WHAT IMPACT DOES TIME OF HARVEST HAVE ON SUGARCANE CROPS IN THE HERBERT RIVER DISTRICT?

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Abstract

SEASON LENGTH, harvest management, and mill starting and finishing dates have significant impacts on all sectors of the value chain in the Herbert River district. The industry needs to seek opportunities to maximise profit across the value chain to ensure industry long-term viability. Previous research findings have been contradictory and difficult to interpret because of confounded effects of crop age, crop management, nutritional status and environmental conditions. Over the past three years a series of trials was conducted in the Herbert River district to investigate what impact season length and harvest time have upon different varieties. The trial results indicated that variety x time of harvest interactions exist and could have a significant effect on industry profitability and sustainability. When season lengthening is required, extension of the season forward, as opposed to lengthening the season at the end of the harvest window should be considered. The disadvantages of an earlier start far outweigh the disadvantages of a late harvest finish, because of the loss in sugar yield, loss of yield in subsequent ratoons, and the possibility of premature ploughing out of a crop due to ratoon failure. Varieties were identified for optimum productivity at different times in the harvesting season and this should assist in improving the management of varieties. The results of these trials will be used by industry to assess the impact of time of harvest on variety performance and to develop strategies to maximise crop profitability.

Introduction

Harvest management, season length and mill starting and finishing dates have significant impacts on industry profitability. Harvest management in any given year can impact on sugar content, cane yield, monetary return, ratooning potential and profitability in the following ratoon crops. A longer harvesting season may allow industry to manage increasing production or to support investment opportunities in value-added by-products (McDonald *et al.*, 1999). Growers are paid on tonnes of cane harvested and sugar content and through a cane price formula (BSES, 1984). The cane-payment formula encourages growers to seek a harvesting season of less than 20 weeks to maximise sugar content and monetary returns. Conversely, millers and harvesters would prefer an optimal season length longer than 20 weeks (SIRWP, 1996) to maximise returns from milling and harvesting capital.

The time when a crop is harvested affects yield by imposing both crop age and seasonal factors on the crop during its growing period (McDonald *et al.,* 1999). Farm-management factors also impact on crop productivity. Good farm managers seek opportunities to maximise monetary return while minimising risk; for example, by harvesting low-lying blocks earlier in the harvesting season to avoid potential waterlogging issues.

Four trials were established in the Herbert district to determine if variety-by-time-of-harvest interactions affected sugar content, cane yield, sugar yield, ratooning and monetary returns we established four trials in the Herbert River district. This paper reports the trial results and reviews the issue of variety by time of harvest for the Herbert River district.

Materials and methods

Four trials were planted in areas within the Herbert River district where climatic and soil conditions might allow early harvest of cane. These areas could be harvested earlier in most years due to drier field conditions and higher CCS levels.

The trials were established as apart of the SRDC project- BSS264. The project partners requested information on the opportunities to harvest cane early in the drier regions of the district. Changes to existing harvest schedules are being considered in the region to maximise capital utilisation and sugar yield.

Table 1 gives details of each trial. Plant crops and first ratoon crops were harvested at all sites and a second ratoon was harvested at site 2. At sites 2–4 there were three harvest times: early (June–July), mid (mid August–September) and late (mid November–December). Crops at site 1 were harvested only early and mid season. Ratoon crops were harvested as close as possible to 12 months after the previous harvest.

Table 1–Details of four variety-by-time-of-harvest trials.

Trial	Location of trial	Soil type	Date planted	Date harvested plant crop	Date harvested 1st ratoon	Date harvested– 2nd ratoon
				Early Mid Late	Early Mid Late	Early Mid Late
1	Blackrock	Solodised solonetz	24/6/04	26/6 19/9 –	14/6 18/9 –	
2	Crystal Creek	Soloth	27/5/04	16/7 11/9 24/11	13/6 14/9 6/11	23/7 20/9 8/11
3	Helens Hill	Solodic	25/5/05	28/7 30/10* 5/12	24/7 17/9 13/11	
4	Wharps	Grey earth	1/5/05	5/8 4/11* 30/11	8/8 20/9 13/11	

* harvesting occurred late due to wet weather

Trials contained commercial and advanced experimental varieties. Varieties with known different harvest windows (such as Q135, Q174[Φ] and Q158), as well as clones with unknown harvest management windows (QC84-621, QN89-1902 and QN91-3285) were assessed. There were at least 20 clones at each site. Collectively, 37 clones were assessed across all sites, with nine in common across all sites.

All trials were laid out as randomised complete-block designs with two replicates, and a plot shape of four rows by 10 m. Cultivation operations were normal (conventional) for the district, with a row spacing between 1.52 and 1.64 m, at different sites. The crops were harvested green and green-cane trash blanketed.

In May 2006 and 2007, we took a six-stalk sample from each plot at site 2 to assess early CCS potential of varieties and to investigate any early-CCS-by-time-of-harvest interactions for the first- and second-ratoon crops. These were crushed with a small mill, and commercial cane sugar (CCS) was determined using standard procedures (BSES, 1984).

During each harvest, we took a six-stalk sample from each plot to determine CCS as above. The trials were harvested using the BSES weigh bin to determine plot weights and cane yield. To calculate sugar yield, CCS and cane yield were combined using the formula (cane yield × CCS)/100.

Several analyses were undertaken on the data. For each trial, the early, mid and late schedules were analysed separately and then combined to determine if the clone*schedule interaction was significant. For all analyses, if a significant difference was detected in the analysis of variance table, the means were separated by Tukeys test. All data were analysed using SAS.

Results

Crop growing conditions

Two notable environmental conditions (Figure 1) that occurred during the growing periods were cyclone Larry on 20 March 2006 and an unseasonal wet period in September 2006.

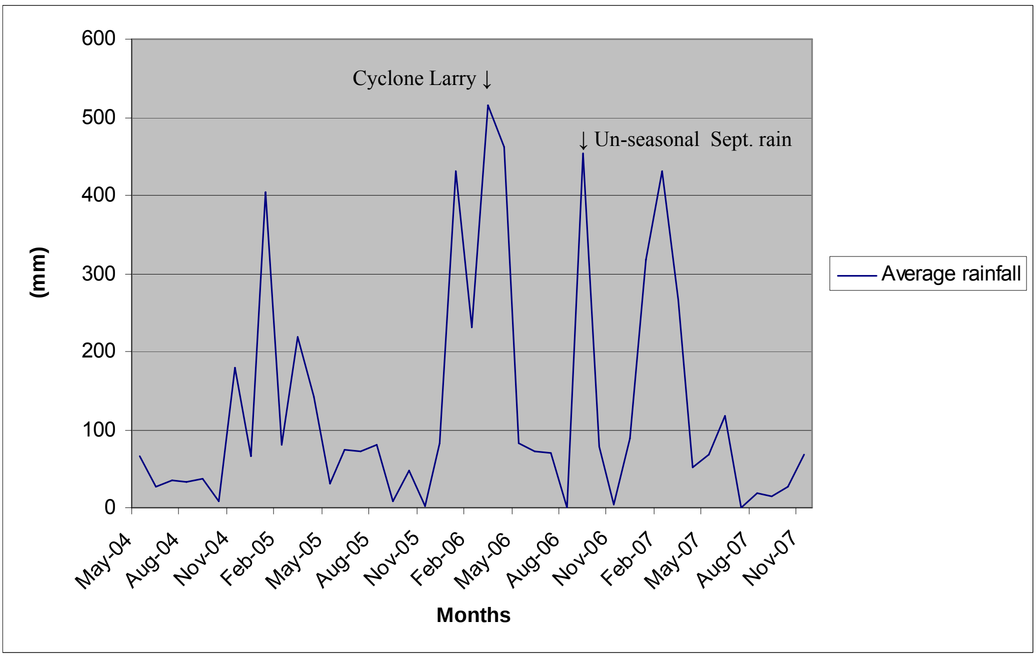

Fig. 1—Monthly rainfall at BSES weather station in the Herbert River district May 2004–November 2007.

Comparison of harvest (time) schedules

There were significant differences in cane and sugar yields and CCS levels among harvest times at all sites, except for CCS levels at site 4 in plant cane. The most noticeable differences were decreases in cane (Table 2) and sugar yields (Table 4) in the late harvests of the ratoon crops. There were also significant differences in CCS levels among the harvest times (Table 3).

Early harvest was defined as the months mid June to mid August, mid harvest as the months mid August to mid October and late harvest as mid October to mid December.

Table 2—Average cane yield (t/ha) for all time-of-harvest trials.

Trial (crop class)	Early harvest	Mid harvest	Late harvest	P value
1 (P)	134.0	136.0	–	0.0377
1 (1R)	122.0	99.0	–	<.0001.
2 (P)	85.3	92.5	95.5	0.0238
2 (1R)	70.3	80.5	68.5	<.0001
2 (2R)	75.0	73.0	45.0	<.0001
3 (P)	136.8	152.2	137.9	0.0003
3 (1R)	130.5	99.6	91.6	<.0001
4 (P)	83.0	96.6	85.5	0.0377
4 (1R)	57.1	56.6	44.8	<.0001
Plant cane average	109.8	119.3	106.3	
1st ratoon average	95.0	83.9	68.3	
2nd ratoon	75.0	73.0	45.0	
Average	99.3	98.4	81.3	
Average- 1R & 2R	90.9	81.7	62..5	

Table 3—Average CCS levels for all time-of-harvest trials.

Trial name (crop class)	Early harvest	Mid harvest	Late harvest	P value
1 (P)	11.31	14.28	–	<.0001
1 (1R)	14.43	15.05	–	0.0085
2 (P)	11.37	14.45	14.31	<.0001
2 (1R)	11.32	14.78	15.62	<.0001
2 (2R)	14.15	18.07	16.90	<.0001
3 (P)	11.95	13.39	13.29	<.0001
3 (1R)	13.96	16.45	16.42	<.0001
4 (P)	13.44	13.71	13.53	0.1371
4 (1R)	15.34	16.56	16.00	<.0001
Plant cane average	12.02	13.96	13.71	
1st ratoon average	13.76	15.71	16.01	
2nd ratoon	14.15	18.07	16.9	
Average	13.03	15.19	15.15	
Average- 1R & 2R	13.84	16.18	16.24	

Table 4—Average sugar yield (t/ha) for all time-of-harvest trials.

Trial name (crop class)	Early harvest	Mid harvest	Late harvest	P value
1 (P)	15.1	19.4	–	<.0001
1 (1R)	17.6	15.0	–	<.0001
2 (P)	9.7	13.3	13.6	<.0001
2 (1R)	7.9	11.9	10.7	<.0001
2 (2R)	10.7	13.2	7.7	<.0001
3 (P)	16.3	20.3	18.3	<.0001
3 (1R)	18.2	16.4	15.0	<.0001
4 (P)	11.1	12.4	11.6	0.0038
4 (1R)	8.8	9.4	7.2	<.0001
Plant cane average	13.0	16.4	14.5	
1st ratoon average	13.1	13.2	11.0	
2nd ratoon	10.7	13.2	7.7	
Average	12.8	14.6	12.0	
Average- 1R & 2R	12.6	13.2	10.2	

For cane yield, plant cane harvested mid season gave significantly higher yields than early season harvested cane at all sites. There was no significant difference between yield for mid and late season harvested plant cane, except at site 3, where late-season cane yield was significantly lower.

In ratoon crops, there were significant reductions in cane yield between the early and late harvest times and between mid and late harvest times.

At all sites the means for mid-season CCS were significantly greater than early CCS, except in the first ratoon at site 2 where CCS peaked at the late harvest time

In plant cane, there was a significant difference in sugar yield between mid and early season, and between mid and late-season harvested cane, except at site 4 where there was no difference between early and late season. In ratoon crops, the differences were not as clearly defined, but at all sites the highest sugar yield was at the mid harvest time.

Variety by time of harvest interactions

In plant cane crops, there were no significant variety-by-time-of-harvest interactions for cane and sugar yields or for CCS (Table 5).

In the ratoon crops, there were significant interactions for cane and sugar yields and CCS at all sites except for cane and sugar yields at sites 1 and 4 and CCS at sites 1 and 2 (Table 5). Figure 2 highlights the interaction for cane yield in some of the clones from the second ratoon at site 2.

Table 5–P values for variety x time of harvest interactions for each trial.

Trial (crop class)	P value- cane yield	P value- Sugar yield	P value- CCS
1 (P)	0.2086	0.5043	0.2032
1 (1R)	0.1916	0.2826	0.3043
2 (P)	0.8994	0.8025	0.0008
2 (1R)	0.0080	0.0004	<.0001
2 (2R)	0.0008	0.0002	0.3341
3 (P)	0.9211	0.8485	0.4018
3 (1R)	0.0001	0.0017	0.0029
4 (P)	0.3471	0.1711	0.2337
4 (1R)	0.3285	0.2407	0.0025

It was observed in the ratoons that some varieties suffered large yield reductions and premature stool death after a late harvest. This would be deemed as ratoon failure by a grower. Growers regularly report that some varieties fail due to premature stool death and lower than expected yields after a late harvest (Di Bella unpublished data). Figure 2 highlights the yield reduction experienced for six representative varieties for late harvest.

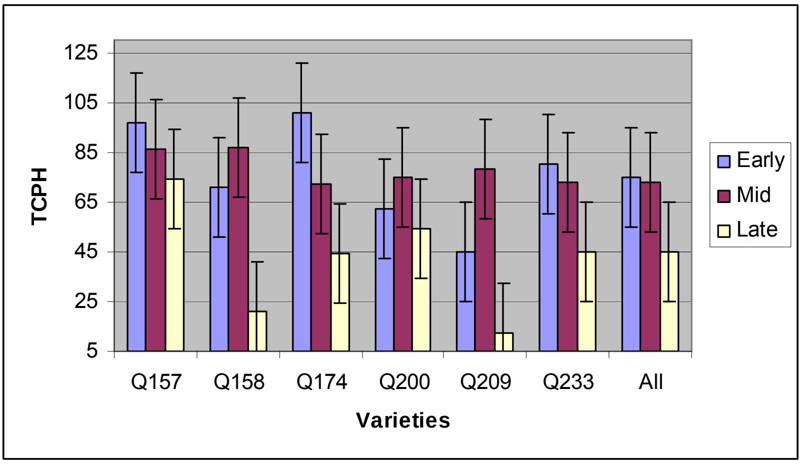

Fig. 2–Cane yield (t/ha) of six varieties at three times of harvest in the second ratoon at site 2.

Variety performance within harvest times

There were significant differences among varieties within a time of harvest for cane and sugar yields and CCS for plant and ratoon crops at sites 2,3 and 4. Figures 3–5 show the differences in CCS, cane and sugar yields respectively, of five varieties at site 2, in the first ratoon. Q174[ⴔ] is commonly harvested as early CCS varieties in the Crystal Creek area, while Q158 is typically harvested late in the season because of its low early CCS potential. Early CCS varieties (Q174 [ⴔ] and Q233[ⴔ]) appear to reach their maximum cane yield at the early harvest, while Q157, Q157 and Q200 [ⴔ] reach their highest cane yield mid harvest.

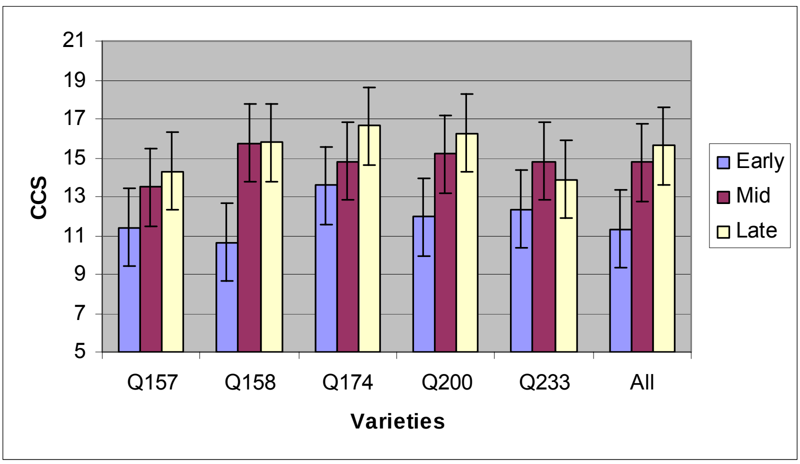

Fig. 3—CCS levels in five varieties at three times of harvest in the first ratoon at site 2.

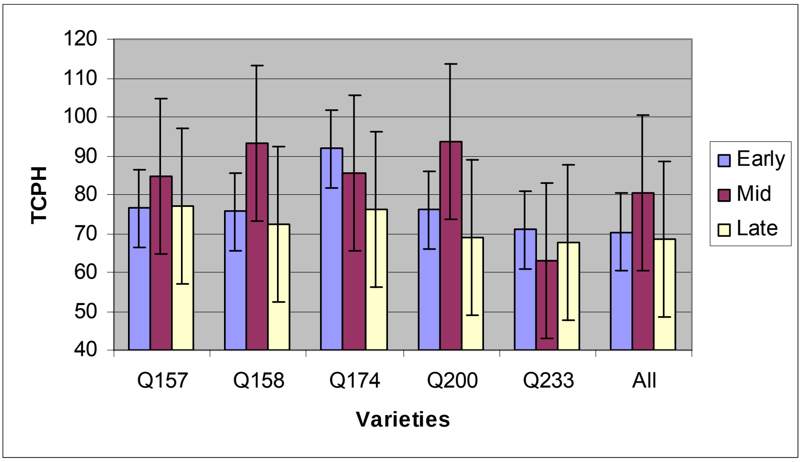

Fig. 4—Cane yield (t/ha) in five varieties at three times of harvest in the first ratoon at site 2.

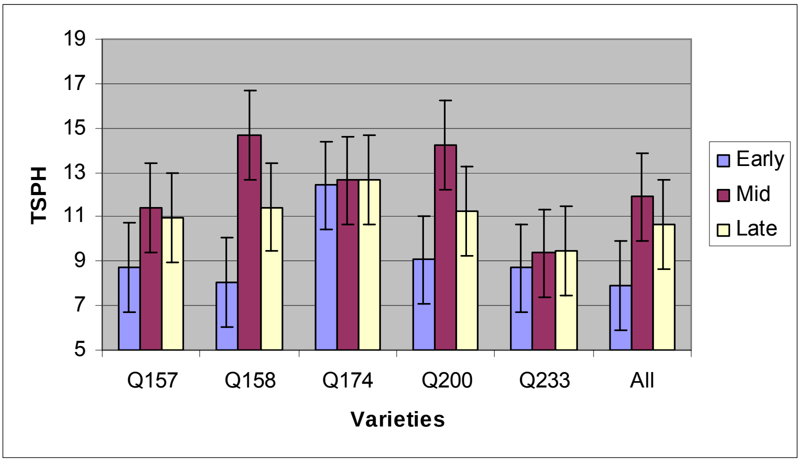

Fig. 5—Sugar yield (t/ha) in five varieties at three times of harvest in the first ratoon at site 2.

Early CCS by time of harvest interactions

CCS levels were determined in May in the first- and second-ratoon crops of site 2 for all time-of-harvest treatments, to assess the effects of crop age . There were no significant clone-by–harvest-time interactions for early CCS. There was also a significant difference in CCS levels between years. Table 6 highlights the CCS levels for four varieties of particular interest to Herbert cane farmers.

Table 6–CCS levels in May for selected clones at three harvest times in the first- and second-ratoon crops at site 2.

Clone	1st ratoon Early	1st ratoon Mid	1st ratoon Late	2nd ratoon Early	2nd ratoon Mid	2nd ratoon Late
Q157	9.9	10.5	10.4	13.6	14.2	12.9
Q158	10.7	11.8	10.6	14.4	13.9	14.1
Q200$^{\Phi}$	7.7	8.4	8.6	13.9	14.9	14.7
Q233$^{\Phi}$	11.7	12.1	11.7	14.9	15.9	13.9

Discussion

Optimum time to harvest plant cane

The trials indicated that the optimum time to harvest plant cane in the Herbert was mid season as this gave the highest CCS, cane yield and sugar yield. Harvesting plant cane late in the harvest season should be avoided because of lodged crops suckering, stalks deteriorating and CCS levels declining (as was the case in the plant crop at site 3).

Mid season harvesting also ensures that adequate yields are achieved in the first-ratoon crop and avoids ratoon failure.

Variety × time of harvest interactions were not significant in plant cane because plant crops in drier areas are usually 12 months of age or older and have had opportunities to accumulate biomass and sucrose over that period.

Optimum time to harvest ratoon cane

Our results clearly indicate that harvest times have a significant effect on cane yield in the following crop. This is similar to findings by Chapman and Leverington (1976) and Leverington *et al*. (1978).

The average loss for all first ratoon crops, comparing mid season and the late harvest schedules, was 15.6 t/ha of cane, while a yield loss of 28 t/ha of cane occurred in the second ratoon at site 2 (Table 2)

Early-harvested cane does not appear to have a yield penalty compared to late-harvested cane. The poor yield response at the late harvest schedule could be attributed partially to prolonged periods of waterlogging and periods of low solar radiation during the growing period.

Chardon and Rudd (1978) and Wood *et al.* (1984) highlighted the potential yield losses associated with waterlogging. However, we do not believe that this is the only limiting factor, as early and mid-season harvested crops do not experience the same yield reduction as late-harvested cane.

Muchow *et al.* (1997) and McDonald *et al.* (1999) reported that potential yield of crops started at different times of the year is achieved through the impact of prevailing radiation and temperature regimes on the processes of canopy development, radiation interception, radiation use efficiency, biomass and sucrose accumulation, and the dry-matter content of stalks.

Crops harvested late in the harvest season are usually at greatest risk due to high probability of significant rainfall events, waterlogging and periods of low solar radiation (due to cloud cover) and lack of time to accumulate biomass, prior to the onset of the 'wet season' period (from late December to late March) (this is highlighted in Figure 6).

The optimum time to harvest cane in the Herbert is mid season. Mid season is when the highest CCS, cane yield (TCPH) and sugar yield (TSPH) are achieved.

However, it is not possible to harvest all the crop at the optimum time due to mill crushing capacities and volume of cane to harvest during a particular season.

Chapman and Leverington (1976) reported that, should there be a need to alter or extend the harvesting period, an earlier start to the crushing appeared to be a better proposition than a later finish because the higher yields of earlier ratooned cane would outweigh the disadvantages of lower sugar content due to an earlier start to crushing. Our results clearly support this.

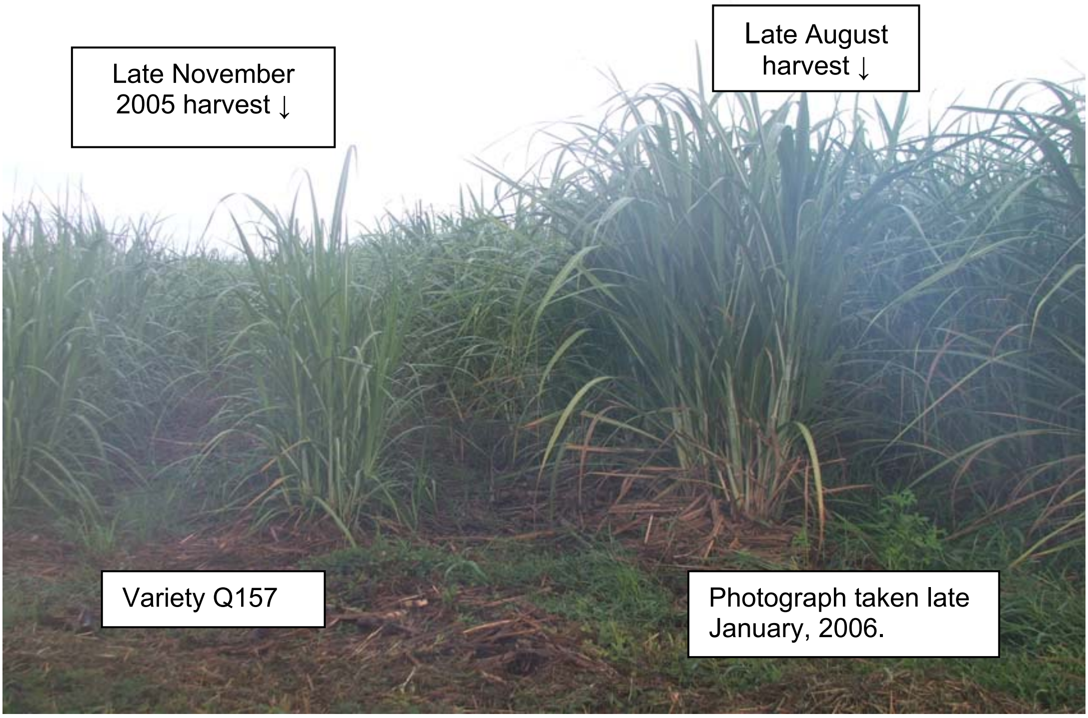

Fig. 6—Difference in crop biomass accumulation between two harvest schedule periods.

The impact of late harvest on ratooning and loss of subsequent ratoons is usually ignored in most financial models assessing season-length scenarios. The loss of a ratoon crop due to a late harvest and the impact of adverse environment conditions is a significant financial cost to a farming enterprise.

Harvesting of cane through mid November and December limits opportunities to improve surface drainage , establish legume crops during the fallow period and may eventuate in pre-mature ploughing out of a block because of low yield potential.

Variety performance among harvest times

In the plant cane, there was no significant variety-by-time-of-harvest interaction for CCS, cane yield or sugar yield. This may be because crops were older than 12 months and had the ability to accumulate biomass and sucrose during the growth period.

The situation in ratoon crops is very different with significant interactions for CCS, cane yield and sugar yield at all sites, except site 1 which may have responded differently because there was a shorter period between the early and mid season harvest times.

To maximise monetary returns from the crop a grower will need to have a good understanding of a variety's performance over a harvesting season and make an informed decision when to harvest. This interaction in ratoons should also be considered by plant-breeding programs to identify suitable varieties for different harvest time schedules. Different varieties will respond differently to the stress mechanisms imposed on the plant and knowledge of variety performance under different conditions will ensure that higher yields are achieved for late-harvested cane.

Variety performance within harvest times

There was a significant yield difference between clones within a time of harvest for plant and ratoon crops for CCS, and cane and sugar yields at all sites, except site 1.

This yield difference indicates the importance of managing varieties to achieve maximum productivity and CCS throughout the harvest window.

A grower should understand a clone's performance (especially for CCS) at various times throughout the harvest season to maximise productivity.

Table 7 highlights the importance of selecting the correct clone for a harvest time.

Table 7—CCS levels in the first ratoon for a selected number of varieties at site 4 (the highest CCS variety for each harvest is highlighted in bold).

Variety	Early	Mid	Late
Q174$^{\Phi}$	**15.73**	16.38	16.69
Q158	14.52	**17.24**	16.25
Q204$^{\Phi}$	15.61	16.44	**17.02**
Average of all clones in trial	15.34	16.00	16.56

Di Bella *et al.* (2007) highlighted opportunities to use a crop ripener such as MODDUS® to improve early CCS. Crop ripeners should be considered as a management tool for early-harvested cane. In addition, it is important that plant-breeding programs select varieties that perform well within a harvest time schedule to maximise potential genetic gains.

Conclusions

Season length, harvest management, and mill starting and finishing dates have significant impacts on all sectors of the value chain in the Herbert River region.

The industry needs to consider all opportunities to maximise profit across the value chain to ensure industry long-term viability.

Our trials highlight:

- The greatest sugar yields for a crop are achieved with mid-season harvesting; however, not all crops can be harvested at this time.
- Variety-by-time-of-harvest has a lesser effect on cane yield in plant cane than in ratoon cane, because the plant crop is usually older than 12 months.
- Variety-by-time-of-harvest has a significant effect on cane yields in ratoon crops, especially for late-harvested cane. Cane yield is adversely affected by late harvest scheduling.
- CCS levels start low at the commencement of harvest, peak mid season and may decline late in the season due to stalk deterioration, suckering and lodging. This issue may be addressed through the use of crop ripeners (Di Bella *et al.*, 2007).
- Crop physiological effects associated with late harvesting are not fully understood, but waterlogging and low solar radiation periods are likely significant contributing factors.

- There are opportunities to extend the season length forward, as opposed to lengthening the season length at the end of harvest window. The advantages for an earlier start far outweigh the disadvantages of a late harvest finish, because of the loss in sugar yield, loss of yield in subsequent ratoons and the possibility of premature ploughing out of a crop due to ratoon failure.
- Industry has the potential to increase monetary returns through:
  - Management of varieties, i.e. selecting the best variety for a particular harvest period and soil type.
  - Avoiding harvesting of ratooning cane after early November in the Herbert.
  - Harvesting plough-out cane last if the harvesting season is going to continue after early to mid November (where possible) to avoid yield losses associated with late-harvested cane.

The entire issue of season length is complex, but the impact of time of harvest on a sugarcane crop affects the productivity and profitability of the entire industry.

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