Maximising genetic gain from family and within family selection

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Sugar Research Australia

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SRA Research Project Final Report

SRA Project Code	**2011343**
Project Title	Maximising genetic gain from family and within family selection
Key Focus Area in SRA Strategic Plan	KFA1 – Optimally-adapted varieties, plant breeding and release
Research Organisation(s)	Sugar Research Australia Ltd
Chief Investigator(s)	Roy Parfitt, Xianming Wei and Joanne Stringer
Project Objectives	The aim of this project is to improve the effectiveness and efficiency of selection in progeny assessment trials (PATs). These improvements will result in increased rates of genetic gain and the release of more productive varieties for the Australian sugarcane industry. Specifically, the objectives are to: 1. Optimise among-family selection through the development of statistical models to account for competition among families; 2. Optimise within-family selection through individual selection for commercial cane sugar (CCS) and smut resistance with modified field selection schemes.
SRA measures of success for Key Focus Area (from SRA Strategic Plan)	• Three varieties which meet expectations released per 5-year period for each region. • Percent production from new varieties (<7 years since release). • Rate of genetic gain (tonnes of cane per hectare (TCH), commercial cane sugar (CCS), tonnes of sugar per hectare (TSH)). • Weighted average disease ratings for varieties in each region.

PART A
To be completed by the Chief Investigator

Section 1: Executive Summary

(Maximum 800 words)
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?*

Varieties are the cornerstone of all sugarcane production systems. The development of improved varieties (yield, quality & disease resistance), is critical to maintain profitability of all industry sectors. Furthermore, the best return on the research investment in plant improvement by the Australian industry is important. To achieve on-going improvement and efficiency, present methodology needs to be reviewed as new technology becomes available and as changes in the plant breeding program (population structure/dynamics; gene frequencies; environment) occur. This project was designed to address/review three specific components (competition, CCS and smut inoculation) in the early stages of the SRA plant breeding program.

b) *R&D Methodology: Succinctly explain the methodology, and indicate the extent of collaboration and/or partnerships, especially with end users.*

Three new and current selection methodologies (competition, CCS and smut inoculation) were completed in PATs (stage 1 of the selection program) and selections from these current and new methods were either planted into CATs (stage 2 of the selection program) or smut screening trials. Yield and quality results from the CATs and smut ratings from the screening trials would indicate the advantage of the new method over the current. This advantage together with the cost of attaining this benefit would be used by researchers in deciding implementation of the new methods.

The project has been a collaborative effort among SRA plant breeding, pathology and biometry staff. Results will be communicated to and potentially incorporated into all SRA selection programs.

c) *The project deliverables i.e. outputs (knowledge, skills, processes, practices, products and technology)*

The specific project objectives were:

i) To improve the effectiveness and efficiency of family selection through the development of advanced statistical models to account for competition among families in PATs.

ii) To improve within-family selection through individual selection for CCS and smut resistance with modified field selection schemes.

Outputs achieved:

i)   Statistical model accounting for family competition effects in PATs developed.

ii)   Methods for assessing and selecting individual seedlings based on CCS.

iii) Procedure and practice to inoculate core seedlings with smut prior to planting in PATs.

iv)   Training and development of staff.

v)   Knowledge on selection method efficiency/ effectiveness at the family stage of the selection program.

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.*

The ultimate aim of this project is to be more efficient and effective in developing new improved varieties for the Australian industry. This is central to key focus area 1: Optimally-adapted varieties, plant breeding and release.

The major outcome of this project to date is new knowledge on family and within-family selection methods at stage 1 of the SRA selection program. Results recently acquired from trials still need to be shared and debated amongst breeders, researchers and technicians. Benefits from implementing certain new methodologies assessed in this project are not that clear for all regions (e.g. smut inoculation of seedlings in the southern region) and possibly require further investigation.   Practical resource constraints still need to be overcome (mobile mills) for implementation of within-family selection for CCS. The knowledge developed in this project will be of benefit to breeders to assist in optimising early stage selection.

The impact of the project outputs on the sugar industry and the Australian community will still take a number of years to realize. The nature of sugarcane breeding is long term and one breeding/ selection cycle typically takes 12 - 14 years. This project focused on stage 1 of the selection program; years 1 - 3.   The long term outcome of this project will be more productive, higher CCS and smut resistant varieties for the Australian sugarcane industry.

Section 2: Background

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

Most sugarcane variety improvement programs start selection in a large population of seedlings. Starting populations can vary in size from ~10,000 to >500,000 seedlings. Selection in original seedlings is primarily to improve the average value of the population by discarding many of the poor clones and retaining most of the superior clones. Selection strategy options at this early stage include individual (mass) selection, family selection, or a combination of family/ individual selection.

By using family as well as individual selection, it is possible to select for all important characters, including those with low individual heritabilities (e.g. cane yield (TCH) and stalk number).

Family and within-family selection has been used routinely in progeny assessment trials (PATs) in the SRA plant breeding program since 1992. Selection involves first selecting the top 40% families based on family mean then selecting clones within these selected families. The mean economic family value ($EFV) is the selection index value used to rank families and includes traits; TCH, CCS and fibre. Selection of individual clones within families is largely based on visual assessment.

This project focussed on two fundamental issues with early stage selection in the SRA variety improvement program:

1. Families are grown in single-row plots and are very likely subject to competition from adjacent plots, specifically for traits such as cane yield. Observed family cane yield is, therefore, a result of combined effects of genetics, competition and other environmental factors. Accounting for the competition effect, using advanced statistical models, would improve the family cane yield estimate. Within this project statistical models based on existing clonal assessment trials (CATs) would be developed to account for the impact of competition among families.

2. Genetic variation within families has not been exploited for CCS and smut resistance. These two characters have a moderate to high individual broad sense heritability and selection on an individual basis should be beneficial (Skinner *et al.*, 1987). Individual selection is logistically difficult in large seedling populations and new methods/equipment to overcome these obstacles would be field trialled in this project.

Benefits from this project would be more productive, higher CCS and smut-resistant varieties for the Australian sugarcane industry. Improved varieties will deliver greater economic benefits to the industry.

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 <u>must</u> 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

This project primarily addressed two key focus area (KFA 1) measures:

1   Rate of genetic gain (tonnes of cane per hectare (TCH), commercial cane sugar (CCS), tonnes of sugar per hectare (TSH)).

2   Weighted average disease ratings for varieties in each region.

Considering the rate of genetic gain for CCS across all regions over the last 30 years, it is alarming that the rate of genetic gain has more or less halved over the last 7 - 8 years (*Figure 1*). There are, however, some regional differences in this trend; the Southern and Burdekin regions having the biggest decline. One of the reasons for this declining rate would be the ongoing genetic improvement in CCS in the SRA breeding program with a resultant decrease in genetic variation for CCS. This current situation highlights the need for alternative methods in the breeding program to better exploit the reducing variation. The rate of genetic gain for TCH has been fairly consistent around 1.1 tonnes/ hectare/ year since 1997.
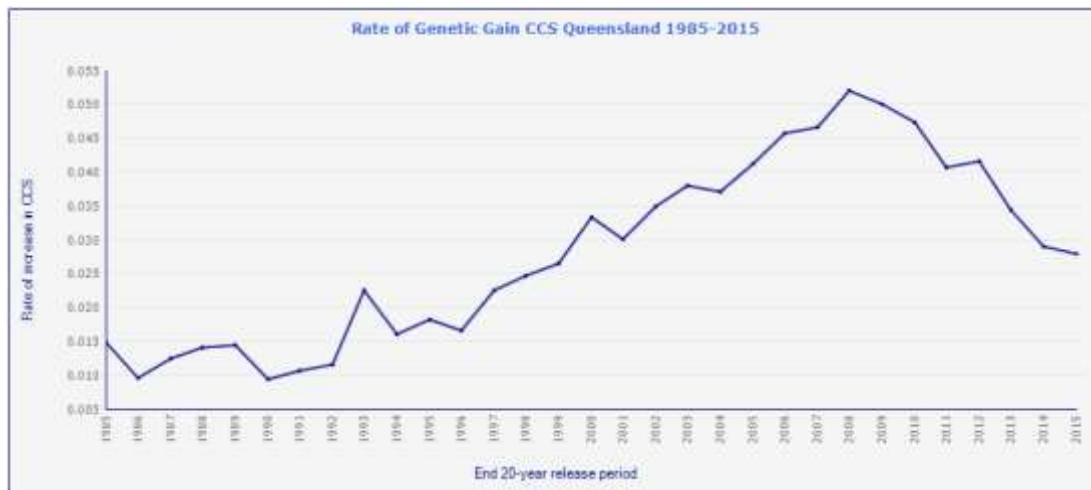
Figure 1: Rate of genetic gain for CCS for Queensland 1985-2015

The weighted average smut rating for varieties across all regions is shown in *Figure 2*. This graph shows remarkable improvement off a high of ~6.6 at the time of the smut incursion/ outbreak in 2006. This reduction in the weighted average smut rating has, however, levelled off at ~3.6 over the last three years. It is desirable to reduce this to an even lower plateau to further reduce the smut inoculum pressure. Susceptible varieties need to be identified and discarded from the selection programs as early as possible and this will require new techniques/ methods to be effective.
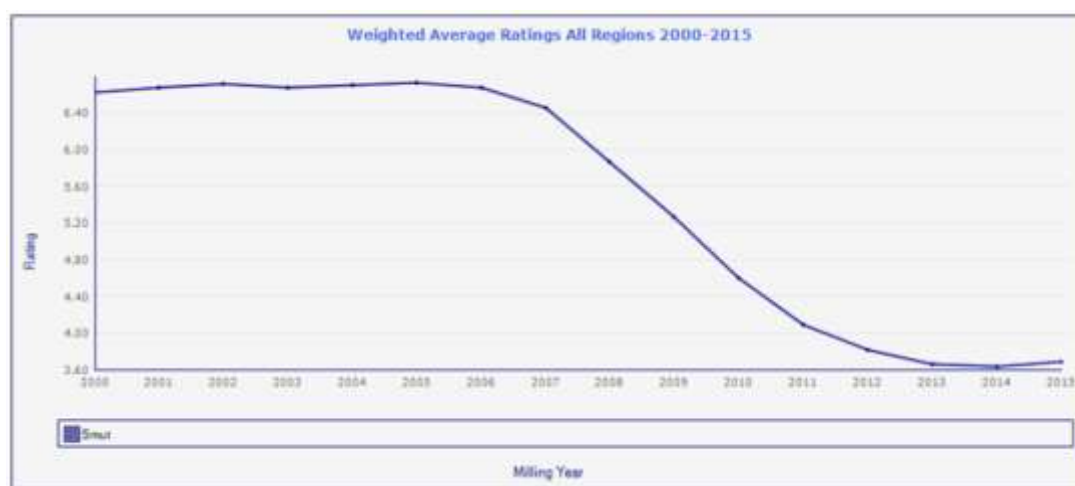
Figure 2: Weighted average smut rating for the whole industry for years 2000 – 2015

The aim of this project was to improve the effectiveness and efficiency of selection in PATs. Improvements would result in increased rates of genetic gain and the release of more

productive and smut resistant varieties for the Australian sugarcane industry. Specifically, the objectives of the project were to:

1. Optimise among-family selection through the development of statistical models to account for competition among families.

2. Optimise within-family selection through individual selection for CCS and smut resistance with modified field selection schemes.

New and current methodologies would be completed in PATs (stage 1 of the selection program) and selections from these current and new methods would be either planted into CATs (stage 2 of the selection program) or smut screening trials. Yield and quality results from the CATs and smut ratings from the screening trials would indicate the advantage of the new method over the current. This advantage together with the cost of attaining this benefit would be used by breeders on deciding on implementation of the new methods.

The project started in 2011 with planting PATs in the Southern and Northern regions. These PATs included a set/ group of families inoculated with smut (new method) and same set/ group of families that were not inoculated (current method) with smut. Clones not showing any smut symptoms were selected from each of these two sets/ groups in the southern and northern PATs and sent for smut screening at SRA Woodford during 2013 and 2014, respectively. The screening results would determine the advantage of inoculating seedlings prior to planting PATs; i.e. would the set/ group inoculated with smut have less susceptible clones than set/group not inoculated. For the competition component of this project, a new statistical model for selecting the top 40% families based on the plant crop PAT data would be assessed. This involved selecting regional PAT families without accounting for competition (current method) and selecting families accounting for competition (new method). Clones from families differentially selected (not in common) using the two methods were planted into CATs in 2013 (Southern) and 2014 (Northern). The yield difference between the set/ group of clones differentially selected using the current or new method would indicate the effectiveness (±) of the new model. The CCS component of this project included a set/ group of top families in each regional PAT from which clones would be selected using visual selection only (current method), and a set/ group of the same families in which clones would be selected on CCS plus visual selection (new method). Selected clones from both these sets/ groups were planted into the two regional CATs and the difference in average CCS of these two sets/ groups would determine the benefit of within family selection for CCS.

Unfortunately, the Southern CAT planted in 2013 failed to germinate satisfactorily due to a number of reasons and was abandoned. This was the first setback for the project and a contingency plan was devised falling back onto two 2013 Southern PATs; MQN13-11 for the CCS component and MQN13-12 for the competition component. The first Southern region replacement CAT containing the CCS component clones was planted in 2014. This CAT (MQN14-21) as well as the two Northern CATs were assessed in 2015 (plant crop) and 2016 (1st ratoon crop). The second Southern region replacement CAT containing the competition component differentially selected clones was planted in 2015.

A milestone variation was requested to extend the project by seven months to enable the plant crop results from this CAT (BIN15-21) to be included. This CAT also had disappointing germination and was only CCS sampled, not weighed. Stalk counts in the clones for the

competition component were completed to get an estimated yield figure. This trial was ploughed out after the plant crop harvest. Extension of the project also allowed the 1st ratoon crop results of the Northern CATs to be included in this report. All the trials planted and harvested as part of this project are listed below in *Table 1*.

Table 1: List of trials planted and harvested (P & 1R) for project 2011343 (2011-2016)

Region	Trial type	Trial code	# clones / families[*]	Date planted	Date harvested Plant	Date harvested 1st ratoon	Notes
Northern	PAT	MUL11-110	239[*]	29-Aug-11	21-Jun-12		
Northern	PAT	MUL11-111	72[*]	24-Aug-11	26-Jun-12		
Northern	PAT	MUL11-113	228[*]	04-Oct-11	15-Nov-12		
Southern	PAT	MQN11-11	218[*]	12-Apr-11	11-Jul-12		
Southern	PAT	MQN11-12	63[*]	13-Apr-11	11-Jul-12		
Southern	PAT	MQN11-13	63[*]	13-Apr-11	11-Jul-12		
Southern	CAT	MQN13-21	2635	25-Nov-13			Abandoned due to poor germination
Southern	PAT	MQN13-11	130[*]	19-Mar-13	na		Addition to MQN11-13 (CCS)
Southern	PAT	MQN13-12	205[*]	05-Jul-13	11-Jul-14		Addition to MQN11-11 (Competition)
Woodford	Smut	SMW13-1	476	23-Sep-13	06-Jan-14	02-May-14	
Northern	Prop	MUL13-242P	1678	16-Jul-13	na		
Northern	CAT	MUL14-224	313	22-Jul-14	30-Jul-15	10-Aug-16	
Northern	CAT	MUL14-238	1092	25-Jul-14	27-Jul-15	15-Aug-16	
Woodford	Smut	SMW14-2	393	17-Sep-14	06-Jan-15	03-Jun-15	
Southern	CAT	MQN14-21	2003	30-Apr-14	18-Jun-15	22-Sep-16	Replacment for MQN13-21 (CCS)
Southern	CAT	BIN15-21	2486	28-Sep-15	19-Aug-16		Replacment for MQN13-21 (Competition)

Smut component

Results obtained, and previously reported, for the smut component of this project (as obtained from smut screening trials) are contrasting for the Northern and Southern regions. Separate analysis of each region indicate no significant gain of inoculating seedlings with smut prior to planting PATs for the Southern region (milestone report 6), but well for the Northern region (milestone report 7). Differences in regional efficiency to lower the average smut rating of selected clones early in the selection program by inoculating seedlings is important to understand prior to implementation. Considering the overall results of the two screening trials (*Table 2*), the Northern region is superior in identifying and discarding smut susceptible clones compared to the Southern region. The Northern region has approximately double the percentage resistant clones and half the amount of susceptible clones compared to the Southern region.

Table 2: Percentage clones rated resistant (2), intermediate (5) and susceptible (8) for smut in project screening trials SMW13-1 (southern clones) and SMW14-2 (northern clones) established at Woodford.

Rating	Screening Trial	
	Southern (SMW13-1)	Northern (SMW14-2)
2	19	49
5	45	31
8	36	20

Results from the 2015 core smut screening trials also show the Northern program being the most successful at selecting resistant (eliminating susceptible) clones from the early selection stages. The percentages in Table 3 show core and SmutBuster clones selected on the plant crop data from regional CATs and rated as resistant, intermediate or susceptible to smut. The Central and Burdekin programs have efficiencies more similar to the Southern program. Irrespective, whether seedlings are inoculated or un-inoculated with smut prior to planting PATs, the northern region has an environment more conducive for clones to develop smut symptoms enabling these clones to be discarded. The cost-benefit of inoculating seedlings with smut is thus going to be region dependent.

Table 3: Percentage CAT tentative selections from four regional programs rated resistant (2), intermediate (5) and susceptible (8) for smut in select 2015 smut screening trials

Rating	Region			
	Central (SMW15-1)	Southern (SMW15-2)	Northern (SMW15-4)	Burdekin (SMW15-6)
2	45	43	66	32
5	28	18	19	29
8	27	39	16	39

Outputs from a combined analysis across both project screening trials using a linear mixed model (SAS) are shown in Appendix 2. The analysis shows a significant difference between regions (N-S), treatment (inoculated-not inoculated) and family within treatment, but no significant difference for treatment x region interaction (p=0.05). For a combined analysis without including families (treatment), the treatment x region interaction was highly significant (p<0.05) (outputs not shown). The combined analysis indicates no significant benefit inoculating seedlings with smut prior to planting PATs irrespective of region, but this benefit will be influenced by the families (genetics) selected to include in PATs.

In the Northern region, smut 'spreader' rows/ plots in PATs (and/ or CATs) could be considered as an alternative to inoculating seedlings with smut. Long term weather forecasts together with the average smut rating of PAT families should be considered when deciding to inoculate seedlings with smut. The additional cost of inoculating seedlings (estimated at ~$5,000) is relatively small and the main consideration for implementing this new method will be the

expected benefit for a regional program. It is recommended that implementation of inoculation seedlings with smut prior to planting PATs be done at a regional level.

Competition component

For the competition component, there was no significant yield difference between the set/ group of clones differentially selected using the current (without competition), or new (with competition) methods in both the Southern and Northern trials. Since the last milestone report, selections to plant into the 2016 (final assessment trial FAT) propagations (to plant 2017 FATs) have been completed and two clones from each of the differentially selected set/ group of families have been selected. These selections were based on the plant and 1st ratoon CAT harvest data (MUL14-224 and MUL14-38). This low number of clones selected to proceed to the third stage of the selection program (FATs) from the differentially selected set/group of families is not surprising as these families rank at the bottom of the 40% families selected using each method.

In hind-sight, possibly the methodology documented to assess the difference between the new and current methods may not have been sufficiently detailed to pick up the small differences. It, however, must be noted that methods used in this project were also chosen for their practicality of implementation in the selection program. The methodology to assess the two models does not take into account the change in ranking of families selected by both methods and subsequent change in percentage of clones selected from each family. Data shown in Figure 3 and Figure 4 indicate the change in ranking of families and change in percentage of clones selected per family, respectively, for the two methods for the 2011 Northern CATs.
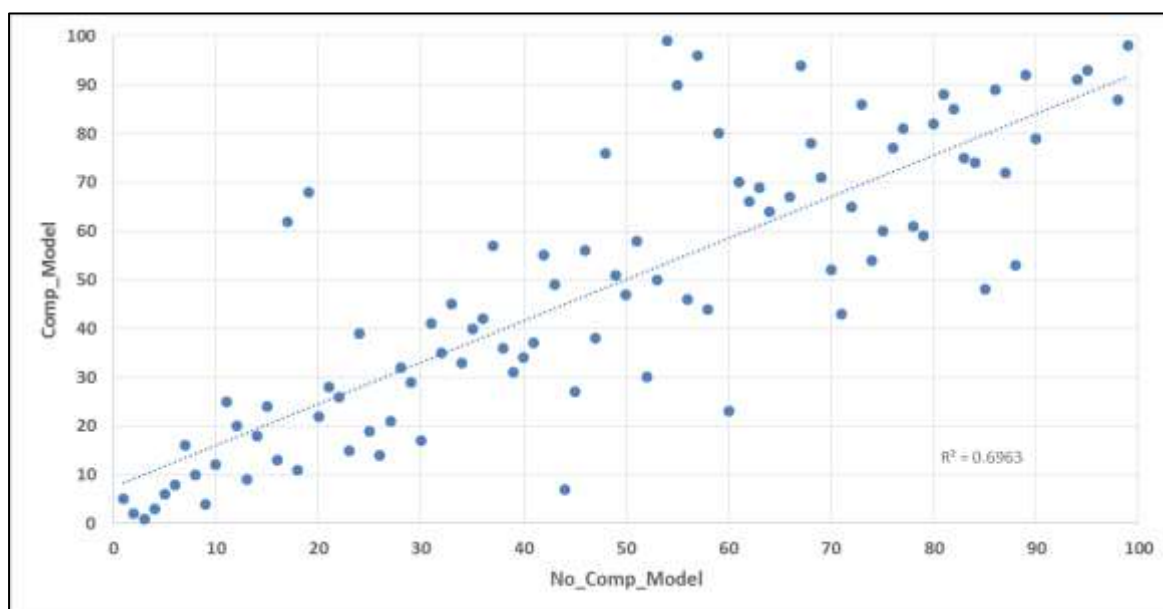

Figure 3: Ranking of families with and without accounting for competition in the 2011 northern PATs
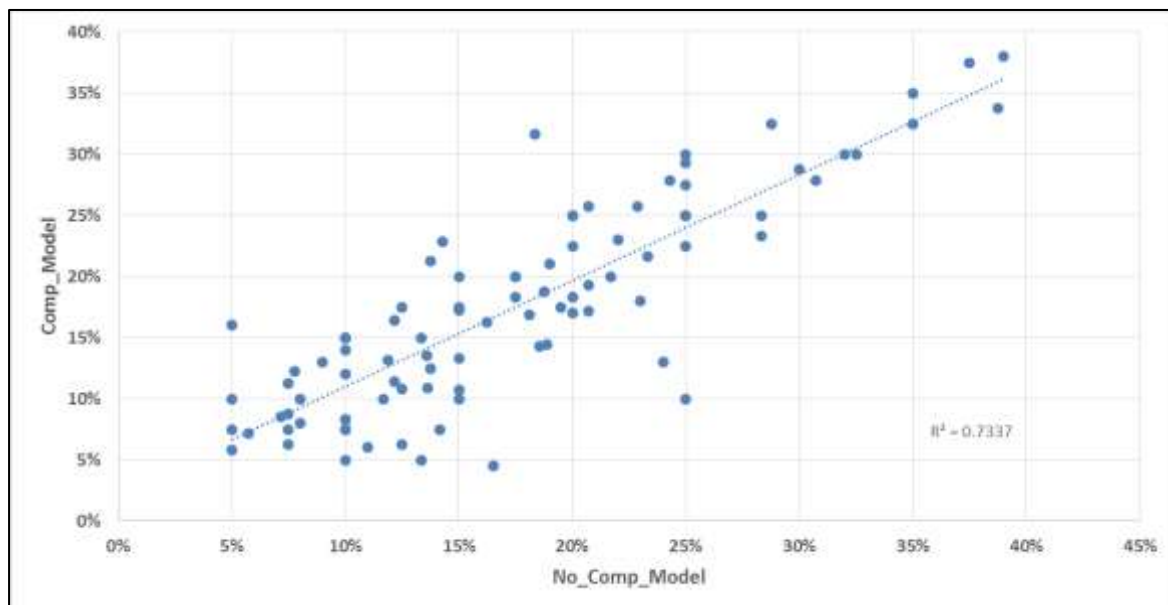
Figure 4: Percentage seedlings selected from each family with and without accounting for competition in the 2011 northern PATs

The impact of the ranking change and selection percentage is dependent on the number of seedlings planted in a PAT. The distribution of the difference in number of selections per family is shown in Figure 5. Some of these differences are quite large; up to 26 clones.

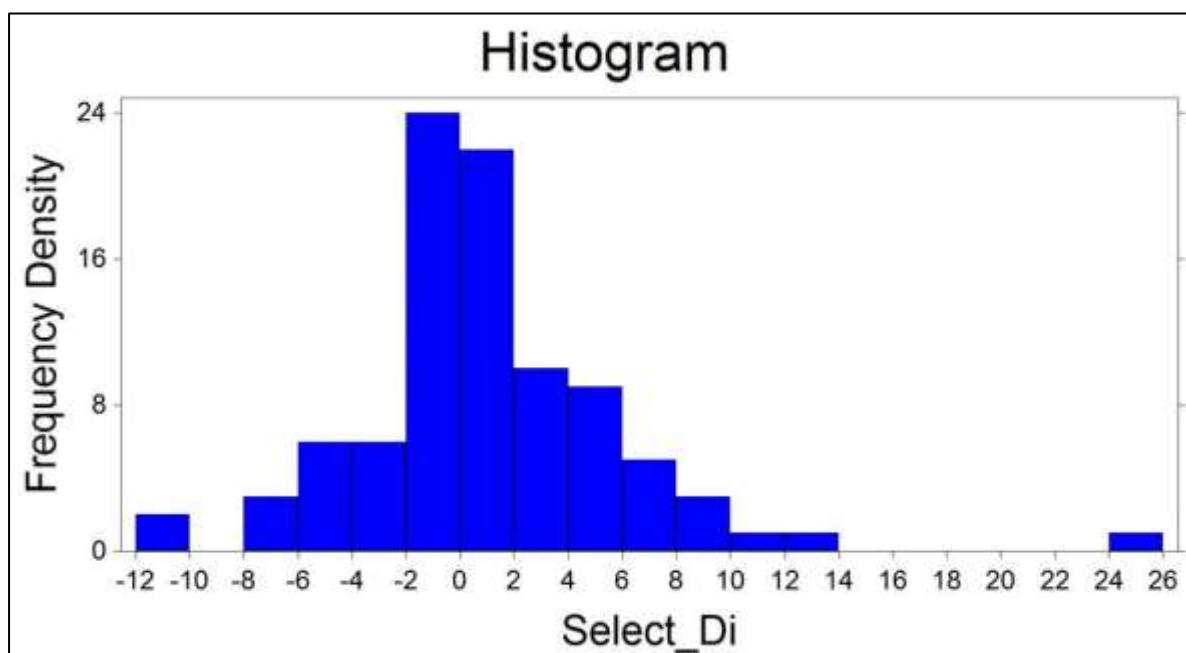**Figure 5: Frequency distribution of difference between number of selections per family with and without accounting for competition in the 2011 northern PATs**

There is no additional cost in running the analysis that takes competition into account compared to the model that does not, except possibly for some computer run time. The benefits, however, are still unclear as the change in number of selections per family using the different models has not been taken into account when comparing the two models. It is thought that the change in number of selections per family would have a greater impact in determining the models performance than the difference between the set/ group of differentially selected families.

Despite the unclear benefits, the competition model has been routinely used for analysing PATs in the SRA breeding program since 2015. Future research will need to be directed at better understanding the benefits of accounting for competition in PATs and improving the competition model.

CCS component

Final selections in the northern CATs based on the plant and 1st ratoon crop data resulted in 29 clones being selected from the CCS component. These clones have been planted in propagation plots and will be included in FATs in 2017. A summary of these selections is shown in Table 4.

Table 4: Average CCS and rEGV for control and treatment sets of clones assessed in northern CATs (P + 1R) and selected to plant in FATs in 2017

Trial	Set	# clones	Mean CCS	Mean rEGV
MUL14-224	Control set (visual)	4	14.38	9.52
MUL14-224	Treatment set (CCS plus visual)	7	14.65	9.73
MUL14-238	Control set (visual)	5	13.67	9.45
MUL14-238	Treatment set (CCS plus visual)	13	14.05	9.42

In both the Northern CATs there are approximately double the number of final selections from the treatment set (CCS plus visual) than the control set (visual only). There was also an improvement of 1.8% and 2.7% in the average CCS of the treatment set above the control set for trials MUL14-224 and MUL14-238, respectively. This is a similar improvement compared to the average plant crop CCS results for all clones in each set reported in milestone 7. The similar rEGV between the two sets for trial MUL14-238 is probably due to selection for high CCS clones (not considering TCH) coming from this set (personal communication with northern breeder: Dr. Felicity Atkin).

The estimated cost of AU$15,000 for an average improvement of ~1.5% in CCS from stage 1 (PATs) to stage 2 (CATs) seems well worth the effort. Critical resources that will influence the adoption of this method are efficient mobile mills and time constraints at the time of this activity. The mobile mills developed for this project did not work satisfactorily and will need re-designing. Activities within an already busy period will need to be prioritized and scheduled accordingly. Progress will need to be continually monitored to make sure cane yield and possibly other traits are not jeopardized.

References

Skinner, J.C., Hogarth, D.M. & Wu, K.K. (1987). Selection methods, criteria, and indices. In D.J. Heinz (Ed.), *Sugarcane Improvement through breeding* (pp. 409-453). Amsterdam, The Netherlands: Elsevier Science Publishers.

SAS/STAT 9.4 User's Guide (2013) SAS Institute Inc, Cary, NC, USA.

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.

Outputs:

1. Statistical model accounting for family competition effects in PATs.

2. Methods for assessing and selecting individual seedlings based on CCS.

3. Procedure and practice to inoculate core seedlings with smut prior to planting in PATs.

4. Training and development of staff.

5. Knowledge on selection method efficiency/ effectiveness at the family stage of the selection program.

Outcomes:

1. The major outcome of this project to date is new knowledge on family and within-family selection methods at the PAT stage of the SRA selection program. The knowledge developed in this project will be of benefit to breeders to guide optimising early stage selection.

2. The long term outcome of this project will be more productive, higher CCS and smut resistant varieties for the Australian sugarcane industry. This will be realised through adoption of more efficient/ effective selection methods at the seedling stage of the selection program.

3. The project has highlighted that there are still some practical/ logistical issues concerning the mobile small mill with in-line refractometer to enable efficient processing of individual seedling samples.

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)

Project milestone reports contain new information/ knowledge regarding early stage selection in a sugarcane breeding program, but no protectable intellectual property. The results/ findings 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?*

There has been very little industry communication, nor adoption of outputs from this project to date.

This is mainly because;

1) Final results for two of the three components of this project have only become available over the last couple of months, and

2) Results/outputs from this project are wholly aimed at breeders and technicians of the SRA regional selection programs.

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

The information generated in this project will be utilised by sugarcane breeders and biometricians in the future as they endeavour to improve early stage selection efficiency and shorten the selection program.

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 to be prepared for presentation at the 2018 ASSCT Conference.

Section 7: Environmental Impact

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

The initial project proposal and all the milestone reports have consistently reported there are no adverse/ beneficial environmental impacts associated with conducting the project and/ or implementing its findings. This understanding has not changed.

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.

There is a concern that the rate of genetic gain for CCS is declining. It is also a concern that the decline in the weighted average smut rating has bottomed out in the last couple of years. This project hoped to address these issues in the early stages of the selection program. The benefits of the new methods assessed in this project are, however, not that clear. The reality is that there is probably going to be varying degrees of success over different years and regions with adopting components of this project. The main recommendation now is that breeders need to get together to discuss the results/ outputs of this project, decide what components to adopt in the selection program, and decide what gaps need to be further investigated.

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.

A poster titled "*Maximising genetic gain from family and within family selection in the Australian sugarcane breeding program*" was presented at the 15th Australasian Plant Breeding Conference held 26 - 29 October 2014 at St Kilda, Victoria (Appendix 1).

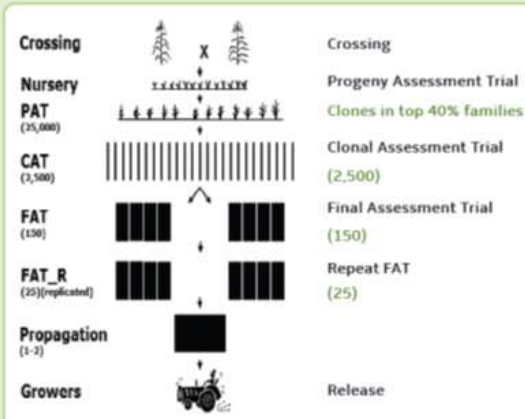# Maximising genetic gain from family and within-family selection in the Australian sugarcane breeding program

Roy Parfitt[1], Richard Cervellin[1], Jo Stringer[2], Shamsul Bhuiyan[3], Felicity Atkin[4] and Mike Cox[1]

[1]Bundaberg, [2]Indooroopilly, [3]Woodford, [4]Meringa

Sugar Research Australia

Sugarcane breeding schematic

|	
Crossing	Crossing
Nursery	
PAT (25,000)	Progeny Assessment Trial — Clones in top 40% families
CAT (2,500)	Clonal Assessment Trial (2,500)
FAT (150)	Final Assessment Trial (150)
FAT_R (25)(replicated)	Repeat FAT (25)
Propagation (1-3)	
Growers	Release

Methods

- **60 Families x 2 Reps x 2 Treatments**
  - 20 clones per family plot
  - 2 locations (Meringa and Bundaberg)
    - Family cane yield adjusted or not adjusted using competition model
    - Clones selected using visual grade or visual grade plus CCS
    - Clones selected from families inoculated and not inoculated with smut
- Clones selected by different selection methods planted to CATs for comparison
- Two sets of selected clones (inoculated and un-inoculated) were screened for smut resistance using standard methods

Introduction/Issues

- **Selection from family trials (PATs) involves:**
  - Identifying top 40% families (family selection)
  - Selecting clones within top families visually (within-family selection)
- **The current system:**
  - Ignores interplot competition for yield in PATs
  - Relies largely on visual assessment to select within the best families
    - No selection for sugar content (CCS)
    - Relies on natural infection for sugarcane smut

Objectives

- **Improve effectiveness and efficiency of selection in PATs**
  - Selection of families with and without competition
  - Optimise within-family selection for CCS and smut

* Ongoing project – further analysis of CAT populations to be completed

Results

- **> 80% families selected using competition model were common to those selected without**
- **Selecting clones using visual grade plus CCS was superior than visual grade alone**
- **Inoculating seedlings for smut increased smut in seedlings but did not show any improvement in CAT populations**
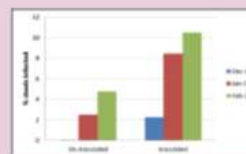
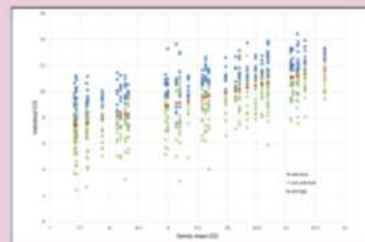**Above:** PAT smut trial - % stools infected with smut in the inoculated and un-inoculated treatments
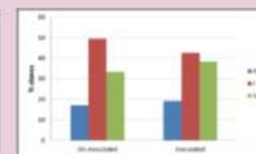
Above: Smut screening trial - % clones selected in PAT that were resistant (R), intermediate (I) or susceptible (S) to smut

Left: Scatter plot of family mean CCS * individual CCS showing clones selected and those not selected

Appendix 2: SAS output on combined northern and southern smut analysis

2011343 trials in Meringa and Bundaberg

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
plantingcode	1	728	9.57	0.0021
Family(Tmt)	92	728	3.08	<.0001
Tmt	1	728	11.62	0.0007
Tmt*plantingcode	1	728	2.93	0.0873

Least Squares Means							
Effect	Tmt	plantingcode	Estimate	Standard Error	DF	t Value	Pr > |t|
Tmt*plantingcode	Control	SMW13-1	5.5377	0.3567	728	15.53	<.0001
Tmt*plantingcode	Control	SMW14-2	4.6752	0.3461	728	13.51	<.0001
Tmt*plantingcode	Inoc	SMW13-1	6.0996	0.5348	728	11.41	<.0001
Tmt*plantingcode	Inoc	SMW14-2	3.0996	0.5392	728	5.75	<.0001

Effect=Tmt*plantingcode   Method=Tukey-Kramer(P<0.05)   Set=1

Obs	Tmt	plantingcode	Estimate	Standard Error	Letter Group
1	Inoc	SMW13-1	6.0996	0.5348	A
2	Control	SMW13-1	5.5377	0.3567	A

Effect=Tmt*plantingcode   Method=Tukey-Kramer(P<0.05)   Set=2

Obs	Tmt	plantingcode	Estimate	Standard Error	Letter Group
3	Control	SMW14-2	4.6752	0.3461	A
4	Inoc	SMW14-2	3.0996	0.5392	A