SRA Research Project

Improving industry returns through harvest best practice: final report 2014/091

SRA Project Code	**2014/091**		
Project Title	**Improving industry returns through harvest best practice**		
Key Focus Area in SRA Strategic Plan	4		
Research Organisation(s)	Sunshine Sugar		
Chief Investigator(s)	Ian McBean and Peter Rose		

Project Objectives	• Actively work with harvest co-op directors and operators and farmers on HBP trials and demos
	• Engage with harvest operators and farmers in an open and honest way to start breaking down the 'them and us' mentality that exists among many harvester operators
	• Build on the recommendations for HBP development from SRA engineer Cam Whiteing, namely:
	    ○ Reducing pickup losses
	    ○ Improving row profiles and crop presentation
	    ○ Determining the effect of high ground speeds on productivity
	• Prepare and extend strategy for improved adoption of HBP at farm level and use the information to develop modified commercial arrangements that ensure the viability of the harvesting sector and equitably distribute the benefits of HBP to the farmers, harvest groups and the mill.		

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SRA 2014/091

Improving industry returns through harvest best practice

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The support of SRA in funding this project is gratefully acknowledged. The co-operation of all harvesting crews involved in the project is also greatly appreciated.

1. Introduction

In NSW the perception was that in field harvesting losses were unacceptably high and were a result of poor harvesting practices (excessive ground and fan speeds), inadequate harvester set up (no toppers), poor crop presentation (yields and profile), field conditions (wet harvest) and excessive bin allocations (high pour rates).

The principles of harvest best practice have been established over many years and are summarised in the SRA publication Harvesting Best Practice Manual: Technical Publication MN14001. These have been developed mainly in green cane in Queensland and there were questions around their applicability to NSW – particularly in 2 year old burnt cane.

Some work done with BSES in 2013 confirmed that extractor losses were less of an issue and that further work was required in reducing pickup losses; improving row profiles and crop presentation; and determining the effect of high ground speeds on productivity (ratoonability).

It was recognised that engagement with growers and the harvesting sector was vital and that NSW specific information needed to be gathered to support any decisions that were made in relation to harvesting practices in NSW.

The intention was to use the information collected through this project to develop and trial modified commercial arrangements that ensured the viability of the harvesting sector and equitably distributed the benefits of changed practice to growers, harvest groups and the mill.

This three year SRA funded project sought to quantify these changes in NSW and in particular in burnt cane in both the 1 year old and 2 year old systems.

2. Summary and Conclusions

2.1 Summary

Two large scale trials showed no difference in the yield of the subsequent sugarcane crop when the initial crop was harvested 15-20mm higher. The higher harvested crops had lower ash levels, but increased pickup losses. These trials were done under good harvesting conditions with relatively low ash levels. A challenge would be to do these trials under less than perfect conditions when ash levels are usually higher.

Contrary to conventional wisdom, analysis of the comparative yield of the subsequent crop to the initial crop from seven large scale sugarcane trials showed no difference when the initial crop was harvested at 4, 6 or 9 km/h. One of the major flaws in doing these trials were that they were done under good harvesting conditions with lighter yielding crops. Any damage to the stool under these conditions is quite easily overcome by the in-built redundancy of the sugarcane plant. However, as a consequence of these results, modelling of the cutting action indicates that damage is occurring due to end cutting by the blunt end of the blade, which increases with increased harvester speed. A solution for this is to use blades that are end sharpened and have a thin layer of hard-facing under the end of the blade. These blades remain sharp for the life of the blade. These cost more but last longer.

A replicated trial with two near identical harvesters, one with a standard chopper and the other with an EHS chopper showed that there was a statistically higher recovered yield of 3.4% from the plots harvested with the EHS chopper. It is suggested that this yield difference is due to the geometry of the cut resulting in a reduction in the number of mutilated billets. It is badly mutilated billets that are able to be sucked out by the extractor fan and provides an explanation for the yield difference.

Agtrix have developed a mobile phone app that is able to display harvester parameters in real time. Currently this only shows harvester speed. Additional sensors would need to be installed and calibrated to show other parameters (e.g. primary fan speed).

2.2 Conclusions and Ramifications for NSW

The data from the height trials is limited and really needs to be repeated under less than ideal conditions to determine the relationship between ratoonability, pickup losses and ash levels in that more critical time. Based on the limited information that was gathered a possible recommendation is that: "The mill would like growers to cut higher to reduce dirt levels, but growers should direct the crews to cut as they see fit and are happy with, typically this is at a height that minimises cane loss."

During the trial period, crops were large and it was difficult to find blocks where the crews were prepared to harvest at 9 km/h. As a consequence, the speed trial sites tended to have cane that was lighter in yield and were more upright. Only two blocks were harvested in less than ideal conditions and they will be harvested in 2017. As a consequence, the current results do not reveal any information on the impact of:

1) Wet weather harvest – the dislocation of the stool caused by knockdown.
2) Lodging – the balancing act of trying to pull cane from the next row without pulling up the stool.
3) Sandy and other loose soil types – cutting the cane without removing the stool as well.

Therefore, even though the trials show no yield impact of harvesting at increased speed, harvester drivers need to travel at a speed, which minimises damage to the stool.

What we have learnt is that there is better technology in the two areas where the cane is cut: Use of "Stay sharp" blades to do the cutting at the base of the plant and EHS choppers to cut the cane into billets. Implementing these two changes should help with ratoonability and cause less sugar to be blown out the back.

A wish list to harvester manufacturers could include:

1) Reduced knockdown angle – The new John Deere is a slight improvement on the previous models, but more would be better
2) Improved basecutter leg – Norris (pers. comm.) indicates that willows are harvested with a similar basecutter leg box arrangement, except that the fins on the side of the legs are rotating at a much slower pace than the basecutter disc. Introduction of this would reduce the bashing that these fins do to the stalks.
3) Separation of the cutting and collecting function of the basecutter discs. The basecutter disc is responsible for directing the cane up to the butt lifter after it is cut. This also results in dirt being directed up the feedtrain. If it were possible to separate these two functions, it may be possible to minimise ash levels in the cane supply.
4) Lean correction – on wider rows and especially dual rows, an uneven cut occurs when harvesting in soft soils, caused by the elevator tilting the harvester. A self-correcting lean mechanism would aid in improving the ratoonability of the crop.

3. Speed trials

3.1 Introduction

Harvester ground speed is considered to contribute to immediate losses (pick up-losses) and future losses (ratoonability and future yields).

Apart from a region wide analysis of crop and harvester GPS data from the Herbert Mill area (SRA 2014 p. 28), no replicated studies have been undertaken on the impact of harvester speed on the subsequent ratoon crop.

Crop presentation (row profile and yield) is considered a major contributor to cane losses (pick up losses) and poor cane quality (dirt in cane measured as NIR ash), which is compounded by variable row spacing and row widths (single, wide and double).

Large scale replicated trials in commercial fields were developed to quantify these losses using standard mill data and to verify the impact of harvester speed on subsequent ratoons.

3.2 Method

An oversight committee for the project identified optimal ground speeds relevant to differing field and crop conditions as follows:

- Plant cane – 4.5 to 6.5km/h
- Good ratoons – 5.5 to 7.5 km/h
- Ploughout and low yielding cane – 10km/h

For the trails harvester speeds of 4, 6 & 9 km/h were selected however, some flexibility in trial design was needed to fit the crew's requirements and field size. Not all sites had a 4 km/h treatment and in some instances the harvester operator was not prepared to drive at 9 km/h and the maximum speed was then set at 8 km/h. At one site the driver chose to drive at 10 km/h.

All crops were burnt prior to harvest, as is the usual practice in NSW.

After an initial learning process some rules for site selection established themselves, which is explained in detail in Section 16. Each site typically involved 9 bins (3 treatments x 3 reps). As this was a series of commercial trials, the only variable changed from what the crew was already doing was to alter the speed of the harvester (i.e. fan speed or cutting height was not stipulated). If the harvester did not have a speed readout, then a handheld GPS device (Garmin CS60) was attached to the windscreen.

While the plots were being harvested, pickup losses (from 3 x 10m sections of row) and row profile (for plant crops) were being assessed. The row profile of the unharvested rows was obtained by stepping into the crop after the harvester had passed and measuring in 150mm intervals the distance down to the ground from a straightedge placed between the next two rows. To assess the effect of row profile on ash levels, the average profile was determined at 150, 300 and 450mm from the row midpoint and plotted against the average ash level at each speed.

Contact with the crew was maintained by handheld UHF. Typically the haulout crews quickly developed the routine required to get the right cane in the correct bin, with only two known and one suspected mistip. For the two known mistips, these occurred within the first two plots and these plots were deleted and the trial restarted. The bin weights for the suspected mistip did not look right, as well as the time stamp for the telemetry. As a consequence, the questionable plots were not used in any analysis.

2 or 3 times after harvest the number of shoots along 2 or 3 x 10m lengths of row were counted in each plot. Shoot counts were identified as an early indicator of the impact of harvesting on the subsequent crop – the premise being that the damage imposed on the sugar cane stool at the higher ground speeds would manifest in poorer and slower shoot development as compared to the slow speeds. This in turn would negatively affect the cane yield of the subsequent ratoon crop.

Analysis of the results from the combined sites was performed utilising relative values using ANOVA. To make allowance for the pour rate/fan speed induced yield difference from the initial harvest adjusted values were utilised in the analysis.

3.3 Results

In total thirteen sites were eventually harvested and included a mixture of one year old and two year old crops from the 2014 and 2016 seasons and from all three NSW mill areas.

3.3.1 Pickup losses

An analysis of the pick up losses shows that there was significantly more cane lost at 4 km/h compared to the faster speeds (Table 3.1) which was unexpected. However, this result should be viewed with caution, as there were considerable differences in the pick up losses between the sites. As a consequence the data was adjusted using the average values for each site at 6 km/h to create relative values. The adjusted values had an inverse exponential distribution and were normalised with a Log_{10} transformation prior to analysis. Analysis of the transformed data showed that there was a significant difference in pick up losses between the 4 and 9 km/h speed groups (Table 3.1).

Table 3.1 Average harvester pick up losses by speed group

Speed (km/h)	N	Pick up loss (t/ha)	Relative pick up loss	Transformed Relative pick up loss
4	63	$2.16^{a} \pm 0.22$	113 ± 5.7	$2.02^{a} \pm 0.022$
6	94	$1.45^{b} \pm 0.13$	100 ± 4.5	$1.95^{ab} \pm 0.028$
8,9 or 10	94	$1.53^{b} \pm 0.14$	104 ± 6.2	$1.91^{b} \pm 0.020$

When the pick up losses data were compared to the grouped pour rates instead of speed, there were no significant differences (Table 3.2).

Table 3.2 Average harvester pick up loss by pour rate group.

Pour rate groups (t/hr)	N	Pick up loss (t/ha)	Relative pick up loss
< 100	89	1.93 ± 0.14	98 ± 3.5
100-150	90	1.88 ± 0.16	107 ± 4.2
>150	66	1.83 ± 0.18	97 ± 6.2

3.3.2 Shoot counts

The data show a significant difference in the shoot counts between the fastest and slowest harvester speeds within 9 days after harvest. This difference had disappeared with all counts taken more than 9 days after harvest (Table 3.3).

Table 3.3 Relative shoot counts for the trials harvested in 2014

	Prior to 9 days after harvest		After 9 days after harvest	
Speed (km/h	N	Relative shoot counts	N	Relative shoot counts
4	18	$91.7^{a} \pm 5.5$	36	98.1 ± 2.3
6	48	$100.0^{ab} \pm 3.8$	96	99.9 ± 1.9
8, 9 or 10	48	$101.3^{b} \pm 3.4$	96	100.2 ± 2.2

One trial (Vince 2 was harvested in wet field conditions in 2015. Post-harvest shoot counts showed a trend (significant at the 15% level) for decreased shoots in the faster harvested plots (Table 3.4). This site will be harvested again in 2017.

Table 3.4 Shoot counts at the Vince 2 site after a wet harvest (Number of shoots per 10m of row)

	9 days after harvest		30 days after harvest		55 days after harvest	
Speed (km/h)	**N**	**Shoot counts**	**N**	**Shoot counts**	**N**	**Shoot counts**
6	12	64	12	184	12	240
8	12	59	12	153	12	207

3.3.3 Row Profile

In order to determine the impact of row profile a simple methodology was developed which involved stepping into the cane after the harvester had passed and placing a straightedge between the next two rows of cane to be cut. The distance from the straightedge down to the ground was recorded at 150mm intervals across the profile. Typically one measurement was obtained in each plot and the values at each measuring point were averaged to give an average row profile for that field.

For the five sites where we had data, all average heights were plotted against the ash values from each bin at the various harvester speeds. Separate plots were used for each of the distances from the middle of the row of cane.

At 150mm from the middle of the row there was no definitive trend indicating that the profile can be flat in the middle 300mm of the row. There was some information indicating that the volcano effect increases ash levels. At 300 mm from the middle of the row two groups appear to form, indicating that the profile should drop by about 20mm. This trend continues at 450mm, where the drop indicated is 30mm (Figures 3.1, 3.2 & 3.3)

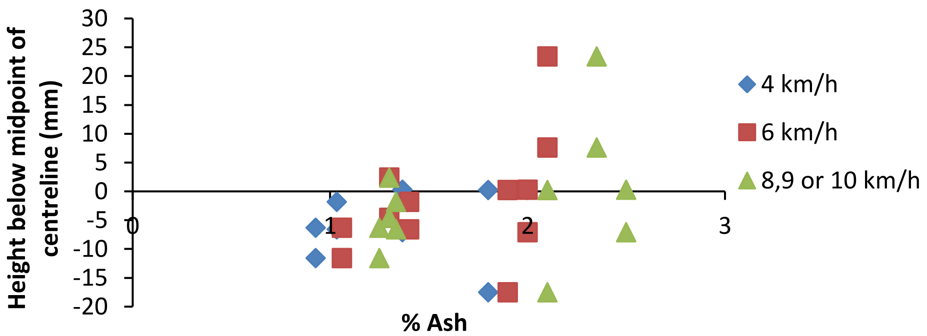


Figure 3.1 Relationship between ash levels and row profile – data from 150mm from the middle of the row.

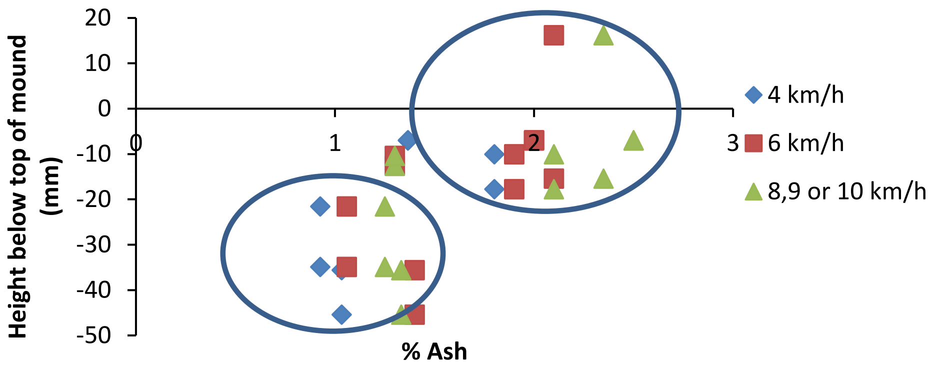


Figure 3.2 Relationship between ash levels and row profile – data from 300mm from the middle of the row.

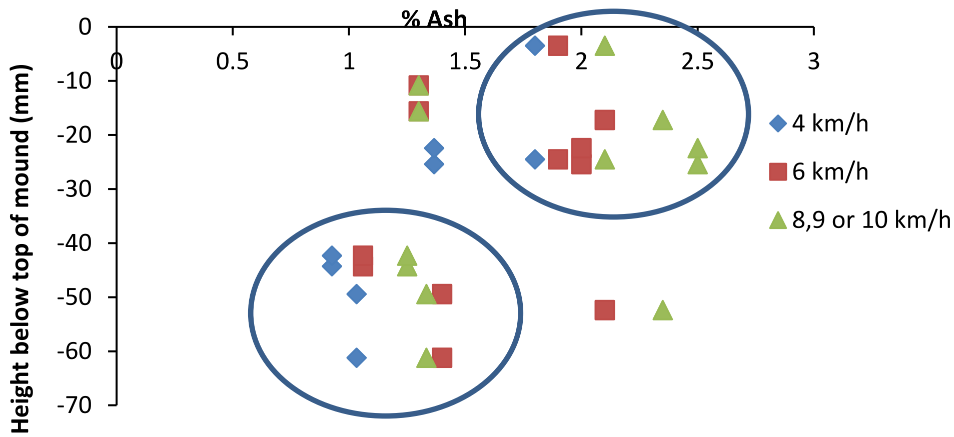


Figure 3.3 Relationship between ash levels and row profile – data from 450mm from the middle of the row.

The trials were all harvested under good harvesting conditions and the ash levels were low (typically <2.5%). Due to the low ash levels and lack of replication, the results should be viewed with caution.

3.3.4 Harvest data

Initially a total of 13 trials were planned of which eight sites were harvested; two will be harvested in 2017 and three were lost. The first one was harvested at the same speed as the initial harvest. However, upon completion of harvesting this site, it was decided that this was not the best method and the remaining seven trials were harvested under 'normal' conditions i.e. as per normal practice.

The trials were assessed using mill data and values typical for each site can be found in Table 3.5, which reports the average values from the plots where the harvester was travelling at 6 km/h. Ash and Fibre showed significant increases across all three speeds (Table 3.5, Figure 3.4).

Table 3.5 Initial harvest crop information and average values at 6km/h for sites in analysis.

						Average at 6km/h					
Site	Year of Harvest /next harvest	Variety	Age	Age at next harvest	Crop class	CCS (%)	Cane yield (t/ha)	Sugar yield (t/ha)	Fibre (%)	Ash (%)	Purity (%)
Barnier	14/-	Q232	1	-	Plant	11.70	125	14.6	13.90	1.3	82.0
Casey	14/-	Empire	1	-	Plant	11.60	110	12.8	13.37	1.8	82.7
Condong	14/-	Q211	1	-	RP	11.70	131	15.3	13.88	1.9	83.0
Llewellyn	14/16	Q208	1	2	Plant	12.76	106	13.6	15.27	2.0	83.0
Rodgers	14/16	Q200	2	2	Plant	13.29	155	20.6	15.17	1.4	84.3
Rose	14/16	Q203	2	2	Plant	12.69	113	14.3	16.50	1.2	85.0
Schaefer	14/15	BN3347	1	1	1R	11.95	91	10.8	17.28	2.1	83.3
Vince	14/16	Q232	1	2	1R	12.18	112	13.7	15.77	1.7	84.7
Vince(2)	14/15	Q183	1	1	Plant	11.69	88	10.3	14.57	1.3	83.0
Young	14/16	BN3120	2	2	1RR	10.93	137	15.0	17.43	1.5	82.3
Carlton	15/16	Q244	1	1	Plant	13.12	123	16.7	-	0.6	-
Rose(2)	15/17	Q232	1	2	Plant	12.10	148	17.9	15.4	1.8	-
Vince(2)	15/17	Q183	1	2	1RR	11.66	134	15.7	16.8	2.2	85.9

There were significantly increased values for sugar yield at 9km/h compared to the lower speeds, which was mainly due to an increase in cane yield, with CCS staying the same.

When this data was analysed using grouped pour rates instead of speed, the difference in sugar yield was no longer statistically significant; however, a trend was still present. The other significant differences were similar (Table 3.6 and 3.7).

Table 3.6 Data assessed by the Mill for each bin of cane, which have been converted to relative values to enable analysis across trial sites. (Data from ten 2014 sites and one 2015 site (Carlton)).

	Harvester speed (km/h)		
	4	6	8, 9 or 10
N	20	42	42
Relative CCS	100.85 ± 0.60	100.02 ± 0.33	100.45 ± 0.34
Relative Yield	99.20^{a} ± 1.25	100.05^{a} ± 0.54	102.86^{b} ± 0.64
Relative Sugar Yield	99.85^{a} ± 1.26	100.02^{a} ± 0.59	103.24^{b} ± 0.73
Relative Fibre	98.25^{a} ± 0.90	100.12^{b} ± 0.32	102.00^{c} ± 0.50
Relative Purity	99.80 ± 0.31	100.03 ± 0.13	100.29 ± 0.11
Relative Ash	82.45^{a} ± 5.97	100.13^{b} ± 3.02	111.55^{c} ± 2.95

Table 3.7 The data from Table 5 (2014 sites only) compared to a grouping of pour rates instead of speed.

	Pour rate (t/h)		
	<100	100-150	>150
N	20	38	38
Relative CCS	100.71 ± 0.41	100.24 ± 0.39	100.01 ± 0.36
Relative Yield	99.37[a] ± 0.90	101.49[ab] ± 0.56	102.26[b] ± 0.92
Relative Sugar Yield	100.04 ± 0.91	101.74 ± 0.74	102.28 ± 0.98
Relative Fibre	98.96[a] ± 0.63	100.30[a] ± 0.34	102.38[b] ± 0.70
Relative Purity	99.99 ± 0.19	99.97 ± 0.14	100.34 ± 0.13
Relative Ash	91.79[a] ± 4.30	99.49[a] ± 3.69	113.08[b] ± 3.11

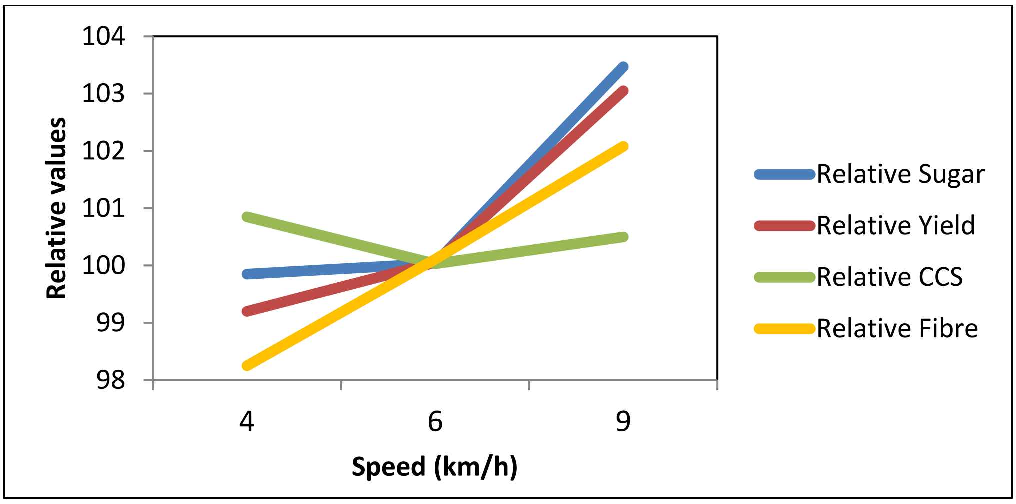


Figure 3.4 Effect of harvester speed on fibre, yield, CCS and sugar yield. (Data from ten 2014 sites and one 2015 site).

There was no statistically significant difference between the treatments for both the yield and the sugar yield from the seven sites in the analysis (Table 3.8).

Table 3.8 Summary of seven harvester speed trials showing the relative yield and sugar yield ratio (latest harvest divided by previous harvest).

Harvester speed at previous harvest	N	Relative yield ratio	Relative sugar yield ratio
4	17	99.7 ±1.4	100.5 ±1.8
6	19	100.2 ±1.4	100.0 ±1.3
9	19	101.4 ±1.3	99.6 ±1.0
		n.s.	n.s.

3.4 Discussion

When the yields from seven trials were compared to the adjusted yields from the previous harvest, no difference in the yield ratio was found due to harvester speed. This is in contrast to conventional wisdom and the whole of mill data from the Herbert (SRA 2014, p. 28). A possible explanation is that all of these trials were conducted under good growing conditions and due to the in-built redundancy of the cane plant (Section 13) any damage could be easily compensated for. There is a possibility that under less than perfect conditions a yield effect from increased harvester speed may be observed. Two trials are still to be harvested. The initial harvest for these was under less than ideal ground conditions, with the track buggy being used at both sites.

Based on unreplicated data from only five sites, there is some evidence that the row profile should be flat in the middle 300mm (Figure 3.1) dropping by 20mm at 300mm (Figure 3.2) from the centre of the row and a further 10mm at 450mm from the centre (Figure 3.3).

Travelling slower results in more cane being left on the ground (Table 3.1). It was assumed that this is a pour rate related effect – the interaction between stalks in a larger bundle of cane is able to hang onto all the stalks more effectively. However, when analysed by pour rate, no differences were noted (Table 3.2).

There was a significant increase in shoot numbers in the 9km/h plots compared to the 4 km/h plots up to 9 DAH. By the next count this difference had disappeared.

Harvesting at different speeds with a constant extractor fan speed has resulted in a pour rate induced yield difference. At the lower harvester speeds the extractors are able to operate more efficiently resulting in more cane being extracted. This has ramifications for determining the effect of harvester speed on the yield of the next ratoon crop and a protocol to correct for this has been developed. There were also quite significant differences in the ash levels between the harvester speeds. Keeping ash levels low is a key target for the factories and this data is used to discuss the economics of the extra cost of travelling slower versus the benefit of less ash in Section 9.

3.5 References

SRA 2014. Harvesting Best Practice Manual, Technical publication MN 14001. Sugar Research Australia. pp 72

4. Height Trials

4.1 Introduction

This series of trials was aimed at assessing the impact of harvester basecutter height on industry returns. Higher basecutters will result in more cane being left in the field with a little bit of extra stalk on the stool, but also there will be more pickup losses. However, as the basecutters are raised, there will be less dirt in the supply. The contentious issue is whether cutting higher causes more damage to the stool or less and subsequent yield of the next ratoon crop.

4.2 Methods

Two heights were used: 1) “Normal” – that height that the harvester operator considered to be best for the field and 2) “Higher” – basecutters slightly higher - typically this was about a half a unit on the sight gauge and was between 15-20 mm higher. Each plot was of a fixed number of rows to enable the same rows to be harvested next time. Typically each trial was of 2 treatments by 4 replicates by one bin per plot. Alternatively, there were three replicates and 2 bins per plot.

The data assessed by the Mill were collected for each bin. To enable analysis across all sites relative values were created by finding the average value at the normal basecutter height treatment. This value was then used to adjust all other values so that they were relative to this value by dividing the value by the average and multiplying by 100. At the end of this process, the average value of the normal basecutter height treatment was 100 for all variables. Variables treated in this way included CCS, Yield, Sugar Yield, Ash, Fibre and Purity. The resulting relative values were analysed across all sites using ANOVA.

In each plot the harvester pick up losses were assessed by collecting and weighing the stalks on the ground after harvest from 3 x 10m randomly selected row sections. The weights were converted to tonnes/ha and analysed across all sites using ANOVA. To determine if there were any relative differences between the treatments all values were adjusted by the mean value of the normal basecutter height treatment at each site, as described previously.

At 2 – 3 times after harvest the number of shoots along 3 x 10m lengths of row was counted in each plot. As for the Mill variables, to enable comparison across sites, relative shoot numbers were created using the average at the normal basecutter height treatment as the common value. The relative shoot numbers were analysed using ANOVA. At one site the shoots along each of the dual rows were counted separately for one section in each plot. In addition, the first 10 shoots were measured for height in each plot.

The ratio of this year’s sugar yield to the sugar yield at the previous harvest reflects the effect of the treatment (i.e. the different basecutter heights). If there is no treatment effect, then this ratio would be statistically equal across all plots.

4.3 Results

In total 4 trials were established, with one at Condong and three at Harwood. The emphasis changed to the speed trials, when it became apparent that the pick up losses on the ground were not being compensated by a decrease in ash levels. Due to the prolonged dry period, the ash levels were already quite low.

4.3.1 Pick-up losses

There was a significant increase of 57% in the amount of pick-up losses when the basecutters were raised. On average this was an extra 1.6 t/ha (Table 4.1).

Table 4.1 Basecutter height and pick-up losses

Basecutter height	N	Stalks (t/ha)	Relative stalks
Normal	46	$3.3^{a} \pm 0.26$	$100^{a} \pm 7.0$
Higher	45	$4.9^{b} \pm 0.39$	$157^{b} \pm 10.8$

4.3.2 Mill assessed data from the initial harvest

Values typical for each site can be found in Table 4.2, which reports the average values from each site for each basecutter height. When the relative values were compared across all four sites two variables had values that were significantly different (Table 4.3). Ash values were reduced by 23% and fibre values by 2% by raising the basecutters. There is a trend for yield and sugar yield to be lower, which reflects the extra cane left on the ground.

Table 4.2 Average values from all height trials

Site	Height	Variety	Age	Crop Class	CCS (%)	Fibre (%)	Ash (%)	Purity (%)	Cane Yield (t/ha)	Sugar yield (t/ha)
Bartlett	1	Q211	1	1R	11.75	12.56	1.26	82.80	146	17.1
Bartlett	2	Q211	1	1R	11.87	11.96	0.82	82.40	147	17.5
Causley	1	Q167	2	Plant	13.05	15.45	1.15	85.50	139	18.2
Causley	2	Q167	2	Plant	13.09	15.05	0.72	85.25	131	17.2
McMahon	1	Q208	2	Plant	14.43	14.93	0.92	87.50	183	26.5
McMahon	2	Q208	2	Plant	14.23	14.70	0.70	87.00	181	25.8
Munro	1	Q232	2	Replant	12.56	14.57	0.85	84.50	165	20.7
Munro	2	Q232	2	Replant	12.60	14.55	0.82	84.67	160	20.2

Height: 1 = Normal; 2= Higher

Table 4.3 Relative values of mill assessed data

		Basecutter height	
	N	Normal	Higher
CCS	15	100.0 ± 0.43	100.0 ± 0.45
Yield	15	100.0 ± 0.86	98.1 ± 1.34
Sugar Yield	15	100.0 ± 0.76	98.2 ± 1.48
Fibre	15	$100.0^{a} \pm 0.45$	$98.0^{b} \pm 0.67$
Ash	15	$100.0^{a} \pm 4.4$	$76.6^{b} \pm 4.4$

4.3.3 Shoot counts

In the counts done prior to 14 days after harvest shoot numbers were significantly greater in the higher basecutter treatment (Table 4.4). This difference had disappeared in later counts. At the site H-Bart-021014 there appeared to be a height difference between the treatments and so the first 10 shoots were counted in each plot and a significant difference was found (Table 4.5). This difference was not noted at other sites and the data was not collected. Also at this site, there appeared to be an effect of the harvester leaning and so the shoots in the duals were counted separately. A significant interaction was found in half the trial (Field 901), where at the normal basecutter height the elevator side had fewer shoots and at the higher basecutter height, the elevator side had the higher number of shoots (Table 4.6).

Table 4.4 Relative shoots at two different basecutter heights and the counts grouped by the number of days after harvest.

	<14 days after harvest		>14 days after harvest		All counts	
Basecutter Height	N	Relative Shoots	N	Relative Shoots	N	Relative Shoots
Normal	42	100[a] ± 3.1	54	100 ± 2.2	96	100[a] ± 1.8
Higher	42	120[b] ± 3.7	54	104 ± 2.4	96	111[b] ± 2.2

Table 4.5 Shoot heights for the first 10 shoots in each plot at the site H-Bart-021014

Basecutter height	N	Shoot height (mm)
Normal	40	300[a] ± 9.6
Higher	40	384[b] ± 8.7

Table 4.6 At the site H-Bart-021014 the trial went across two fields, with two of the four replicates in each field. The shoots in each side of the dual rows were counted separately once in each plot.

		Elevator side		Non-Elevator side	
Field	Basecutter height	N	Shoots (10m of row)	N	Shoots (10m of row)
901	Normal	2	41 ± 15	2	76 ± 7
	Higher	2	82 ± 12	2	53 ± 3
902	Normal	2	66 ± 35	2	67 ± 35
	Higher	2	69 ± 1	2	106 ± 8

There was a statistically significant interaction for Field 901 between Basecutter height and the elevator side.

4.3.4 Next harvest

One height trial was harvested in 2015 and another one in 2016. Both trials showed no difference between treatments (normal height and 15-20mm higher) of the ratio of the sugar yield of the last harvest to the previous harvest (Table 4.7). Two trials were lost.

Table 4.7 Ratio of sugar yield in last harvest to the sugar yield of the previous harvest*100 for two different basecutter heights.

	Ratio of sugar yield in last harvest to the sugar yield of the previous harvest*100			
Basecutter height	**N**	**Bartlett (Condong)**	**N**	**Munro (Harwood)**
Normal height	5	90.6 ±1.8	3	85.3 ±2.0
15-20mm higher	5	93.2 ±1.2	3	85.7 ±3.0
		n.s.		n.s.

4.4 Discussion

Raising the basecutters by 10-20mm resulted in a significant reduction in ash by 23% (Table 4.3), but also a significant increase in pick-up losses (1.6 t/ha; 57%; Table 4.1). Although not significant, there was a 1.8% decrease in sugar yield when the basecutters were raised (Table 4.3), which reflects the extra cane left on the ground.

There is a non-statistically significant trend for the higher basecutter position to generate a higher yield in the subsequent ratoon from one of the two sites. However, when pick-up losses are taken into account, this would negate any gain (if there is any). Note however, that these conclusions are derived from only two trials with only a limited number of data points. Ideally, more data is needed to confirm these conclusions.

The shoots counts from the Bartlett trial highlight the issue of harvester lean under softer soil conditions with dual row farming systems.

5. EHS chopper box trial

5.1 Introduction

Two harvesting groups in NSW agreed to install EHS chopper drums in one of two similar harvesters. EHS provided a discount and the SRA funded Harvesting Best Practice project funded 50% of the purchase price of each of the units. As these new chopper drums were put into one of two similar machines, the aim during the 2016 season was to put both of these machines in the one block and see if any differences could be determined.

In their promotional material EHS claim:

- Significant decrease of mud present in extractor caused by sugar juice and dirt/ash;
- The improved blade approach angle results in a cleaner cut, reducing juice losses and improving trash separation and extraction. Consistent increases in bin weights of 5-10% achieved due to a cleaner, denser sample;
- Smooth even chopper pressure.

5.2 Method

A large field (9.68 ha) of second ratoon 2 year old Q208 in the Harwood Mill area was selected for the trial. The estimate for the block was 150 t/ha. The cane was burnt, with very little trash remaining. The row length was between 311 and 325m and with a row width of 1.8m gave a calculated 8.5 t/row, which gave a target of two rows for a multilift bin. In practice, the average yield was 161.3 t/ha which was still within the two Powerhaul tips into a multilift bin and this allowed the trial to flow quite efficiently.

Prior to the start of the trial chopper blades and basecutters were changed on both Case 8800 harvesters. The driver was instructed to drive as he normally would (i.e. a focus more on pour rate than on harvester speed).

The treatments were the two harvesters each with fan speeds of 600, 800 and 1000 rpm to give a total of six treatments. A 2013 Case 8800 and a 2014 Case 8800 with the EHS copper drum with both driven by the same person. There were four replicates with treatments distributed randomly.

Assessed were the mill data from each bin. Yield was determined by utilising the row lengths as measured from the farm maps in a GIS program. Allowance was taken for the slightly shorter rows, as a total of 5m of headlands were cut prior to the trial beginning. All data was analysed using multivariate ANOVA.

A sample of 10 billets was taken from 24 of the treatments, washed and assessed for billet end damage using a rating of 1 -3 with 1 being slight damage (approx. $1mm^2$), and a rating of 3 being severe damage (approx. $10mm^2$). The damage was split into chips and bruising. It was assumed that the stalk fed butt first and so the ends were split into the leading and trailing ends (determined by the location of the eye relative to the node) and a nominal top and bottom. In this way it was possible to assign four damage ratings to each billet across eight categories (four locations by two damage types). To provide a more realistic representation of the amount of damage that each rating impacted on the billet, each rating was squared prior to analysis. Various sums of position and damage type were analysed using ANOVA.

The billet length and diameter was measured from 10 billets from eight treatments and analysed using ANOVA.

5.3 Results

The Mill data did not record any data for two treatments (EHS @ 800 RPM and Case @ 1000RPM). The statistics program adjusted for this missing data. An exercise in replacing the missing values with the average from the other replicates produced similar results from a statistical point of view.

Within this dataset, there is a significant yield increase of 4.3% with the EHS chopper drum and also a significant sugar yield increase of 3.4% (Table 5.1). All other data were not significantly different.

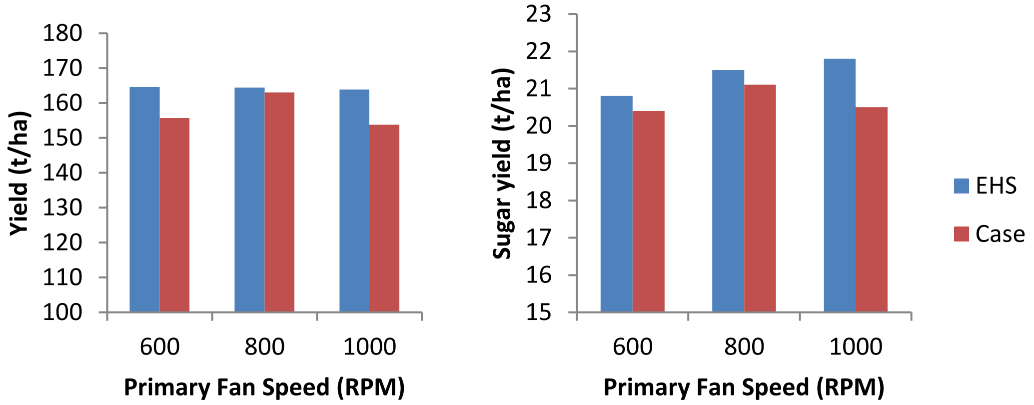
Table 5.1 Mill data and calculated values for two chopper systems.

Chopper system	Yield (Tonnes/ha)	Sugar yield (Tonnes/ha)	CCS (%)	Fibre (%)	Ash (%)	Purity (%)
EHS	164^{a}+/- 1.3	21.4^{a}+/- 0.20	13.0	15.9	2.16	85.8
Case	158^{b}+/- 1.7	20.6^{b}+/- 0.22	13.0	15.7	2.06	85.7
Difference	4.3%	3.4%				

Analysing only for extractor fan speed, showed that the only significant difference was between the fibre content of the 600 and 1000 RPM treatments; CCS, Ash and Purity all showed the expected trends (Table 5.2). There was an expectation that the yield at the lowest fan speed would be the highest and perhaps also have the highest sugar yield. This however was not the case, with yields for each chopper system being similar across all fan speeds (Figures 5.1 a) & b)).

Table 5.2 Multivariate ANOVA between chopper systems x fan speed for all mill data and calculated values using only the Sunday data (replicates 3-6) (Appendix IV for ANOVA output).

Fan Speed (RPM)	Yield (Tonnes/ha)	Sugar yield (Tonnes/ha)	CCS (%)	Fibre (%)	Ash (%)	Purity (%)
600	160	20.6	12.9	16.0 [a]	2.2	85.6
800	164	21.3	13.0	15.8 [ab]	2.2	85.6
1000	159	21.2	13.2	15.5 [b]	1.9	86.1



a) Yield

b) Sugar yield comparison

Figure 5.1 Comparison of yield attributes at different primary fan speeds between the two chopper systems

The length of the billets between the two harvesters were the same, but there was a significant difference in the diameter of the stalks between the samples from the two harvesters, with the stalks from the harvester with the standard chopper drum having a diameter that was 4.8% greater (Table 5.3). The question is whether this difference was due to sampling error or was due to more of the smaller diameter stalks being damaged and not making it into the bin for sampling. If the latter is true, this could be an explanation for the yield difference between the two chopper systems. Conversely, the author only measured relatively undamaged stalks, as he assumed that badly damaged stalks were a function of feedroller damage and therefore of limited interest for this study. As a consequence, the values in Table 5.3 may be valid and could explain the yield difference.

Table 5.3 ANOVA between chopper systems for samples of stalks taken from four bins for each treatment.

Chopper system	N	Length (mm)	N	Diameter (mm)
EHS	41	190+/- 3.6	41	21.9[a]+/- 0.33
Case	40	191+/- 3.3	39	23.2[b]+/- 0.52

An assessment of billet end damage showed that the only significant difference was between the chips on the leading end of the billet (Figure6.2). The differences seen would not explain the yield differences between the two chopper systems.

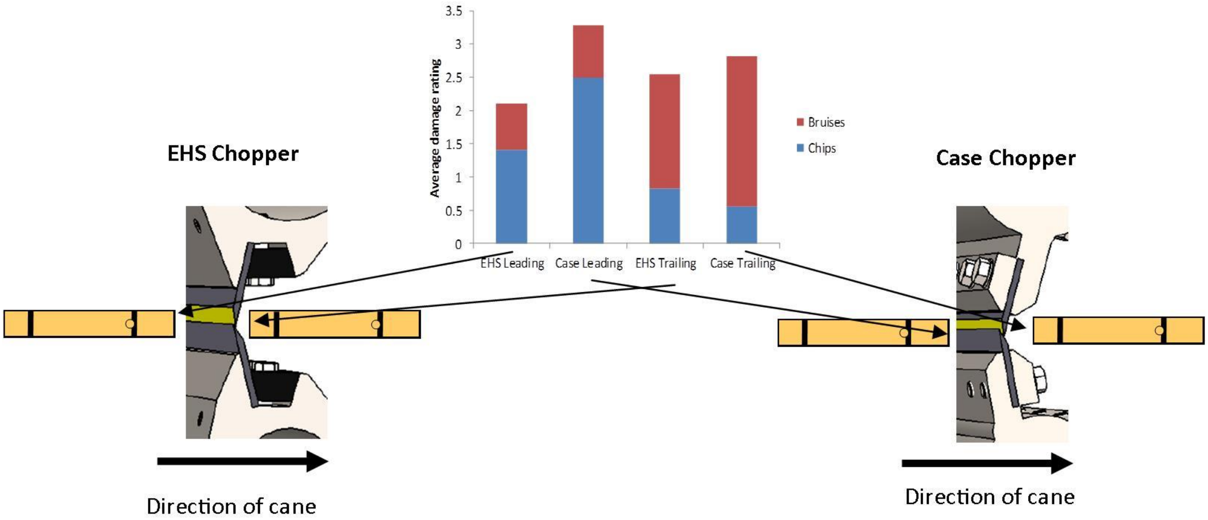


Figure 5.2 Graph of the damage rating on billets cut by the EHS and Case chopper drums and a pictorial explanation of the location of the leading and trailing end of the billet with respect to the cutting knives.

An analysis of the Agtrix harvester tracks data showed that on the Sunday during the duration of the trial the EHS fitted harvester was travelling considerably faster than the harvester fitted with the standard Case chopper (Table 5.4), as a consequence, there is a considerable increase in the pour rate.

Table 5.4 Distance travelled and time taken while cutting using Agtrix GPS data to give average speed and pour rate for the two harvesters in the trial.

Chopper system	Distance travelled (m)	Time taken to travel (secs)	Average speed (km/h)	Average pour rate (t/hr)
Case	8,410	8,234	3.7	104
EHS	8,770	5,533	5.7	168

Both harvesters were modified to divert some of the topper oil into the chopper circuit. Unbeknown to the harvester driver involved in doing the trial work, the machine with the Case choppers were operating the main feed rollers at a 17% slower speed (Table 5.5).

Table 5.5 Speed of the main feed rollers

	Roller speeds (RPM)		
Harvester	Lower roller adjacent to the butt-lifter	Feedrollers	Choppers
Case	90	174	239
EHS	90	209	235

5.4 Discussion

The significant increase in cane (4.3%) and sugar (3.4%) yield obtained with the EHS chopper drum needs further investigation.

The question we have not been able to answer is 'where is the increase in yield coming from?' As there was only a small decrease in billet end damage (Figure 5.2) this would not be sufficient to explain the yield increase. EHS have suggested that due to the better flow through the chopper drums that there is less billet damage caused by the feedtrain and the chopping action resulting in a significant reduction in the number of billets that are blown out the back by the extractors. This suggestion was confirmed by Patane (2016) where assessment of billets from an EHS chopper and a standard chopper showed that the standard chopper produced 7% mutilated billets, whereas the EHS chopper had only 0.1% mutilated billets. If it assumed that the more mutilated billets have been blown out the back, then this could explain the yield difference observed in this trial.

5.5 Reference

Patane (2016) *On-ground work demonstrates harvesting efficiency at a regional level*. Cane Connection Summer 2016. Sugar Research Australia. pp36

6. Mill area ash analysis – impact of row profile

6.1 Introduction

Growers are urged to work their plant cane in such a manner that the profile across the row is one that suits the profile of the basecutters on the harvesters. Originally this was a small dome about 100mm high. SRA has suggested a new profile that is basically flat. (Figure 6.1)

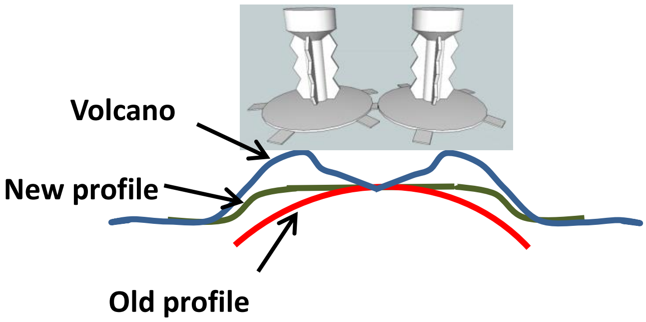


Figure 6.1 Row profiles

The rationale is that if all profiles are perfect, then average ash levels will fall, which will result in better outcomes for the factory (and eventually for the growers, due to increased profit). For NSW it has been calculated that a reduction in ash levels across all three factories from 2.8% to 2.0% will save about $1.0m or about 50c/t of cane.

However, it is only the plant cane profile that the grower is able to influence, as the ratoon profiles are to a large extent determined by the harvester as it cuts the previous crop. Plant crops tend to be cut when it is dry with ratoon crops being the ones that are preferred to be sacrificed in the wet.

This paper will look at the average ash levels for plant and ratoons for a dry year (2014) compared to a wet year (2010).

6.2 Analysis

All bin data for 2010 and 2014 for the Harwood mill were utilized in this analysis. All ratoons greater than 2nd ratoon were grouped together as the 3rd ratoon.

There was a significant difference between the crop classes in the ash levels for both years with the trend always with the plant crop having the lowest ash levels and the oldest ratoon the highest. In the wet year (2010), the difference in the ash levels between the crop classes was very minimal. In 2014 the difference was more evident (Table 6.1).

Table 6.1 Ash levels by ratoon and year

	2010		2014	
Crop Class	**No of bins**	**Ash (%)**	**No of bins**	**Ash (%)**
Plant	8677	2.989[a]	11657	1.575[m]
1st	8493	3.040[b]	4823	1.808[n]
2nd	6772	3.151[c]	1949	2.082[o]
3rd	4789	3.187[c]	1616	2.207[p]

The spread of the values can be seen in Figures 6.2 & 6.3. The key piece of information is the relative thickness of the tail in the plant cane between the two years, as shown by the red arrow. In 2014 the tail drops off very quickly, but in 2010 the tail is quite fat. This is most probably a result of plant crops being harvested in the wet and with the ground being relatively soft, mud levels can be expected to rise accordingly. The small tail in the 2014 plant crop could be either due to crops harvested in the wet or those with a poor profile.

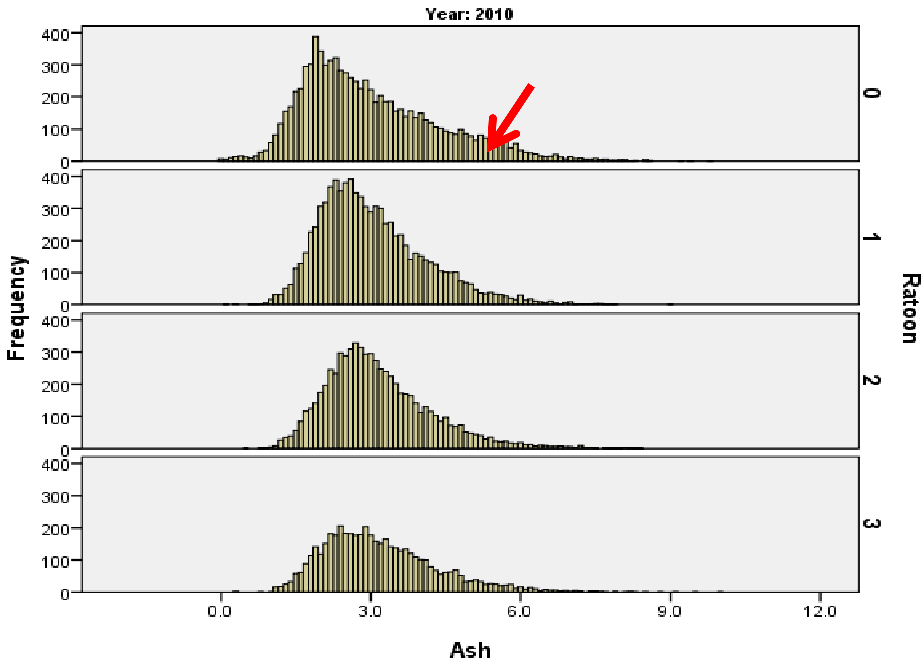


Figure 6.2 Histogram of the Ash values by Crop Class for the wet year 2010

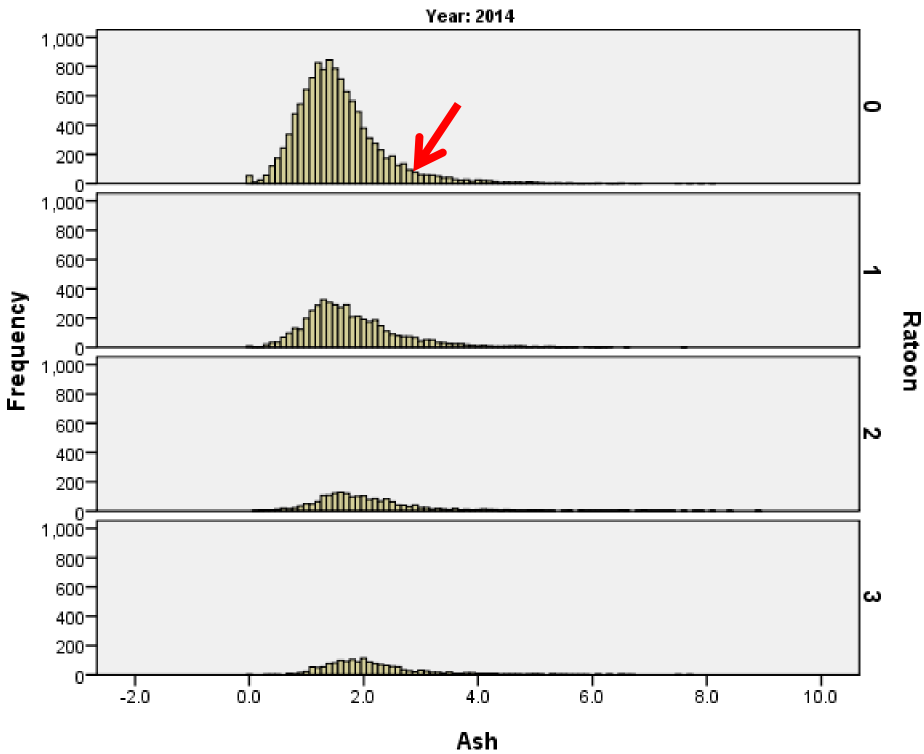


Figure 6.3 Histogram of the Ash values by Crop Class for the dry year 2014

6.3 Discussion

The small number of sites that were analysed for row profile during the HBP trials in 2014 showed that poorer profiles tended to have ash values around about 2.0% and those with better profiles around 1.0% (Section 3.3.1). In the scheme of things even the higher values from these trials are quite low when compared to the 2010 values, when a lot of cane was cut when it was wet.

As an exercise lets replace 50% of the ash values between 2.0% and 3.0% in the plant cane for 2014 with the value of say 1.0% - the assumption is that these values are due to poor row profile and the new figure is what it might be if the profile was better. The result is that average ash values would drop from 1.72% to 1.66% - an improvement of 0.06%. However, as can be seen in Figure 6.3 and in Table 6.1, the distribution of cane between the crop classes is still affected by the impact of the three years of floods, with the plant crop having a much higher proportion of the crush than is usual (e.g. compared with 2010). In 2014 plant represented 58% of the crush, while it was only 30% of the 2010 crop. The calculated ash load for the plant crop was 53% in 2014 and 25% in 2010 (these are lower than the previous figures, as the plant crop has lower ash levels). Therefore in a 'normal' year it would be reasonable to expect the 0.06% gain to be halved to 0.03%

Of course it all depends on the chosen assumptions, if the values to be adjusted are changed to the range 1.5% to 3.0%, then the new average ash value is 1.60% - an improvement of 0.12% (or 0.06% when adjusted for a normal year).

For crop of 2.0m tonnes, reducing ash levels from 2.8% to 2.0% would deliver a saving of $1.04m - a reduction of 0.06% would be a saving of about 4c/t.

6.4 Conclusion

Based on the assumptions in this study, improving the row profile of the plant crop will only have a marginal effect on reducing mill average ash levels. Improved row profiles will, however, improve the outcomes for the individual grower.

7. Stalk Survivability Trial

7.1 Introduction

This trial was inspired from two of the results from the large scale Harvest Best Practice trials that were conducted as part of a SRA grant to the NSW sugar industry. These results indicated that there was a statistically significant increase in shoots from the 9km/h plots compared to the 4km/h plots in the first 9 days (Table 3.3) and also a significant increase in shoots from the higher cut cane prior to 14 days (Table 4.4). Shoot counts taken after that were not statistically different. These results suggested that the faster speed and higher cutting, which in theory means more stool damage, resulted in more initial shoots. The question that this raised was: which shoots made it to harvest? From previous work, we know that nearly half the shoots that emerge do not make it to harvest. The aim of this observation trial was to keep track of when each shoot emerged and see which ones made it to be harvested.

7.2 Method

A harvester speed trial was conducted on the author's farm 24th November 2015, in a block of plant one year old Q232 with 4 replicates of two treatments: 6 km/h and 8 km/h. The usual target upper speed for these trials was 9 km/h. However, as it was wet and the track buggy was being used, the upper speed was reduced to 8 km/h.

In the first three replicates an approximate 0.7m of row of one of the two duals was selected to be studied. The process was to visit the same plots at semi regular intervals and place a coloured cable tie around any emerged shoots that did not already have a cable tie (Figure 7.1). The cable ties were kept loose, to allow the cane to grow. The assessment dates were the following days after harvest (DAH): 11 (white); 17 (black); 25(red); 41(blue); 52(yellow) and 71(green), which gave 6 different age cohorts in the study. By the next assessment date (98 DAH) all shoots had emerged and subsequent visits involved collecting cable ties from dead shoots. This was at DAH: 98, 125 and 160. At 248 DAH each stalk was numbered, cut at ground level and total weight and stalk diameter measured at the middle of the internode near the base of the stalk. At the 98 DAH assessment a map of the location of each stalk was drawn and the diameters near the base of each stalk recorded.

Figure 7.1 Coloured cable ties recording the age of emergence of tillers

7.3 Results

Shoot counts for the speed trial show that no effect of harvester speed was seen on shoot number/m of row (Table 7.1)

Table 7.1 Shoot counts from two harvester speed treatments at the Rose(2) site.

Harvester speed (km/h)	Shoot counts per 10 row		
	N	8 DAH	25 DAH
6	12	145 ±6.7	305 ±11.9
8	12	142 ±6.9	303 ±14.7
		n.s.	n.s.

As there were differing numbers of stalks in each plot, all data is presented as a proportion of the maximum number of shoots in the plot, which was at 71 DAH.

The data was summed across the reps and the data is presented in three different forms:

1) Percentage of surviving stalks by age cohort (Figure 7.2)
   This indicates that about three quarters of the millable stalks had emerged by 17 DAH.

2) Percentage survival of each age cohort (Figure 7.3).
   This shows that a very high percentage (>80%) of the early emerging shoots survived through to harvest. The survival rate for each subsequent age cohort halved, indicating that the survival rates has an inverse exponential relationship to the time of emergence. This relationship is confirmed, by the linear relationship of the $\log_{10}$ transformed data (Figure 7.4)

3) Time sequence of survival numbers (Figure 7.5).

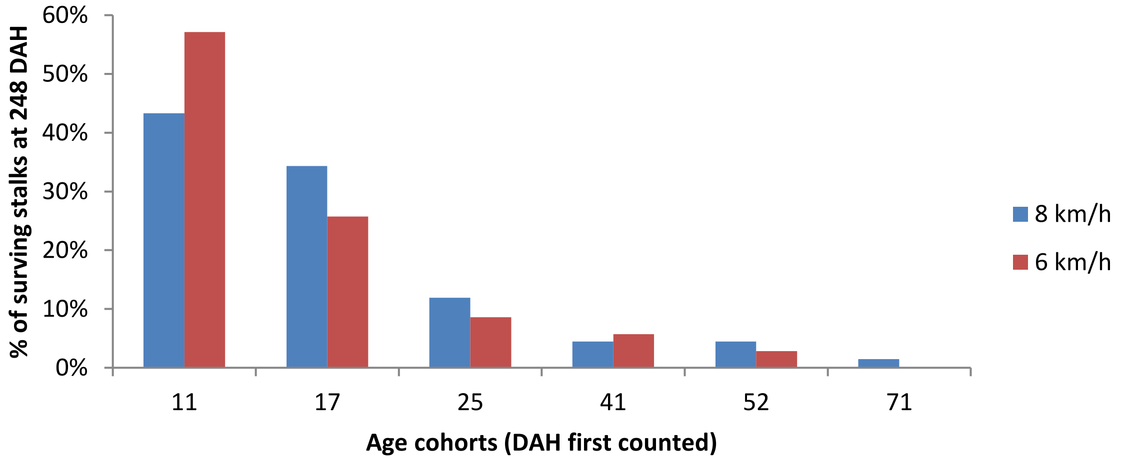


Figure 7.2 Percentage of surviving stalks at 248 DAH by age cohorts.

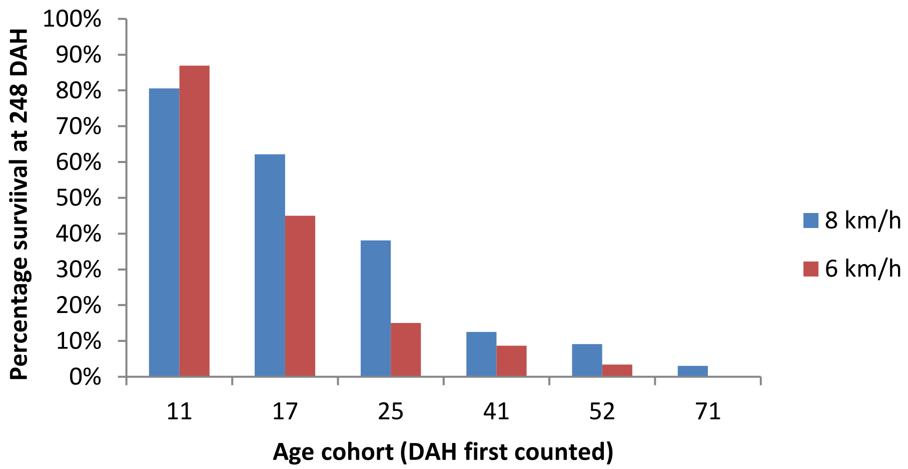


Figure 7.3 Percentage survival of each age cohort at 248 DAH

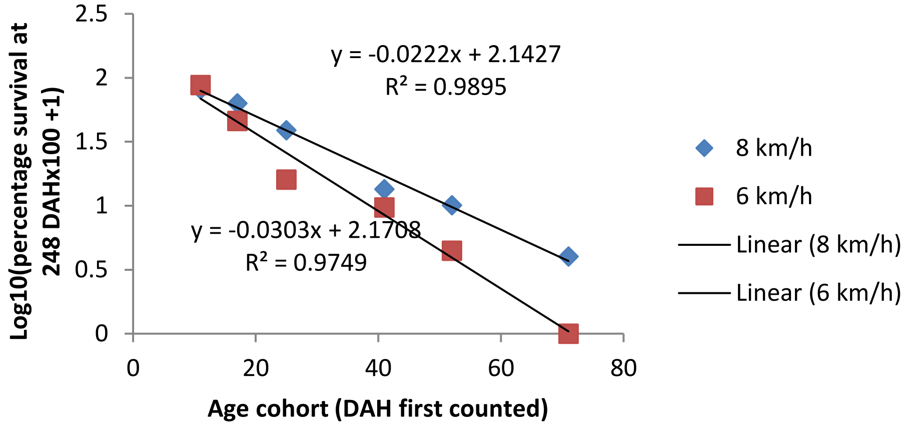


Figure 7.4 Plot of Log_{10} transformed data in Figure 7.2. The percentage figures have been multiplied by 100 and due to the presence of a zero value, 1 has been added to all values.

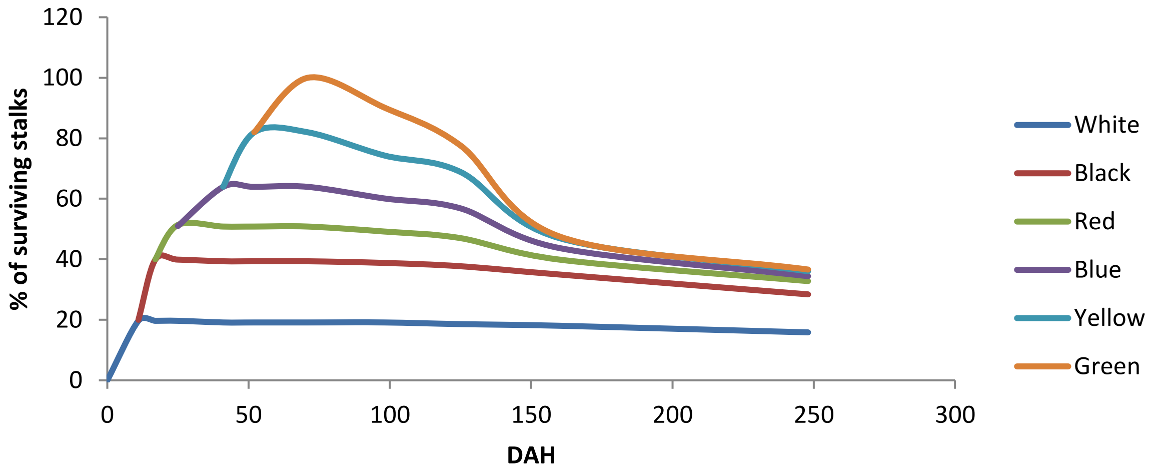


Figure 7.5 The percentage survival of the age cohorts over time (DAH) for the 8km/h plots.

There is no significant difference in the weights or the diameters of the stalks between age cohorts or between harvester speeds or the combination (Data not reported).

Analysis of the relationship between the stalk diameter at 98 DAH to the stalk diameter at 248 DAH indicates that most stalks had already reached their final diameter by 98 DAH as the slope of the graph is close to 1 and close to intersecting the y-axis at 0 (Figure 7.6). The variation would be due to the difficulty in obtaining a diameter in the field. Separating the data by age cohorts reveals a similar pattern, except for the younger cohorts, where the small amount of data makes it difficult to derive any reliable conclusions.

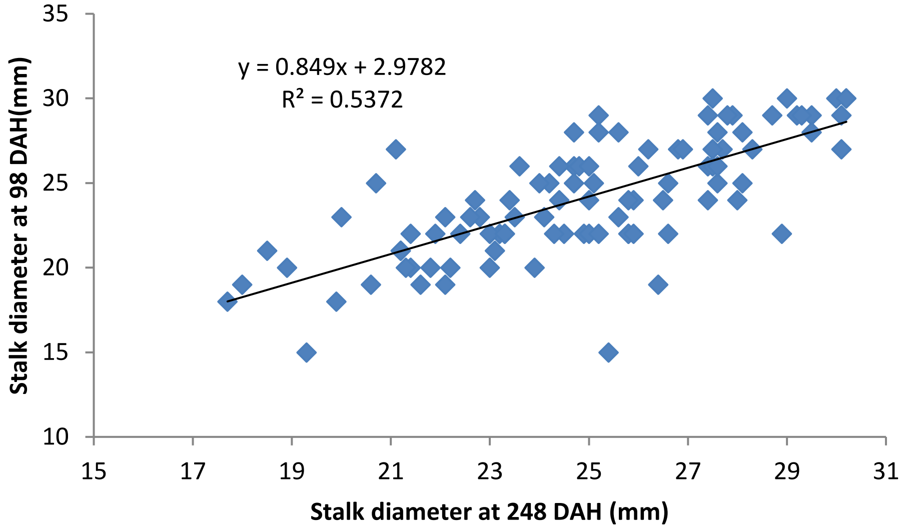


Figure 7.6 The relationship between stalk diameter at 98 DAH to the stalk diameter at 248 DAH

There is no statistical difference between the weight of the stalks at 248 DAH between speed treatments or age cohorts (Table 7.2). However, when the data is plotted only against the age cohorts, there is a non-statistically significant trend for the later emerging stalks to have a lower stalk weight (Figure 7.7).

Table 7.2 Average weight of stalks 248 DAH by age cohort and harvester speed.

Age cohort (DAH)	Stalk weights (kg)			
	Harvester speed (km/h)			
	N	6	N	8
11	20	0.83 ±0.066	29	0.99 ±0.060
17	9	0.80 ±0.134	23	0.81 ±0.073
25	3	1.13 ±0.099	8	0.64 ±0.085
41	2	0.92 ±0.040	3	0.73 ±0.262
52	1	0.73	3	0.72 ±0.111
		n.s.		n.s.

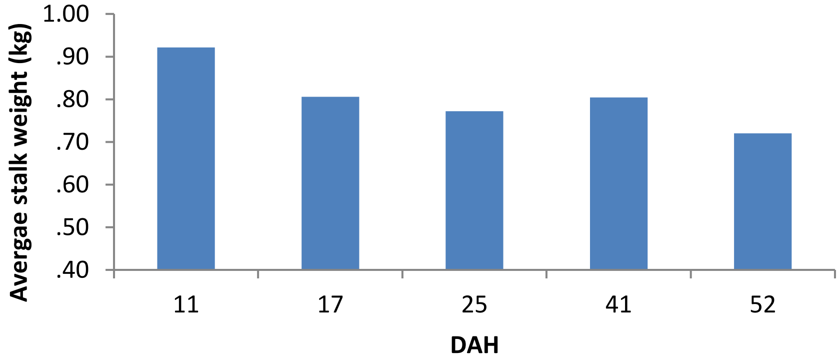


Figure 7.7 Average stalk weights at 248 DAH for shoots emerging at differing times after harvest.

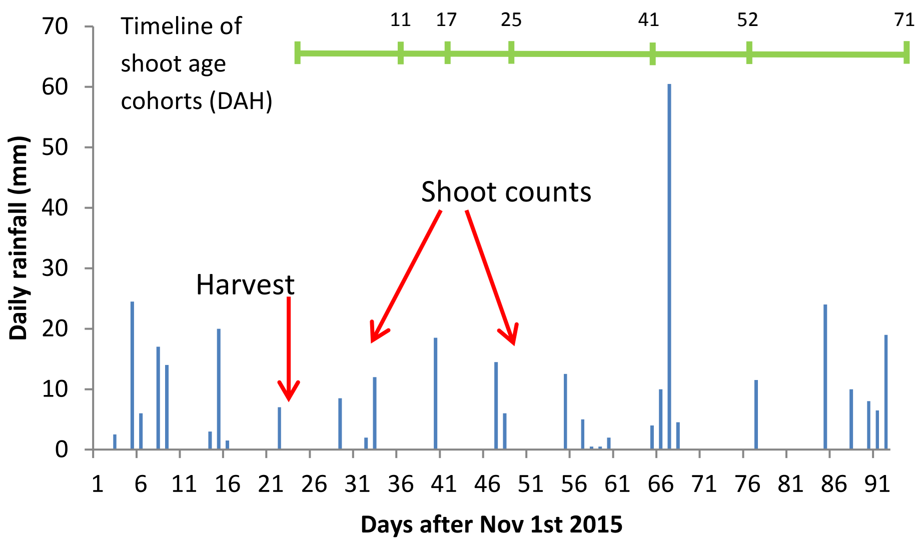


Figure 7.8 Rainfall for the three months around the harvest date and initial shoot growth.

7.4 Discussion

At this site an early increase in shoot numbers in the higher speed plots was not observed (Table 7.1). This is in contrast to what was observed in the majority of the speed trials (Table 3.3) and may be due to the fact that this trial was harvested under damp conditions that required the track buggy. In addition, quite reasonable rainfall fell over the initial establishment phase of the ratoon crop (Figure 7.8).

This is a very small observation trial of one variety at one time of the year and thus may only be a small subset of the possible results. This preliminary work indicates that there is an inverse exponential relationship of stalk survivability to the time of emergence after harvest (Figures 7.3 & 7.4). As a consequence, shoots emerging within 25 DAH represented about 90% of the stalks that survived to be millable. This ratoon crop began on 24th November, which is a near optimal time for crop establishment. It would be expected that ratoon crops that were initiated in less favourable times would have a stalk survival relationship that would be modified to some extent by the growing conditions. The results from this study are in contrast to the work of Arceneaux (1935) where it was reported that all 10 varieties from Louisiana had a stalk survival rate of about 75% for the first three age cohorts, each about 10 days apart. The difference in these results may be due to plant spacing or perhaps due to a change in the emphasis in the plant breeding program or a combination of these factors.

The age structure of the shoots appears to be different between the two harvester speed treatments. At the slower speed, shoots emerging within 11 days had a greater chance of survival than those from the 8 km/h treatment and provided a greater proportion of the harvestable stalks. Shoots emerging in the subsequent 14 days evened this imbalance out. There is no statistical difference in stalk weights 248 DAH, but there is a trend for the later emerging stalks to be lighter.

The speed trial in which this observational trial is located is due to be harvested in 2017.

7.5 Reference

Arceneaux (1935) A study of sugar cane stalk age groups under Louisiana conditions. *Proc. 5th Cong. Int. Soc. S.C. Tech. Brisbane*, 777 -787

8. Basecutter blade end cutting

8.1 Introduction

The usual basecutter setup involves two discs of about 590mm diameter that rotate in opposite directions. Each disc will usually have 5 blades that are 90mm wide and they extend beyond the disc between 75 and 100mm (Figure 8.1). The blades that are used in NSW are sharpened on four sides, but not the ends. In “normal” ground the crews will change the basecutter blades once a day. In sandy soil, they may change them twice a day.

As the harvester moves forward, some of the cutting will be done by the blunt end of the blade. Kroes (1996) noted in his thesis on the cutting of sugarcane that end cutting by the blades is an issue (Figure 8.1), but he did not investigate the magnitude of this issue.

This paper will investigate the issue of end cutting of cane.

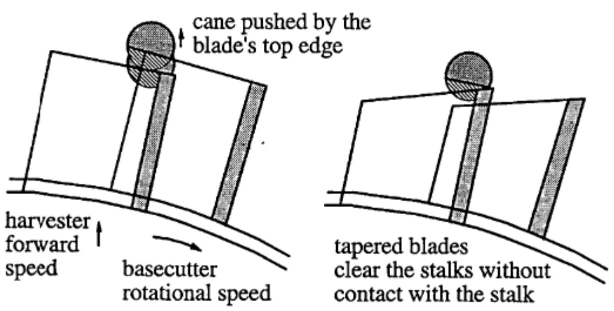


Figure 5.15 The blade top edge (a) pushing the stalk and (b) clearing the stalk

Figure 8.1 Blade end cutting (Kroes 1996 p. 5-13)

8.2 Analysis

There are two ways to determine the magnitude of the issue of end cutting.

8.2.1 Circumference method

The simple way to calculate this is to imagine that the circumference at the tips of the basecutter blades would be doing all the cutting if this was a complete disc. Therefore, the proportion of the circumference that the end of the blades will be equal to the amount of cutting that the blade ends do. In the case of 5 blades each 90mm wide and a radius of 390 mm, 18% of the cutting is done by the end of the blades.

8.2.2 Diagrammatic modelling

The second method involves calculating the position of the leading and trailing edges of one blade and the next one (Figure 8.2). The distance between the blue and red curves, represents the area cut by the end of the blade. The distance between the red and green curves, is the area cut by the sharp edge of the blade. Looking at the calculated values from the model shows that the proportion of cutting by the end is a constant 18% for 5 blades per disc and 22% for 6 blades per disc.

Utilising this model, it is possible to calculate the magnitude of the end cutting. At the usual harvester parameters it is found that each km in harvester speed represents about 1mm of end cutting. Therefore at 9km/h, the blunt end will cut a swath about 9mm wide through the stalk of cane for a partial cut. A few mm is unlikely to be a problem, but this amount of blunt cutting will cause stalk splitting and other damage. It is suggested that this is one of the causes for stool damage at higher harvester speeds. This zone of ragged end cutting can be seen by observing the cut stalks (e.g. Figure 8.3).

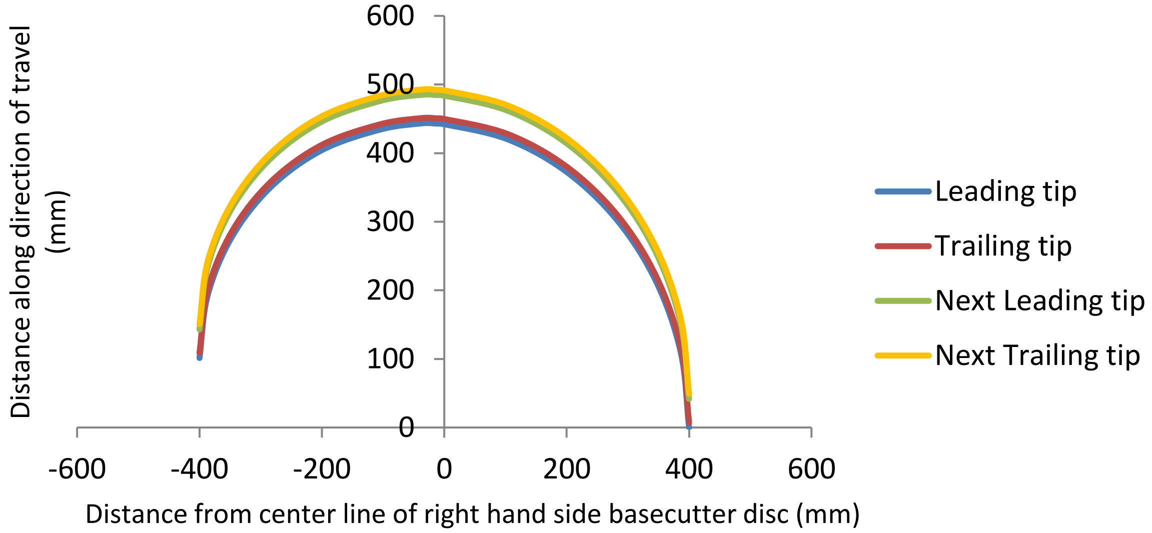


Figure 8.2 Graphical representation of the movement of two blades on the right hand basecutter disc. Basecutter speed: 600rpm; Harvester speed: 7.5 km/h; No. of blades: 5; Blade extension: 100mm

Figure 8.3 Photo of a cut stalk showing the zone of end cutting.

8.2.3 Impact of blade overlap

The zone where the blades from each disc overlap can be seen in Figure 8.4, where the movement of four of the blades on each disc is modelled. It can be shown that each blade will cross the path of the previous blade on the other disc when it is at 40^{o} forward of the line between the two discs, which is about 250mm along the centre line. At a 100mm blade extension on a 580mm diameter disc, the zig-zag zone is only about 20mm wide at 7.5 km/h. This will get wider, as the blades wear shorter, or the harvester travels faster. In this zone, the proportion of end cutting increases to a maximum of double at the point where the two blades intersect. However, as this zone is only about 20mm wide this would have negligible impact on the overall damage to the stool.

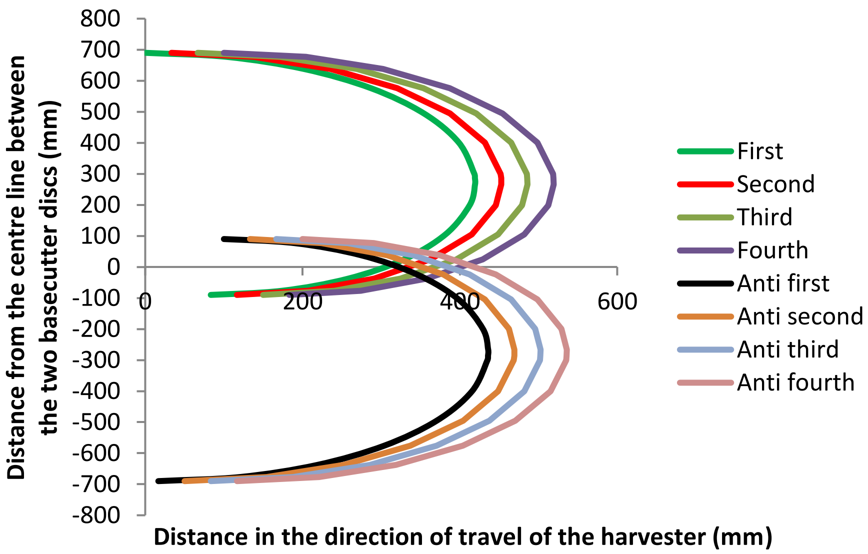


Figure 8.4 Graphic representation of the path of four of the blades from each of the two discs.

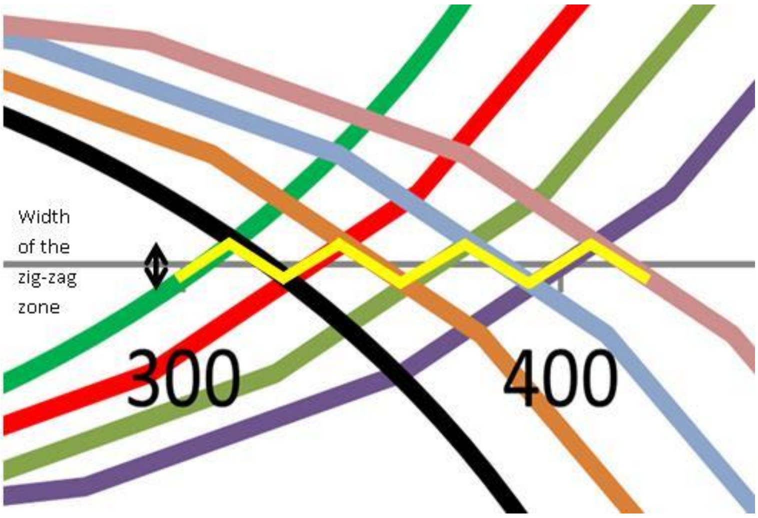


Figure 8.5 Close up view of the zone of overlap of the blades from Figure 8.4, showing the zig-zag zone (yellow line).

8.2.4 Solutions for end cutting

There are three solutions to avoid the effect of end cutting:

1) **Angled back end of blade**: This is a solution suggested by Kroes (1996) (Figure 8.1) and Kroes and Harris (1994). However, in NSW where each blade has four edges, this would reduce the number of edges to two and effectively double the cost of a blade.
2) **End sharpening**: This is possible and blades do exist on the market with end sharpening. However, there is a lot of wear on the significantly thinner tip and it would be expected that this critical part of the cutting edge will become blunter quicker. This can be solved by blades that have a thin layer of hard facing under the tip of the blade (Figure 8.6). These blades are an advance on hardfacing options investigated by Spinaze and Subramanian (1999). In this study they found a cost benefit in using hardfacing and recommended further investigation of this concept. Limited use during the 2016 season indicates that these blades that cost 2-3 times as much as a standard blade may last 2 – 2.5 times as long. The significant advantage is that the blades stay sharp for the entire life of the blade. Therefore, the issue of blunt end cutting and blunt blades is totally negated.
3) **Discs with standard blades angled back**: These (Figure 8.7) are available from at least two suppliers and allow standard four edged blades to be used. Harris (2002) has suggested that this disc/blade setup was the cause of problems with feeding. However, it was noted that the cane was being cut above ground level. When cut at ground level no problems were noted. As this configuration may be of interest a replicated trial investigated some parameters associated with the use of this disc configuration.

Figure 8.6 Basecutter blade showing a thin layer of hardfacing on the underside of the blade.

Figure 8.7 Basecutter disc with angled back blades on the left and the standard configuration on the right.

8.3 Method

A replicated trial in two neighbouring blocks of differing varieties compared a standard basecutter setup and a one with angled back blades. Two harvester speeds were also used to give four treatments on two blocks. Pick up losses and shoots counts were assessed.

8.4 Results

Pick up losses (Table 8.1) and shoots counts (Table 8.2) were assessed and no significant difference was determined between any of the treatments.

Table 8.1 Pick-up losses from a trial comparing angled back basecutter blades with standard blade arrangement

	Block 1 (Q183)		Block 2 (Q232)	
Treatment	N	Pick-up losses (kg/10m row)	N	Pick-up losses (kg/10m row)
Standard 7.5 km/h	6	1.1 ± 0.44	6	1.1 ± 0.55
Standard 5 km/h	6	1.0 ± 0.56	6	1.0 ± 0.33
Angled 7.5 km/h	6	1.2 ± 0.19	6	0.9 ± 0.47
Angled 5 km/h	6	1.1 ± 0.52	6	1.1 ± 0.47
		n.s.		n.s.

Table 8.2 Shoot counts from a trial comparing angled back basecutter blades with standard blade arrangement

	Block 1 (Q183)		Block 2 (Q232)	
Treatment	N	Shoots (/10m row)	N	Shoots (/10m row)
Standard 7.5 km/h	8	84 ± 4.7	8	94 ± 8.7
Standard 5 km/h	8	97 ± 5.8	8	81 ± 6.9
Angled 7.5 km/h	8	93 ± 6.6	8	70 ± 8.1
Angled 5 km/h	8	82 ± 5.5	8	86 ± 9.9
		n.s.		n.s.

8.5 Discussion

Three harvester drivers who have used these discs have not noticed any issues with feeding and one commented that a lower basecutter pressure resulted with the angled back blades. This may be due to the slicing action of the blade rather than the more aggressive impact cut of the standard arrangement.

8.6 References

Harris, H (2002) Improvements in base cutter design and cane feeding. Final Report: Project NCE 004. Sugar Research Australia.

Kroes, S 1996 The cutting of sugarcane. PhD Thesis. Uni Sth Qld.

Kroes, S and Harris, H D (1994) Effects of cane harvester basecutter parameters on the quality of the cut. *Proc. Aust. Soc. Sugar Cane Technol*. 16: 169-177

Spinaze, D and Subramanian, C (1999) Surface engineering of basecutter blades to reduce wear. *Proc. Aust. Soc. Sugar Cane Technol*. 21: 191-195

9. Economic considerations

9.1 Introduction

One of the aims of this project was to utilise the results to develop a payment system that shared the costs and benefits of changed harvesting practice equitably across the supply chain. The assumption being that current economic drivers incentivise poor harvesting practice and that changing that practice would benefit the grower and the miller while penalising the harvesting contractor.

Previous reports (SRDC) and modelling (Pollock) suggested that adoption of HBP benefitted the grower by $3/t cane, the miller $1.0/t cane while the harvesting contractor’s costs increased by about $0.5/t cane.

The results reported do not provide any useful data upon which a valid model could be proposed.

9.2 References

Pollock, J (2013) An examination of losses in the sugar industry value chain and opportunities to reduce them. Final Report: Sugar Industry Value Chain Analysis.

RK Jones (2004) A Review of Sugar Cane Harvesting Practices and Options for Improvement. SRDC Technical Report 2/2004 Cane Harvesting to Improve Industry Performance.

10. Real time harvester information

10.1 Introduction

One of the project objectives was *The development of real time monitoring of the harvesting operation*. The NSW industry has utilised the harvester recoding system developed by Agtrix for over ten years. This system utilises GPS and two data inputs (harvester on/off, elevator on/off) to record some harvester outputs (e.g. Figures 10.1; 10.2; 10.3). However, these outputs are currently not available to growers and the only use for the Agtrix system is as a harvest progress and consignment confirmation tool to manage cane supply.

Harvesting Report by Farm : 2016-10-01 00:00 +11:00 - 2016-10-05 00:00 +11:00 AGTRIX

1027 - CASTLE VH & PJ (SOUTH)		First Cut	Last Cut	Time Spent Cutting	Avg Speed	Distance Cutting (kms)	Turn %	Est Ha Cut	Est Tons Cut	Est Bins
1/10	1027-01200 (38)	8:03	13:27	1:20	5.2	7.0	25	1.1	172.5	8.0
2/10	1027-01200 (38)	7:58	8:42	0:14	5.9	1.5	2	0.2	35.9	1.7
1/10	1027-01300 (38)	8:07	13:26	1:19	5.0	6.5	11	1.0	161.1	7.5
2/10	1027-01300 (38)	8:01	8:41	0:13	5.9	1.3	64	0.2	31.6	1.5
1/10	1027-02500 (38)	15:23	17:40	1:20	6.0	8.0	14	1.3	205.1	9.5
2/10	1027-02500 (38)	14:35	17:29	1:08	5.9	6.7	3	1.1	170.3	7.9
3/10	1027-02500 (38)	8:15	11:08	1:22	6.1	8.4	13	1.3	214.7	10.0
2/10	1027-02810 (38)	9:00	14:31	2:10	4.8	10.5	8	1.7	268.0	12.4
1/10	1027-02820 (38)	14:21	15:05	0:19	4.9	1.5	4	0.2	39.4	1.8
	1027 - CASTLE VH & PJ (SOUTH)				**5.5**	**51.3**	**16.0**	**8.1**	**1,299**	**60**

Figure 10.1 An Agtrix harvesting report by farm

H:34 North Clarence 2		First Cut	Last Cut	Time Spent Cutting	Avg Speed	Distance Cutting (kms)	Turn %	Est Ha Cut	Est Tons Cut	Est Bins
1/10	1327-01800	4:47	11:15	2:46	6.0	16.6	4	2.7	499.4	23.2
2/10	1327-01800	4:45	7:38	1:33	6.0	9.4	3	1.5	281.4	13.1
2/10	1328-01500	7:56	11:22	1:01	6.3	6.4	2	1.0	174.9	8.1
3/10	1328-01500	4:53	8:04	1:41	5.6	9.4	3	1.5	257.0	11.9
3/10	1328-01600	4:47	11:18	1:36	6.0	9.6	4	1.5	251.6	11.7
4/10	1328-01600	8:55	18:02	3:43	6.5	24.3	3	3.9	633.1	29.4
5/10	1118-01310	11:55	14:02	0:19	6.2	2.0	2	0.3	31.7	1.5
5/10	1118-01900	8:11	11:44	1:30	7.2	10.9	2	1.8	140.1	6.5
5/10	1328-01600	6:42	7:02	0:10	6.9	1.2	10	0.2	31.5	1.5
5/10	2119-00110	14:17	17:42	0:22	5.1	1.9	5	0.3	19.4	0.9
5/10	2119-00120	14:20	17:09	0:35	6.2	3.6	2	0.6	113.6	5.3

Figure 10.2 An Agtrix report by harvester

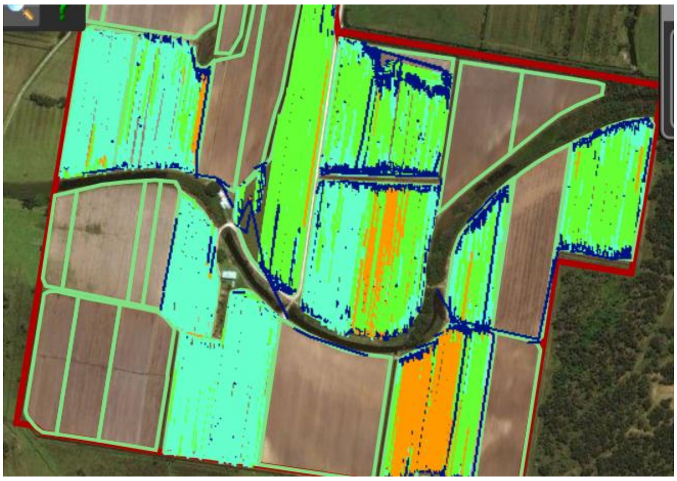


Figure 10.3 Agtrix output in AgDat showing harvester speed tracks from the 2016 harvest. The orange tracks (faster) in the bottom left is from a field of one year old with pig damage. The field in the centre with orange tracks was poor yielding two year old Q208. The blue tracks are high yielding two year old Q232.

The Agtrix infrastructure, where data is downloaded and processed at 15 minute intervals, is able to be used to provide even more data about harvester performance if the appropriate data is collected.

10.2 Real time monitoring

At the beginning of the project, it was assumed that the HBP principles established in Queensland were valid. On this basis the consultative team agreed upon a number of principles to guide the development of a real time HBP reporting framework (Figure 10.4). The end target was to combine all the attributes with appropriate weighting into a single output that was either red or green for HBP compliance.

Rules					Speed			Fan			SecondaryFar		Topper	
Name	Plant	CutYear	YieldLow	YieldHigh	lo	Hi	wgt	lo	Hi	wgt	In	wgt	In	wgt
Plant 2 year old	Yes	2	0	99999	4.5	6.5	40	800	900	35	1	15	1	10
Good Ratoon 2 Year	No	2	90	9999	5.5	7.5	40	800	900	35	1	15	1	10
Old Ratoon 2 year	No	2	0	90	7.5	10	40	800	900	35	1	15	1	10
Plant 1 year old	Yes	1	0	99999	4.5	6.5	35	800	900	25	1	15	1	25
Good Ratoon 1 Year	No	1	80	9999	5.5	7.5	35	800	900	25	1	15	1	25
Old Ratoon 1 year	No	1	0	80	7.5	10	35	800	900	25	1	15	1	25

Figure 10.4 HBP rules used by Agtrix in their HBP app.

The major problem in collecting the data is the lack of co-operation from the harvester manufacturers to provide access to their monitoring data. As a consequence, there is considerable work involved in attaching sensors and calibrating them. In addition, maintaining them all in a fully functioning state during the season is a time consuming exercise. A critical output like the primary extractor fan speed which needs to be an analogue output will take a few hours to calibrate correctly for each machine.

As the field trial data did not give firm guidance on HBP settings in the context of NSW harvesting, the emphasis on this part of the project was decreased. Of interest, though, was that even at the end of the project many members of the oversight committee still wanted to know what the harvester was doing and so there is still a requirement for the display of real time information. However, as a consequence of the complexity in wiring and calibrating to collect the extra data and the question marks over the HBP settings, the extra data collection was never fully implemented on the six HBP designated harvesters

In reality, to ensure that good data can be collected, Case and John Deere need to be lobbied to allow third party access to a limited data set from their systems.

Agtrix have done the hard work in setting up the data collection and processing framework and the mobile phone output interface. From this point on it is merely a matter of deciding what data is to be collected, the type of processing and how it should be displayed. Some of the outputs that are currently available can be viewed in Figures 10.3

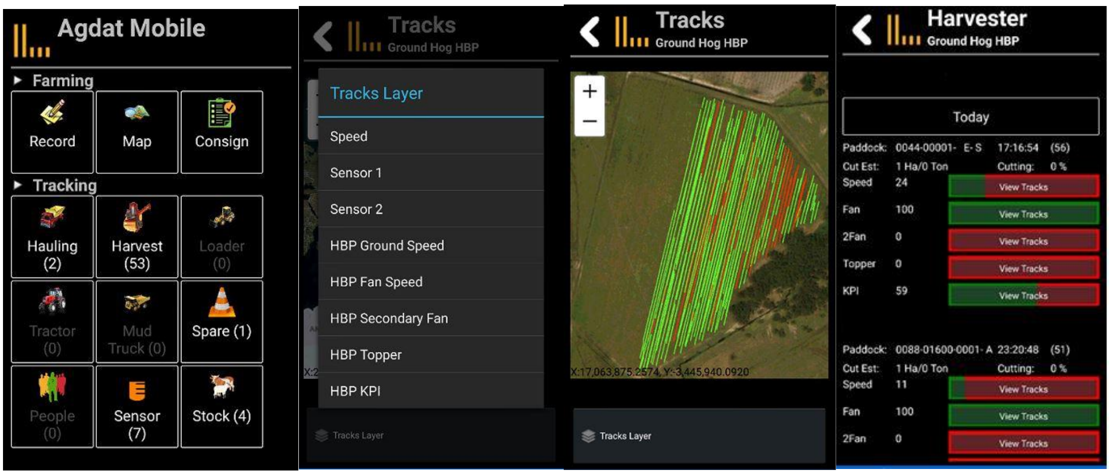


Figure 10.3 Four screen shots from the Agtrix harvester monitoring app showing some of the possible outputs.