't work and what could have been done to improve project delivery.>

7 CONCLUSIONS

Body Copy here

<Delete these guidelines prior to submission. Conclusion goes here.>

8 RECOMMENDATIONS FOR FURTHER RD&A

What is needed, if anything, to further develop, disseminate, commercialise or exploit the Project Outputs?

What additional research is recommended to fully address the project objectives?

9 PUBLICATIONS

Body Copy here

<Delete these guidelines prior to submission. Please do not change font styles. List any academic publications or project publications (e.g. a manual or booklet) that have been published or are expected as a result of this project. Please do not attach journal articles or deep link to pdfs. Rather, provide the journal article Digital Object Identifier (DOI) if available.>

10 ACKNOWLEDGEMENTS

Body Copy here

<Delete these guidelines prior to submission. Please cite acknowledgements here.>

TABLE HEADING STYLE (PLEASE USE "TABLE HEADING" STYLE FOR TABLES)

TABLE DATA HEADING		
Table Data		

Figure Heading (Heading 6, Figure)
Figure Caption (Caption, SRA Caption

11 REFERENCES

Body Copy here

<Delete these guidelines prior to submission. Please do not change font styles. Provide full alphabetised reference list as per Harvard reference guidelines.>

12 APPENDIX

12.1 Appendix 1 METADATA DISCLOSURE

<Delete these guidelines prior to submission. Please do not change font styles. Fill in the following details regarding the data generated in the course of this project. Provide details about the location, accessibility and contact details of those managing the data. Delete if not required.>

TABLE 11 METADATA DISCLOSURE 1

Data	(Description)
Stored Location	(I.e. organisation and server)
Access	(I.e. publically accessible or restricted? Please provide details.)
Contact	(I.e. Details of person/position with access)

TABLE 12 METADATA DISCLOSURE 2

Data	(Description)
Stored Location	(I.e. organisation and server)
Access	(I.e. publically accessible or restricted? Please provide details.)
Contact	(I.e. Details of person/position with access)

12.2 Appendix 2

13 SRA-RMS MANAGER, RESEARCH MISSIONS' RECOMMENDATION

(To be completed by the SRA-RMS Manager, Research Missions)

<table>
<tr><td>Milestone Number</td><td colspan="3"></td></tr>
<tr><td>Milestone Title</td><td colspan="3">Final Report</td></tr>
<tr><td rowspan="2">Final Report Due Date</td><td rowspan="2"></td><td>Date submitted</td><td></td></tr>
<tr><td>Date of submission of revised version (if relevant)</td><td></td></tr>
<tr><td>Date Reviewed</td><td></td><td>Date of review of revised version (if relevant)</td><td></td></tr>
<tr><td>Reason for delay (if relevant)</td><td colspan="3"></td></tr>
<tr><td>Milestone Payment</td><td colspan="3"></td></tr>
<tr><td>Total Project Funding by SRA-RMS</td><td colspan="3"></td></tr>
<tr><td>Project Objectives (Contracted)</td><td colspan="3"></td></tr>
<tr><td>Success in achieving the objectives</td><td colspan="3">☒ Completely Achieved
☐ Partially Achieved
☐ Not Achieved</td></tr>
</table>

SRA-RMS Manager, Research Missions' Comments:

Project Outputs (brief version)

Activities to further develop, disseminate, commercialise or exploit the Project Outputs (after discussion with CI)

Recommendation: