



FINAL REPORT

Optimising productivity and variety
recommendations through analysis of
mill data: final report 2014/054

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Research organisations:	SRA
Co-funder(s):	
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Key Focus Area (KFA):	1

sra

Sugar Research
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Queensland
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SRA Research Project Final Report

SRA Project Code	2014/054		
Project Title	Optimising productivity and variety recommendations through analysis of mill data		
Key Focus Area in SRA Strategic Plan	KFA1		
Research Organisation(s)	Sugar Research Australia		
Chief Investigator(s)	Dr Joanne Stringer		
Project Objectives	<ol style="list-style-type: none"> 1) Identify factors associated with fluctuating productivity at the mill, sub-district and individual grower level. 2) Develop creative ways to present the analyses that will assist advisors and growers to optimise management strategies and variety choice at the farm level across the crop cycle. 3) Investigate methods of early prediction of variety performance based on mill data from the first years after release. 4) Establish secure data storage protocols and develop automated analysis methods. 5) Identify knowledge gaps that can be addressed in future projects. 		
Milestone Number	6		
Milestone Due Date	1 September 2016	Date submitted	1 September 2016
Reason for delay (if relevant)			
Milestone Title	Submit Final Report		

<p>Success in achieving the objectives</p>	<p><input checked="" type="checkbox"/> Completely Achieved <input type="checkbox"/> Partially Achieved <input type="checkbox"/> Not Achieved</p>
<p>SRA measures of success for Key Focus Area (from SRA Strategic Plan)</p>	<ul style="list-style-type: none"> - To deliver a world-class variety development program that produces varieties that provides increased cane and sugar yields - Enhance the variety breeding, selection and release program through increased collaboration with growers, millers and productivity services groups in the Herbert - An understanding of soil health issues such as <i>Pachymetra</i> that that may be negatively affecting sugarcane productivity - Provide an understanding of the importance of modern farming systems - To facilitate the practical application of the value chain model to enhance grower, harvester and miller interfaces and improve the adoption of harvesting best-practices - Development of a Decision Support Tool (<i>QCANESelect™</i>) to disseminate research findings to end-users to facilitate their uptake by growers and millers.

PART A

Section 1: Executive Summary

Production peaked in the Herbert River mills in 2005 at 5.5 Mt, and in 2015 was 4.5 Mt. Cane and sugar yields during this period have also been below average, particularly in 2011, and significant areas went from growing cane to other uses. Although some of this regional variation can be explained by extreme weather events or disease incursions, it is important to identify those causes that can be controlled in order to increase production/ profitability for industry. Huge amounts of data are captured annually by Wilmar and HCPSL (Herbert Cane Productivity Services Limited) and this significant investment is under-utilised in decision making. Productivity within a mill region is highly variable and depends on many factors. Development of innovative tools to analyse and summarise mill data by region could be used to identify production units performing below potential and the factors associated with this.

Analysis of mill data in the Herbert has successfully identified groups of farms with similar productivity over time and the major factors associated with these groupings. One of the major findings was that those growers who have adopted modern farming systems had significantly higher productivity than those who use traditional practices. The impact of the *Pachymetra* resistance of previous varieties on yield of the current crop was also significant, suggesting that incorrect variety choice may be a major factor contributing to poor ratooning in the Herbert. In the small-farm-size groups, low and high performing growers had similar proportions of plant, young crops, old crops and old varieties. However, the low and high performing groups varied significantly in terms of new varieties, suggesting that the small-farm-size low-performing group were not adopting the new, more productive varieties to the same extent as the small-farm-size high-performing group. Age of the manager making the business decisions on the farm was also an important factor associated with cane yields. Growers who regularly (five or six years out of six) obtained clean seed had more than 10 % higher yields than growers who never or infrequently obtained clean seed and greater than 6 % higher yields than growers who only obtained clean seed in three or four years out of six. Timing of all operations, including planting, weed and nutrient management and harvesting, engagement with industry organisations and good soils with high CEC, were important factors that discriminated the small-sized low-producing farming enterprises from the small-sized high-producing farming enterprises.

Although many factors affecting productivity have been identified in this project, future work should focus on identifying climate zones within the Herbert region to further refine productivity performance groupings (clusters). The climate zones could then be linked to soil type and farming systems information to improve variety recommendations.

Previous research identified that selecting harvester ground speed according to crop size is a simple practice change that can result in significant improvement in sustainable productivity for all sectors of the industry, provided that harvester operators are appropriately rewarded. Results of this project suggest that reducing harvesting speeds to 8.5 km/h or less in crops with yields of 60 - 80 t/ha and 7 km/h and less in crops of 80 - 100 t/ha could lead to improvements in ratoon-crop yields. Using outputs from this project Wilmar, HCPSL and SRA have heavily promoted and invested in harvesting best outcomes in the Herbert. Further work needs to be undertaken to characterise harvesting contractor groups and their clusters so differences between high-and low-performing clusters can be understood.

Since project outputs have been widely disseminated to Herbert industry the importance of clean seed and the *Pachymetra* resistance of previous varieties to yield of the current crop has been highlighted. Many more growers now undertake *Pachymetra* testing and want to source *Pachymetra* resistant varieties from HCPSL approved clean seed plots. In the past two years HCPSL have distributed between

800 - 1200 tonnes of cane as whole stalks and billets out of clean seed plots compared to 200 tonnes previously.

This research in this project has allowed HCPSL and SRA to design strategic adoption strategies for targeted audiences. Packages based on individual productivity drivers are being developed for growers whose business enterprise is greater than 175ha. Small farming enterprises with productivity in the 75 - 85 t/ha will be involved in group extension activities.

This project has resulted in enhancements to *QCANESelect*TM, which is being widely used by growers, millers, advisors and researchers. The ability to produce reports in *QCANESelect*TM, especially by soil type and crop class, will enable growers and advisors to evaluate variety and district performance so that better variety recommendations can be made and a range of factors that could be affecting productivity can be analysed. This will improve regional productivity as growers and advisors can base their variety selections or recommendations on the best available data and investigate factors that could be affecting regional productivity. In the past, this data has not been fully utilised and if it was analysed it required advisors many days to collate and produce reports. The data can now be uploaded at the end of each season and a wide range of reports will be immediately available to all users.

Approximately 20% of growers in the Herbert participated in a pilot program for the Whole of Farm Planning module in *QCANESelect*TM. This will assist growers to plan, manage and implement their variety program, minimise the risk of disease and improve productivity. In future projects, further enhancements to *QCANESelect*TM will include allowing growers to easily complete a whole of farm plan by automated entry of farm data (block, area, variety, crop class etc.) directly from mill data. Many mill regions have also requested that benchmarking individual grower's performance relative to subdistrict and/or mill level by soil type, sub-district, and crop class would be very beneficial.

Ratoonability is a feature of varieties that has been identified by growers as having great importance to profitability. In this project several measures of ratoonability, based on the mill data, were examined: loss in area from P crop through to 4th or 5th ratoon for a given planting year, actual yield and the rate of loss in yield (TCH, TSH or \$/ha relative to mill average) across crops, slope of the regression line of crop class vs cane yield and cumulative cane yield relative to the P crop for the ratoons. All measures have some drawbacks. The best measures are the last two; however, what they suggest as good ratooning varieties does not agree with expert opinion. Future work should consider such factors as time of harvest in the development of a ratooning index.

Section 2: Background

Long-term average cane and sugar yields in Herbert River mill area are 80 and 11 t/ha, respectively (Garside *et al.*, 2014). However, since 2005 cane supply to the mill has declined from 5.5 Mt to 4.2 Mt in 2014. Cane and sugar yields during this period have also been below average, particularly in 2011, and some land has gone from growing cane to other uses. Although some of this regional variation can be explained by extreme weather events or disease incursions, it is important to identify those causes that can be controlled in order to increase production/profitability for industry. As part of this process, the Herbert Cane Productivity Services Limited (HCPSL) launched an initiative to increase productivity to 85 t/ha (Target 85) in 2014.

Garside *et al.* (2014) identified issues affecting productivity in the Herbert—they examined the impact of varieties, season conditions and crop management on productivity. Water management, and aspects of harvesting and season length were the main factors influencing productivity in the Herbert.

This project reports on innovative methods to analyse and summarise mill data to optimise recommendations on variety choice and management practices, delivering increased productivity at the farm, mill and industry level in the Herbert. Selecting the best variety can significantly influence yields for a whole crop cycle but requires growers to consider many complex factors. After a variety has been released, data become available on its performance in different soil types, crop classes and seasons. Development of a Decision Support System (QCANSelect™) incorporating mill data can provide growers with up-to-date variety information to assist them to make the complex decisions involved in optimising variety composition on their farm.

Section 3: Outputs and Achievement of Project Objectives

Objective 1: Identify factors associated with fluctuating productivity at the mill, sub-district and individual grower level.

Analysis of productivity data

Materials and methods

Cluster analyses

Rake data from the Herbert River mills for 2005 - 2015 from Wilmar Sugar Australia was used in this project. Exploratory data analyses were undertaken on cane yield versus farm size to identify any potential outliers. Across all years there were only three values of cane yield that were greater 160 t/ha. These very high values were identified as outliers and were removed before any further analyses were conducted.

To identify and understand the key factors affecting productivity in the Herbert, an exploratory data mining tool called *cluster analysis* was used. This method groups a set of objects in such a way that objects in the same group (cluster) are more similar to each other than to those in other groups (Tabachnick and Fidell, 2013).

Previous research by Garside (2013) and Larsen (unpublished data) in the Herbert suggests that 25 - 30% of the variation in cane yield is due to weather. Hence, prior to cluster analyses the effect of season was removed by a fixed effect in the linear mixed model. These analyses were performed using ASReml (Gilmour *et al.*, 1996).

Hierarchical agglomerative clustering using Ward's method was undertaken on the rake data (Ward, 1963). Four sets of clustering were undertaken:

1. 2005 - 2013 for cane yield and hectares harvested at the Farm level
2. 2006 - 2014 for sugar yield and hectares harvested at the Farm level
3. 2010 - 2014 for cane yield and hectares harvested at the Farm level
4. 2012 - 2015 for cane yield and hectares harvested at the ABN level

These different clustering sets were needed as the factors that were used to relate to the groupings were not across all years.

The rake data from 2005 - 2014 contained 1029 unique *FarmSplits*. Note that in the Herbert a *FarmSplit* is equivalent to a *FarmNo* in other mill regions. *FarmSplits* < 10ha were omitted prior to analyses and a *FarmSplit* had to have data across all years to enable the major trends to be identified. Hence, if a grower was farming in the early years but not now, or only recently joined the industry, they would not be included. In the second set of clustering undertaken on sugar yield and hectares harvested, 2005 was dropped, as this contained a higher than normal amount of plant crop due to the large expansion in this year.

In the final set of clustering undertaken rake data from 2012 - 2015 were analysed. Analyses were undertaken on cane yield and area harvested at the business enterprise or ABN level.

All clustering analyses were undertaken using SAS 9.4 (User's Guide, 2013) and R (R Core Team, 2016).

Factors associated with clusters

The objectives of the study were to identify the factors associated with clusters and then develop different extension programs for farms within the clusters, with the aim of optimising variety recommendations and increasing productivity. Some of the factors associated with the clusters which have been considered are:

- Districts
- Demographics
- Management practices/ farming systems
- Effect of *Pachymetra* resistance of previous variety on *Pachymetra* levels and yield
- Variety performance and management
- Clean seed
- Soil type
- Timing of all operations
- Use of "new" ground
- Engagement with industry organisations
- Young family helpers
- Readily take up new varieties
- Off farm income
- Elevation
- CEC
- Harvesting speed and pour rate.

Most of the data which relate to cluster groupings were made available by HCPSL except for the GPS tracking data and raw CEC data from Wilmar Sugar Australia, kriged CEC data from Dr Rob Bramley, CSIRO, and *Pachymetra* resistance ratings from SRA.

Results

Cluster analyses at the farm level

Results of the cluster analysis undertaken on rake level data from 2005 - 2013 for cane yield and area harvested are given in Figure 1. The number of clusters that have similar productivity over time is somewhat arbitrary, but with eight clusters there seemed to be quite good differentiation within each group – groups are distinguished by a different colour in Figure 1. Each cluster contains a different number of *FarmSplits*. The highest performing cluster in 2005 (cluster 4) was consistently the highest performing group up to 2013 and similarly for the low performing group (cluster 2).

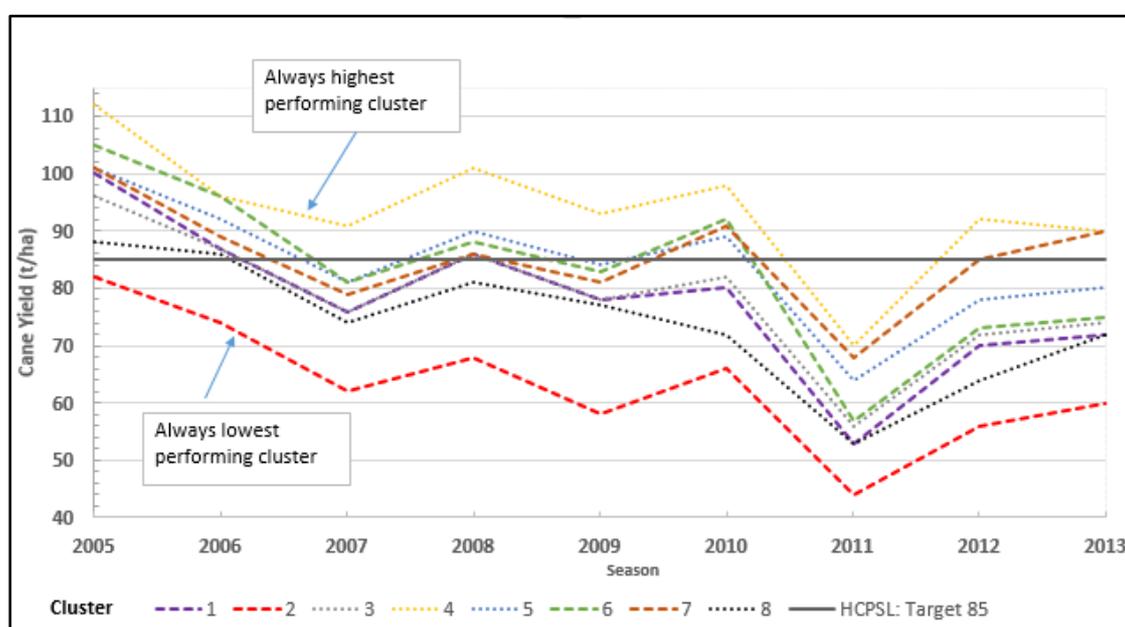


Figure 1: Performance of clusters for cane yield from Herbert River mills from 2005 to 2013

The performance of the eight clusters versus area harvested for cane yield from 2005 - 2013 is given in Figure 2. To maintain confidentiality for the small number of growers who harvest greater than 400 ha per *FarmSplit*, their performance has been hidden in Figure 2. The different colours in the graph are for the eight clusters. The number of *FarmSplits* in each cluster is identified in Figure 2. Cluster 1 is the high-performing small-farm-size growers and contained 125 *FarmSplits*, while Cluster 4 is the poor-performing small-farm-size growers and contained 169 *FarmSplits*. The *FarmSplits* circled in dark blue lie just below the HCPSL Target 85. It is possible that with tailored extension practices these *FarmSplits* could increase productivity to above 85 t/ha.

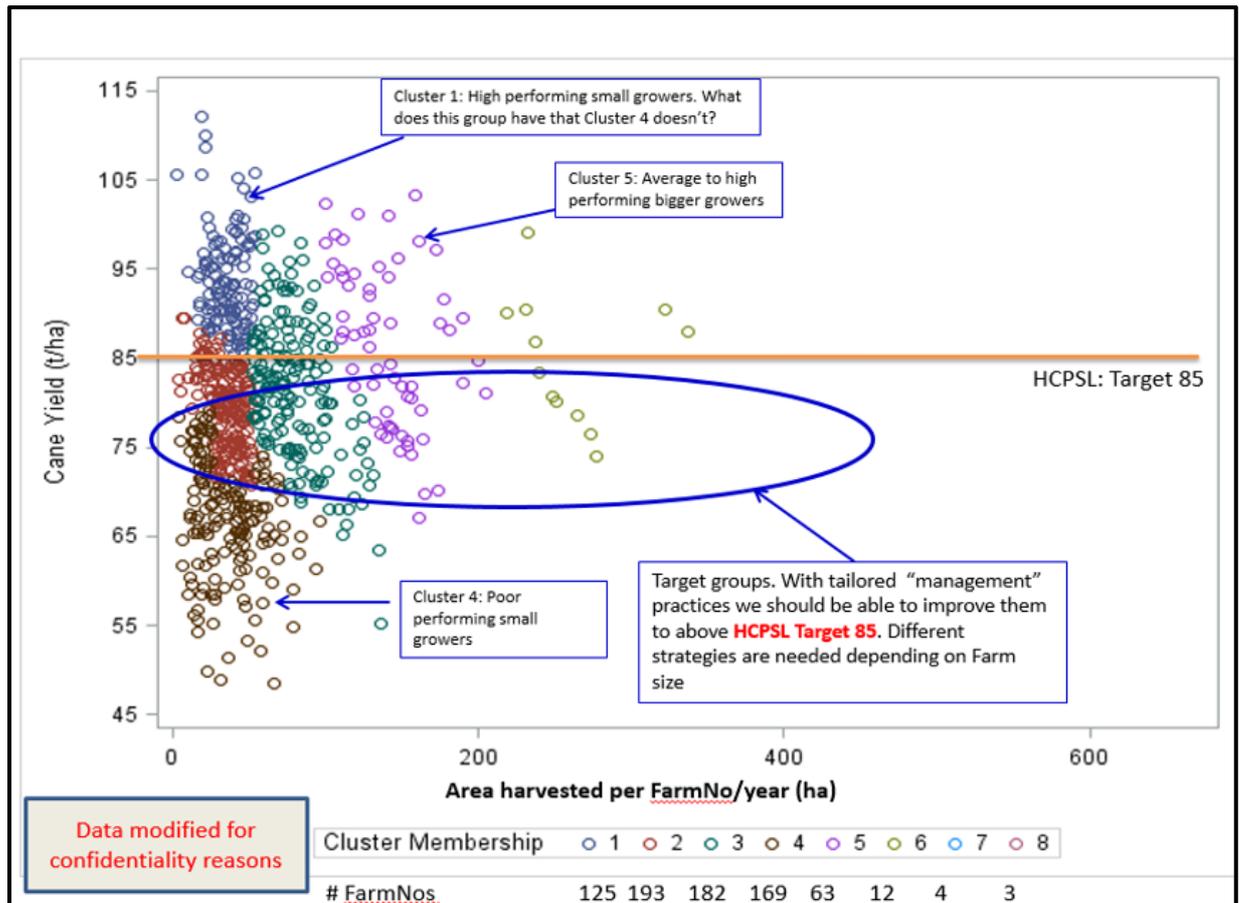


Figure 2: Performance of 8 clusters versus area harvested for cane yield in the Herbert from 2005 to 2013. FarmSplits > 400ha have been hidden due to confidentiality reasons.

The performance of the eight clusters versus area harvested for sugar yield from 2006 - 2014 is given in Figure 3. To maintain confidentiality for the small number of growers who harvest greater than 400 ha per FarmSplit, their performance has been hidden in Figure 3. As for Figure 2 the different colours in the graph are for the eight clusters.

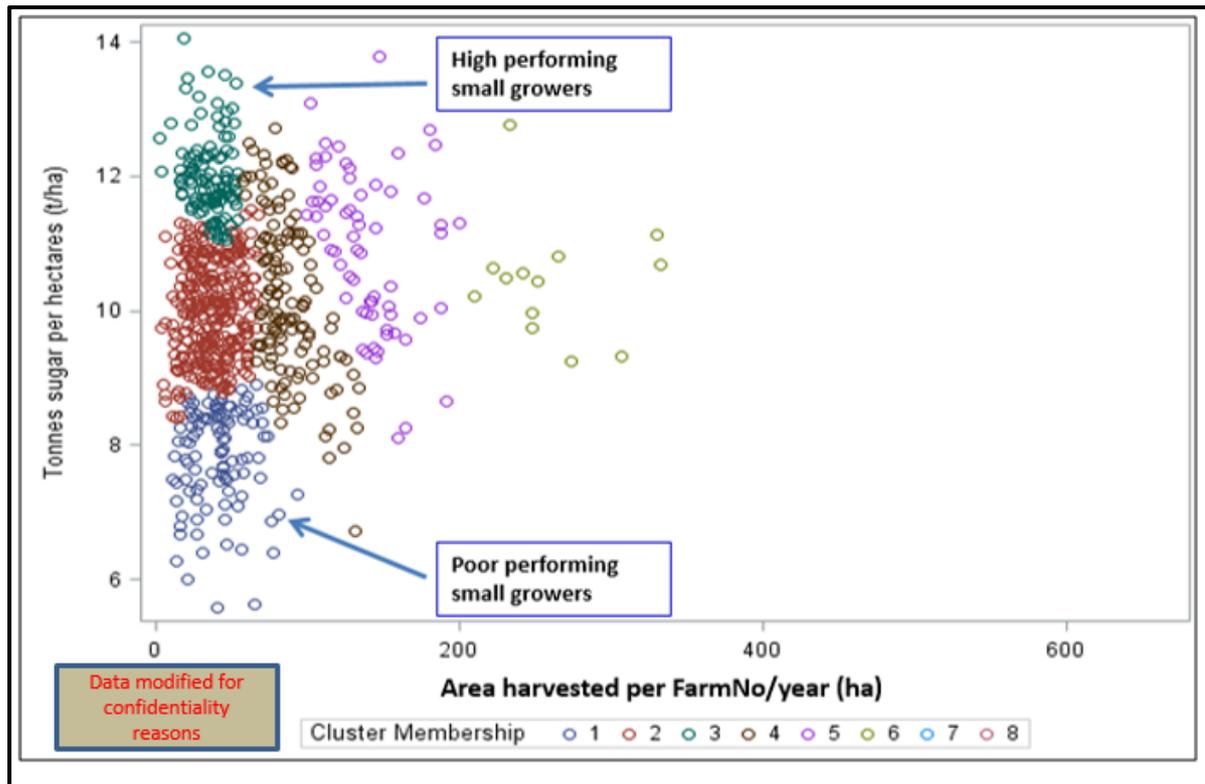


Figure 3: Performance of eight clusters versus area harvested for sugar yield in the Herbert from 2006 to 2014. FarmSplits > 400ha have been hidden due to confidentiality reasons.

In the analysis of data from 2010 - 2014 10 clusters were needed to obtain good differentiation between the small-sized low-performing group and the small-sized high-performing group. The performance of the 10 clusters versus area harvested for cane yield from 2010 - 2014 is given in Figure 4. To maintain confidentiality for the small number of growers who harvest greater than 400 ha per FarmSplit, their performance has been hidden in Figure 4. As for Figure 2 the different colours in the graph are for the 10 clusters.

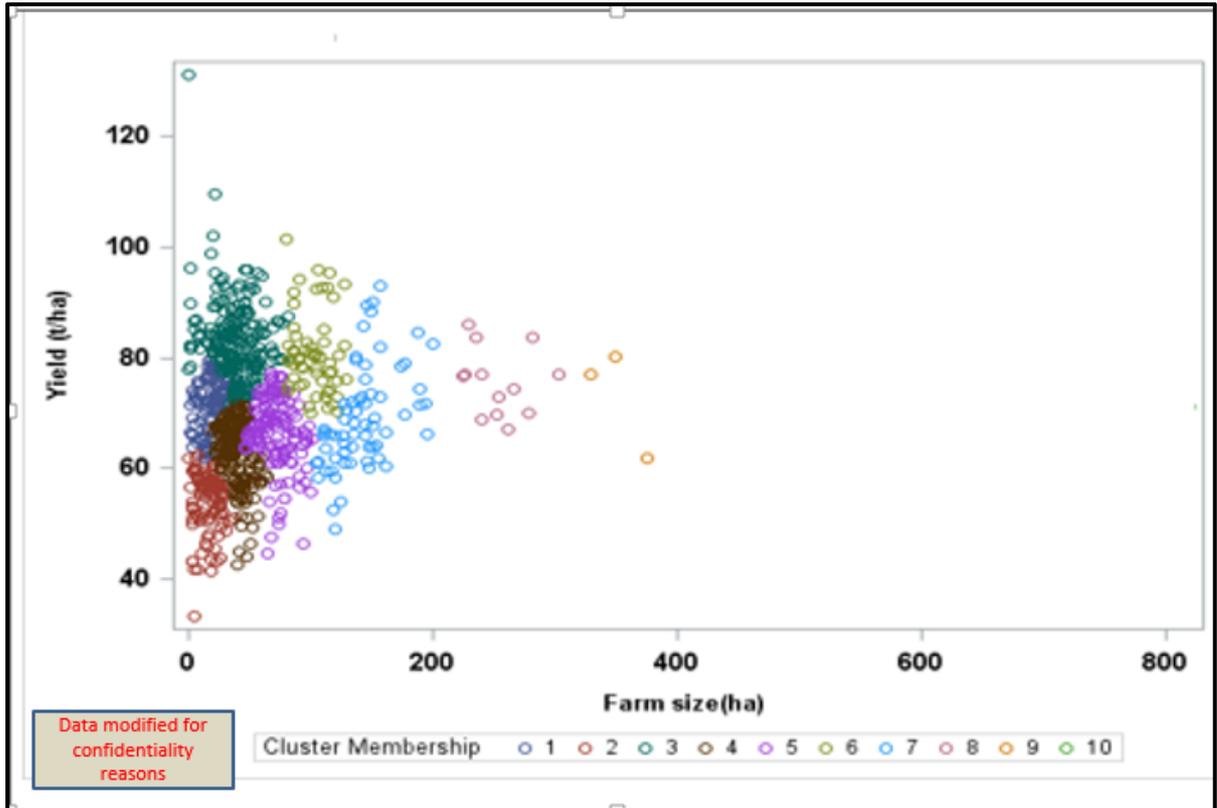


Figure 4: Performance of 10 clusters versus area harvested for cane yield in the Herbert from 2010 to 2014. FarmSplits > 400ha have been hidden due to confidentiality reasons.

Factors associated with clusters

Districts

Within the Herbert River mills areas there are six districts that tend to reflect different climatic zones to some extent (Garside, 2013). The average cane yield for the six districts from 2005 - 2013 and proportion of total area are given in Figure 5. Approximately 70 % of the area is designated 'wet' and 30 % 'dry'.

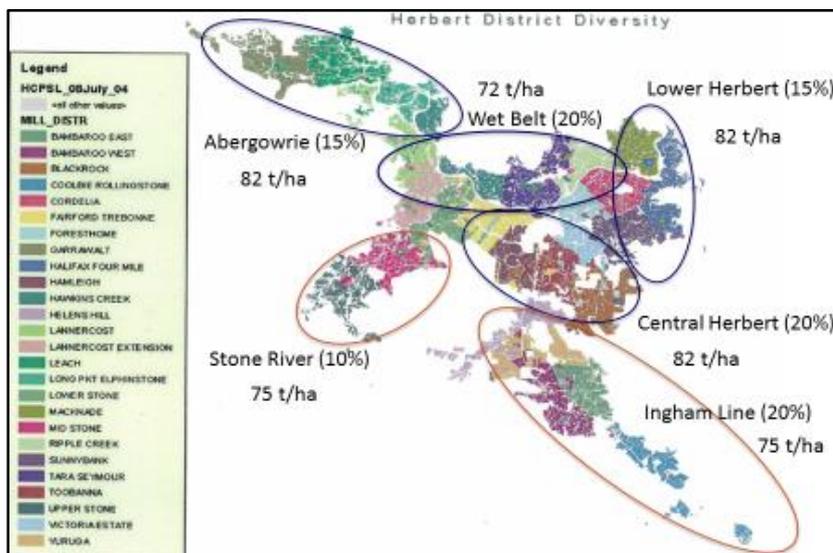


Figure 5: Average cane yield from 2005 to 2013 and proportion of total area for six Herbert districts

In Figure 6 the colours in the map and cluster graph correspond, so cluster 1 (royal blue) in both is the small-sized high-performing *FarmSplits* and cluster 4 (brown) is small-sized low-performing group. Examination of Figure 6 reveals that there is no association between cluster group membership and district. Figure 6 has been removed to maintain confidentiality.

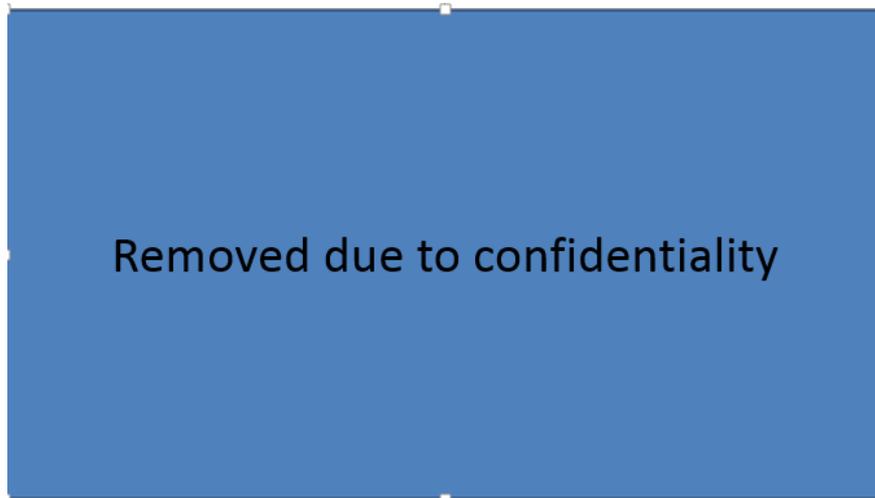


Figure 6: Map of the clusters in relation to cluster grouping. This figure is not shown due to confidentiality reasons.

Demographics

HCPSL has data on the age of the managers of *FarmSplits* in the Herbert from 2008 - 2012. The data was broken up into ages of < 40, 40 - 50, 50 - 60, 60 - 70 and > 70. Figure 7 gives the cane yields for the five different age groups together with the proportion of *FarmSplits* in each group. Highest productivity was noted for managers in the 40 - 50 age group and this represents 33 % of the area in the Herbert.

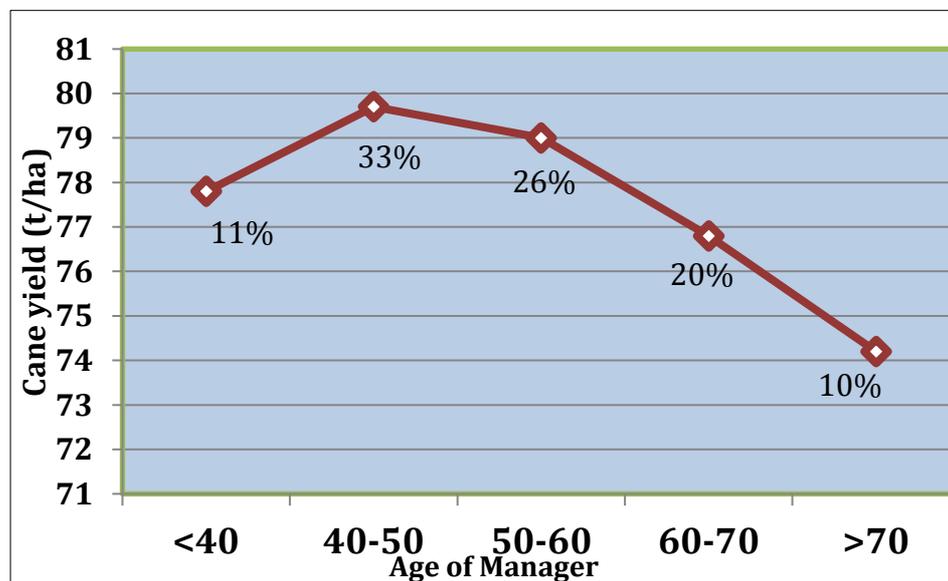


Figure 7: Age categories for managers of *FarmSplits* and cane yield in the Herbert

The proportion of each age group in the eight clusters is given in Figure 8 with Figure 2 positioned in the top right hand corner as a reference.

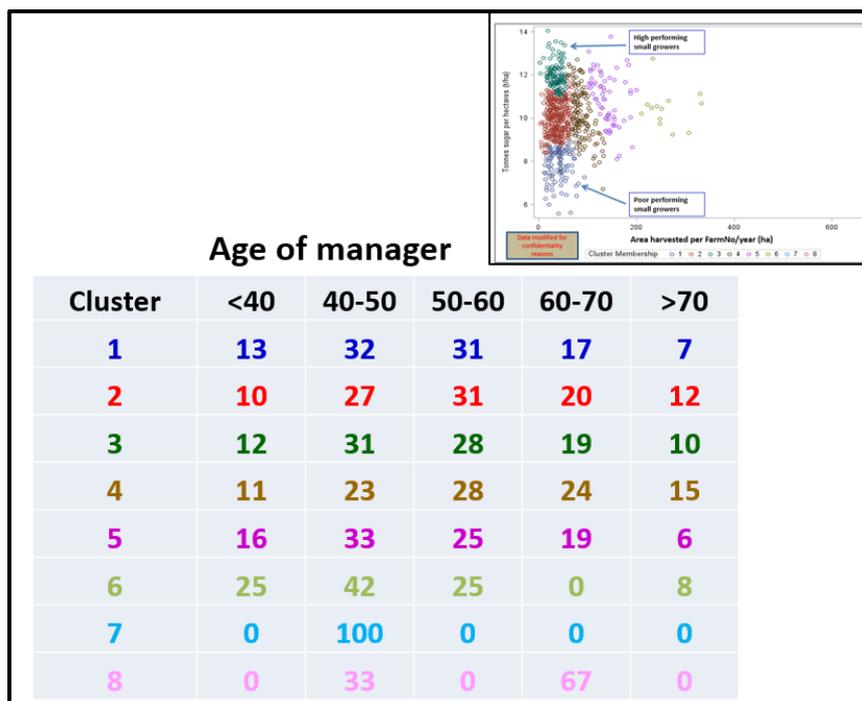


Figure 8: Demographic data (% of cluster in each age group) for each cluster for cane yield from 2005 to 2013. FarmSplits > 400ha have been hidden due to confidentiality reasons.

FarmSplits > 400ha have been hidden in Figure 8 due to confidentiality reasons. Age of the managers of the *FarmSplits* was an important factor affecting cane yields. In cluster 1 which is the high-performing small-farm-size group, 76 % of the managers of the *FarmSplits* were younger than 60. In contrast to this was the small-farm-size low-performing cluster 4 which had 62 % younger than 60.

Management practices/ farming systems

The 863 *FarmSplits* in the 2014 season were categorised into two groups:

1. *MT* (modern technology) *FarmSplits* that have adopted at least 2 out of 3 of the following:
 - matching row spacing with machinery wheel tracks
 - mound or double-disc-opener planting methods
 - zonal tillage.
2. *TM* (traditional management) *FarmSplits* that use traditional farming practices.

Of the 863 *FarmSplits* 149 were designated MT and 714 TM.

The MT and TM groups were compared for cane yield and sugar yield in plant (P), plough-out replant (RP) in 2013 and first ratoon (1R) in 2014. This was done over all districts and by district. Results are given in Table 1 and Table 2.

Table 1: Comparisons of users of modern technology (MT) and traditional management (TM) practices in Herbert for cane and sugar yields for plant and plough-out replant in 2013. Comparisons were undertaken for the six districts and overall

	District	Modern technology (MT)	Traditional management (TM)	Difference	Means significantly different (p < 0.05)
Cane yield (t/ha)	Overall	92.7	86.6	6.1	Y
	Abergowrie	95.4	92.9	2.5	N
	Central Herbert	104.2	93.9	10.3	Y
	Ingham Line	89.3	78.1	11.2	Y
	Lower Herbert	94.2	84.2	10.0	Y
	Stone River	92.3	86.1	6.2	N
	Wet Belt	85.2	81.7	3.5	N
Sugar yield (t/ha)	Overall	12.7	12.1	0.6	Y
	Abergowrie	12.6	12.3	0.3	N
	Central Herbert	14.5	13.4	1.1	N
	Ingham Line	11.9	11.1	0.8	N
	Lower Herbert	13.2	11.8	1.4	Y
	Stone River	12.9	12.1	0.8	N
	Wet Belt	11.6	11.3	0.3	N

Table 2: Comparisons of users of modern technology (MT) and traditional management (TM) practices in Herbert for cane and sugar yields for first ratoon in 2014. Comparisons were undertaken for the six districts and overall

	District	Modern technology (MT)	Traditional management (TM)	Difference	Means significantly different (p < 0.05)
Cane yield (t/ha)	Overall	87.0	80.2	6.8	Y
	Abergowrie	93.2	86.1	7.1	N
	Central Herbert	89.7	76.2	13.5	Y
	Ingham Line	82.5	73.2	9.3	Y
	Lower Herbert	92.9	86.7	6.2	N
	Stone River	86.7	72.4	14.3	Y
	Wet Belt	79.6	79.5	0.1	N
Sugar yield (t/ha)	Overall	11.6	10.7	0.9	Y
	Abergowrie	11.9	11.4	0.5	N
	Central Herbert	11.6	10.2	1.4	Y
	Ingham Line	11.5	10.5	1.0	Y
	Lower Herbert	12.4	11.4	1.0	Y
	Stone River	11.8	9.8	2.0	Y
	Wet Belt	10.2	10.5	-0.3	N

Over all districts for cane and sugar yield in both P/RP and 1R crops the mean yields for the modern technology adopters were significantly higher compared to the group using traditional management practices ($p < 0.05$). This difference was also significant for many of the districts, although not for the Wet Belt ($p > 0.05$).

Effects of previous variety on Pachymetra level

Levels of smut susceptible (S) varieties have decreased substantially from 91 % in 2005 to 2 % in 2014. However, the level of intermediate (I) varieties for *Pachymetra* has increased dramatically from 4 % in 2005 to 90 % in 2014 (Figure 9). This increase was of major concern and prompted two courses of action: 50 % population of seedlings planted from resistant crosses (RxR) in the SRA breeding program and an updated *Pachymetra* survey undertaken in the Herbert by HCPSL in 2014 - 2015.

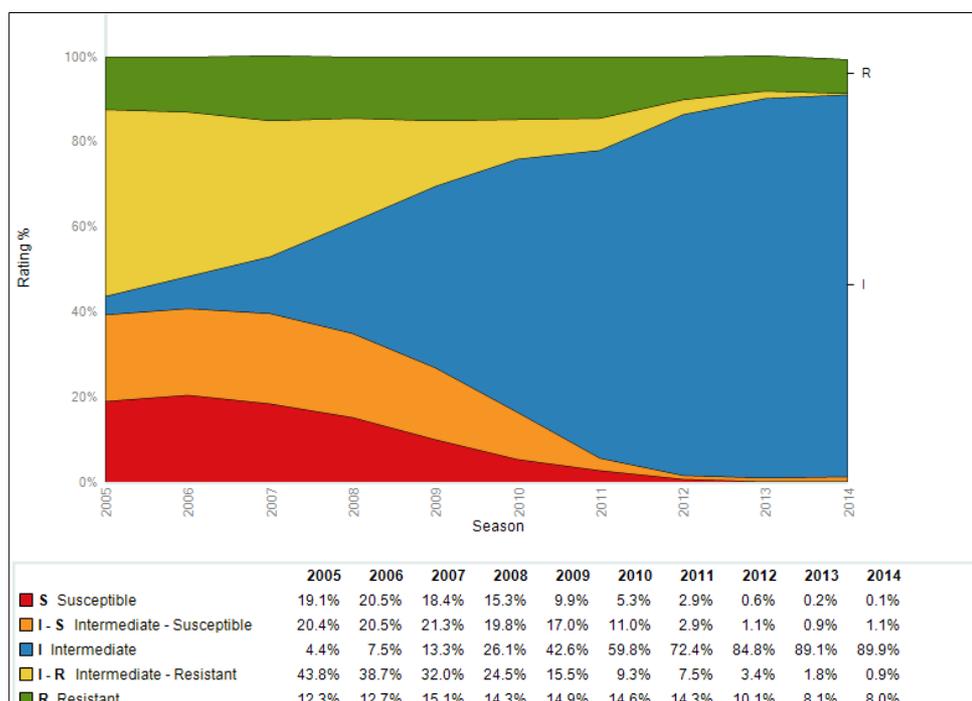


Figure 9: *Pachymetra* ratings for varieties in the Herbert 2005-2014

The levels of *Pachymetra* spores in each of the 26 productivity zones is given in Figure 10. In 51 % of the samples, the *Pachymetra* levels exceeded the economic threshold of 50,000 spores /kg. In the Fairford-Trebonne (Central Herbert) and Forest Home (Lower Herbert) areas, levels exceeded 100,000 spores/kg and are likely to cause significant yield losses in intermediate varieties. Further details about the *Pachymetra* survey are given by Holzberger *et al.* (2016).

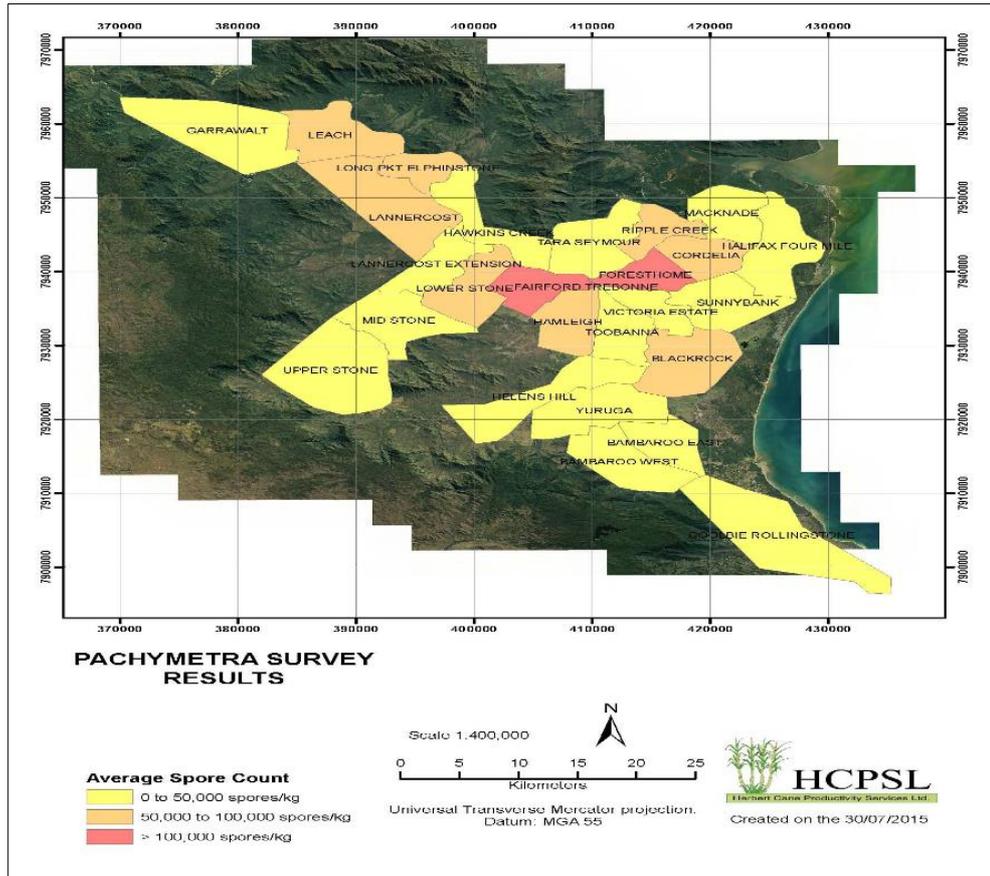


Figure 10: *Pachymetra* survey results in the 26 productivity zone in the Herbert conducted during 2014 - 2015

The survey found that the previous variety grown on a block had a significant effect on ratoon cane yield (Figure 11). Up to 15 % reduction in cane yield was found if a susceptible variety was planted following a susceptible variety, compared to industry best practice.

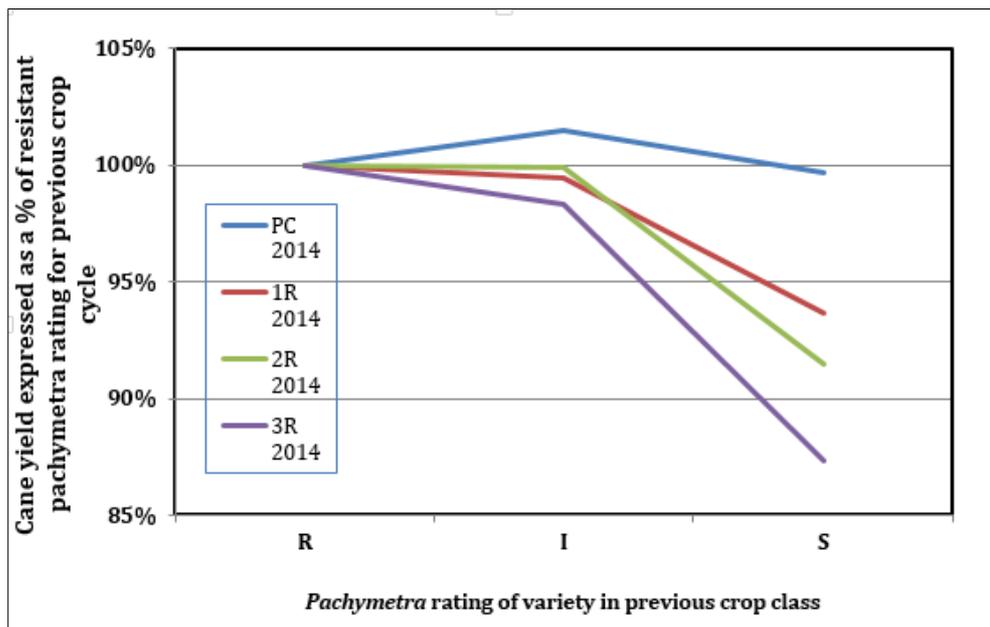


Figure 11: Effect of *Pachymetra* resistance of the variety in the previous crop on the yield of the current crop. The values are the average of all blocks planted with R, I, S following previous crops of R, I, S averaged over all crop classes

Variety performance and management and crop class

Another important factor which may discriminate cluster groups is variety performance and proportion of different crop classes. Varieties released prior to 2000 were classified as old. Old and new varieties considered were:

- Old varieties: Q138, Q157, Q158, Q164, Q174[Ⓛ], Q186[Ⓛ]
- New varieties: Q190[Ⓛ], Q200[Ⓛ], Q204[Ⓛ], Q208[Ⓛ], KQ228[Ⓛ].

Using the results of the second set of clustering (Figure 3) undertaken on sugar yield and area harvested from 2006-2014, cluster groups 1 – small-farm-size low-performing group (royal blue) and Cluster 3 – small-farm-size high-performing group (green) were compared in terms of:

- % Plant: including plough out replant (RP)
- % Young crops: P, 1R, 2R and RP
- % Old crops: 3R, 4R, 5R and > 5R
- % New varieties: Q190[Ⓛ], Q200[Ⓛ], Q204[Ⓛ], Q208[Ⓛ], KQ228[Ⓛ]
- % Old varieties: Q138, Q157, Q158, Q164, Q174[Ⓛ], Q186[Ⓛ].

The results are given in Table 3.

Table 3: Comparison of small-farm-size high-performing and small-farm-size low-performing cluster based on sugar yield from 2006 to 2014

Comparison	Cluster	% Plant	% Young crops	% old crops	% new varieties	% old varieties
Small low performing	1	18.5	52.5	45.8	40.8	28.5
Small high performing	3	17.2	51.9	47.4	53.1	25.6

The proportions for clusters 1 and 3 were very similar for plant, young crops, old crops and old varieties. The two clusters varied significantly in terms of proportion of new varieties ($p < 0.05$).

Approved seed

HCPSL approved seed records from 2009 were made available. *FarmSplits* were classified on their usage pattern of clean seed over a six-year period:

- Never
- Infrequent: 1 - 2 times
- Frequent: 3 - 4 times
- Regular: 5 - 6 times.

The cane yields for the four categories are given in Figure 12. Regular users of approved seed have a significantly higher cane yield than those who never use it or use it infrequently ($p < 0.05$).

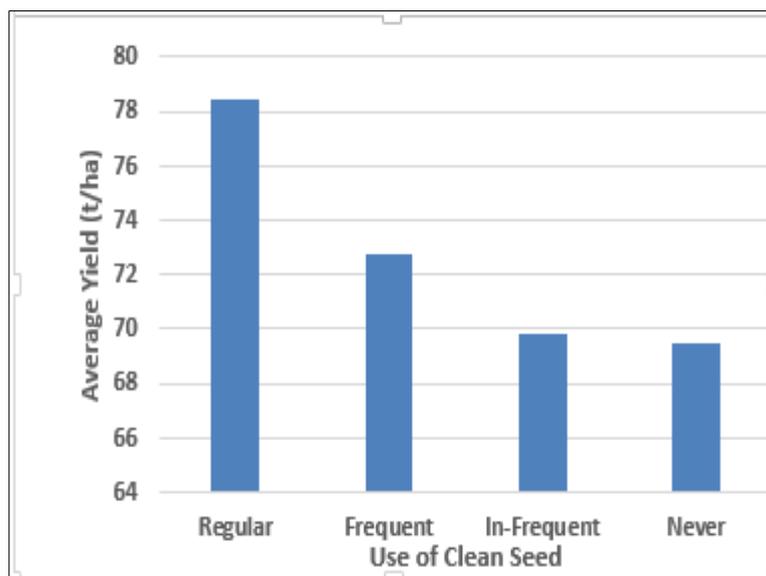


Figure 12: Average cane yield from 2010 - 2014 for different categories of users of approved seed

Using the results of the third set of clustering (Figure 4) undertaken on cane yield and area harvested from 2010 - 2014, the small-farm-size high-performing *FarmSplits* (cluster 3) was compared to the small-farm-size low-performing group (cluster 2) in terms of their usage of approved seed (Figure 13). To maintain confidentiality for the small number of growers who harvest greater than 400 ha per FarmSplit, their performance has been hidden in Figure 13. In Figure 13 the cluster graph is included to aid in interpretation. Larger sized growers are clearly the most frequent users of approved seed (clusters 6 - 9).

Overall the smaller growers have poor adoption of approved seed but the small-farm-size high-performing Cluster group 3 has more than double the adoption of approved seed (35 % usage) compared with the small-farm-size low-performing cluster 2 (14 % usage).

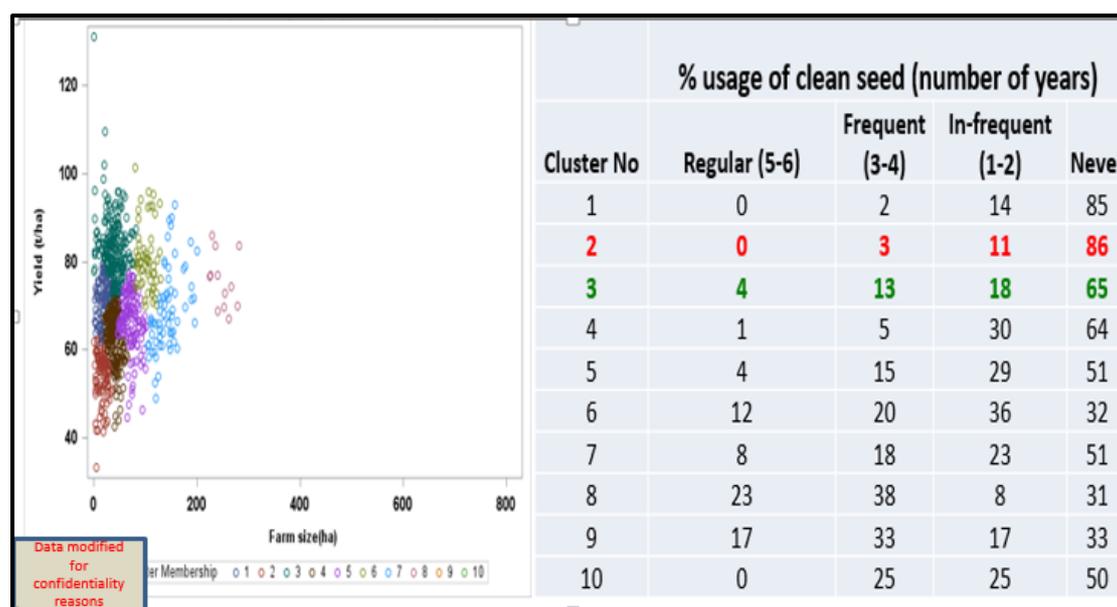


Figure 13: Clean seed data (% of cluster in each usage group) for each cluster for cane yield from 2010 to 2014. FarmSplits > 400ha have been hidden due to confidentiality reasons.

Soil types

Many markedly different soils are found in the Herbert (Wood *et al.* 2003). Most of the Herbert has been mapped to a scale of 1:5,000 but 10,000 ha in the Ingham Line area has not been mapped (Figure 14). The Wilmar database contains both the 6 broad soil groupings and a detailed classification that is a combination of the DNR Baker Wilson and Andrew Wood's soil types (Table 4).

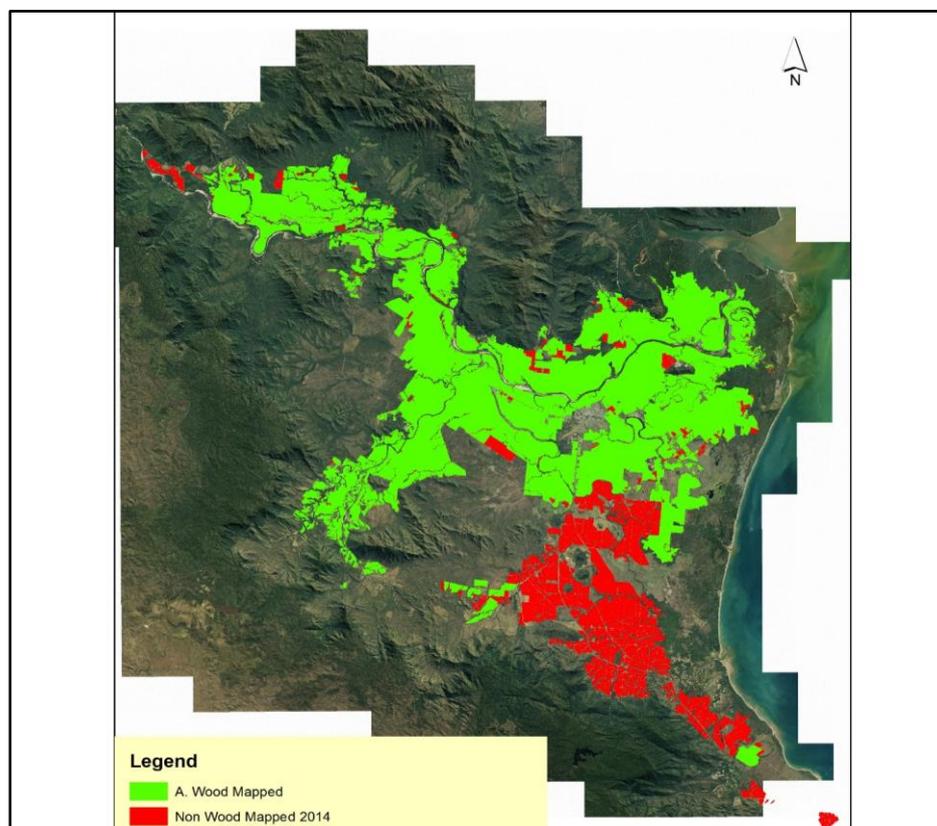
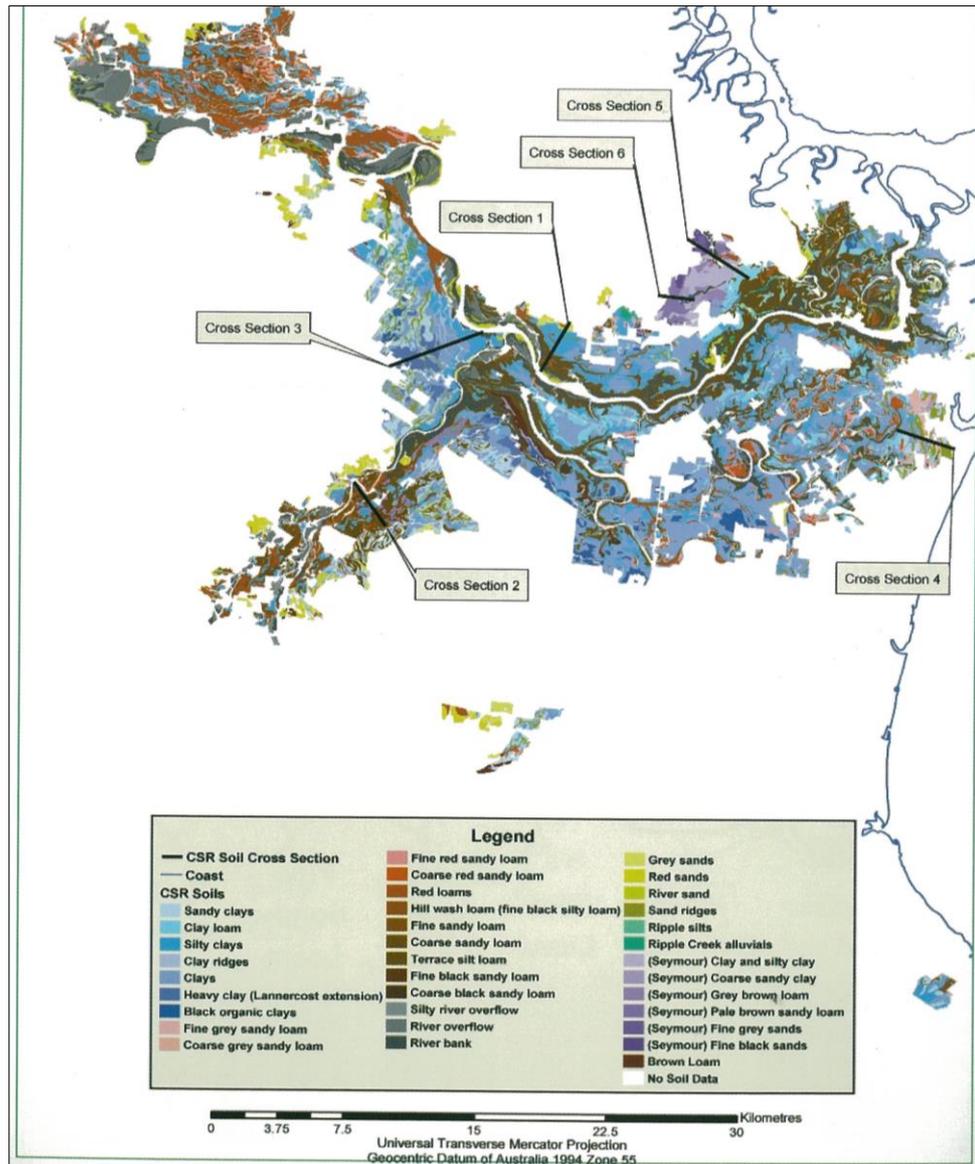


Figure 14: Soil map of the Herbert showing the area mapped to a scale of 1:5,000

Table 4: Broad and detailed soil classifications in the Herbert

Zone	Name	Prod Zone	Name
1	Alluvial	101	Unknown Alluvial
1	Alluvial	102	Ripple Creek Alluvial
1	Alluvial	103	River Bank Alluvial
1	Alluvial	104	River Overflow Alluvial
1	Alluvial	105	River Sand Alluvial
1	Alluvial	106	Silty River Overflow Alluvial
2	Clay	111	Unknown Clay
2	Clay	112	Seymour Silty Clay
2	Clay	113	Black Organic Clay
2	Clay	114	Clay Loam
2	Clay	115	Clay Ridges
2	Clay	116	Clays
2	Clay	117	Heavy Lannercost Clay
2	Clay	118	Silty Clays
3	Hillslope	121	Unknown Hillslope
3	Hillslope	122	Grey Sands Hillslope
3	Hillslope	123	Red Sands Hillslope
4	Sandy	131	Unknown Sandy
4	Sandy	132	Coarse Black Sandy Loam
4	Sandy	133	Coarse Grey Sandy Loam
4	Sandy	134	Coarse Red Sandy Loam
4	Sandy	135	Coarse Sandy Loam
4	Sandy	136	Fine Black Sandy Loam
4	Sandy	137	Fine Grey Sandy Loam
4	Sandy	138	Fine Red Sandy Loam
4	Sandy	139	Fine Sandy Loam
4	Sandy	140	Sandy Ridges
4	Sandy	141	Sandy Clays
5	Seymour	151	Unknown Seymour
5	Seymour	152	Fine Black Sand Seymour
5	Seymour	153	Fine Black Silty (Hill Wash) Loam
5	Seymour	154	Fine Grey Sand Seymour
5	Seymour	155	Grey Brown Loam Seymour
5	Seymour	156	Pale Brown Sandy Loam Seymour
5	Seymour	157	Coarse Sandy Clay Seymour
6	Terrace Loamy	161	Unknown Terrace Loamy
6	Terrace Loamy	162	Red Loams
6	Terrace Loamy	163	Ripple Silts
6	Terrace Loamy	164	Terrace Silt Loams
9	Unknown Zone	199	Unknown Zone

The results of the cluster analysis and the 40 soils in the combined DNR Barker Wilson and Andrew Wood's classification were overlaid onto the one map. Unfortunately, to obtain the resolution needed to be useful this produced a series of 32 maps for the Herbert district (not given here). However, Andrew Wood's soils are mapped in Figure 15 (Wood *et al.*, 2003). Interpretation of both revealed that cluster membership appears not to be simply due to soil type.



Note: from Page 21 of Soil-Specific Management Guidelines for Sugarcane Production (2003) by A. Wood, B. Schroeder and B. Stewart

Figure 15: Soil map of the Lower Herbert River

However, it is important to examine the various soil types as this may influence where to put our breeding selection trials and, hence, variety recommendations for *QCANESelect*TM. When deciding where to plant our variety trials we need all major soils types in the Herbert represented.

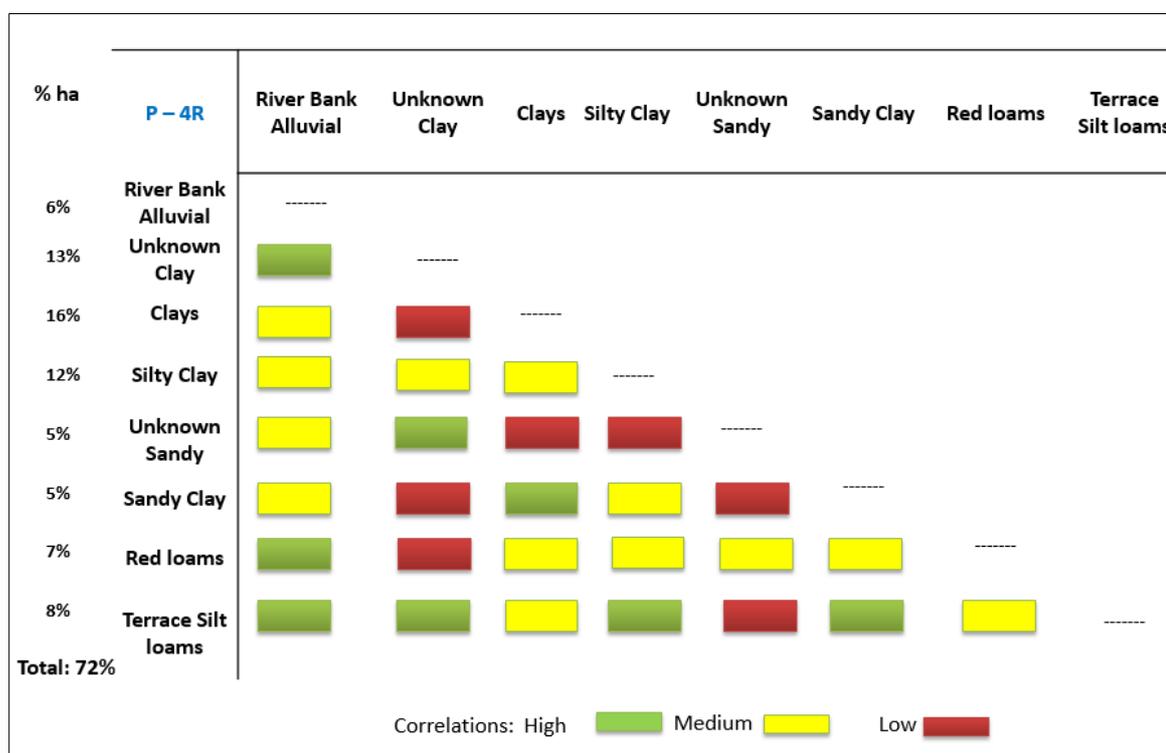
Currently, in *QCANESelect*TM we use the 6 broad groupings for variety recommendations. However, we may be able to optimise recommendations if more soils are used.

Hence, it was important to know from the detailed classification which contained 40 soils if:

- the soils we group together are well correlated with each other *i.e.* the various clays
- recommendations for the combined group are relevant for the individual soils that make up the group
- some soils would be better grouped with another group if they are better correlated with that group
- one larger soil group can help us to give better recommendations for another larger soil group.

To examine these questions, we used Herbert mill data for sugar yield (TSH) from 2005 - 2014 for the major varieties: Cassius, KQ228[Ⓛ], Mida[Ⓛ], MQ239[Ⓛ], Q115, Q117, Q119, Q152, Q157, Q158, Q162, Q164, Q174[Ⓛ], Q183[Ⓛ], Q186[Ⓛ], Q190[Ⓛ], Q194[Ⓛ], Q200[Ⓛ], Q204[Ⓛ], Q208[Ⓛ] and Q232[Ⓛ]. As there would be low tonnes with some soil types we only used data from soils that represented > 5 % of the 2014 crop based on hectares. The soils in this restricted group represented 72 % of the area of the 2014 crop. We then did a rank correlation on the performance of the soils in the various categories for P-4R crops. To facilitate easier interpretation of the results, a colour coding scheme was used: correlations > 0.6 are green, correlations > 0.4 and < 0.6 are yellow and correlations < 0.4 red. These results are given in Table 5.

Table 5: Correlations amongst major soil types for the dominant varieties on DNR Baker Wilson/ Andrew Wood’s soils for sugar yield: 2005 - 2014



Hence, three of the clay soils, *i.e.* Sandy Clay, Clays, Silty Clay, are reasonably correlated with each other so a variety recommended for planting on one of these would be expected to do perform well on another. In addition, Clays, Terrace Silt loams, River Bank Alluvials are moderately correlated with most others so this simplifies the number of soils for variety recommendations. Unknown Sandy and Sandy Clay are poorly correlated. Further work is being done on the soils to explore these correlations.

Cluster analyses at the ABN level

A technique commonly used in psychology (Toledo Piza *et al.* 2014) is to characterize contrasting groups and then apply the results to target groups.

Hence, the small-sized high-producing group and small-sized low-producing group were characterized according to the following factors:

- Timeliness of all operations including planting, weed and nutrient management and harvesting. This is a subjective measurement and is difficult to quantify any other way. A team of HCPSL staff were consulted in the development of this data.
- Use of modern farming systems (consisting of controlled traffic, mound planting and reduced

tillage). Growers must undertake 2 out of the 3 practices. HCPSL has “Greensheet” data on what practices growers are undertaking.

- Use of ground that had been out of cane production for numerous years due to MIS tree plantations or not been previously under cane. HCPSL has data on what farms were returned from MIS trees.
- Good soils. This classification is based on Andrew Wood’s soil mapping data or the DNR Baker Wilson mapping classifications.
- Engage with industry organisations (such as HCPSL and SRA). HCPSL maintains a database of which growers it engages with on an annual basis.
- Young family helpers who are under 40 years old and who work on the farm full time or part time.
- Age of manager making the business decisions on the farm if greater than 70 years. HCPSL has a database consisting of the age of the farm owner and manager.
- Readily uptake new varieties in the first 5 years post release. The data used are from the Cane Block Mapping Layer from Wilmar. HCPSL also has a database on the uptake of new varieties through its Approved Seed Plots, plant tissue culture and hot water treatment programs.
- Off farm income.

The top 30 growers in the small-sized high-producing and small-sized low-producing groups were each scored Y or N for each of the factors given above.

In the analysis of data from 2012 - 2015 at the ABN level six clusters were needed to obtain good differentiation between the small-farm-size low-performing group and the small-farm-size high-performing group. The performance of the 6 clusters versus area harvested for cane yield from 2012 - 2015 is given in Figure 16. As for Figure 2 the different colours in the graph are for the six clusters.

In Figure 16 Cluster 6 (green) is the small-sized high-producing ABNs while Cluster 4 (red) is the small-sized low-producing group. To maintain confidentiality for the small number of growers who harvest greater than 600 ha pe, their performance has been hidden in Figure 16. The groups of ABNs from 70 - 85 t/ha across all the different sized area harvested will have targeted extension practices ranging from group-based extension activities for Cluster 3 and one-on-one for Clusters 1 and 5.

To determine if cluster performance was related to district a map of the clusters was undertaken (Figure 17). To maintain confidentiality for the small and large ABNs, Figure 17 is not given. Long-term averages in the 6 productivity zones ranges from 72 t/ha in the Wet Belt, 75 t/ha in Stone River and Ingham Line and 82 t/ha in Central Herbert, Lower Herbert and Abergowrie. Although there are more of Cluster 6 in Abergowrie, Lower Herbert and Central Herbert, there are some high producing ABNs in all other productivity zones.

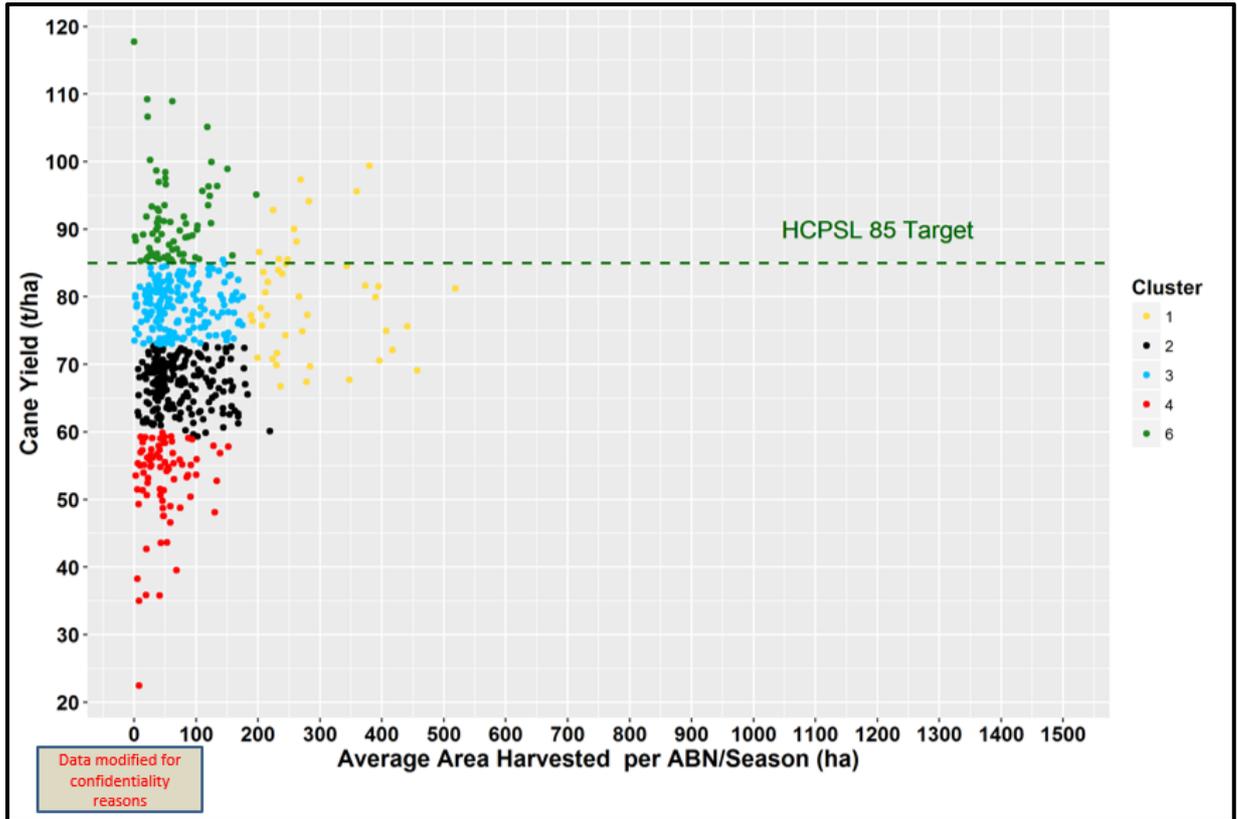


Figure 16: Performance of six clusters versus area harvested for cane yield at the ABN level in the Herbert from 2012 to 2015. ABNs > 600ha have been hidden due to confidentiality reasons.

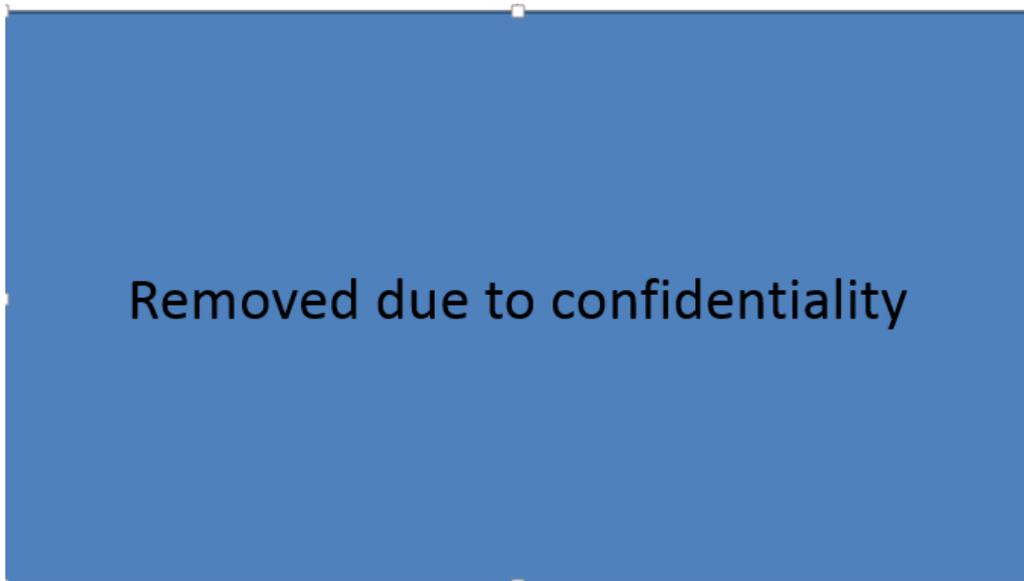


Figure 17: Map of the clusters in relation to cluster grouping undertaken at the ABN level. This figure is not shown due to confidentiality reasons.

The 30 top ABNs in cluster 6 and the 30 lowest ABNs in cluster 4 were characterized and the results are given in Table 6.

Table 6: Characterization of small sized high producing ABNs and small sized low producing ABNs

		Timing	Modern Technology	New ground	Good Soils	Engage	Young Family helpers	Old	New varieties	Off farm income
Small high ABNs	N	4	20	25	13	6	21	29	5	17
	Y	26	10	5	17	24	9	1	25	13
Small low ABNs	N	27	28	30	30	29	26	23	27	20
	Y	3	2	0	0	1	4	7	3	10
	Total	30	30	30	30	30	30	30	30	30

The factors which are contrasting between clusters 4 and 6 are highlighted in orange and are timing of operations, good soils, engagement with industry organisations and adoption of new varieties.

For Cluster 6 – the small sized high producing ABNs, many of the farms in the Abergowrie district were high in elevation, although in the Lower Herbert there are many high-producing ABNs low in elevation (Figure 18b). For the small-sized low-producing ABNs there were farms which were both low and high elevation (Figure 18a). To maintain confidentiality for the small and large ABNs Figure 18 is not given.

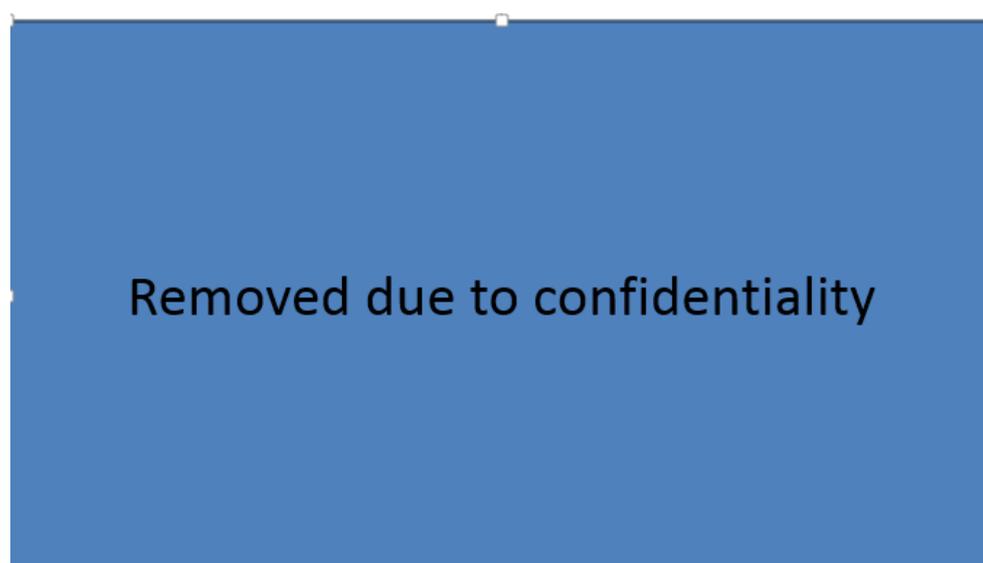
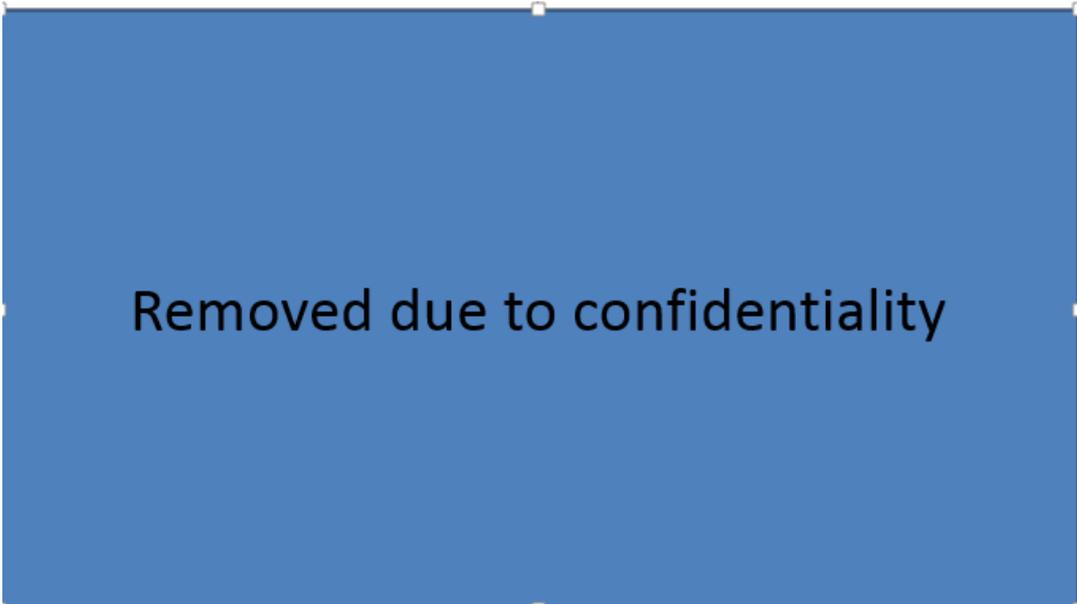


Figure 18: Maps of clusters 4 and 6 undertaken at the ABN level in relation to elevation in the landscape. This figure is not shown due to confidentiality reasons.

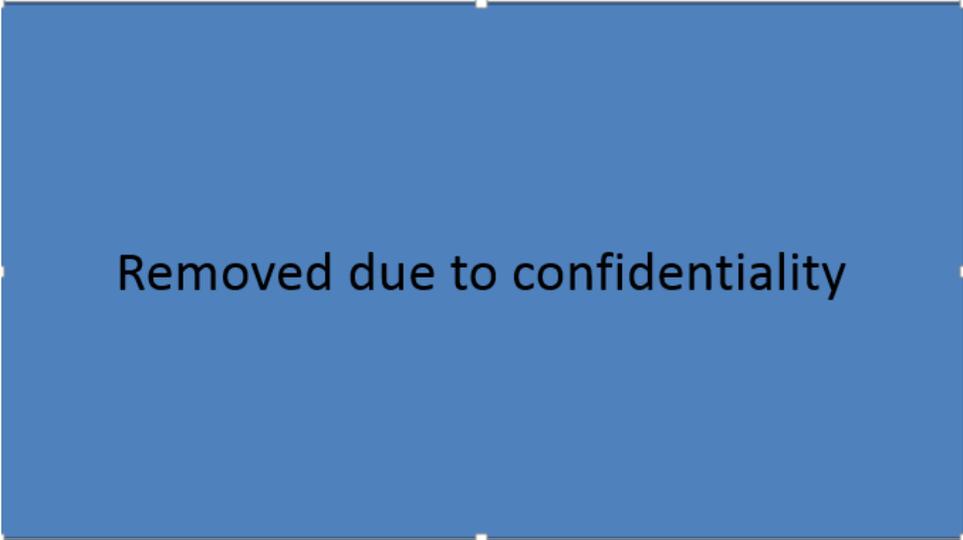


Removed due to confidentiality

Figure 19: Maps of clusters 4 and 6 undertaken at the ABN level in relation to soil type. This figure is not shown due to confidentiality reasons.

The small-sized high-producing growers are generally found in the pale brown, sandy loam, red loam and silty clay soils, but there are numerous exceptions (Figure 19). These soils are usually well drained and have higher CEC and are located along the Herbert River systems and its tributaries. It is interesting that very few high producing smaller growers are located in the Stone River and Ingham Line areas. This can be attributed the low general soil fertility of these soils and that general farm size being larger in in the Stone River and Ingham Line areas. To maintain confidentiality for the small and large ABNs Figure 19 is not given.

Small-sized low-producing growers they are generally spread throughout the district and soil type appears to have little influence on productivity with these growers. The main factor driving productivity on these growers appears to be determined by management practices.



Removed due to confidentiality

Figure 20: Maps of clusters 4 and 6 undertaken at the ABN level in relation to CEC in the topsoil. This figure is not shown due to confidentiality reasons.

Cluster 6, the small-sized high-producing ABNs, are generally found on the higher CEC soils in the Abergowrie and Lower Herbert districts (Figure 20 cluster 6). Generally, the small-sized low-producing ABNs are scattered throughout the district and there is no specific link to CEC in soils (Figure 20 cluster 4). Soil CEC can assist growers in obtaining higher productivity, but improved management practices such as good liming practices, legume fallows, increasing and conservation of organic matter will be able to mitigate some of the issues associated with low CEC soils. To maintain confidentiality for the small and large ABNs Figure 20 is not given.

Analysis of harvesting speed and pour rate data

Introduction

Declining ratoon yields in sugar cane have been linked to the introduction of machine harvesting (Anon., 1992). Machine harvesting is a highly complex process with many variables that need to be taken in to account when considering its impact on productivity in the sugarcane industry (Anon., 2014).

Selecting harvester ground speed relative to crop size has been identified as an area where simple practice change can result in significant improvement in sustainable productivity for all sectors of the industry (Kroes, 1997).

In this exploratory study, cane yield and GPS tracking data enabled us to examine the impact of harvester ground-speed on stool damage resulting in ratoon yield loss for various crop sizes in the Herbert region.

Materials and methods

Data and definitions

Cane yield and harvester GPS tracking data from the Herbert captured between 2012 and 2015 at rake level was used for analysis. Plant and plough-out replant crops have been excluded from the datasets to control for crop age at harvest. For the purposes of measuring yield loss from one ratoon to the next, the data were separated in to 3 seasonal datasets. Each of these datasets contained harvester speed information for the season of interest, and yield information for the season of interest, and the following season. For example, the 2012 dataset contained harvesting speed for the 2012 season, as well as yield information for both the 2012 and 2013 seasons.

The difference in yield from one ratoon to the next was measured by taking the harvested yield as a percentage of the yield in the following year. For example, the change in yield from 2012 - 2013 was measured as $(2013 \text{ yield} \div 2012 \text{ yield}) \times 100$. For the remainder of the report, this will be referred to as the following year yield fraction.

Data were summarised at the harvesting contract group level for cluster analysis of group performance, and farm level for Cate-Nelson analysis. Cane yield and following year yield fraction were averaged for each group or farm.

It has been shown that damage to the stool and subsequent reduction in ratoon yield caused by average ground speed varies depending on the size of the crop harvested (Kroes *et al.*, 1994). To account for the impact of average ground speed in different crop sizes, the data were further broken down into six yield size groups for each season:

1. less than 40 t/ha
2. between 40 and 60 t/ha
3. between 60 and 80 t/ha
4. between 80 and 100 t/ha
5. between 100 and 120 t/ha
6. more than 120 t/ha.

These groups were created in consultation with experts in harvesting and agronomy to assist in understanding the impact of ground speed on different crop sizes.

Upon review, these groups were further refined to include only the 60 - 80 t/ha, 80 - 100 t/ha and 100 - 120 t/ha groups. This decision was made to reflect the fact that yields below 60 t/ha are likely to be influenced by factors other than harvester speed, and yields of above 120 t/ha are not common in the Herbert region.

For data summarised at harvesting contractor group or farm level for cluster and Cate -Nelson analysis, only harvested yields of less than or equal to 100 t/ha were included since average yields at a harvesting contractor group or farm level were rarely over 100 t/ha.

A following year yield fraction greater than three standard deviations from the mean was considered an outlier and excluded from analysis.

Statistical methods

Linear mixed models were used to assess if there was a relationship between following year yield fraction and harvest contractor. Linear mixed models were chosen for their iterative estimation methods that handle unbalanced data well.

Simple linear regression was used to assess the relationship between following year yield fraction and average harvester ground speed. Regressions were also performed to further explore this relationship for each yield size group.

Cate-Nelson analysis (Cate and Nelson 1971), a technique common in agronomy, was used to explore the impact of different harvester ground speeds on different yield size groups to determine an optimum speed for each yield size to maximise following year yield fraction.

The technique was originally used to assess the point at which adding more nitrogen to a crop would cease to have a yield response. This was referred to as the critical point. At this critical point nitrogen use was at its most efficient – less nitrogen would generate a lesser yield, while more nitrogen would not likely lead to an increase in yield. Here, I applied the same principle to harvester speed. However, rather than increasing nitrogen and testing for yield response, we are reducing harvester ground speed and testing for an increase in following year yield fraction. The critical point in this case would be the speed at which following year yield fraction is maximised and further reductions in speed would not likely lead to further increase in yield fraction.

K-means cluster analysis (Hartigan, 1975) was used to divide the data into clusters of harvesting groups that were similar in terms of following year yield fraction and speed.

Results

Linear mixed model results

The linear mixed model analysis indicated a relationship between following year yield fraction and harvest contracting group in all three seasons ($p < 0.001$).

Notwithstanding the highly significant results of contracting group as a predictor of following year yield fraction, it should be noted that there is a large portion of unexplained variation in following year yield fraction indicated by the models. This suggests there are many other factors affecting following year yield fraction which we have not measured or reported here. These need to be taken into account in future research.

Simple Linear regression

Given our primary interest in this study is relating to stool damage leading to a reduction in cane yield which has been linked to harvester ground speed (Hurney *et al.*, 2005), average ground speed was selected as the variable of interest in exploring the relationship between contracting group and ratoon yield loss.

Results from a simple linear regression indicate a relationship between average ground speed and following year yield fraction in 2012 and 2013 seasons. While the effect of average speed is significant, the R-squared value is low, indicating that average ground is one of many possible predictors of following year yield fraction. Figure 21 shows regression results.

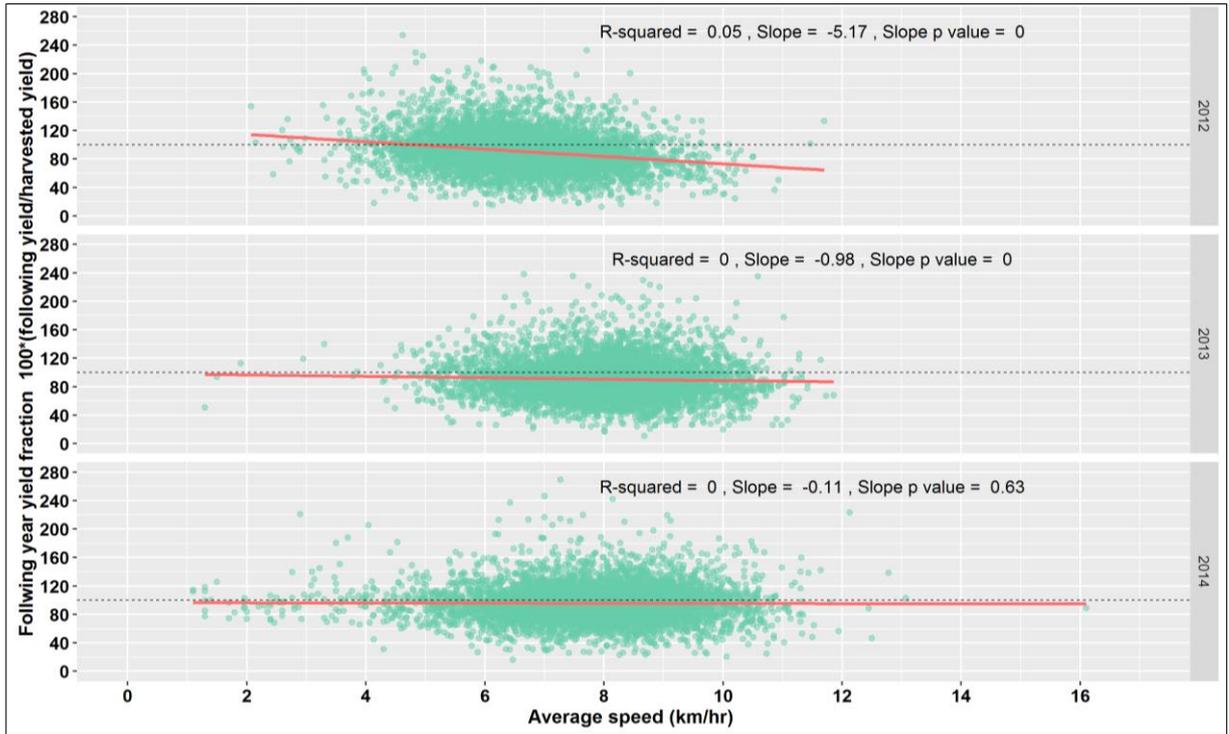


Figure 21: Simple linear regression results of speed in current year versus following year yield fraction: 2012 - 2014

Simple linear regressions were performed within these yield size groupings. A stronger relationship between average ground speed and following year yield fraction is seen within yield size groups in 2012 with higher R-squared observed in each yield size group. Similar improvements are seen in 2013 and 2014 when split into yield size groups, albeit with lower coefficient and R-squared values than in 2012. Results are given in Figure 22, Figure 23 and Figure 24.

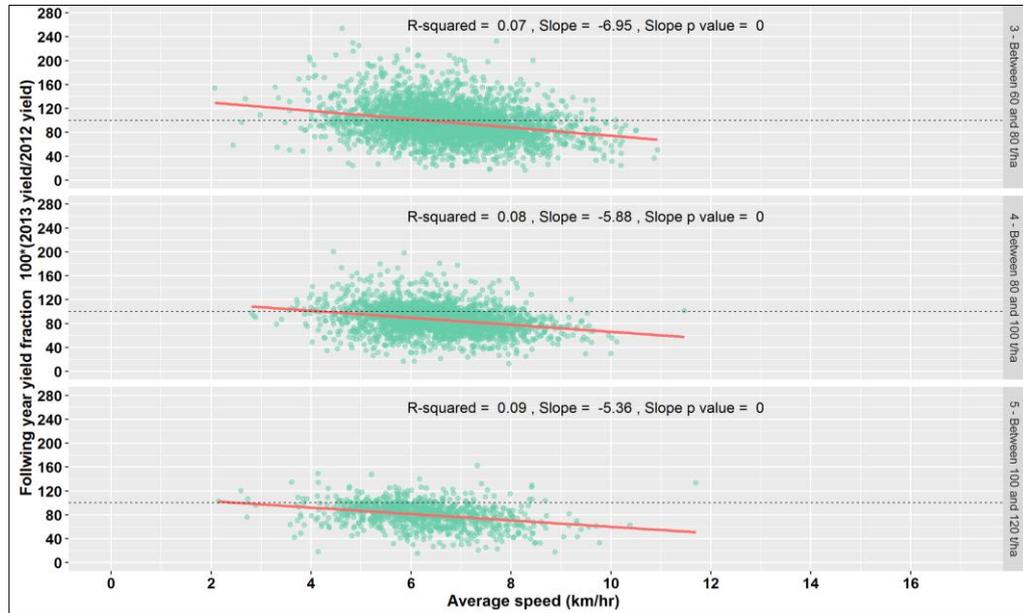


Figure 22: Simple linear regression results of speed in 2012 on the following year yield fraction by yield size groups

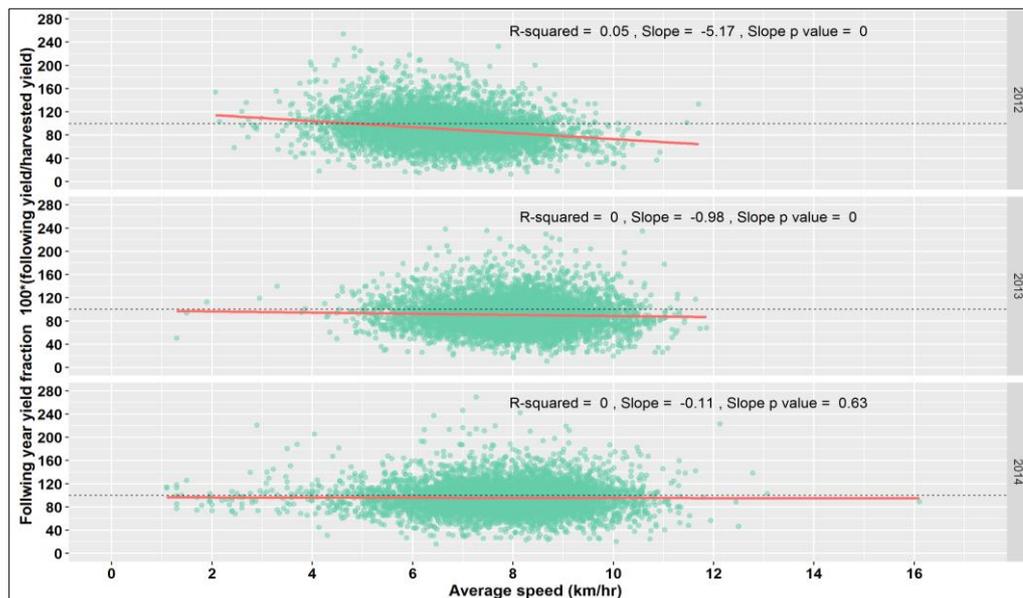


Figure 23: Simple linear regression results of speed in 2013 on the following year yield fraction by yield size groups

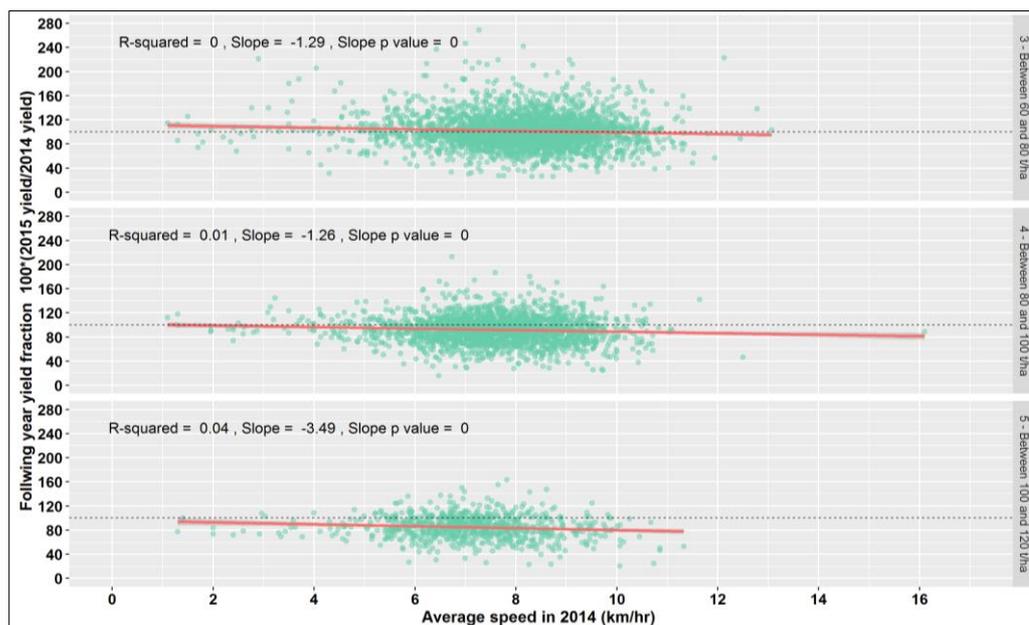


Figure 24: Simple linear regression results of speed in 2014 on the following year yield fraction by yield size groups

Cate-Nelson analysis

For the purposes of extension, it was pertinent to recommend a commercially viable ground speed which has potential to maximise the following year yield fraction. Cate-Nelson analysis was found to be a simple and effective method for achieving this. Critical x is the recommended average speed to maximise the following year yield fraction. In this analysis we targeted a ground speed of between 6 and 8 km/h and a following year yield fraction of 100 %.

Results from 2012 and 2013 are shown in Figure 25, Figure 26, Figure 27 and Figure 28. No significant models were found for 2014 data and, hence, are not reported here. Cyclone Ita, which occurred in 2014, is likely to have played a part in this. Critical x (critical average speed) is shown in red, critical y in green. The transparent dots are points that do not fit the model. Across the 2 seasons, approximately 80 % of points fit the specified model.

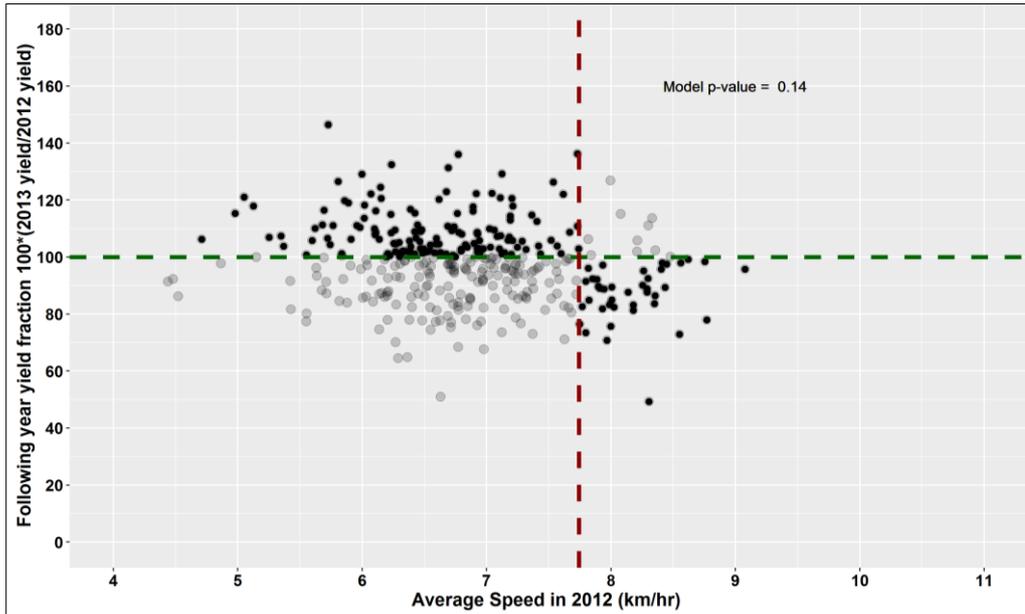


Figure 25: 60 - 80 t/ha – The effect of average speed in 2012 on following year yield fraction with Cate-Nelson analysis

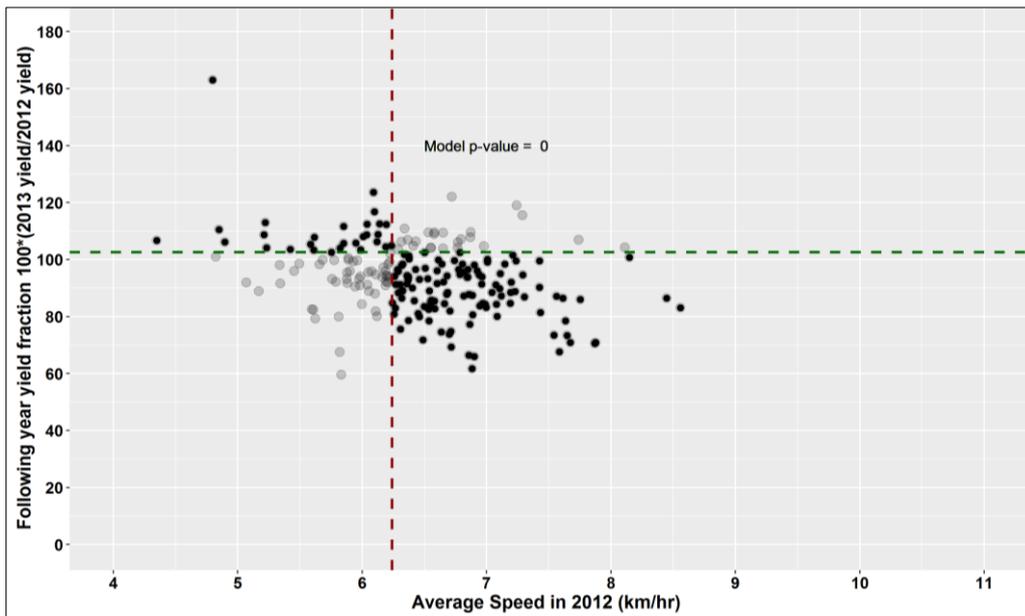


Figure 26: 80 - 100 t/ha – The effect of average speed in 2012 on following year yield fraction with Cate-Nelson analysis

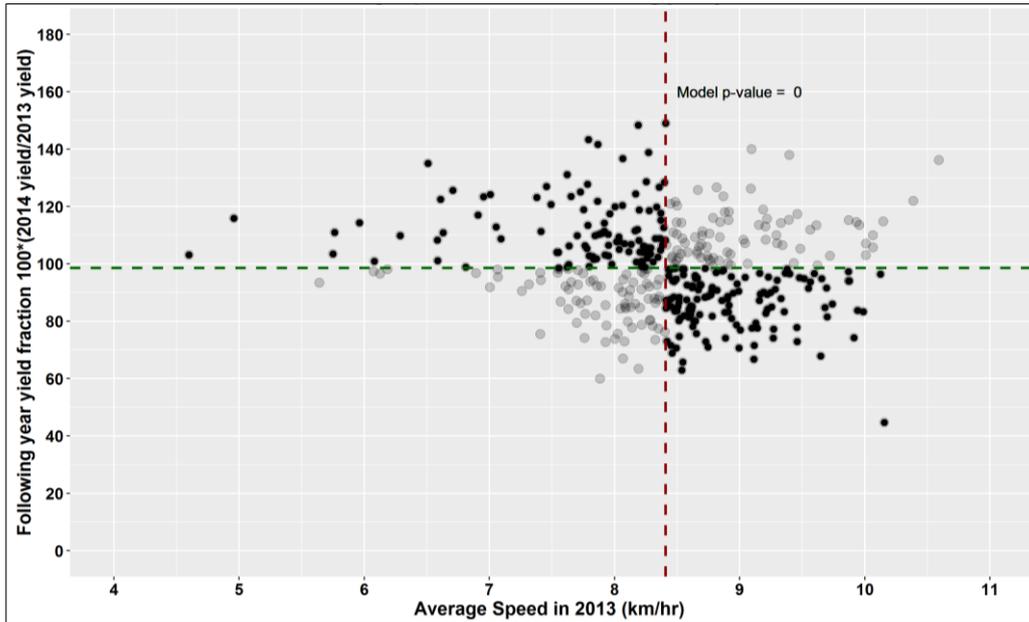


Figure 27: 60 - 80 t/ha – The effect of average speed in 2013 on following year yield fraction with Cate-Nelson analysis

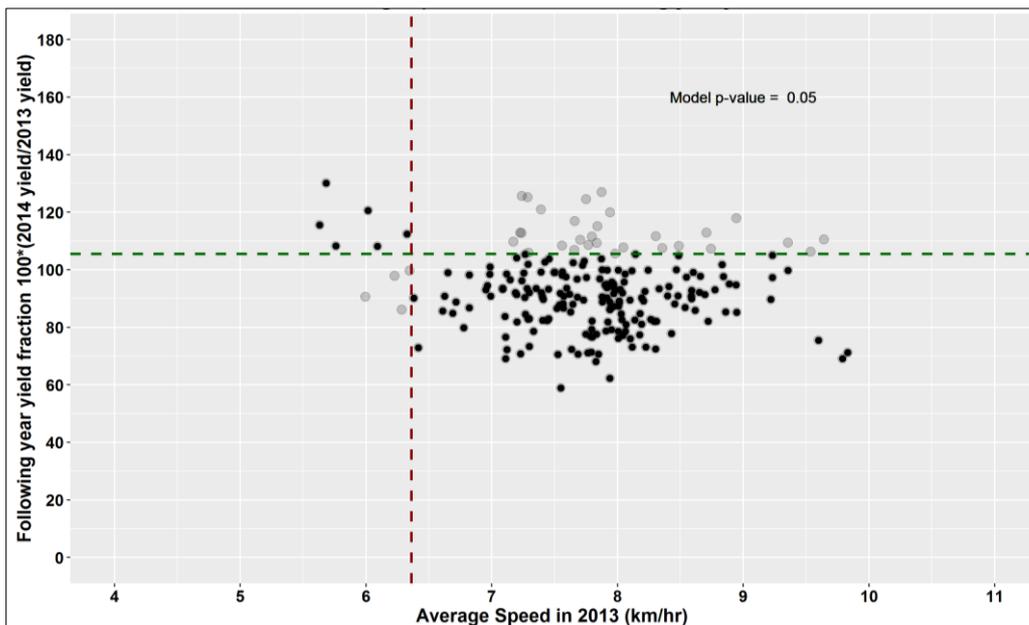


Figure 28: 80 - 100 t/ha – The effect of average speed in 2013 on following year yield fraction with Cate-Nelson analysis

The data indicates significant models ($p < 0.05$) for 2012 80 - 100 t/ha and 2013 60 - 80 t/ha and 80 - 100 t/ha (3 out of 4) groups.

Models results suggest that reducing harvesting speeds to 8.5 km/h or below in crops with yields of 60 - 80 t/ha and 7 km/h and below in crops with 80 - 100 t/ha could lead to improved following year yield fractions.

Cluster analysis

K-means cluster analysis was undertaken with a view to indicate contractor groups where extension could be beneficial and as a tool for illustrating where improvements could be made to contractor groups and relevant growers where appropriate.

Further work needs to be completed to characterise contractor groups and their clusters so the difference between high- and low-performing clusters can be understood. Plots showing clusters are included for completeness in Figure 29 through to Figure 31. However, no conclusions are made here and will be the subject of future harvesting and extension projects.

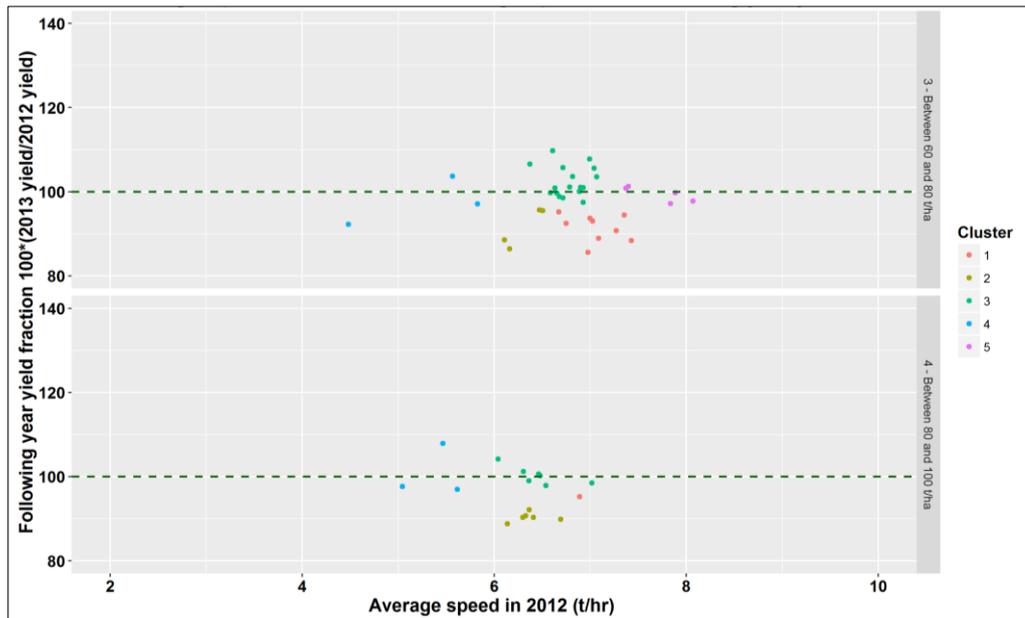


Figure 29: Contractor groups clustered on 2012 average speed and following year yield fraction

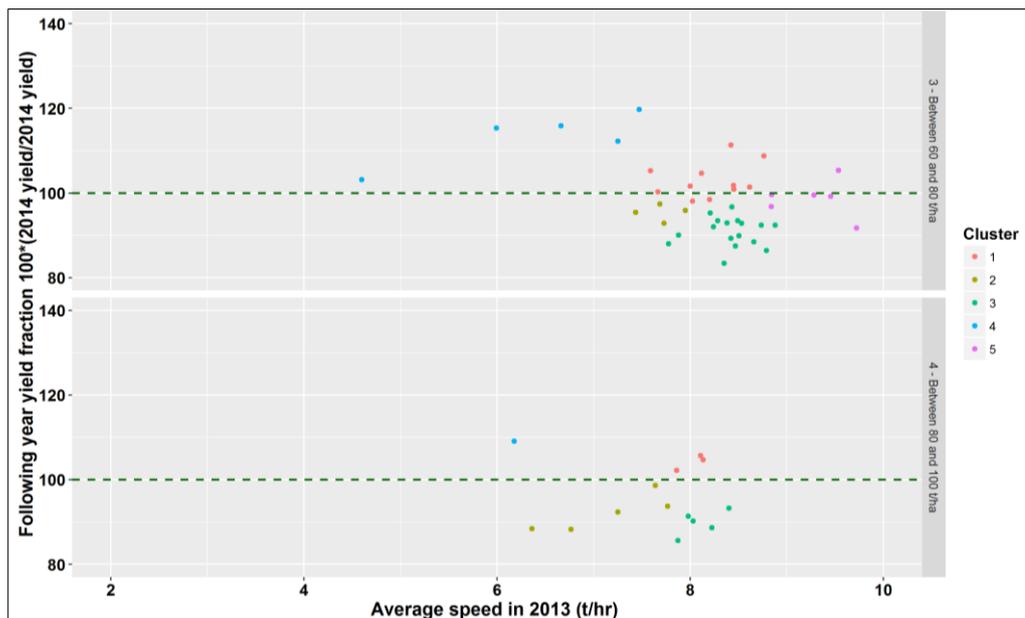


Figure 30: Contractor groups clustered on 2013 average speed and following year yield fraction

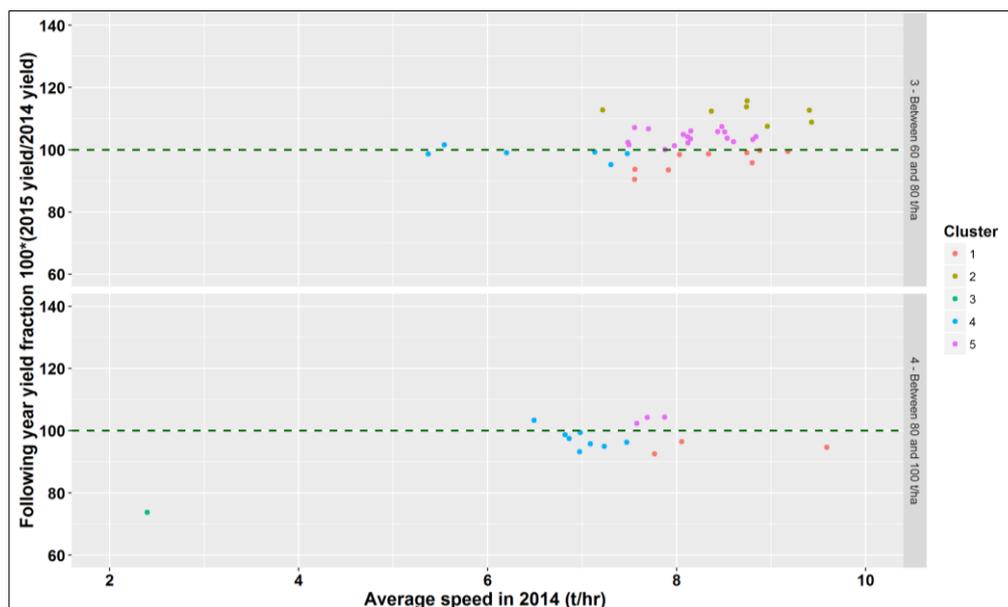


Figure 31: Contractor groups clustered on 2014 average speed and following year yield fraction

Discussion

In this project, we have analysed and summarised Herbert River mill rake data by using innovative techniques to identify some of the key drivers affecting productivity.

The recently conducted *Pachymetra* survey by HCPSL (Holzberger *et al.*, 2016) showed that the previous variety grown on a block had a significant effect on ratoon cane yield. Attention should be given by Herbert River farmers to the *Pachymetra* resistance of varieties they select for commercial production, not only taking into account the current crop, but when planning varieties to be grown in their fields into the future. This observation is consistent with known yield effects of the disease (Magarey, 1994) and with the effect varietal resistance on spore populations (Magarey and Mewing, 1994).

The majority of the current crops are planted to intermediate varieties (90 %). These intermediate varieties are suffering significant yield losses when they follow susceptible varieties. There is less of an effect if they follow intermediate varieties. The impact of previous crop cycle *Pachymetra* rating on cane yield highlights the importance of rotating varieties based upon *Pachymetra* rating to better manage the disease. The data also highlight that the impact is much greater in older ratoons and that *Pachymetra* may be a major factor contributing to poor ratooning in the Herbert region. Further analyses are being conducted to better understand the impacts of *Pachymetra* when intermediate varieties such as Q208^(b) and Q200^(b) are planted following previous crops of Q208^(b) or Q200^(b). High *Pachymetra* spore levels have been recorded under some crops of Q208^(b) and other intermediate varieties in the Herbert and other regions (Holzberger *et al.*, (2016). Growers have reported poor growth when Q208^(b) is planted following a crop cycle of Q208^(b). Analysis of the mill data may allow the effect of previous variety on the current crop to be investigated.

Age of the managers of the *FarmSplits* is also an important factor affecting cane yields. HCPSL is now using demographic data to develop targeted extension strategies in the Herbert region. It has made investments through its Target 85 program into training and additional extension support to those growers under 40 years of age.

This study is the first time the industry has been able to quantify the impact of new technologies and farming systems. Data analysis suggest that growers who adopt modern technologies and farming systems have generally seen the benefits from making the change. It also allows HCPSL to target its extension strategies within the region.

This study has found that the small farm high performing cluster of *FarmSplits* had a significantly higher uptake of new varieties compared to the small farm low performing group. This suggests that the small farm low performing group were not adopting the new, more productive varieties to the same extent as the small farm high performing group.

Clean (disease-free) seed assists growers to manage systemic diseases, especially ratoon stunting disease, leaf scald and chlorotic streak (Croft *et al.*, 2000). Increasing the adoption of clean seed could significantly increase productivity for the whole region. This was particularly evident in the small size low and small size medium performing clusters who had the lowest adoption of clean seed with 85 - 86 % of these clusters never obtaining clean seed. New varieties are distributed from the clean seed plots and these figures would confirm that these lower performing clusters are slower to adopt new varieties. In some cases, small growers access clean seed and new varieties from neighbours, but because this may mean the clean seed is propagated for a number of years on-farm before they obtain the planting material it would be at a higher risk of being re-infected with diseases.

This study has identified a number of factors associated with farm performance. Regularly obtaining clean seed, adoption of new varieties, modern farming systems, timeliness of operations and good soils with high CEC were the factors most associated with better farm performance.

Some of the factors in this study are clearly interrelated, for example, growers who adopt new varieties usually obtain supplies of these new varieties from the clean seed plots so they are regular users of the clean seed plots. Early adopters of new technologies are often growers who adopt new varieties quicker, obtain clean seed regularly and may also be better at other farm operations such as weed control and timeliness of operations. The study clearly shows that productivity in the Herbert River district can be improved and has highlighted some areas where extension programs could have a big impact. The potential maximum cumulative advantage from all the major controllable factors is estimated to be > 20 t/ha.

The harvesting elements of this project have largely been a gateway study for a number of dedicated harvesting and extension projects scheduled to begin in the months following the submission of this report. These projects will examine more closely the relationship between speed and ratoon yield loss and the impact of harvester optimisation on ratoon yield loss as well as cane and sugar loss in the year of harvesting, while controlling for appropriate harvester settings. Preliminary results in this project suggest that reducing harvesting speeds to 8.5 km/h or below in crops with yields of 60 - 80 t/ha and 7 km/h and below in crops with 80 - 100 t/ha could lead to improvements in ratoon crop yields.

Objective 2: Develop creative ways to present the analyses that will assist advisors and growers to optimise management strategies and variety choice at the farm level across the crop cycle.

Many changes have been made to *QCANESelect*[™] since the project commenced. Some of the new features include:

- 1) Enhancements to regional reporting
- 2) Calculations of weighted relative \$/ha and tonnes sugar per hectare to assist with yield scores
- 3) Whole-of-farm planning.

Regional reporting

QCANESelect[™] has been modified to accept Herbert mill data to the rake level from 2005 - 2015 and to produce reports on productivity by variety, crop class, soil type, productivity zone, year and combinations of these groups. *QCANESelect*[™] could previously provide some productivity reports but these were very limited because it did not have access to full mill data. Because the Herbert, Burdekin and Plane Creek mills use the same data collection system, it was also possible to use the same programming to provide productivity reports for the three Wilmar regions at the same time. Within these groups users can design reports to their own specifications for the following productivity measures:

- Tonnes cane
- % tonnes
- Hectares
- % hectares
- Tonnes cane per hectare (TCH)
- Tonnes sugar per hectare (TSH)
- \$ return per hectare, user can set sugar price, harvesting cost and levies
- Average sugar (CCS)
- Seasonal sugar
- Weekly supply – tonnes harvested per week of the season, CCS and mill average CCS for each week for the selected variety
- Fibre (only available for mills with NIR)
- Diseases – percent of crop planted to susceptible, intermediate and resistant varieties.

The ability to produce these reports, especially by soil type and crop class, will enable growers and advisors to evaluate variety and district performance so that better variety recommendations can be made and a range of factors that could be affecting productivity can be analysed. This will improve regional productivity as growers and advisors can base their variety selections or recommendations on the best available data and investigate factors that could be affecting regional productivity. In the past, this data has not been fully utilised and if it was analysed it required advisors many days to collate and produce reports. The data can now be uploaded at the end of each season and a wide range of reports will be immediately available to all users. HCPSL will now be able to use *QCANESelect*[™] to produce their annual mill productivity report saving staff many days of time.

The new productivity reports for the Herbert region can be accessed from the *QCANESelect*[™] web site: <http://tools.sugarresearch.com.au/QCANESelect/Default.aspx>. The reports are accessed from the home page at the regional reporting tab (Figure 32).

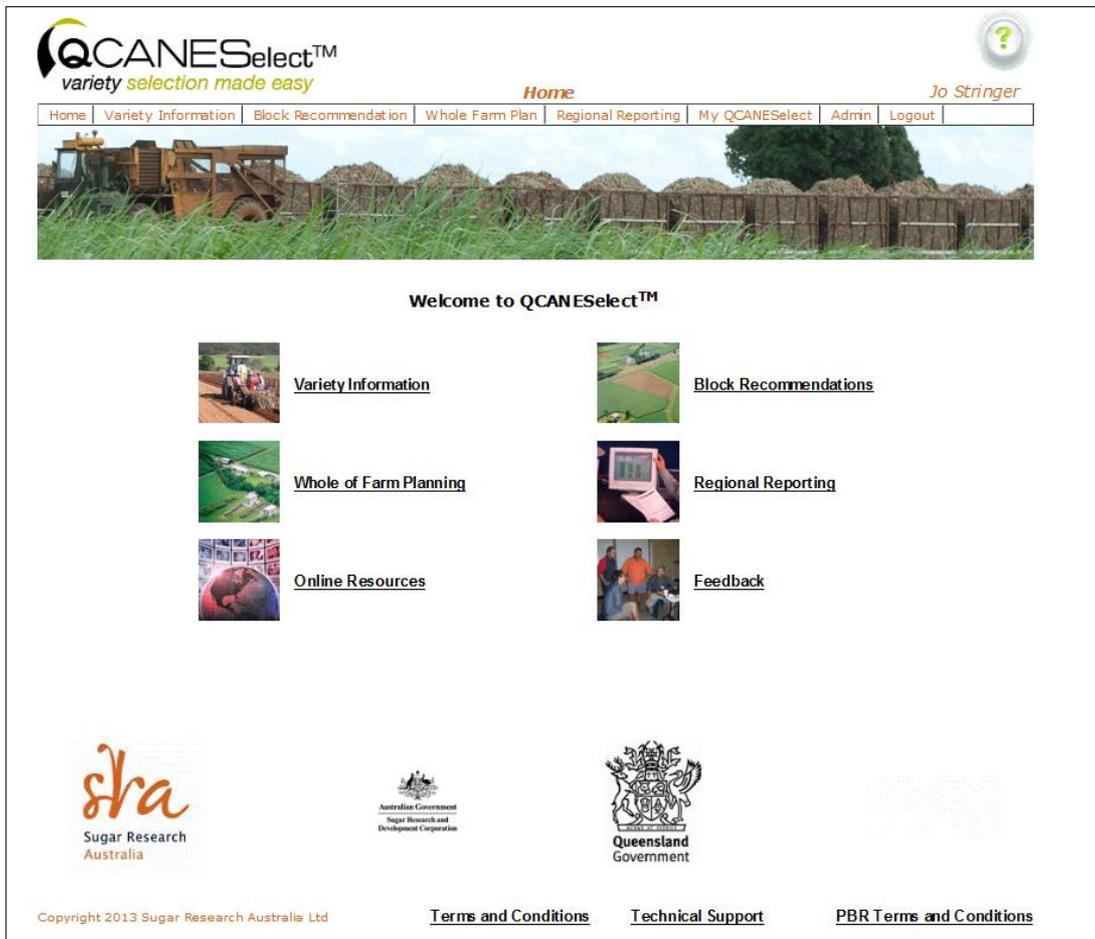


Figure 32: QCANESelect™ home page

The regional reporting page allows users to design their own reports and QCANESelect™ will access the mill data, analyse the data and return a report in a graphical form (Figure 33).

QCANESelect™
variety selection made easy

Regional Reporting Roderick Fletcher

Home | Variety Information | Block Recommendation | Whole Farm Plan | **Regional Reporting** | TC Plants | My QCANESelect | Admin | Logout

Regional Reporting

What would you like to report on? by Variety Region District Crop Class Soil Type

Y axis range:

Region: District: Crop Class: Soil Type:

Years - From: To:

Variety Select All

<input type="checkbox"/> TRITON	<input type="checkbox"/> Q220	<input type="checkbox"/> Q124
<input type="checkbox"/> SRA3	<input type="checkbox"/> Q219	<input type="checkbox"/> Q122
<input type="checkbox"/> Q253	<input type="checkbox"/> Q218	<input type="checkbox"/> Q121
<input type="checkbox"/> Q252	<input type="checkbox"/> Q217	<input type="checkbox"/> Q120
<input type="checkbox"/> Q250	<input type="checkbox"/> Q216	<input type="checkbox"/> Q119
<input type="checkbox"/> Q249	<input type="checkbox"/> Q215	<input type="checkbox"/> Q117
<input type="checkbox"/> Q247	<input checked="" type="checkbox"/> Q208	<input type="checkbox"/> Q115
<input type="checkbox"/> Q246	<input type="checkbox"/> Q204	<input type="checkbox"/> Q114
<input type="checkbox"/> Q245	<input type="checkbox"/> Q201	<input type="checkbox"/> Q113
<input type="checkbox"/> Q242	<input checked="" type="checkbox"/> Q200	<input type="checkbox"/> Q107
<input type="checkbox"/> Q240	<input type="checkbox"/> Q199	<input type="checkbox"/> Q100
<input checked="" type="checkbox"/> MQ239	<input type="checkbox"/> Q198	<input type="checkbox"/> Q99
<input type="checkbox"/> Q238	<input type="checkbox"/> Q195	<input type="checkbox"/> Q96
<input type="checkbox"/> Q237	<input type="checkbox"/> Q194	<input type="checkbox"/> Q90
<input type="checkbox"/> KQ236	<input type="checkbox"/> Q192	<input type="checkbox"/> Q77
<input type="checkbox"/> Q233	<input type="checkbox"/> Q191	<input type="checkbox"/> Q57
<input checked="" type="checkbox"/> Q232	<input type="checkbox"/> Q190	<input type="checkbox"/> PINДАР
<input type="checkbox"/> Q231	<input type="checkbox"/> Q188	<input type="checkbox"/> MIDA
<input type="checkbox"/> Q230	<input type="checkbox"/> Q187	<input type="checkbox"/> H56-752
<input type="checkbox"/> Q229	<input type="checkbox"/> Q186	<input type="checkbox"/> CASSIUS
<input checked="" type="checkbox"/> KQ228	<input checked="" type="checkbox"/> Q183	<input type="checkbox"/> BADILA
<input type="checkbox"/> Q226	<input type="checkbox"/> Q181	<input type="checkbox"/> ARGOS

Figure 33: QCANESelect™ Regional Reporting page

The system also allows users to download the analysed data so that they can use the data to create different reports or in further analyses. A few examples of productivity reports are shown in Figure 34 through to Figure 38.

Figure 34 demonstrates how varieties can be compared for productivity on an individual soil type, in this case clay soil, and across crop classes plant to fifth ratoon. From this report growers and advisors can see which variety performs best. In this example Q208^(b) over the crop cycle is the highest yielding variety. KQ228^(b) performs well in plant crop, but productivity drops away in later ratoons. A tonnes legend is included below the chart and this is used to represent a level of confidence or caution in the charted data.

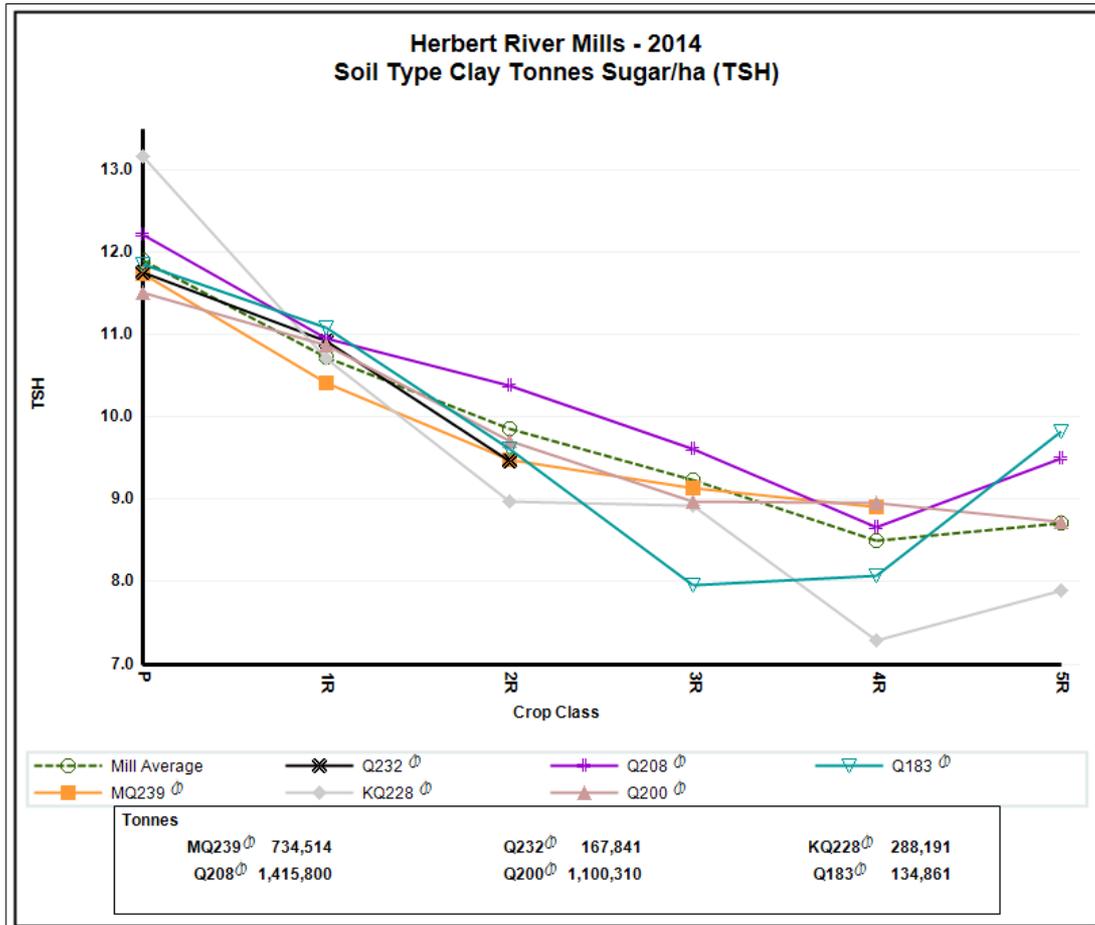


Figure 34: Productivity report for tonnes sugar/ ha (TSH) for selected varieties for Herbert clay soil for crop classes plant to fifth ratoon (P-5R) in 2014

Figure 35 shows the \$/ha for a sugar price of \$400 /t, harvest costs of \$8.60 /t and industry levies of \$1 /t for the same varieties on clay soils. In this report, Q200[Ⓛ] gives a similar \$/ha to return as Q208[Ⓛ].

Q200[Ⓛ] has slightly less tonnes sugar/ha than Q208[Ⓛ] but because its CCS is above mill average for the majority of the season (Figure 36), its \$/ha returns are similar to Q208[Ⓛ].

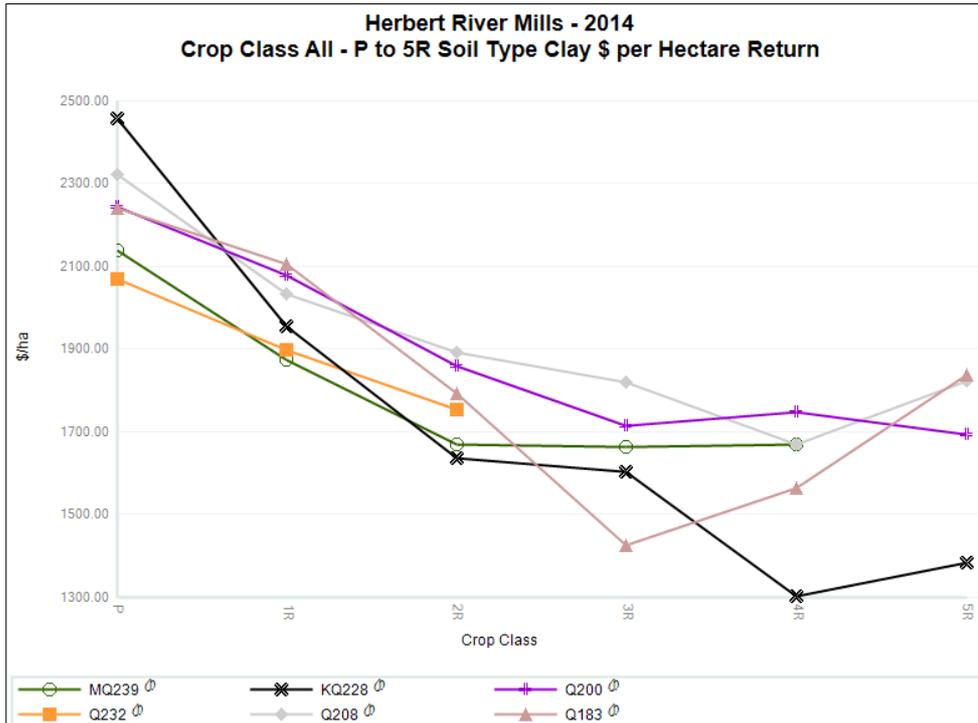


Figure 35: Productivity report for \$/ha for selected varieties for Herbert clay soil for crop classes plant to fifth ratoon (P-5R) for 2014

Figure 36 shows that growers are aware that Q200[Ⓟ] has excellent late season CCS and the proportion of this variety harvested late in the season is much higher than earlier in the season. Current recommendations for this soil type rank Q200[Ⓟ] lower than would be indicated by this data.

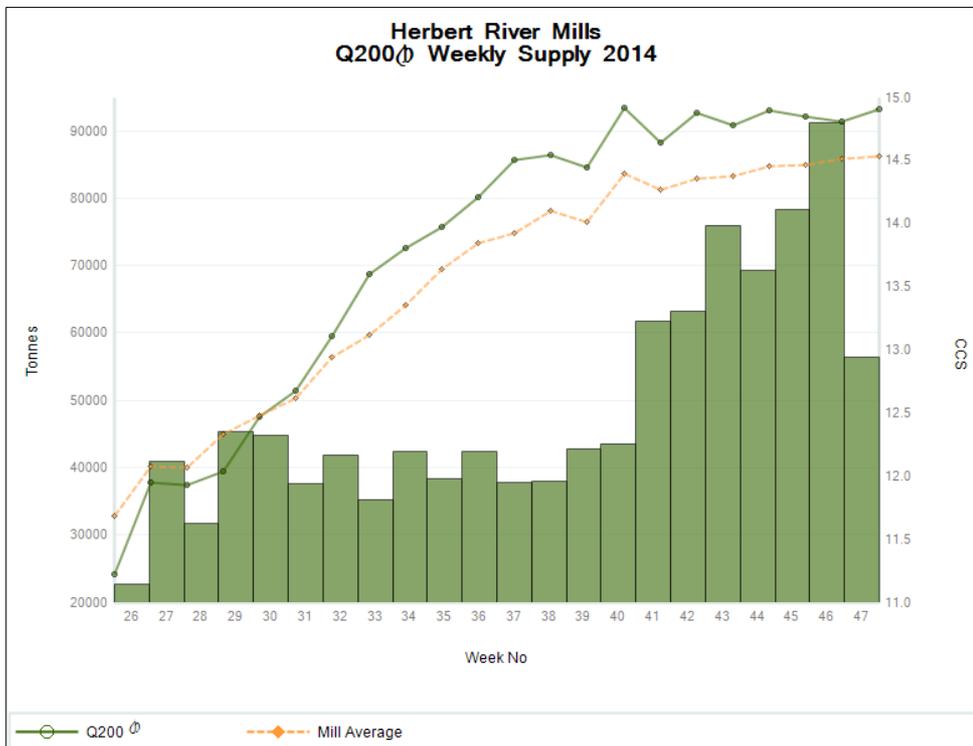


Figure 36: Weekly supply of Q200[Ⓟ] and CCS for Q200[Ⓟ] and mill average in the 2014 season

Figure 37 shows that the proportion of the crop harvested in each crop class from 2005 - 2014. The obvious feature of Figure 37 is the standover (SO) crops harvested in 2011 after the very wet harvest season in 2010 that prevented all crops from being harvested in that year. The proportion of crop classes can have a significant influence on regional productivity. Figure 34 shows the fall in productivity with increasing crop class. If the proportion of plant crop and younger ratoons increases, the relative mill productivity should also increase and conversely if the proportion of older ratoons increases productivity will fall. Figure 37 shows that proportion of plant crop in 2011 and 2012 was lower than the average for the 10 years. This would be a carryover from 2010 when many growers were prevented from planting because of the extended period of wet weather during the normal planting season. The proportion of plant crop increased significantly in 2013 and 2014.

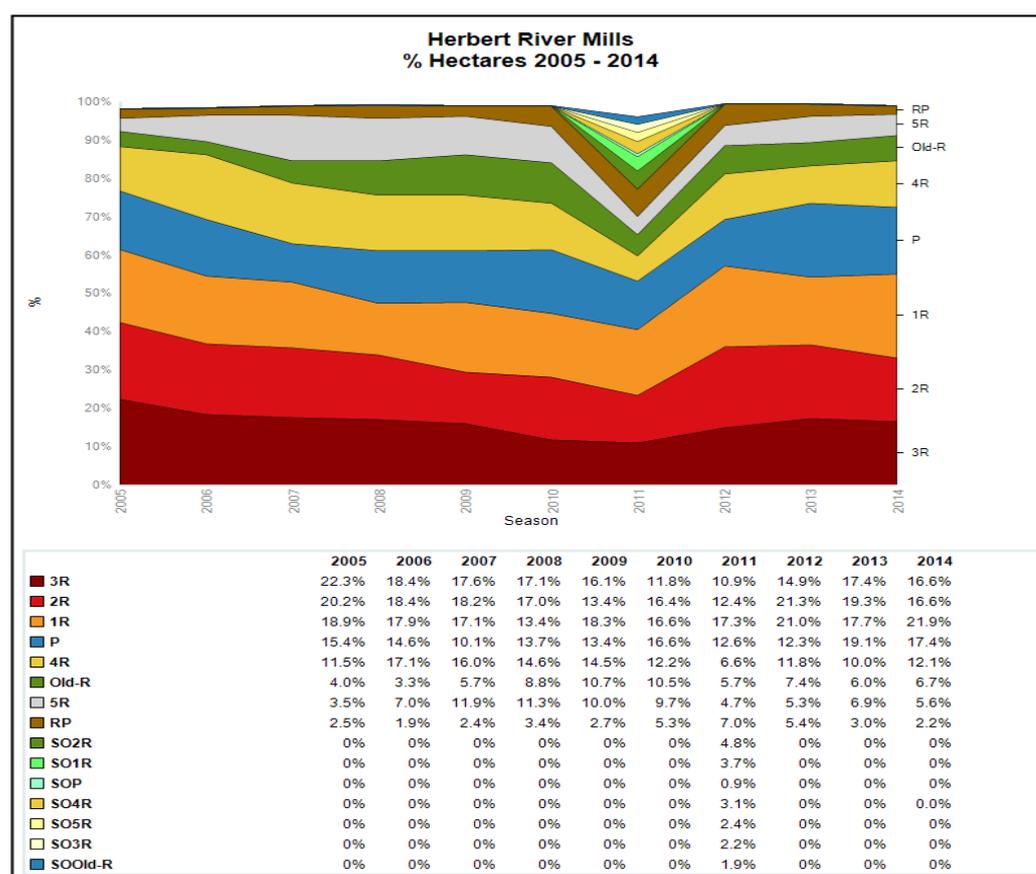


Figure 37: Productivity report for percent hectares of each crop class from 2005 to 2014

Figure 38 provides a graph which shows the proportion of the crop made up by varieties that are susceptible, intermediate and resistant to smut. *QCANESelect*TM can plot this graph for any of the diseases which have resistance ratings in the SRA *SPIDNet* plant breeding database. Growers and advisors can monitor the success of programs to replace susceptible varieties, in this case smut susceptible varieties. Changes in the disease risk profile of a region can be monitored with these reports in *QCANESelect*TM.

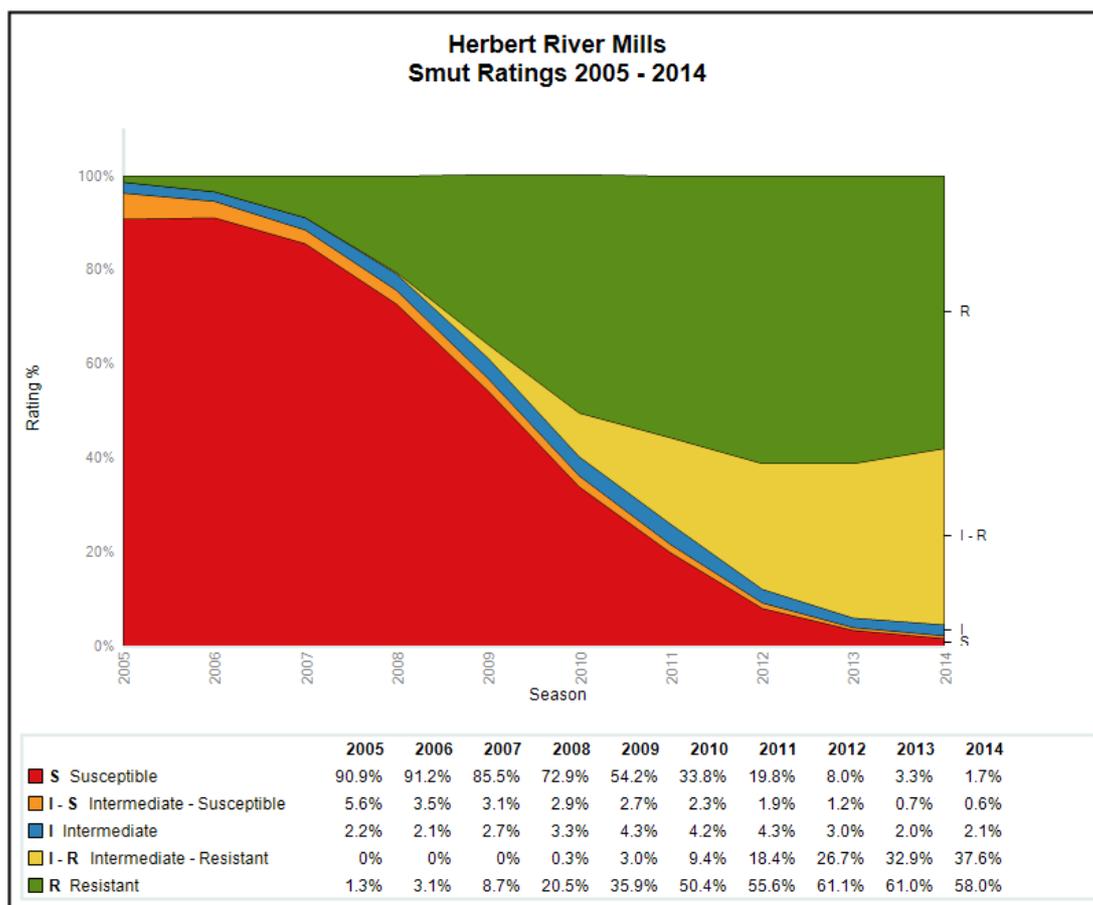


Figure 38: Percent of crop planted in the Herbert to Smut susceptible, intermediate and susceptible varieties from 2005 to 2014

Yield scores

One of the newest features in *QCANESelect*TM is calculation of weighted relative \$/ha and TSH to assist growers and advisors in choosing which variety to plant. Programming of this feature has commenced but not completed. *QCANESelect*TM has been updated using mill data for the Herbert and Burdekin by soil types for 2013 - 2015 to enable comparison to the current *QCANESelect*TM yield scores. *QCANESelect*TM uses yield scores to make recommendations and this is updated annually before the planting season commences. Local industry representatives and SRA staff can now use weighted relative \$/ha to assist them in making recommendations on varieties thorough *QCANESelect*TM yield scores. The benefit of these analyses is that they summarise the mill data across years into one figure for each variety x soil type comparison and will aid in assigning the *QCANESelect*TM yield scores. By calculating the yield relative to mill average it accounts to some extent for the season and crop class effects. Although the graphs from *QCANESelect*TM for P-5R for TSH (Figure 34) or \$/ha (Figure 35) for each soil type and each year are an excellent way of looking at the performance of varieties we have to summarise the data in the graphs into one "Yield Score" to be entered into *QCANESelect*TM to make variety recommendations.

The weighted relative \$/ha and TSH will help us to give better estimates of "Yield Score" especially for the varieties with adequate tonnages to give a reliable estimate. Like all mill data the figures need to be interpreted with care when they are based on a small sample or the values are very variable and/or there are data for limited crop classes, for example, there are some anomalies where there is data for only small samples in one or two crop classes. To aid in interpretation we use the total tonnes and

the weighted relative \$/ha for each crop class. These analyses were used last year and the updated analyses can be used again to help with *QCANESelect*TM meetings.

The relative \$/ha or TSH is calculated for each variety in each soil type and for each crop class relative to mill average for that same comparison. For example, we calculate the values for 2013, 2014 and 2015 and then calculate a weighted average over years. We have used a cube root transformation of the tonnes for each year to weight the averages. This gives the values which have the largest tonnage the highest weight while still giving some weight to lower tonnages in a different season.

The relative \$/ha were used to assist in assigning *QCANESelect*TM yield scores for varieties by soil types at the annual *QCANESelect*TM meetings in the Herbert and Burdekin in 2015 and 2016.

Whole-of-farm planning

An example Whole of Farm (WOF) plan for 'Stephen Adenata Farm number 6249A' is attached in



Appendix 1 - Stephen
Adenata - whole of fa

Appendix 1. This is based on real data although the Contact Name and Farm Number are fictitious for privacy reasons. Stephen only has one farm and this is in the Ingham Line district. He wants to plant a variety in his a clay block that is good for mid-season sugar.

At the front of the report are graphs to show seasonal CCS, cane yield and sugar yield trends for the Ingham Line district by major varieties for 2015. Examination of these trends will assist Stephen in deciding what variety to plant. Q208[Ⓛ] had CCS levels above mill average for most of 2015 season although Q240[Ⓛ] had the highest sugar yield of the selected varieties. Stephen wants a variety that performs in his area as well as a variety that is resistant to smut and resistant/ intermediate to pachymetra root rot. He only recently purchased his farm on which the previous owner originally planted a lot of Q208[Ⓛ]. Stephen wants to change the variety and crop class make-up of his farm but even after selecting Q200[Ⓛ] to plant in his fallow block he has 67 % of Q208[Ⓛ]. The use of *QCANESelect*TM will assist him to plan, manage and implement his new variety program which will help to minimise the risk of disease and improve his productivity.

In the 2016 season approximately 20 % of Herbert growers (by area) were invited to participate in a pilot program for the Whole of Farm Planning module. Many useful comments were obtained from this and due to the enthusiastic response this program will be expanded in 2017.

Objective 3: Investigate methods of early prediction of variety performance based on mill data from the first years after release.

Ratoonability is a feature of varieties that has been identified by growers as having great importance to profitability. Maintaining acceptable productivity for more ratoon crops can greatly improve a grower's profitability because he can spread the high cost of planting over more years and have less periods of fallow when no income is produced. Several measures of ratoonability, based on the mill data have been considered:

- 1) Loss in ha from P crop through to 4th or 5th ratoon for a given planting year
- 2) Actual yield and the rate of loss in yield (TCH, TSH or \$/ha relative to mill average) across crops
- 3) Slope of the regression line of crop class vs cane yield
- 4) Cumulative cane yield relative to the P crop for the ratoons.

The benefit of 1 is that it is a measure of the actual decisions made by growers on how long to continue ratooning a variety. The problems with this measure is that it requires many years to obtain data for a variety (perhaps at least 5 - 6 years) and events such as disease incursions can mean that growers make decisions not on ratoonability but to remove a susceptible variety before the disease causes serious losses.

Measure 2 has the benefit that it measures the economic return to the growers over a crop cycle. In discussions with growers they have pointed out that in some cases the mill data for older ratoons is biased because the poor yielding crops have been ploughed out and only the better ratooning (yielding) crops are retained. In an attempt to reduce this bias and to reduce the number of years to obtain an estimate of the ratoon performance of varieties, a model has been produced that measures the rate of decline in yield from first to third ratoon and uses this prediction to model economic returns across a 10-year period. The average \$/ha/yr return over 10 years is proposed as a ratooning index for the variety. An example of the output of this model is shown in Figure 39. This model will be discussed with advisors, researchers and industry.



Figure 39: Ratooning index and ratooning model for four varieties based on Herbert mill data from 2012-2014.
A. ratoon index \$/ha/year based on a 10-year period. **B.** Cumulative \$/ha for 10-year period. Assumptions used in the model were that the grower ploughs out crop when returns drop below \$1500/ha, the field is fallowed and it costs \$1500/ha to replant the new crop. Actual average plant and first ratoon crop \$/ha returns were used in the model and the predicted returns for 2R and subsequent ratoons were calculated from the rate of decline in yield for each individual variety from 1R to 3R in 2012 to 2014.

The final two measures of ratooning examined the performance of three new varieties on 3 dominant soil types based on hectares from the 2014 crop which are Clay 47 %, Sandy 17 % and Terrace Loam 17 %. Rake data from 2012 - 2014 were examined to determine suitability. Data from 2010 (very wet/ Cyclone Yasi), 2011 (large standover crop) and combinations < 10 t were not included.

Ratooning was defined to be performance over 1R-5R and P crop was not included. As seasonal conditions have a large effect on cane yield, each year was analysed separately for each soil type and crop class effects were predicted as random effects. Crop class was then regressed against predicted cane yields for each soil type and slopes calculated. Values close to zero indicate that ratoons have not declined from 1R.

Another measure, which does not assume a constant slope and uses the above data, is to calculate the cumulative cane yield relative to the P crop for 1R to 5R. Higher values indicate better ratooners with a maximum value of five. These results are given in Table 8.

Table 7: Slope of regression lines for crop class versus cane yield for major varieties x soils 2012 - 2014

Variety	Soil	Slope of regression line
Q200 ^(b)	Clay	-1.9
Q208 ^(b)	Clay	-2.5
KQ228 ^(b)	Clay	-1.2
Q200 ^(b)	Sandy	-2.2
Q208 ^(b)	Sandy	-1.2
KQ228 ^(b)	Sandy	-0.7
Q200 ^(b)	Terrace Loam	-3.3
Q208 ^(b)	Terrace Loam	-3.3
KQ228 ^(b)	Terrace Loam	-2.5

Table 8: Cumulative cane yield relative to P crop for major varieties x soils 2012 - 2014

Variety	Soil	Cumulative cane yield relative to P crop
Q200 ^(b)	Clay	4.5
Q208 ^(b)	Clay	4.1
KQ228 ^(b)	Clay	4.5
Q200 ^(b)	Sandy	3.9
Q208 ^(b)	Sandy	4.4
KQ228 ^(b)	Sandy	4.9
Q200 ^(b)	Terrace Loam	4.1
Q208 ^(b)	Terrace Loam	3.9
KQ228 ^(b)	Terrace Loam	4.0

Results from Tables 7 and Table 8 suggest that KQ228^(b) is the best ratooner on all soils. However, this does not reflect what happens in the field. When managed and harvested early to mid-season, KQ228^(b) ratoons well. Time of harvest has a significant impact on ratoonability of KQ228^(b) and inflates the yield performance when compared to other varieties that are harvested mid to late in the season (which are subjected to additional crop stresses like drought and an early onset of the wet season).

The data indicate that, for Terrace Loams soils, ratooning is generally not as good as on other soil types. The recent HCPSL *Pachymetra* district survey has found moderate to high levels of disease in this soil type, which is having a significant impact on cane yield and ratoonability. This soil has also been experiencing significant impacts due to YCS for the past four years.

Further work needs to be undertaken on these ratooning measures to indicate the reliability of the estimates by weighting the values by hectares harvested or similar values. Once this is done, this information can be incorporated into *QCANEselect*TM Whole-of-Farm Plan module that growers use to assist them in what variety to plant.

Objective 4: Establish secure data storage protocols and develop automated analysis methods.

On commencement of the project a Penetration Test conducted by PWC IT Security Consultants validated SRA's IT network security environment. *SPIDNet* database is held on a secure SRA SQL Server instance. Access to this data is controlled by individual user controls and limited to IT administrative staff and a consultant for the *SPIDNet* and *QCANESelect*TM web sites. Sensitive rake level data are not displayed in either web site. Loading of rake data is also restricted to *SPIDNet* administrators. All data displayed in *SPIDNet* are aggregated to district and soil type levels – individual rake data are not displayed or exportable anywhere in either web site. In future development of a benchmarking module for Farms in *QCANESelect*TM access will be by secure password and the password is stored in an encrypted fashion using the PBKDF2 encryption approach. The login page uses HTTPS secure sockets for encrypted transmission of user credentials.

Objective 5: Identify knowledge gaps that can be addressed in future projects.

Although many factors affecting productivity have been identified in this project, future work should focus on identifying climate zones within the Herbert region to further refine productivity performance groupings (clusters). The climate zones could then be linked to soil type and farming systems information to improve variety recommendations.

Further work needs to be done on classifying the 10,000 ha of soils in the Ingham Line which represents 15 % of the Herbert area. For this purpose, HCPSL have purchased a DUALEM-421. The Ingham Line area has many soils with sodic issues and other productivity constraints. Knowing where these zones are would allow for improved varietal recommendations, variety trials and remedial strategies such as variable rate lime and gypsum. The Dual EM is the most advanced instrument available and can map depths down to 1, 2 and 4 m through the soil profile and field elevation in one pass. It operates on the principle of electrical inductance created by alternating current and, therefore, has the advantage of not having to physically make contact with the soil, compared to the Veris unit. Given that productivity at times is driven by soil properties at different depths and not simply the top soil, this instrument provides a detailed multi-layer or multi-horizon 3-dimensional view of soil properties and, therefore, allows for improved understanding of the soil property x variety interaction.

Knowledge gaps in the harvesting area which were identified during this project that can be addressed in future research include:

- What are the key factors limiting the reduction of ratoon yield loss in crops greater than 80 t/ha?
- How does harvester front end setup affect the relationship between speed and ratoon yield loss? What are the key factors causing differences between ratoon following year yield fraction and speed clusters identified in multivariate analysis?
- Can classification trees or other statistical learning methods provide useful decision support for harvest contractors and growers in selecting harvester settings appropriate to field and crop conditions?

Further work needs to be completed to characterise contractor groups and their clusters so difference between high- and low-performing clusters can be understood. The harvester data have been characterized in terms of fan type, chopper configuration, use of GPS guidance and GPS auto steer and make, model and colour of harvester. After completion of the 2016 season, this data will be related to the productivity data clusters and farm performance.

In future projects further enhancements to *QCANESelect*TM include allowing growers to easily complete a whole of farm plan by automated entry of farm data (block, area, variety, crop class etc.) directly from

mill data. Discussions with many mill regions have also requested that benchmark individual grower's performance relative to subdistrict and/or mill level by soil type, sub-district, and crop class would be very beneficial.

Using the recommendations from the Ratooning Workshop different methods of developing a ratooning index will be investigated. These new measures should consider time of harvest.

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Phil Lethbridge provided all the SQL programming for collation of the data and made many enhancements to *QCANESelect*TM. Chris and Stuart Norris from Norris ECT provided interpretation in the results of the GPS tracking data.

This project relied heavily on quality data from many organisations and I thank them for providing this. Wilmar Sugar Australia provided the rake data from the Herbert River mills for 2005-2015. Most of the data which relate to cluster groupings were made available by HCPSL except for the GPS tracking data and raw CEC data from Wilmar Sugar Australia, kriged CEC data from Dr Rob Bramley, CSIRO, and *Pachymetra* resistance ratings from SRA.

The HCPSL Board, CANEGROWERS Herbert and many growers and harvesting contractors have contributed to this project and their support is greatly acknowledged.

The financial support of Sugar Research Australia and Queensland Department of Agriculture and Fisheries to undertake this research is gratefully acknowledged.

Section 4: Outputs and Outcomes

Outputs:

Specific outputs from this project include:

- A consistent and automated approach to the collation, analysis and reporting of annual mill data through the use *QCANESelect*TM
- Summary information on relative performance of varieties under similar conditions (soil, crop classes, sub-districts and productivity zones), which will lead to optimal variety recommendations
- Identification of management practices to improve productivity for groups of farms with similar production trends.

Outcomes:

This study has identified a number of factors associated with farm performance and these include regularly obtaining clean seed, adoption of new varieties, modern farming systems and the impact of the *Pachymetra* resistance of previous varieties on yield of the current crop. Project outputs have been widely communicated to the Herbert industry. This has resulted in one of the largest growers in the Herbert adopting wider row spacing from the commencement of the 2016 season and approximately 200 samples have been tested for *Pachymetra*. Approximately, 67 % of the *Pachymetra* samples have been greater than the economic threshold.

Age of the grower making the business decisions on the farm is also an important factor affecting cane yields. HCPSL is now using demographic data to develop targeted extension strategies in the Herbert region. It has made investments through its Target 85 program into training and additional extension support to those growers under 40 years of age.

Some of the factors in this study are clearly interrelated, for example, growers who adopt new varieties usually obtain supplies of these new varieties from the clean seed plots so they are regular users of clean seed. Early adopters of new technologies are often growers who adopt new varieties quicker, obtain clean seed regularly and may also be better at other farm operations such as weed control and timeliness of operations. The study clearly shows that productivity in the Herbert River district can be improved and has highlighted some areas where extension programs could be directed to have a big impact. The potential maximum cumulative advantage from all the major controllable factors is estimated to be > 20 t/ha.

Section 5: Intellectual Property (IP) and Confidentiality

The original version of this final project report was “Commercial in Confidence” as it contained sensitive grower data which is protected under the *Privacy Act 1988* (Cth). This information has been removed in this version.

Section 6: Industry Communication and Adoption of Outputs

The overall aim of the project is to develop a decision support system to optimise variety recommendations and to do this we needed to consult with all sectors of the industry who will be the end users. Over the past two years, growers, millers, advisers and researchers across the industry have been consulted widely on the features they would like in *QCANESelect*TM and been continually updated

on project outputs. The following meetings have been held since the project commenced and many of these have involved SRA Adoption staff:

- Tully Sugar Limited (TSL) and Tully Cane Productivity Services Limited (TCPSL) – June 2014
- Wilmar and HCPSL – 22 - 23 July 2014
- Bundaberg Sugar – 7 August 2014
- MSF, TSL, TCPSL – 8 September 2014
- HCPSL Board – 27 November 2014
- Sunshine Sugar – 3 February 2015
- Wilmar Burdekin – 3 March 2015
- Review into Northern-Herbert plant breeding program – 11 March 2005
- Herbert Variety Adoption Committee (VAC) – 16 April 2015
- Burdekin VAC – 23 April 2015
- SRA Adoption Team meeting – 13 May 2015
- Herbert River CANEGROWERS – September 2015
- TSL – 4 January 2016
- SRA Adoption Team meeting – 1 March 2016
- QUT/ SRA Milling workshops – 2 March 2016, 8 March 2016, 17 March 2016
- Herbert River CANEGROWERS, Victoria and Macknade mill management – 9 - 10 March 2016
- HCPSL Shed meetings – 6 - 7 April 2016
- Herbert industry – 11 April 2016
- Young Industry participants – 20 April 2016
- Herbert Walk and Talk day – 21 April 2016
- Harvesting forums – 3 - 4 May 2016, 23 - 24 May 2016

Mostly recently a series of targeted extension meetings were held on 1 - 4 July 2016 and 10 - 12 August 2016 with growers and harvesting contractors from the Herbert. The aim of these meetings were to communicate the outcomes from the project which includes identification of the key drivers of productivity including the effects of harvesting speed and pour rate and enhancements to *QCANESelect*[™]. In these one-on-one meetings with medium-large growers and contractors, individual productivity drivers were discussed. In one such meeting, a large pro-active harvesting contractor and his growers discussed ways to improve productivity for both sectors of the industry.

Since there has been widespread communication of project outputs to industry one of the largest growers in the Herbert has adopted wider row spacing from the commencement of the 2016 season and approximately 200 samples have been tested for *Pachymetra*. Approximately, 67 % of the *Pachymetra* samples have been had spores numbers higher than the economic threshold of 50,000 spores /kg.

Section 7: Environmental Impact

This project will result in better variety recommendations. Better selection of varieties will ensure that the Herbert industry grow the largest crops that will make the most efficient use of inputs such as nitrogen. Harvesting best outcomes will result in less sugar being left in the field and a reduction in BOD in runoff.

Section 8: Recommendations and Future Industry Needs

This project used the Herbert as a pilot study to access, analyse and make improved recommendations based on Herbert mill data collected over the last 10 years. Detailed cluster analysis identified adoption of new varieties and modern farming systems, uptake of clean seed and management of *Pachymetra*, timing of all farm operations as factors associated with productivity in the Herbert regions. HCPSL has developed targeted extension programs using the factors identified and is delivering these programs to show growers the potential benefits they could achieve and encourage them to adopt the practices identified. These targeted extension programs are expected to result in greater grower uptake of the technologies and improved productivity. New improvements to *QCANESelect*[™] using the detailed mill data has allowed better and more specific variety recommendations. Detailed yield and CCS reports are now available for the Herbert for the last 10 years for varieties by soil type, crop class and sub-district. These reports were used extensively at the Herbert variety adoption committee meeting and made substantial improvements to the variety recommendations that are now available on-line in *QCANESelect*[™], through SRA variety guides and HCPSL staff one-on-one recommendations. The analyses have been automated in *QCANESelect*[™] and will be updated each year and available immediately as new mill data is available. Improved variety recommendations will lead to improved yields for growers and improved and more reliable cane supply for the mills. A new project funded by SRA, 2016/032, will extend these benefits to all mill areas

Section 9: Publications

An ASSCT paper was submitted to the conference in May 2016 and was titled “Optimising productivity and variety recommendations through analysis of mill data”. A copy can be obtained at [ASSCT](#).

An article was written for Milling Matters on Mill Statistics and Varietal Composition and Distribution publications and how the data are accessible via *QCANESelect*[™]. In the article the importance of decision support tools in increasing productivity for growers and millers was highlighted.

A press release encouraging growers to use *QCANESelect*[™] was distributed to media outlets.