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# Economic evaluation of post-harvest cane cleaning

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**Abstract** This paper examines three cane supply treatments, Commercial Harvesting, Low-Loss Harvesting and Low-Loss Harvesting plus Cane Cleaning, to determine if post-harvest cane cleaning offers economic benefits over current harvesting strategies. The project involved field and factory measurements of different harvesting and cane-supply strategies in an effort to identify strategies that maximise the total industry benefit, considering, in particular, the cost of the harvesting and cane-supply strategy, the resulting cane loss and the impacts of the resulting extraneous matter in the cane supply. The economic analysis quantified harvesting costs and the resulting product income. The economic analysis was undertaken on three large Tableland experiments to assess the most economical harvesting and cane-cleaning option of the three strategies tested. The analysis considered costs associated with harvest and haulouts, transport, trash and cane-cleaner operation, along with gross income based on tonnes of cane and CCS at the factory. The results did support the expectation of higher CCS yield with lower extractor fan speed, but much of the higher yield measured by low-loss harvesting was lost during post-harvest cane cleaning. In one experiment, the treatment with post-harvest cane cleaning was less economic than the normal harvesting treatment, even after allowing for the lower transport cost to the Mossman Mill, a distance of 81 km away. These trials and subsequent analysis did not measure an increase in CCS yield from the low-loss harvesting plus cane-cleaning treatment compared to the commercial harvesting treatment and, therefore, showed no improvement to sugar income.

**Key words** Economics, mobile cane-cleaner, sugar income

## INTRODUCTION

A project examining the addition of a post-harvest cleaning operation as part of a cane supply strategy has recently been completed (Ginns *et al.* 2019). As a basic concept, it was expected that reducing the extractor-fan speed of the harvester would reduce sugarcane loss, resulting in increased CCS yield but also increased trash content, and that a post-harvest cane-cleaning operation would remove the additional trash, while maintaining the higher CCS yield. To facilitate this project, a mobile cane cleaner (MCC) was leased to the project from Sugar Research Australia Limited. This paper examines three cane supply treatments, Commercial Harvesting, Low-Loss Harvesting and Low-Loss Harvesting plus Cleaning, to determine if post-harvest cane cleaning offers benefits over commercial harvesting alone.

This project mainly consisted of field experiments to measure the impact of different cane supply strategies involving different harvesting parameters, with and without post-harvest cane cleaning, and economic analysis of the alternatives to identify the most economical strategy. The yield aspects of this work were reported by Kent *et al.* (2020).

The mobile cane cleaner (MCC) was introduced experimentally into the cane-supply process with the aim of delivering a cleaner product to the mill by significantly reducing the trash and extraneous matter (EM) content. The project involved field and factory measurements of the different harvesting and cane supply strategies in an effort to identify strategies that maximise the total industry benefit, considering in particular the cost of the harvesting and cane-supply strategy, the resulting cane loss and the impacts of the resulting extraneous matter in the cane supply.

An economic analysis was undertaken on the three large Tableland experiments to assess the most economically attractive harvesting and cane cleaning strategy. The analysis considered costs associated with harvest and haulouts, transport, trash and cane cleaner operation, along with gross income based on tonnes of cane and CCS at the factory. The NorrisECT 180 mobile cane cleaner (MCC 180) was a prototype machine and was supplied as a commercial machine however the machine was only used for trials. After initial field testing in year 1, major modifications to the machine were carried out.

## THE EXPERIMENT

### Overview

Three harvesting treatments were assessed:

- “Commercial practice”. Commercial harvesting practice for the area/contractor (relatively high primary extractor fan speeds coupled with secondary extraction) at commercial ground speed and typically at a reduced billet-length setting. The outcome is a high harvester pour rate and “typical” load density.
- “Low-loss” harvesting. The primary extractor fan at lower speed to reduce cane loss and the secondary extractor turned off. The harvester operated at similar pour rate to commercial practice.
- “Low-loss harvesting and post-harvest cleaning”. Low-loss harvesting followed by post-harvest siding/field edge cane cleaning using a Norris ECT 180 mobile cane cleaner (Figure 1) to clean the cane prior to forwarding to the mill.

***Figure 1.*** Norris ECT180 mobile cane cleaner and haulouts.

### Methodology for the economic analysis

Economic analyses were conducted for Tableland experiments 3, 4 and 5 as described by Kent et al. (2020). Since the cane cleaner was located in the field, we assumed that the grower or harvest group was the investor in the harvest and cane-cleaning machinery. As a result, the economic focus was placed on developing a partial budget analysis, whereby the MCC could be introduced into the harvesting and transport process. For this analysis, the gross income from the experimental harvest was calculated based on CCS (NIR) results, less harvesting and haul-out contract rates (including fuel and labour). When the cane cleaner was used, additional costs included FORM (fuel, oil, repairs and maintenance), depreciation and operating labour.

For experiments 3, 4 and 5, treatments compared standard practices with varying harvester fan speeds, as well as a treatment that incorporated the MCC. Table 1 provides a summary of the treatments in each experiment.

***Table 1.*** Summary of the economic analyses conducted for each experiment.

| Experiment detail | Treatment 1 (TR1) | Treatment 2 (TR2) | Treatment 3 or 4 (TR3 or TR4) |
|---|---|---|---|
| Experiment 3 (June 2018) | Commercial | Normal | Low loss + Cane Cleaner |
| Experiment 4 (August 2018) | Commercial | -* | Low loss + Cane Cleaner |
| Experiment 5 (October 2018) | Commercial | Normal | Low loss + Cane Cleaner |

*Experiment 4 only conducted trials for commercial practice and harvesting with cane cleaner.

The results for each treatment, within each separate experiment, were assessed similarly to derive a gross income per hectare and per tonne, to provide a standardised basis for comparison. The cost structures for each treatment were accounted for on this basis to provide a net income calculation for the same units of measure. Some of the base harvest parameters for each of the experiments and treatments are listed in Table 2.

***Table 2.*** Harvest-output parameters for each experiment.

| Parameter | Experiment 3 (EXP3) | | | Experiment 4 (EXP4) | | Experiment 5 (EXP5) | | |
|---|---|---|---|---|---|---|---|---|
| | TR1 | TR2 | TR3 | TR1 | TR3 | TR1 | TR2 | TR4 |
| Harvested area (ha) | 1.30 | 1.44 | 1.56 | 2.55 | 2.23 | 2.73 | 3.08 | 3.36 |
| Tonnes harvested/ha | 154 | 149 | 141 | 151 | 160 | 125 | 116 | 119 |
| CCS (NIR) | 15.40 | 15.44 | 15.29 | 16.45 | 16.33 | 14.19 | 14.46 | 14.46 |

The cane supply for each treatment was randomly selected across the field using the mass-balance or linear method. This proven method involves harvesting a haul-out load of cane using one treatment and then applying another treatment, in random order, so that each treatment is composed of cane supply from across the block, minimising the effects of field variability on the experimental results. Harvesters were equipped with GPS navigation systems to log the start and end point of each treatment, enabling cane yield assessments to be made.

All treatments were harvested using established protocols, with key field measurements of:

- Total harvested yield/ha, clean cane (total – EM) yield/ha and CCS yield/ha delivered to the mill for the different treatments.
- Extraneous matter percentage (EM%) where 15-20 kg samples were randomly taken from each bin. The collected material was processed to determine EM%. The sample components were sorted into cane billets, tops and trash and then weighed.

## ECONOMIC RESULTS AND DISCUSSION

### Introductory remarks

For each of the trials considered (Tableland experiments 3, 4 and 5), components considered for the economic analysis included transport parameters and costs, harvest parameters and gross income, harvest and haulout costs and the 'cleaning' costs. We set fuel (less rebate) at $1.20 per litre and the wage rate at $35.00 per hour based on current industry payments (M. Poggio and S. Ginns, unpubl. data).

### Transport to mill

For each trial, trucks were used to deliver the cane to the designated mill. Each of the trials had differing parameters relating to transport capacity and cost. Table 3 outlines the transport parameters and costs across each of the trials.

***Table 3.*** Transport parameters and associated costs in experiments 3, 4 and 5.

| Parameter | EXP3/ TR1 900 r/min | EXP3/ TR2 800 r/min | EXP3/ TR3 700 r/min + cleaning | EXP4/ TR1 900 r/min | EXP4/ TR3 700 r/min + cleaning | EXP5/ TR1 850 r/min | EXP5/ TR2 750 r/min | EXP5/ TR4 600 r/min + cleaning |
|---|---|---|---|---|---|---|---|---|
| Tonnes transported | 214.9 | 200.2 | 220.0 | 385.05 | 355.64 | 358.0 | 340.0 | 400.0 |
| Truck trips to mill | 10 | 10 | 10 | 17 | 17 | 10 | 10 | 10 |
| Trash % | 4.0 | 5.0 | 2.5 | 4.3 | 1.8 | 3.9 | 6.0 | 2.0 |
| Distance to mill (km) | 10 | 10 | 10 | 10 | 10 | 81 | 81 | 81 |
| $ per km to mill | $4.50 | $4.50 | $4.50 | $4.50 | $4.50 | $4.50 | $4.50 | $4.50 |
| Total cost per trial | $450 | $450 | $450 | $765 | $765 | $3645 | $3645 | $3645 |
| Total cost per tonne | $2.09 | $2.24 | $2.05 | $1.98 | $2.15 | $10.18 | $10.72 | $9.11 |

Tableland and Mossman Mills pay for transport cost to the mill, but it is a cost to the industry.

## Harvesting and haul-out

The harvester contract rate was estimated through established harvesting cost spreadsheets developed by DAF economists working in north Queensland. Data for each of the trials was supplied to the economics team working under the SRA Project 2016/955 *Adoption of practices to mitigate harvest losses* to estimate the harvest cost per tonne (before and after cleaner). Where there were data gaps, the average cost of inputs provided by harvesting groups across industry was used.

Another difference from the standard practice caused by the introduction of the MCC is the requirement for an addition haul-out. Standard practice commonly utilises two haul-outs, one at the harvester and one in transit to the siding to unload (or waiting at the harvester). The addition of the cleaner changes the practice. Two haul-outs continue rotating between the harvester and the cleaner rather than the siding or pad for transport to the mill, while a third haul-out will manages the clean cane from the MCC to the siding or pad for transport to the mill for processing. The additional haul-out increases fuel and labour costs to the contractor, and the rate per tonne increases (Table 4) as the cost is spread over a decreased amount of cane due to trash and EM exiting the cleaner.

***Table 4.*** Harvesting and haul-out parameters and associated costs in experiments 3, 4 and 5.

| Parameter | EXP3/ TR1 | EXP3/ TR2 | EXP3/ TR3 | EXP4/ TR1 | EXP4/ TR3 | EXP5/ TR1 | EXP5/ TR2 | EXP5/ TR4 |
|---|---|---|---|---|---|---|---|---|
| Contract rate $/t | $5.72 | $5.58 | $6.39 | $5.66 | $6.44 | $5.87 | $5.80 | $7.70 |
| Number of haul-outs | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 3 |
| Harvest cost (ex. fuel) | $1,229 | $1,117 | $1,406 | $2,179 | $2,290 | $2,101 | $1,972 | $3,080 |
| Total harvest cost$/t (incl. fuel) | $6.29 | $6.16 | $7.09 | $6.25 | $7.10 | $6.37 | $6.36 | $8.47 |

Contract harvester rate does not include fuel to capture shift in travel distances for harvesters and haul-outs.

The contract rate in Table 4 clearly shows the increased rate per tonne of cane processed through the cleaner.

## Mobile cane cleaner

Due to the nature of the experimental design, spatial challenges and data variability, the option to undertake long-term investment analysis was limited. As such, the partial analysis observes a one-year harvest for a farmer, with and without the cane cleaner, as part of the harvest and transport process. The operational cost for the MCC was estimated at $1.49 per tonne of cane entering the MCC and $1.54 per tonne for the cleaned cane exiting the machine. The cost of the mobile cane cleaner incorporated FORM (fuel, oil, repairs and maintenance), depreciation and operating labour (Table 5).

***Table 5.*** Operational cost parameters of the mobile cane cleaner.

| Parameter | Unit / Cost |
|---|---|
| Fuel usage (L/hour) | 28.00 |
| Total fuel and oil cost (per hour) | $36.96 |
| New price (capital) | $325,000 |
| Productive life (hours) | 10,000 |
| Repairs and maintenance cost (per hour) | $24.38 |
| FORM (per hour) | $61.34 |
| Salvage value | 40% |
| Interest rate used to calculate depreciation | 8% |
| Depreciation and interest cost (per hour) | $18.20 |
| Labour cost (per hour) | $35.00 |
| Total operation cost per hour | $134.04 |
| Cleaner pour rate - average during experiment (t/hour) | 90 |

## Trash options

One important facet of the MCC is that it removes trash from the harvested cane before being transported to the mill, by either truck or cane train. While no nutrient deficit to the farmer is realised as the harvester still operates under normal conditions to provide a trash blanket, there is a significant trash issue at the MCC site.

Numerous options to deal with the trash have been discussed throughout the project including some of the following that are considered logistically feasible, but remain un-costed or investigated:

- Sale of trash to commercial processors or nursery outlets for processing and packaging as garden mulch;
- Private contractor to spread the concentrated trash back over the harvested area to return organic matter and nutrients to the farm, as well as add to soil moisture preservation and weed control;
- Potential for use in co-generation of electricity at mill sites (requires transport from field processing site to the mill and probable storage).

A significant amount of trash would be generated through the use of the cane cleaning concept across a sugarcane district. For example, under experiment 3 using the standard harvesting process (treatment 1), around 8 t of trash per hectare would be generated by the harvest and transported to the mill (excluding that returned as trash blanket by the harvester. Looking at treatment 3 of the same experiment that uses the use of the MCC, 3.5 t of trash per hectare would be sent to the mill as part of the harvest. Therefore, approximately 4.5 t of trash are deposited at the MCC unit per hectare of cane processed. Given that southern Queensland harvests around 45,000 ha of cane (Canegrowers Annual Report 2016-17) then theoretically (under full adoption) 180,000 t of trash could be generated each year. This throws up another potential hurdle, 'adoption', if there was only small or partial adoption by industry innovators. There is potential for benefits such as reduced repairs and maintenance costs in transport and processing a shift in processing capacity (less trash equals more billets), and cleaner product. Indications are that mills might not be able to respond, incrementally to this innovation due to 'choke' points along the sugar-processing chain.

However, despite all the 'what ifs' the study has placed an economic cost on the trash in lieu of a defined trash strategy that would be able to deal with the volume of trash that could be potentially generated. For the purpose of this study, the economic cost of trash was approximated using a western Queensland baling cost for large round bales (F. Chudleigh, pers. comm.). Removal or transport of the bales off-site would need to be covered by the estimated sale price of the bales so not to burden the farming operation further. The cost for baling 1 t of cane trash was $27, equating to three bales. Table 6 outlines the trash cost for each of the trials using the MCC.

***Table 6.*** Approximate trash-baling costs using the mobile cane cleaner.

| Experiment / treatment | Cost per trial | Cost per ha |
|---|---|---|
| EXP3 / TR3 | $121.77 | $78.05 |
| EXP4 / TR3 | $272.12 | $122.20 |
| EXP5 / TR4 | $334.80 | $99.64 |

## Economic summary

The summary of data collected represents three different experiments under which numerous tests were conducted to examine standard harvesting and transport practice versus a process that incorporated the MCC. Due to the variability between experiments, each should be considered separately, and so examining the result within each experiment and not among experiments. The economic summary distils the data to per hectare and per tonne for comparability within experiments, as harvest areas, travel speeds and other variables were not constant among trials. Table 7 outlines the key economic parameters from the project.

***Table 7.*** Economic summary of trial data with and without the mobile cane cleaner.

| Parameter | EXP3/ TR1 | EXP3/ TR2 | EXP3/ TR3 | EXP4/ TR1 | EXP4/ TR3 | EXP5/ TR1 | EXP5/ TR2 | EXP5/ TR4 |
|---|---|---|---|---|---|---|---|---|
| Gross income per ha | $6,412 | $6,236 | $5,816 | $6,858 | $7,184 | $4,644 | $4,447 | $4,554 |
| Cost per ha | $1,296 | $1,252 | $1,583 | $1,245 | $1,846 | $793 | $741 | $1,291 |
| Net income per ha | $5,116 | $4,984 | $4,233 | $5,614 | $5,338 | $3,851 | $3,706 | $3,263 |
| Net income per tonne | $33.22 | $33.40 | $30.02 | $37.18 | $33.43 | $30.92 | $31.88 | $27.41 |

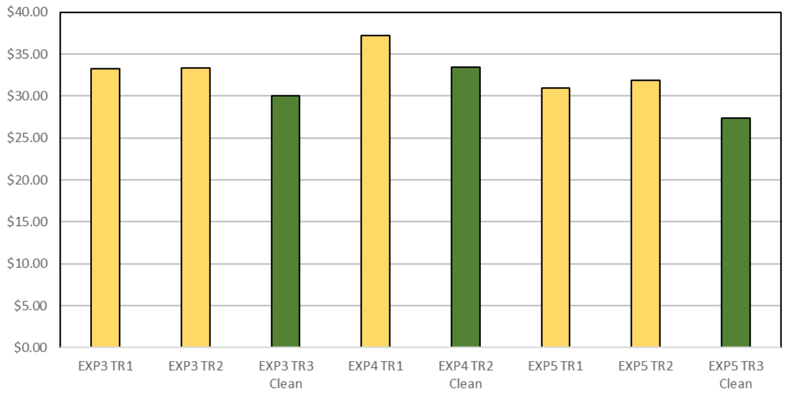


***Figure 2.*** Net income per tonne of cane harvested.

Figure 2 shows the net income per tonne of cane harvested from each treatment under the three experiments examined. In each case, the cleaned cane treatment is represented in green (EXP3/TR3, EXP4/TR2, EXP5/TR3). In each instance, the income generated in trials utilising the MCC was less than each of the standard practice treatments. The income generated by the MCC trials is $3.21 per tonne less than the income generated by EXP3/TR1, $3.75 per tonne less than the income generated by EXP4/TR1, and $3.51 per tonne less than the income generated by EXP5/TR1.

It was expected that gains in CCS may overcome any additional harvesting and transport costs generated by the inclusion of the MCC in the process. Table 8 outlines the existing CCS results for the MCC trials and what they would need to achieve to breakeven with the standard practice in each case.

***Table 8.*** Comparative CCS results from trials with the mobile cane cleaner (MCC) and CCS required to achieve a breakeven result in terms of net income per hectare.

| Experiment / treatment | CCS with MCC | Breakeven CCS |
|---|---|---|
| EXP3 / TR3 | 15.29 | 16.18 |
| EXP4 / TR3 | 16.33 | 17.37 |
| EXP5 / TR4 | 14.46 | 15.44 |

## CONCLUSIONS

The economic analysis was undertaken on three large Tableland experiments to assess the most economically attractive harvesting and cane cleaning strategy of the three strategies tested. The analysis considered costs associated with harvest and haulouts, transport, trash and cane cleaner operation, along with gross income based on tonnes of cane and CCS at the factory. In all three experiments, the treatment with post-harvest cane cleaning was found to be less attractive than the harvest-only treatments. In Experiment 5, that result was achieved even with the lower transport cost for moving the cleaned cane to Mossman Mill, a distance of 81 km. It was expected that the subsequent processing of 'cleaner' cane at the mill would deliver an improved CCS rate to compensate for, or exceed, the increase in overall harvest and haul-out costs.

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