BUREAU OF SUGAR EXPERIMENT STATIONS

QUEENSLAND, AUSTRALIA

FINAL REPORT - SRDC PROJECT BSS189

FACILITATION OF BEST PRACTICE TO REDUCE EXTRANEOUS MATTER AND CANE LOSS

by

C Whiteing

SD02009

PRINCIPAL INVESTIGATORS:

Mr C Whiteing
Research Officer
BSES
Private Bag 4
BUNDABERG DC QLD 4670

Mr C P Norris
Senior Research Officer
BSES
Private Bag 4
BUNDABERG DC QLD 4670

Funding for this activity was provided by the sugar industry and the Commonwealth Government through SRDC, and is gratefully acknowledged. BSES is not a partner, joint venturer, employee or agent of SRDC and has no authority to legally bind SRDC, in any publication of substantive details or results of this project.

BSES Publication
SRDC Final Report SD02009 **June 2002**

CONTENTS

SUMMARY

Green cane harvesting and trash blanketing are important agronomic production techniques in the northern sugar producing areas. Cane losses are accepted to be higher with green cane harvesting and extraneous matter levels can be high, especially in difficult conditions. A series of harvester trials was conducted throughout the north from 1997 to 2000 to quantify the performance characteristics of current cane harvesters. Samples taken in the field and at the mill were assessed to determine the effect of harvester pour rate and extractor fan speed on extraneous matter. In addition, cane loss was measured using yield data and collection of scrap cane from the extractor systems. Mill weighbridge data and laboratory analysis enabled the impact of harvesting on industry returns to be quantified.

Results indicate that current harvester designs have limited ability to clean cane effectively without excessive cane loss, especially at current harvesting rates. The results of trials at commercial pour rates imply that significant cane losses, up to 20 t/ha in some cases, are occurring in the harvesting process.

Harvesting Best Practice (HBP) guidelines have been developed to enable harvester operators make informed decisions about operational settings. The guidelines aim to produce high quality cane with minimal cane loss. Extension of this information to growers, millers, harvester operators and manufacturers has encouraged more efficient harvesting and widespread recognition of the limitations of current harvesting technology. Adoption of HBP in the Mulgrave district has potentially reduced losses by a conservative estimate of 3-4 t/ha. This equates to 50,000 more tonnes of cane or a 5% boost in productivity for a district cutting one million tonnes.

1.0 BACKGROUND

The move to green cane harvesting in Australia has been driven by a range of factors, including cane freshness, harvesting flexibility and the agronomic and financial benefits of trash retention. Steady improvements in the capacity of newer harvesters to process large green crops have facilitated the swing to green cane harvesting. More than 90% of the Northern Region crop and over 80% of the Central Region crop are now cut green (Australian Sugar Milling Council Crushing Statistics, 1996). Apart from harvester limitations to gather and feed unburnt crops, the most significant machine related factor impacting on green cane harvesting is the ability to produce a product of acceptable quality (with low extraneous matter levels) while achieving acceptable levels of cane loss. Performance characteristics of current harvesters must be understood before improved operating techniques can be recommended.

In their 1984 report, Hurney *et al.* stated that "over the past decade, harvester cleaning systems have been increased considerably in power in an endeavour to cope with extraneous matter entering the harvester from sprawled or uneven crops". They went on to observe that "mill data indicate that harvester modifications have not been effective in counteracting the effect of adverse field conditions on extraneous matter levels".

Shaw and Brotherton (1992) reporting on their 1991 survey in the Mulgrave mill area had sought to "Establish whether an optimum cleaning level was available where both loss (cane) and extraneous matter levels were minimised". Tarpaulins were placed on the ground beside the path of the harvester to collect cane fragments and trash coming out the extractor. This technique has become known as 'The Blue Tarp' method of cane loss determination (Linedale *et al*., 1993). They noted that although there is a lack of precision with this method the "cane collected is a visible definite loss and is thus a firm minimum value". The work found that trash was the most readily removable form of extraneous matter (EM) but as the cleaning system attempts to remove heavy trash loads, billets are drawn through the extractor. In one case, "reducing EM by one per cent, cane loss was increased by 4.2 t/ha in Q120" and this led the investigators to conclude that "there is little evidence of an optimum harvester setting which minimises both loss and EM".

Since these trials, manufacturers have significantly increased the engine power of sugarcane harvesters, so increasing the power available to key cane feed components. The primary goal of this change has been to increase the harvesting rate. Cleaning systems have typically increased marginally in physical size but the available power has increased significantly. Throughout this period, EM levels in cane arriving at mills have steadily increased (Cargnello and Fuelling, 1998).

In response to this increase in harvester power, a series of trials was undertaken on recent makes and models of harvesters in the 1997-2000 harvesting seasons to quantify the effect of these changes and characterise the performance of modern harvesters.

2.0 OBJECTIVES

Initially, this project had a significant focus on harvester modifications to improve harvester performance. The original objectives listed below assumed that simple engineering retrofits or modifications would improve harvester performance, but initial trials and consultation with operators indicated very little scope for improvements of this nature, so new objectives were proposed. Original objectives were:

Undertake a targeted extension and field demonstration program for growers and operators and have active communication with manufacturers, dealers and after-market suppliers. Key elements of the program will be:

1. increase the awareness in the industry of correct machine settings and maintenance to reduce both cane loss and EM levels;

2. inform the industry of the significant further enhancement in cleaning performance, which can be achieved by a range of modifications to the harvester;

3. demonstrate that further enhancement of the cleaning function can be achieved by relatively minor modifications to the extraction chamber, particularly on pre-1995 machines at high pour rates;

4. interact with after-market equipment suppliers to assist in the development of options for and modifications to harvesters to improve cleaning performance and extend this information to the industry;

5. demonstrate that appropriate instrumentation/driving aids, such as Cane Loss Monitors and video cameras, can significantly enhance the ability of the operator to optimise machine performance.

The results from the first season of harvester trials indicated that the project should focus on efficient harvester operation rather than harvester modifications. There was limited opportunity to 'engineer' improvements in cleaning capacity through modifications because bigger gains could be made through understanding harvester performance and operating the machine within the limitations of the existing system. Changes to the project objectives were proposed in milestone report number two. Increased emphasis was placed on operator issues and optimisation of machine set-ups because there appeared to be limited potential for 'simple mechanical fix' solutions.

The revised objectives of the best practice harvesting project are to:

- define the performance of modern harvesters with respect to cane loss and EM at varying pour rates and fan speeds and under a range of crop and harvesting conditions;

- define the parameters of machine set-up and operator techniques, which allow optimisation of machine performance, and so develop "best practice" guidelines to minimise cane loss and EM. This will include techniques to maximise productivity whilst minimising maximum harvester pour rates;

- assess the usefulness of accessories such as cane loss monitors as guides for best practice harvester operation;
- interact with manufacturers and after-market equipment suppliers to assist in the development of options for and modifications to harvesters to improve cleaning performance and extend this information to the industry.

3.0 METHODOLOGY

Cane quality and machine parameters were defined at the beginning of the project to ensure consistency when comparing or presenting results.

Definitions

Extraneous matter - referred to as EM in this report. Extraneous matter is any material processed at mill other than clean billets. EM includes trash, tops, suckers, dirt and stool.

Cane loss - there are many sources of cane loss in the harvesting process but in this report we are always referring to billets removed by the primary or secondary extractor in the cleaning process. These billets are typically smashed into small pieces by the fan blades.

Fan speed - harvesters have two extractor fans to remove trash. One small fixed speed fan at the end of the elevator and one large variable speed fan above the choppers. In this report, fan speed refers to the rotational speed of the extractor. Typically its fan speed is variable up to a maximum of 1400 rpm.

Pour rate - is the instantaneous rate at which cane flows off the elevator. Pour rate is simply a product of ground speed and crop size.

Topping – to mechanically remove the uppermost green leaf material prior to harvest.

Initial information indicated that the development of better operating guidelines could enhance harvester performance in terms of improved EM removal and minimised cane loss. Operators tended to push harvesters to the limit of their cleaning capacity without being fully aware of the economic impact of excessive cane loss. This project sought to find the balance between effective cleaning and cane loss whilst maintaining economically viable pour rates. The initial phase of the project defined the field performance of current machines with respect to EM levels and cane loss over a range of operational settings (eg pour rate, fan speed, billet length etc).

Trial protocols

Data were collected over a range of field and operational settings. To obtain statistically valid results trials were conducted on a large scale and required considerable planning. With this in mind the approach taken was as detailed below.

- To ensure realistic results, trials were conducted at commercial cutting rates for the field and crop conditions.

- Each trial would focus on a single operator controlled variable such as fan speed or crop pour rate with all other parameters kept as constant as possible. A radar unit was fitted to the trial harvester to ensure ground speed was accurately measured and maintained.
- As in-field crop variability has a major impact on the validity of trial results, the selection of uniform blocks was critical. Fields of cane, typically plant crop or early ratoons, that appeared consistent in both presentation and yield were targeted for trials.
- For each operational setting or 'treatment', a small plot of 4-6 rows was harvested. The cane from each plot was forwarded to the mill as an individual consignment. The tonnage from each plot had to be large enough to be analysed as a separate rake at the mill. This was about 30 tonnes for most mills.
- Row length and drill spacing were accurately measured to determine the harvested area for each treatment. Using mill weighbridge data, harvested yield for each treatment was calculated.
- Different treatments were replicated across the field in accordance with a randomised trial design. At least three or four replicates were required to obtain statistically valid results. The trials were comprised of up to 500 tonnes of harvested material, requiring large blocks of sugarcane and the cooperation of harvesting crews and mill staff.
- In-field cane loss estimates were made using the 'blue tarp' method of catching the material ejected from the cleaning chamber, sorting to collect billet fragments and weighing them. After adjustment using the standardised multipliers, this weight gave an estimate of cane loss.
- In a number of trials, "fans off" treatments were conducted with the total plot biomass taken to the mill. This allowed determination of the maximum potential cane yield without the losses produced by the cleaning system.
- Extraneous matter samples were collected for each treatment to determine the percentages of clean cane, trash, tops, suckers and loose dirt. These samples were taken directly from the bins either at the rail siding or at the mill. To ensure an acceptable level of accuracy, five or six 10-12 kg samples were taken from each rake (about 30 tonnes). These samples were then hand sorted into clean cane and EM components and these components weighed. This was a very labour intensive process with up to 500 kg of cane to be manually sorted for a single trial.
- At the mill, each plot was processed as a separate rake allowing determination of individual plot weights. Full laboratory analysis was undertaken for each treatment to give individual pol, brix and fibre using standardised industry techniques.

The basic field layout for one replicate of a fan speed trial is shown in Figure 1. For full-scale trials, treatments were randomised and three or four replicates were completed to ensure statistically sound results.

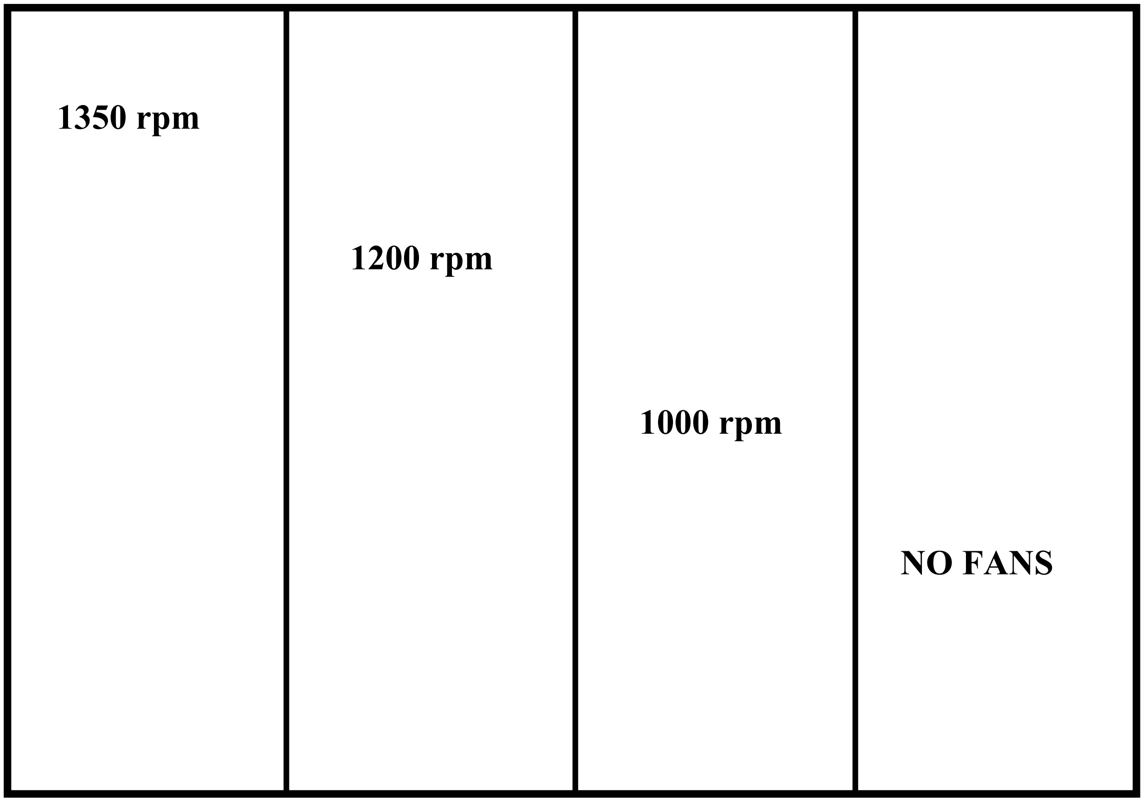


Figure 1 - Fan speed trial layout

The trial protocols developed allowed the effect of harvester variables on biomass, clean cane yield, recoverable sugar yield and cane loss to be determined. Importantly, the impact of harvester operation on actual grower returns could be determined from real mill data. In a time of low industry profitability these data allow operators to modify practices to achieve better returns. The use of laboratory and weighbridge information meant growers, millers, harvester operators and BSES researchers could be confident that the results were as realistic and accurate as possible. See Appendix 1 for a detailed trial listing.

4.0 TRIAL RESULTS

During the three crushing seasons (1997,1998 and 1999), in excess of 50 extensive field trials were conducted assessing the performance of harvesters over a broad range of field conditions and operating parameters. In the first year, the majority of work was undertaken in the Mulgrave Central Mill district with trials conducted in Tully, Mossman and other areas in the second and third seasons. Mulgrave Mill had the advantage of access to an automated EM sampling system and sorting room, as well as the full support of mill management and laboratory staff. The 1997 crop provided a wide range of cutting conditions from ideal to challenging situations. Crop yields were good with uniform yielding blocks readily available. The 1998 and 1999 crops lacked this consistency with lower and variable yields making trial work very difficult.

Analysis of trial results revealed that the three main factors affecting EM levels and cane loss were **field conditions,** harvester **pour rate** and primary extractor **fan speed.**

4.1 Field conditions

Field conditions include factors such as crop size, crop presentation, weather conditions and to some extent soil conditions. Crop presentation defines the crop as standing, sprawled or lodged prior to harvesting. Crop presentation has a big impact on the machine's ability to effectively gather and top the cane. Obviously if a crop is sprawled and cannot be topped then the cleaning system is presented with the additional green leaf and 'cabbage' associated with the tops. Sprawled and lodged crops cause feeding problems resulting in large bundles or gluts of cane being processed rather than a constant layer of cane moving through the feed-train. The cleaning system then experiences cyclic overloading which dramatically reduces its ability to clean efficiently. Grower controlled aspects of crop presentation include row profile and drill spacing, both of which have a significant impact on gathering and feeding efficiency.

Field conditions were found to be the primary factor affecting machine performance. Using current harvesting technology, it is very difficult to produce a clean quality product when cutting under difficult conditions and at the harvesting pour rates desired by today's operators. Operator controlled variables such as fan speed have negligible impact on cleaning performance when compared to the overriding effect of field conditions.

Figure 2 illustrates the effects of crop and field conditions on cleaning system performance. The data compare the cleaning performance of a 1997 model harvester operating under three different field conditions from dry, erect cane to damp and badly sprawled. The lowest trash levels were obtained when harvesting the erect crop under dry conditions despite operation at a high pour rate of 120 t/hr. This crop was topped effectively and hence the cleaning system did not have to process the majority of the green leaf material. Trash levels in the harvested sample were higher when cutting the semi-lodged block despite reducing the pour rate to 100 t/hr. This illustrates the interaction of two factors. The absence of topping prior to harvest meant a greater percentage of the difficult to remove green leaf and cabbage material had to be processed by the cleaning system. The second factor was uneven cane feed due to the sprawled presentation of the crop. The highest trash levels were recorded in the badly sprawled block cut under wet field conditions. Despite a conservative harvesting rate of only 90 t/hr, the cleaning system was unable to reduce trash levels much below 14% even when the cleaning system was operated at maximum fan speed. The badly tangled sugarcane crop caused the cane feed into the machine to be very erratic and produced constant overloading of the primary extractor. This combined with the dampness of the trash made effective cleaning very difficult. Most significantly, in all situations, the effect of extractor fan speed on final trash levels was minimal.

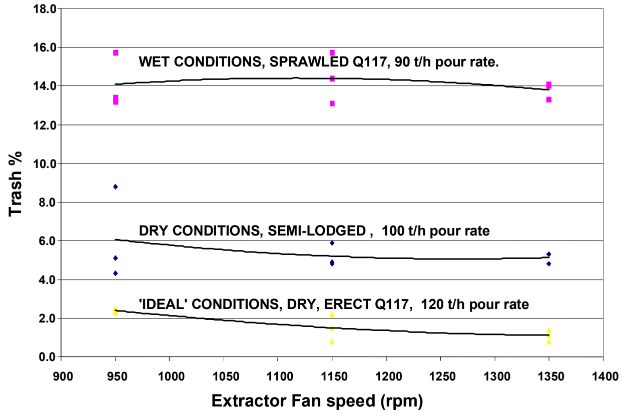


Figure 2 - Effect of field conditions and primary extractor fan speed on final trash levels

Figure 3 presents data from a series of trials undertaken with Mulgrave Central Mill in 1998. In these trials, samples were hand harvested from a wide range of fields to assess total biomass before the harvesting operation. The fields were then harvested by commercial harvesters using normal operating practices. The harvested cane was sampled at the mill and trash levels determined. The trash removal efficiency was then calculated. Harvester trash removal efficiency was as low as 50% as crop size increased. A major reason for this trend is the tendency for larger crops to lodge, thus creating feeding and cleaning problems. The variability in removal efficiency at any nominated crop size is explained by differing variety, crop conditions and harvesting conditions.

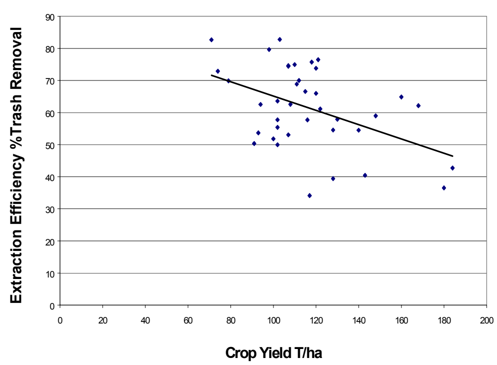


Figure 3 - Effect of crop size on trash removal efficiency (42 trials)

4.2 Harvester pour rate

A number of trials were conducted to investigate the effect of pour rate on harvester performance. Pour rate is the instantaneous rate at which cane is leaving the elevator and is not the average delivery rate of the machine. For example, a harvester travelling at 7 km/hr in a 100 t/ha crop would have an instantaneous pour rate of 105 t/hr. After turning and waiting time is accounted for, this operation might deliver cane to the rail siding at 60 t/hr. This is the difference between instantaneous pour rate and delivery rate.

Under given field and crop conditions, harvester pour rate had a significant impact on the final trash levels in the harvested product. Pour rate trials were conducted with fan speed and all other parameters kept constant while ground speed was varied. The results from trial 8 in 1997 show an increase in trash levels and a corresponding decrease in ccs as pour rate increases (Figure 4).

Figure 5 shows the final trash levels of Q152 harvested at two pour rates. As pour rate is reduced, the layer of material passing through the machine becomes thinner, reducing the overload on the extractor system, thus improving cleaning performance. Trial results highlight the limitations of the current cleaning system to remove trash efficiently at high pour rates. While current machines have the power to process cane at in excess of 150 t/hr, the cleaning system will only clean efficiently at less than half this rate. This mismatch makes the harvester operator's job of producing a quality product at desired pour rates very difficult.

Figure 6 summarises all trial results to give a representation of harvester performance under typical conditions. It can be seen that at a given pour rate, extractor fan speed has limited impact on trash levels in the bin. Changing pour rate however, causes significant changes in trash levels. Brazilian research data complement our data, indicating similar harvester performance characteristics, which would be expected.

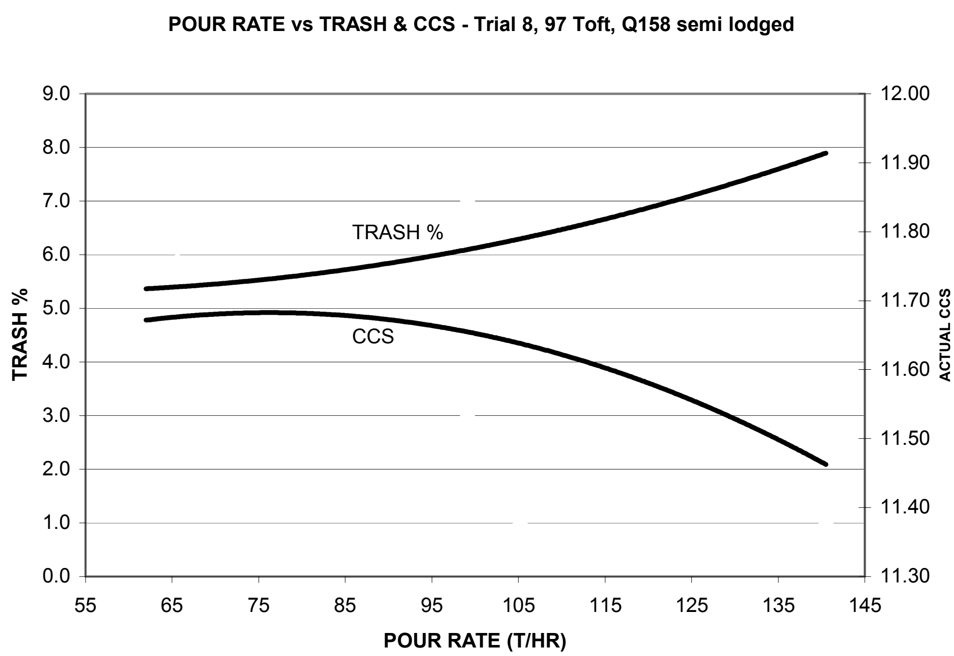


Figure 4 – Effect of harvester pour rate on trash in cane and ccs

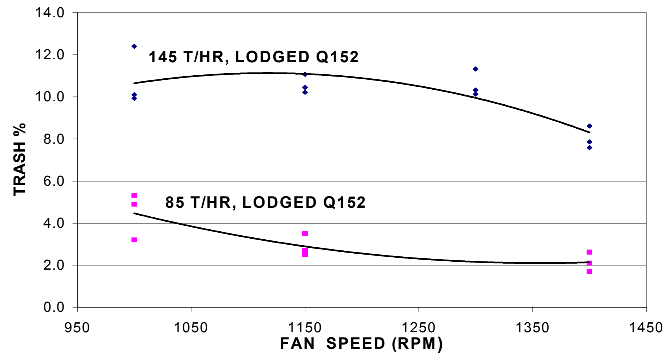


Figure 5 – Typical trial results demonstrating the effect of pour rate and extractor fan speed on final trash levels in cane

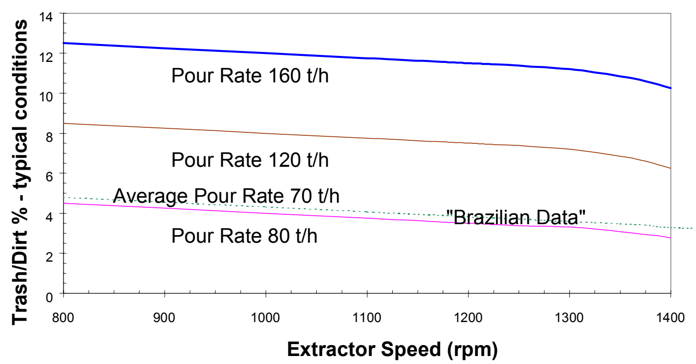


Figure 6 - Characterisation of extractor performance for pour rate and fan speed in 'average' field conditions

From the harvester operator's viewpoint, this shows that when the quality of the product being produced is not satisfactory, reducing pour rate is the best approach to improve quality. This was contrary to the attitudes of operators at the beginning of the project. The opinion of most operators was that the cleaning system had the capacity to handle high pour rates and simply increasing fan speed was the solution to cleaning issues, not reducing throughput.

4.3 Primary extractor fan speed

Discussions with harvester operators at the outset of the project revealed a strong focus on producing bins of 'polished' cane. Most machines were running high fan speeds (>1200 rpm) in the pursuit of 'high quality' cane and high bin weights, issues pushed heavily by most mills. In the minds of operators and growers, increasing the primary extractor speed resulted in lower EM levels, thus improving ccs, which in turn meant more money in the grower's pocket. Although cane loss had been identified as a problem in the past, the day to day pressure to present clean (EM free) cane to the mill and the invisible nature of the cane losses meant many harvesters were extracting considerable amounts of cane during the cleaning process.

Many trials examining the impact of primary extractor fan speed on harvester performance were conducted throughout the state. Harvester models manufactured from 1985 to 1999 were tested under a broad range of crop conditions with similar performance characteristics being exhibited in all situations. The magnitude of cane loss was estimated at all sites using the "blue tarp" method (cane fragments ejected in the cleaning process are weighed and this mass multiplied by a predetermined factor). The trial data demonstrated that cane loss though the extractor system was primarily determined by extractor fan speed. Most modern machines can vary primary extractor speed from 0 rpm to 1400 rpm. Our trials examined the useable range of fan speed from 800 rpm to 1400 rpm. A "no fans" treatment was included in some trials. In the ‘no fans’ treatment, both primary and secondary extractors were turned off so the total crop biomass was sent to the mill. Hand sorting gave an estimate of the maximum potential clean cane yield with no cleaning losses. The comparison between the yield with no extractor cane loss to the yields with fans operating gave an estimate of the true level of cane loss. This ‘mass balance’ method of calculating cane loss gave early indications that the ‘blue tarp’ cane loss measurement seriously underestimated cane loss because the majority of billets passing through the fan blades were reduced to juice and shattered fibre particles.

The results of a typical fan speed trial are shown in Figure 7. This trial examined the effect of fan speeds between 1000 rpm and 1400 rpm on cane cleaning and cane loss.

Trial 9 – Primary Extractor Trial								
Pour rate t/hr	**Fan speed rpm**	**Total yield t/ha**	**Tarp cane loss t/ha**	**Mass bal cane loss t/ha**	**Trash & dirt %**	**Clean cane yield t/ha**	**ccs group fibre**	**Group fibre net income $/ha**
131	1400	146.2	8.8	25.0	8.0	134.5	11.85	2553
145	1300	163.8	7.6	13.1	10.6	146.4	11.20	2571
151	1150	174.2	4.2	4.9	10.6	155.8	10.99	2621
151	1000	175.8	2.9	2.9	10.8	156.6	11.13	2720

Figure 7 - Typical fan speed trial data (Q152)

Another advantage of full scale, replicated trials was the ability to determine the impact of fan speed on the grower net income. In this trial, the harvester cut a heavily lodged block at a high pour rate ensuring the cleaning system was heavily loaded. Trash levels remained constant between 1000 rpm and 1300 rpm with a modest reduction (<3%) achieved at the 1400 rpm setting. All primary extractor trials demonstrated a small reduction in trash levels for a large change in fan speed. The tarp method indicated losses of 9 t/ha at 1400 rpm and yet the clean cane yield decreased by over 20 t/ha as the fan speed increased. Obviously, the total disintegration of billets subjected to high fan speeds means the tarp method does not quantify the true magnitude of cane loss. The bins cut using the 1400 rpm fan speed had less trash and higher ccs, but the massive cane loss sustained to produce cleaner bins offset any financial gains from improved ccs. In fact, under the class fibre system, the grower was $170/ha worse off when running the fan at 1400 rpm. In this trial each treatment was cut from an equal area of four rows with the cane from each plot sent as a separate rake. Each increase in fan speed reduced the rake size by one Mulgrave bin (4 t), which was a clear indication of the alarming volume of cane loss.

Trials on many different machines under a range of field conditions produced consistent performance characteristics. Large increases in fan speed led to increasing cane loss with minimal impact on trash levels. The fan speed trial shown in Figure 8 incorporated 'no fans' treatments, which showed the inefficiency of the cleaning system. The volume of cane lost in the cleaning system meant in this case, grower income was nearly $800/ha lower with the fan operating at 1350 rpm than with the fans turned off.

Typically, the ‘mass balance’ method gave a cane loss indication considerably higher than the tarp method. Losses as high as 25 t/ha were observed in some conditions, particularly in heavy crops and at high pour rates. Of interest in trial 17 is the large difference between tarp loss and mass balance loss at 950 rpm. Running the primary extractor too slow (<1000 rpm) tended to overload the secondary extractor causing excessive cane loss, which was not able to be captured on the tarp. Field variability and error sources meant that mass balance results tended to be erratic at low loss situations, but were robust at high loss situations. Cane loss data from all trials are summarised in Figure 9.

Trial 17 – Primary Extractor Trial – 16/10/1997								
Q152 semi lodged 3rd ratoon								
Pour rate t/hr	**Fan speed rpm**	**Total yield t/ha**	**Tarp cane loss t/ha**	**Mass bal cane loss t/ha**	**Trash & dirt %**	**Clean cane yield t/ha**	**ccs group fibre**	**Group fibre net income $/ha**
83	1350	122.4	9.8	17.7	2.1	119.8	14.31	3054
88	1150	135.5	4.3	5.9	2.9	131.6	14.03	3271
86	950	134.3	1.8	9.1	4.5	128.3	14.24	3329
-	fans off	165.0	0.0	0.0	16.6	137.5	13.73	3825

Figure 8 - Fan speed trial incorporating 'no fans' treatments

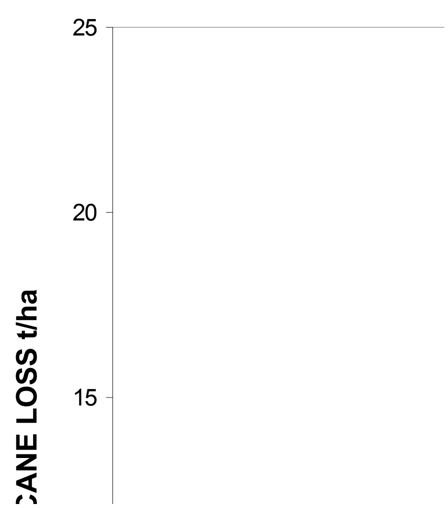


Figure 9 - Probable cane loss versus extractor fan speed

The lower boundary of the probable cane loss zone represents typical cane loss figures as determined using the blue tarp estimations. The upper boundary represents cane loss as determined by the mass balance method. At low to moderate fan speeds, the cleaning system rejects the bulk of the trash with minimal loss but as fan speed is increased further, cane loss increases dramatically with only marginal improvements in cleaning performance. Unfortunately, under adverse harvesting conditions, operators almost universally increase fan speed in an attempt to reduce EM levels. In heavy lodged crops the unevenness of feed through the machine causes cyclic overloading and underloading of the extractor chamber, resulting in excessive cane loss as the operator attempts to produce a clean sample.

Results from trials conducted over three seasons have clearly demonstrated the limitations of the current extractor system to perform efficiently, especially in heavy uneven crops or difficult harvesting conditions. Harvesters perform very well in ideal conditions but as crop conditions deteriorate, cleaning performance decreases markedly, irrespective of fan speed. With crop condition being the overriding factor in terms of harvester performance, operators should not be pressured into producing a 'polished' product under adverse field conditions because high fan speeds can only lead to reduced sugar recovery. This is the harvester operators’ dilemma:

To produce a high quality product with minimal cane loss whilst still maintaining an economically viable pour rate, often in challenging field conditions.

4.4 Harvesting best practice (HBP)

The first season of trials produced statistically valid data relating the impacts of fan speed and ground speed to cane quality and cane loss. This information was presented to operators, growers and millers and operational implications were discussed. It was clear that all parties would benefit from reduced cane loss. The existing practice of running high fan speeds to 'clean the cane' was marginally reducing the EM processed at the mill but this was at the expense of substantial cane loss. With this in mind, the focus of HBP guidelines was directed towards reducing cane loss whilst maintaining or improving cane quality. By reducing primary extractor fan speed, operators could minimise cane loss but to maintain cane quality the trial data suggested that the pour rate needed to be reduced. This combined reduction of fan speed and ground speed formed the basis of the Harvesting Best Practice guidelines that were to be taken to the industry in the form of an extension document. The document distributed by BSES staff to millers, growers and operators can be seen in Appendix 2.

Although the link between cane loss and extractor speed had been previously identified and widely publicised, the magnitude of losses identified by these trials surprised many within the industry. By following these trials through to the milling stage, the true economic impact of the harvesting process could be measured. The results were undeniable, cane cleaning was reducing industry profitability. With some scepticism regarding the potential gains of best practice operation, further trials were conducted in the second season examining the impact of reducing fan speed and pour rate.

Figure 10 shows the results of a best practice trial conducted in a block of lodged cane, variety Q120, in Mulgrave. Cane was initially cut at the operator's 'normal' mode of operation with the primary extractor running at 1300 rpm and an instantaneous pour rate of 125 t/hr. Cane was then cut at recommended best practice with the fan speed reduced to 1100 rpm and the pour rate reduced to about 100 t/hr. The perception of many operators was that reducing the fan speed would make cane quality significantly worse. However, trial results suggested the impact on EM levels would be small. Lower pour rate reduces the overload on the cleaning system and hence compensates for the reduced fan speed. In this trial cane quality was slightly better with best practice operation, with trash decreasing by nearly one per cent and the ccs being higher than 'normal' operation. The real gain can be seen in the clean cane yield (total yield less EM), which increased from 138 t/ha to 149 t/ha. This significant reduction in cane loss coupled with improved quality led to an improvement in the grower's income of over $200 per hectare.

Fan Speed and Pour Rate Trial – 97 Austoft 7000 – 6-10-1998								
Averages								
Ground speed km/hr	**Pour rate t/hr**	**Fan speed rpm**	**Total yield t/ha**	**Tarp cane loss t/ha**	**Trash & dirt %**	**Clean cane yield t/ha**	**ccs group fibre**	**Group fibre net income $/ha**
5.5	125	1300	149.1	2.5	5.9	138.2	10.31	1932
4	97	1100	159.7	1.2	5.1	149.4	10.47	2145

Figure 10 - Harvesting best practice versus 'normal' operation

The sugar industry would accrue substantial benefits if harvesting best practice were widely adopted with growers and millers to benefit the most. The major barrier to the adoption of this practice is the fixed price per tonne paid to harvester contractors, which was a negative incentive to reducing pour rate. Although the operator benefits from reduced cane loss because he delivers more tonnes, there are additional costs associated with slowing the harvester down. Reduced pour rate meant more time spent in the field, thus increasing wages and fuel usage. This effectively reduces the operations hourly income. Sharing some of the growers' and millers' increased returns with the harvesting business would greatly increase the adoption of HBP. The difficulty in quantifying how to split this money is a major impediment to full scale adoption of HBP. The benefits are clear but in practice growers are reluctant to take the next step of paying more to earn more, possibly because of the difficulty in assessing whether the harvester was operated at best practice.

4.5 Modifications and monitoring systems

During the course of this harvesting project a number of modifications built by operators and harvester repairers were tested. One concept that reduced cane loss was the fitting of a modified paddle in the primary extractor. Paddles had been fitted to some early Massey Ferguson harvesters and were available as an option on pre-1998 Austoft machines. A flat plate or 'paddle' was positioned below the extractor and parallel to the chopper shaft, midway within the cleaning chamber. The paddle was hydraulically powered and rotated through the stream of material exiting through the extractor. This prevented billets from being extracted with trash. This worked to reduce cane loss but in its original format the large surface area of the paddle caused interference to the airflow within the cleaning chamber. A local harvester repairer modified the original design, retaining the main shaft but replacing the paddle with fingers. These fingers were simple diamond-shaped pieces of plate evenly spaced along the shaft as can be seen in Figure 11.

Figure 11 - Modified extractor paddle - Mulgrave district

The improved version still knocked down billets being extracted but did not interfere with airflow. Field testing of this device showed a marked reduction in cane loss without any loss of cleaning efficiency. Figure 12 shows how cane loss varies when the paddle was removed and replaced repeatedly across a block. With a fan speed of 1100 rpm cane loss was reduced from 8 t/ha to 5 t/ha when using the paddle, and at 1300 rpm cane loss reduced from 18 t/ha to less than 10 t/ha. This represents a very significant reduction in cane loss from a simple modification costing around $2,000. A number of machines in the north now have a modified paddle fitted and the response seems very positive.

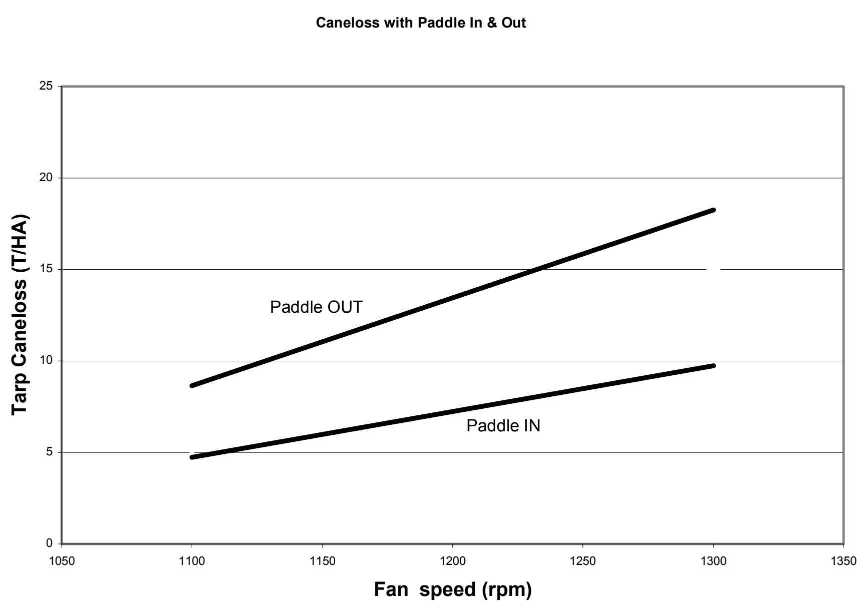


Figure 12 - Effect of extractor paddle on cane loss

Another concept developed by a local harvester repairer and inventor is the counter-rotating fan. This modification involved the addition of a second primary extractor fan below the existing fan. The fans counter-rotated and the fan blade angles were reversed so that both fans draw air upwards. A major problem in the primary cleaning chamber is the swirl or 'cyclone' effect where the rotating airstream concentrates material on the outer circumference of the cleaning chamber. This characteristic is easily identified by the stream of trash coming out of only one side of the hood. With counter-rotating fans in operation, this cyclone effect was negated with airflows becoming much more consistent as evidenced by the even band of trash leaving the hood. Initial testing showed promise with excellent cleaning performance. Below is a trial comparing the performance of the counter-rotating fan to a standard single fan. At a similar level of cane loss, the dual fan set-up had lower EM than the standard system. The original system built in Mulgrave is still operating on a commercial harvester.

Counter-Rotating Fan vs Standard Extractor		
Q120 cut at 6 km/hr		
Counter-rotating fan set-up – Fan speed 750 rpm		
cane loss – 5 t/ha	**% trash**	**1.00**
NIR Fibre 14.06	ccs 13.95	
NIR Ash 1.49		
Standard extractor set-up – Fan speed 1000 rpm		
cane loss – 3 t/ha	**% trash**	**3.10**
NIR Fibre 15.16 NIR Ash 1.85	ccs 13.39	

Figure 13 - Standard extractor performance versus counter-rotating fan concept

Cane loss monitors were checked against tarp cane loss figures in several trials. While the crude calibration process means the number displayed on the loss monitor is not a quantitative measure of cane loss, the device does give a good indication of relative changes in cane loss. Reducing fan speed obviously reduced cane loss and this was reflected in the output of the loss monitors tested. The major problem with the 'Rimik'® cane loss monitors is their poor reliability. The harshness of the harvesting environment meant that most loss monitors fitted to harvesters were not operational due to damaged wires or sensor failure.

5.0 ADOPTION: OUTCOMES AND BENEFITS

Initial extension was basically on a one to one basis with the operators and growers involved in the harvester trials. The magnitude of the cane losses (>20 t/ha) caused a fair degree of scepticism and concern for all parties involved. Although the political sensitivity of the data caused some concerns, well laid out trials, intensive sampling and mill data resulted in trial results that could not be ignored. The intensive trial program of 1997, followed by extension meetings, produced widespread understanding of the cane loss issue in the Mulgrave Mill district. Observations and discussion in the 1997 season revealed that harvester operators focusing on the mill priorities of bin weight and ccs were running consistently high fan speeds with correspondingly high levels of cane loss. A wide reaching extension program presenting initial trial results involved industry players in Queensland Mechanical Cane Harvesters Association Forums from Bundaberg to Innisfail. Information on harvester performance was distributed through extension staff in the lead up to the 1998 harvest. It was reassuring to see a shift in the attitudes of operators, growers and mill staff with the level of cane loss being considerably reduced by informed operators avoiding operation at excessive fan speeds. While cane quality and bin weight were still recognised as important issues, all parties must consider cane loss if industry returns are to be maximised.

The 1998 season saw trials conducted further afield to confirm that the harvester performance characteristics observed in Mulgrave were applicable to all mill areas. Trials were done in the Tully district combining BSS189 resources with the Tully Sugar cane quality project to back up the data produced in Mulgrave. Conducting trials throughout the north gave results that were relevant to each area and although trials were repeated with similar results, local data were essential to give the project credibility. Large-scale trials conducted at commercial pour rates gave operators a practical understanding of their machines' limitations and how to operate within these limits. With trial results backing up the initial data, the adoption of HBP concepts began to gather momentum.

Good attendances at the Northern Information Meetings, shed meetings, field days and workshops throughout north Queensland in 1999 led to widespread understanding of the Harvesting Best Practice guidelines.

The basic machine performance characteristic defined by the BSS189 research formed the foundation for the Harvesting Best Practice project BSS227, funded under the scope of CP2002. The third season of the project saw harvester trials and extension activities conducted from Mackay to Mossman with the full support of local mills. While all parties benefit from reduced cane loss, reducing pour rate comes at a cost to the harvester operator. The poorer crops in 1999 did not encourage reduced ground speed but operators were focused on minimising extractor losses. The issue of compensating the harvesting business for reduced pour rate continues to prevent total adoption of HBP guidelines. Some grower owned machines were being operated at HBP because there was no financial barrier to adoption. Additional costs to the group of growers are offset by reduced cane loss, improved quality and potentially better ratoons due to a higher quality ground job.

Other outcomes

Throughout the trial and extension program of BSS189, harvester manufacturers were kept up to date on trial results and harvester performance characteristics. Data demonstrating the limitations of the current machines have maintained pressure on manufacturers to improve the existing system. Change will be slow but harvest data and demands from the industry for high cane quality with minimal loss will lead to improvements and new concepts.

Discussions with operators revealed the need for increased feedback to the harvester driver on how the machine is performing. The development of monitoring equipment to study machine performance such as the data-logging and in-cab display system used by BSS227 has had a positive response from the industry. Other equipment such as a new cane loss monitor is being developed to enable operators to assess machine performance under harvesting conditions.

Concepts such as the paddle have now been adopted in other areas with good success.

6.0 EXTENSION ACHIEVEMENTS

Key technology transfer achievements have been:

- presentation of initial results to the Extraneous Matter Seminar held in Cairns on 8 September 1997;
- presentation of results to harvester operators at Tully, 21 November 1997;
- presentation of results at Queensland Caneharvesters Forums at Bundaberg, Mackay, Ayr, Ingham and Innisfail over the period 12-18 December 1997.

This provided an excellent opportunity to discuss preliminary results with both operators and manufacturers and to receive feedback from the industry.

The raw data on specific trials, along with relevant analysis, were made available to all interested parties, including harvester owners and operators, growers, millers and harvester manufacturers. Increasing industry awareness of harvesting issues provided many opportunities for constructive discussions as well as the chance to work more closely with manufacturers on improving machine performance. Graphical demonstrations of the impact of operator decisions on cane quality and financial returns clearly illustrated the value of best practice guidelines for harvester operation. The close liaison between project staff and QMCHA provided a number of opportunities to facilitate effective communication with harvester operators.

Prior to the start of the 1998 crushing season, QMCHA ran approximately 15 workshops for harvester operators, focusing on the issue of cane quality. The workshops were held from Maryborough to Mossman where trial results were presented in more depth, increasing awareness of the way machine operation can affect cane quality and profitability.

The scope of BSS189 provided several avenues for extending information to the industry. The field trials themselves proved to be an excellent tool for demonstrating harvester performance under a range of conditions. The 1998 trial program incorporated a "demonstration" focus on trials where possible. Effective trials showed operators how they could impact directly on cane quality and industry profitability.

Prior to the 1998 crush, information outlining the key components of the trial results and providing positive operational options for operators was distributed via BSES extension staff throughout the northern mills area. This extension package (Appendix 2) was promoted through mill publications, field days and harvester forums. Communication was maintained with extension officers and, as new information was developed, local extension staff were informed.

Technology transfer via meetings, seminars and field days was a major focus for 1999. Extension staff in the Central and Wet Tropics regions took an active role in organising and attending grower and industry meetings. Workshops and meetings attended included the following.

- Mackay Best Practice workshop (16-17 February 1999). Presented trial data relevant to BSS227. The harvester trial process and instrumentation required were also discussed.

- Tully Sugar Harvesting subcommittee meeting (24 February 1999). Presented data on 1998 trials.

- Mossman shed meetings with growers and harvester operators. (1-4 March 1999). This forum provided an opportunity to present harvester trial data and obtain feedback on how best practice operation might affect growers and contractors.

- Northern Information Meetings. (8-11 March 1999). These meetings were very well attended and the harvesting presentation generated a great deal of interest and feedback.

- Tully Industry Workshops 15 March 1999. Presentation of harvester research data to groups involved with best practice harvesting program in 1999 season. The focus for the meetings was to assess the potential gains for the group from best practice harvesting .

- BSES Field Days at Moreton, Bundaberg, Mackay, Ingham and Meringa. At all sites, information on the project and trial results was presented, and a short formal presentation was made. Engineering staff were then available for one to one discussion.

- Mourilyan Productivity Awards and the South Johnstone Productivity Awards (20 April 1999). The interest generated at these meetings provided an opportunity for more detailed presentations at special meetings attended by over 250 growers and contractors at Mourilyan, Babinda and South Johnstone on the 7-8 June 1999.

- The project chief investigator was the guest speaker at the Caneharvesters AGM. in Mackay on 15 May 1999. Results of BSS189 and other SRDC funded projects were presented.

- Mossman Industry Field Day, 27 May 1999. Presentation of project results.

The 1999 harvest season saw north Queensland harvester operators tackling a cyclone and flood damaged crop which proved to be quite challenging. The wide range of harvesting best practice information presented at meetings and productivity awards prior to the season meant operators were able to make informed decisions about their harvest management. The Northern Information Meetings and harvester workshops initiated a large number of requests for more information and field demonstrations, indicating that the extension of BSS189 results had been successful. Relevant harvesting information was distributed to extension staff and mill productivity committees, providing interested parties with access to information.

The focus for the 1999 harvest was to undertake an industry-wide extension program, demonstrating to the industry the benefits of best practice operation. Harvester field trials were conducted in Mossman, Mareeba, Mulgrave, Tully, Murray and Ingham. This widespread trial program further increased awareness within the harvesting sector. This program was conducted in conjunction with harvester monitoring and extension being conducted as part of SRDC project BSS227 (Improved Harvest Efficiency), providing the industry with a harvesting research program extending from Mackay to Mossman and the Tableland.

Publications arising from BSS189: Presentation of a paper at the 2001 ISSCT Congress generated considerable interest from both harvester manufacturers and industry representatives. The paper was titled “Extraneous Matter versus Cane Loss: Finding a Balance in Chopper Harvested Green Cane” by Whiteing, Norris and Paton.

7.0 CONCLUSIONS

- This project saw a major field testing program undertaken throughout the north assessing the performance of the modern cane harvester under a broad spectrum of field conditions and operation settings. Crop condition was recognised as the primary determinant of final EM levels arriving at the mill. In given field conditions, pour rate was seen to have a significant effect on cleaning performance. Primary extractor fan speed had limited impact on cleaning but was linked directly to cane loss. Intensive sampling protocols and the use of full mill data on individual rakes for determination of returns to growers led to widespread acceptance of trial results.

- Reducing pour rate to improve cleaning efficiency and reducing fan speed to minimise cane loss formed the basis of Harvesting Best Practice guidelines. The traditional approach of attempting to produce quality cane at excessive pour rates by running high fan speeds costs the sugar industry millions of dollars in extractor cane loss. Harvesting Best Practice guidelines indicated the potential for both grower and contractor to increase returns and this message has certainly reached a wide audience with changes to attitudes and harvester operation seen throughout Queensland. 'Optimum' machine settings under one set of field conditions may be far from optimum under other circumstances, this makes 'prescription' machine settings of little value.

- Accessories such as cane loss monitors can provide useful feedback to harvester operators on machine performance; however, reliability problems limit their use.

- Communication of results to manufacturers continued throughout the life of the project, giving them opportunities to engineer solutions to harvesting efficiency issues.

8.0 ACKNOWLEDGMENTS

This project has demonstrated a collaborative effort between various organisations working together for the common benefit of the sugar industry. The authors thank the following.

- Doug Paton, former BSES Extension Officer, for identifying this issue and initiating this project
- All field hands involved in sorting thousands of kilograms of EM samples and tarp tests (John, Hayley, Kent, Richard, Andrea)
- Harvesting contractors and haulout operators for their patience conducting trials
- Mill transport staff
- Mill laboratory and EM sampling staff, thanks especially to Ann Rizzo

- Mulgrave Mill's production manager Glenn Pope for encouraging the ‘no fans’ treatments
- All canegrowers involved in the trials
- BSES extension staff throughout the state for their support in the promotion of HBP
- John Powell and members of the Queensland Mechanical Caneharvesters Association

The funding from the Sugar Research and Development Corporation (SRDC) and the Bureau of Sugar Experiment Stations (BSES) was essential and is gratefully acknowledged.

9.0 REFERENCES

Anon., Crushing Statistics, Australian Sugar Milling Council, 1996.

Cargnello, R and Fuelling, T (1998). Cane Cleaning Systems. Proceedings of Australian Society of Sugar Cane Technologists **20**:28-33.

Hurney, A P, Ridge, D R and Dick, R G (1984). Evaluation of the Efficiency of Cane Harvesters in Removing Extraneous Matter, and in Limiting Cane Losses During the Cleaning Process. Proceedings of Australian Society of Sugar Cane Technologists **6**:11-12.

Linedale, A I, Ridge, D R and Chapman, F L (1993). A Coordinated Extension Approach For Maximising Returns From Mechanical Harvesting. Proceedings of Australian Society of Sugar Cane Technologists **15**:45-51.

Shaw, G R and Brotherton, G A (1992). Green Cane Harvesting – A Dilemma. Proceedings of Australian Society of Sugar Cane Technologists **14**:1-7.

APPENDIX 1 – Trial listing 1997-1999 harvesting seasons

1997 TRIALS

Trial	Date	Machine	Crop	Variables
1	30/7/97	1985 Austoft 7000	Q113 4th ratoon erect	EM sampling system trial. Bins filled so as to minimise variation through the rake.
2	1/8/97	1985 Austoft 7000	Q158 Erect	EM sampling system trial. Bins filled so as to minimise variation through the rake.
3	5/8/97	Fulltrack Austoft 7000	Q120 Erect	27 bins filled normally, 18 bins filled to minimise variation.
4	6/8/97	1985 Austoft 7000	Q158	18 bins cut running a ¾ fan blade 4 bins cut using standard blade
5	7/8/97	1985 Austoft 7000	Q124 Badly lodged	**Fan speed** 1000 rpm @ 4 km/hr 1300 rpm @ 4 km/hr 1250 rpm @ 3.5 km/hr 1250 rpm @ 5.5 km/hr
6	14/8/97	1997 Case IH Austoft 7000	Q138 Semi lodged	**Pour rate** @ 1200 rpm fan speed 105 t/hr (5.5 km/hr) 85 t/hr (4.5 km/hr) 65 t/hr (3.5 km/hr)
7	18/8/97	1997 Case IH Austoft 7000	Q138 Semi lodged	**Fan speed** @ 90 t/hr 1350 rpm 1100 rpm 800 rpm
8	20/8/97	1997/8 Case IH Austoft 7000	Q158 Semi lodged	**Pour rate** @ 1200 rpm fan speed 135 t/hr 100 t/hr 65 t/hr
9	22/8/97	1996 Cameco	Q152 Badly lodged	**Fan speed** @ 145 t/hr 1400 rpm 1300 rpm 1150 rpm 1000 rpm
10	28/8/97	1996 Cameco	Q117 Some lodging	**Billet length** @ 1200 rpm fan speed, 95 t/hr pour rate. (8.5, 7.5 and 7 inches)
11	16/9/97	1996 Cameco	Q117 2nd ratoon erect	**Pour rate** @ 1270rpm 130 t/hr (9 km/hr) 95 t/hr (7 km/hr) 65 t/hr (5 km/hr)

Trial	Date	Machine	Crop	Variables
12	23/9/97	1997 Case IH Austoft 7000	Q124 Some lodging, cut one way @ 4.5 km/h (85 t/hr)	**Secondary Extractor** / Primary Extractor ON 1300 rpm OFF 1300 rpm ON 1100 rpm OFF 1100 rpm NO FANS
13	27/9/97	1985 Austoft 7000	Q113 R/P Semi erect	**Deflector** above choppers run fully up and fully down, also a no fans treatment. 1350 rpm fan speed 100 t/hr pour rate
14	1,2&6/ 10/97	1995 Cameco	Q152 Moderate lodging	Rotating **Paddle In & Out** at two fan speeds plus No Fans. 1300 rpm & 1100 rpm fan speeds 125 t/hr pour rate
15	7/10/97	1985 Austoft 7000	Q113 R/P erect	**Topped vs Untopped** 1220rpm fan speed 90 t/hr pour rate
16	10&11/ 10/97	1997 Case IH Austoft 7000	Q117 2nd ratoon lodged	**Fan speed** @ 95 t/hr 1350 rpm 1150 rpm 950 rpm No Fans
17	16/10/97	1998 Austoft 7000	Q152 3rd ratoon some lodging	**Fan speed** @ 85 t/hr 1350 rpm 1150 rpm 950 rpm No Fans
18	20/10/97	1996 Austoft 7000 full-track	Q158 1st ratoon some lodging	**Fan speed** 1350 rpm 1150 rpm 950 rpm
19	27/10/97	1997 Case IH Austoft 7000	Q117 3rd ratoon semi erect	**Secondary Extractor** / Primary Extractor ON 1200 rpm OFF 1200 rpm ON 1000 rpm OFF 1000 rpm
20	29/10/97	1995 Austoft 7000	Q152 1st ratoon moderate lodging	**Fan speed** @ 95 t/hr 1400 rpm 1200 rpm 1000 rpm

Trial	Date	Machine	Crop	Variables
21i 21ii 21iii	3/11/97 4/11/97 7/11/97	1997/8 Case IH Austoft 7000	Q117 3R Q127 3R Q127 3R All lodged	**Fan speed** trials 1400 rpm 1200 rpm 1000 rpm New choppers for 21ii
22	7/11/97	1997/8 Case IH Austoft 7000	Q117 1st ratoon semi erect	Rotating **Paddle In & Out** at three fan speeds plus No Fans. 1400 rpm, 1200 rpm & 1000 rpm
23	11/11/97	1990 Austoft 7000	Q113 3rd ratoon semi erect	**Fan speed** trial 1200 rpm 1000 rpm 850 rpm No Fans
24	12/11/97	19 Austoft 7000	Q152 lodged	**Standard Paddle** **Custom Paddle** No Paddle } @1280 rpm
25	17&18/ 11/97	1990 Austoft 7000	Q113 6th ratoon semi erect	**Fan speed** @ 60 t/hr pour rate 1400 rpm 1150 rpm 950 rpm

1998 TRIALS

Trial	Date	Machine	Crop	Variables
1	23/6/98	1998 Cameco 1989 Austoft in Tully	Q117 Q138	Demonstration of trial methodology and tarp test techniques with Rod Bell for Tully cane quality project
2	24/6/98	1998 spec. Austoft	Q138 5th ratoon badly lodged plough out block	Initial testing of extractor performance with Quinn's modified paddle fitted during slack
3	25/6/98	1998 Cameco	Q117 1st ratoon semi erect	Initial testing of brand-new machine to check performance at different deflector settings. High losses found due to damaged choppers and full profile secondary extractors
4	26/6/98	1998 Cameco (as above)	Q117 1st ratoon semi erect	Further testing showed greatly reduced losses from previous day following replacement of chopper blades and secondary blades. Further trials planned.

Trial	Date	Machine	Crop	Variables
5	27/6/98	1989 Austoft fitted with modified paddle	Q152 lodged	Cane loss & EM assessment at operator's request revealed quite low levels of cane loss.
6	29/6/98	1995 Cameco	Q120 Plant erect	**Fan speed trial** 100 t/hr pour rate 1350 rpm 1200 rpm 1050 rpm
7	1/7/98	1995 Cameco	Q113 4th ratoon semi erect	Pour rate and fan speed trial to demonstrate relevance of last season's results.
8	2/7/98	1998 Cameco	Q117 1st ratoon erect	**Fan speed trial** 130 t/hr pour rate 1350 rpm 1250 rpm 1100 rpm
9	2/7/98	1998 Cameco	Q120 1st ratoon erect	Fan speed trial 140 t/hr pour rate 1350 rpm 1250 rpm 1100 rpm
10	7/7/98	1985 Austoft with modified paddle	Q124 3rd ratoon green	Cane loss & EM assessed at 1350 rpm 1280 rpm 1150 rpm
11	7/7/98	Same 1985 Austoft with modified paddle	Q138 5th ratoon burnt	Cane loss & EM assessed at 1350 rpm 1250 rpm 1100 rpm
12	8/7/98	1997 Austoft with modified paddle and new choppers fitted	Q138 2nd ratoon lodged	Cane loss levels assessed and found to be considerably lower than previous year's performance without paddle.
13	9/7/98	1998 Cameco working in Tully	Q152 2nd ratoon Erect	Fan speed trial 1300 rpm 1200 rpm 1100 rpm at 5.5 km/hr
14	10/7/98	1996 Austoft in Tully	Q124 2nd ratoon erect	Cane loss & EM levels measured to initiate further trials in Tully.
15	14/7/98	1998 Cameco	Q117 1st ratoon Erect	Assessment of billet length variation achievable with variable speed feed-train and choppers

Trial	Date	Machine	Crop	Variables
16	15/7/98	1998 Austoft full track	Q152 Plant erect	**Fan speed trial** 110 t/hr pour rate 1320 rpm 1200 rpm 1100 rpm 1000 rpm low pour rate, <800 rpm
17	24/7/98	1998 spec. Austoft fitted with modified paddle	Q120 2nd ratoon lodged	**Paddle In vs Paddle Out** 4.5 km/hr ground speed 1300 rpm 1200 rpm 1100 rpm
18	27/7/98	Standard 1996 Austoft with no paddle	Q120 2nd ratoon erect	Tarp cane loss > 5 t/ha @ 1350 rpm
19	28/7/98	Same 1996 Austoft as above with a modified paddle fitted	Q120 2nd ratoon erect	Tarp cane loss < 2 t/ha @ 1350 rpm
20	28/7/98	1998 Cameco	Q120 3rd ratoon erect	Fan speed trial 105 t/hr pour rate 1350 rpm 1250 rpm 1100 rpm & low pour rate, <800 rpm
21	7/8/98	Older model Austoft	Q152 plant	Full profile vs standard half profile extractor blades EM & cane loss @ 1280 rpm
22	18/8/98	1996 Austoft full track working in Tully	Q120 plant erect	**Fan speed trial** 110 t/hr pour rate 1350 rpm 1200 rpm 1050 rpm
23	14/9/98	SRI modified Austoft Vs Standard 1998 model Austoft in Mossman	Q107 Semi lodged	1150 rpm fixed fan speed 4.7 km/hr fixed ground speed plus No Fans treatment
24	16/9/98	SRI modified Austoft Vs Standard 1998 model Austoft in Mossman	Q152 90% erect	1150 rpm fixed fan speed 4.7 km/hr fixed ground speed plus No Fans treatment
25	6/10/98	1998 spec. Austoft	Q120 Replant lodged	**Pour rate & fan speed trial** 1300 rpm @ 130 t/hr 1100 rpm @ 130 t/hr 1100 rpm @ 95 t/hr low pour rate, <800 rpm

Trial	Date	Machine	Crop	Variables
26	23/10/98	MF405 vs 1997 Austoft 7000	Q124 Burnt 3rd ratoon Some lodging	**Long billets vs Short billets** Both machine run at 6.5 km/hr with negligible extractor losses
27	13/11/98	1998 Cameco	Q138 1st ratoon semi lodged	**Billet length trial** 6 inch vs 8 inch billets 1320 rpm @ 85 t/hr low pour rate, <1000 rpm
28	14/11/98	Older model Austoft fitted with dual, counter-rotating extractors.(4.5 foot)	Q113 4th ratoon lodged	**Pour rate and fan speed trial** 3 km/hr @ 1300 rpm 3 km/hr @ 1150 rpm 4 km/hr @ 1150 rpm plus No Fans treatment
29	17/11/98	Older model Austoft fitted with dual, counter-rotating extractors.(4.5 foot)	Q117 1st ratoon semi lodged	**Fan speed trial** @ 4.5 km/hr 1300 rpm 1150 rpm plus No Fans treatment
30	18/11/98	1985 Austoft	Q113 4th ratoon lodged	**Pour rate and fan speed trial** 4.5 km/hr @ 1300 rpm 3.5 km/hr @ 1300 rpm 3.5 km/hr @ 1200 rpm low pour rate, <900 rpm
31	24/11/98	1998 spec. Austoft	Q127 1st ratoon lodged	**Billet length trial** 6.5 inch vs 8.5 inch 1300 rpm @ 1300 rpm

1999 TRIALS

Trial	Date	Machine	Crop	Variables
1	1/7/99 Mossman	1985 Austoft 7000	Q120, 2nd ratoon	EM sampling system trial. Bins filled so as to minimise variation through the rake.
2	14/7/99 Mossman	1985 Austoft 7000	Q124, 5th ratoon	EM sampling system trial. Bins filled so as to minimise variation through the rake.
3	16/7/99 Mossman	Fulltrack Austoft 7000	Q124, 3rd ratoon	27 bins filled normally, 18 bins filled to minimise variation.
4	23/8/99 Mulgrave	1999 Austoft 7000	Q135 erect	Fan speed trial – 1050 to 1350 rpm.
5	25/8/99 Mulgrave	2000 prototype Austoft 7000	Q152, 2nd ratoon, sprawled	1300 rpm @ 5 km/hr 1200 rpm @ 4 km/hr 1000 rpm @ 3.5 km/hr

Trial	Date	Machine	Crop	Variables
6	8/9/99 Mulgrave	1995 Austoft 7000, paddle fitted	Q138 plant, slightly sprawled	Fan speed/Pour rate trial 1300 rpm/90 t/hr 1150 rpm/70 t/hr 1000 rpm/60 t/hr
7	10/9/99 Mulgrave	1989 Austoft 7000, horizontal arm extractor	Q158, 2nd ratoon, lodged in places	Fan speed/Pour rate trial 1250 rpm/95 t/hr 1100 rpm/70 t/hr 1000 rpm/70 t/hr
8	22/9/99 Tully	1995 Cameco	Q135, 2nd ratoon	Demonstrative Fan speed/Pour rate trial 1250 rpm/120 t/hr 1000 rpm/90 t/hr
9	23/9/99 Tully	1998 Cameco	Q152, 2nd ratoon	Demonstrative Fan speed/Pour rate trial 1200 rpm/110 t/hr 1050 rpm/95 t/hr
10	5/10/99 Mulgrave	1997 Austoft 7000, paddle fitted	Q127, 4th ratoon, badly lodged	Demonstrative trial comparing normal operation with best practice.
11	6/10/99 Mulgrave	1998 Cameco	Q120	Short vs Long Billets at 1200 rpm and 1350 rpm
12	8/10/99 Mulgrave	1995 Austoft 7000	Q120, 2nd ratoon, erect	Fan speed/Pour rate trial 100 t/hr, 1300 rpm 85 t/hr, 1100 rpm
13	12/10/99 Tableland	1999 Austoft 7000	Q120, erect	Fan speed demonstration trial 1250 rpm, 1100 rpm & 1000 rpm @ 100 t/hr
14	13/10/99 Tableland	1998 Austoft 7000	Q117, erect, thin stalk	Fan speed demonstration trial 1250 rpm, 1150 rpm, 1050 rpm @ 110 t/hr
15	26&27/10/99 Ingham	1996 Cameco	Q124, 2nd ratoon, lodged	Demonstration pour rate/fan speed trial 110 t/hr @ 1200 rpm 85 t/hr @ 1100 rpm
17& 18	24&25/11/1999 Bundaberg	1994 Austoft 7000 with removable counter-rotating fan	Q135, 5th ratoon, sprawled	Counter-rotating extractor system compared with standard extractor

APPENDIX 2 – Recommendations for reducing EM and improving ccs

The following information provides some suggestions for operators and growers to improve cane quality. Extensive harvester trials were carried out in Mulgrave during the 1997 season by BSES staff with assistance from Mulgrave Mill. These trials have provided some useful guidelines for minimising extraneous matter (EM) and cane loss. All trials were conducted on green cane.

EXTRANEOUS MATTER

- Under given field conditions, EM is predominantly controlled by harvester **pour rate** (the flow rate of cane through the machine).

- As ground speed increases the flow rate of material through the extractors increases and fan speed becomes relatively ineffective in reducing EM.

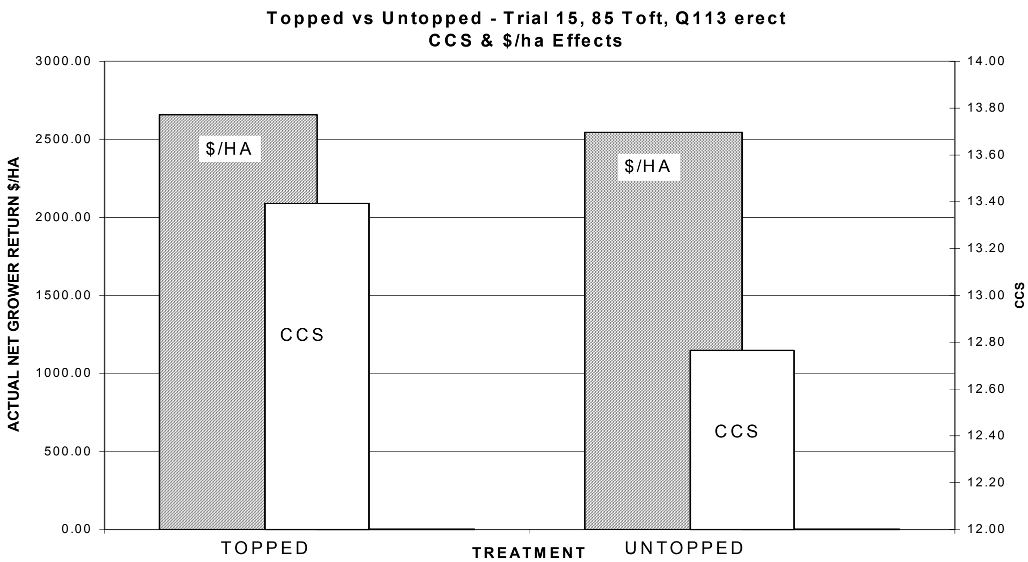
- Up to a fan speed of 1000 rpm, the bulk of the EM is removed by the extractors with minimal losses. As fan speed increases further, the extractor becomes less effective at reducing the EM level. Also, cane loss increases rapidly as fan speed approaches its maximum.

- Field conditions significantly impact on the final EM a harvester will achieve. In difficult conditions (eg damp or lodged), reducing ground speed is the best option to reduce extraneous matter.

Pour rate (flow rate) is the rate at which material is actually moving through the harvester and is the product of *crop size* and *ground speed*. The following chart aids in selecting an appropriate forward speed for a given crop size. For example, aiming for say 100 tonnes/hour flow rate in a 100 t/ha crop would require a ground speed of between 6 and 7 km/hr.

OTHER BEST PRACTICE GUIDELINES

- **Topping**. Tops are a major ccs reducing factor comprising around 30% of the total EM.
- Use of a topper where possible will improve ccs by reducing EM.



- Crop presentation impacts soil intake by the harvester as well as EM levels and ease of harvest.
- Consistent row spacings and an even row profile make for better harvester performance.
- When harvesting, it is important to match basecutter angle settings to the row profile. Generally, the higher the mound, the steeper the basecutter angle.
- To prevent shattering of the cane, basecutter blades should be maintained in a long, square and sharp condition.
- Accurate control of basecutter height prevents excessive dirt intake.
- Knockdown rollers should be set at highest position for standing cane to avoid stalk splitting or stool tipping.
- **Choppers.** Maintaining sharp chopper blades and avoiding overloading will reduce billet damage and subsequent losses or cleaning problems.
- Match chopper and feed-train speeds.

The following graphs have been developed from the results of the trial program run in Mulgrave last season. The data indicate that:

- EM levels in the bin are determined primarily by the harvester pour rate (see Figure 1).
- fan speed has limited impact on EM levels, but strongly impacts on cane loss (see Figure 2).

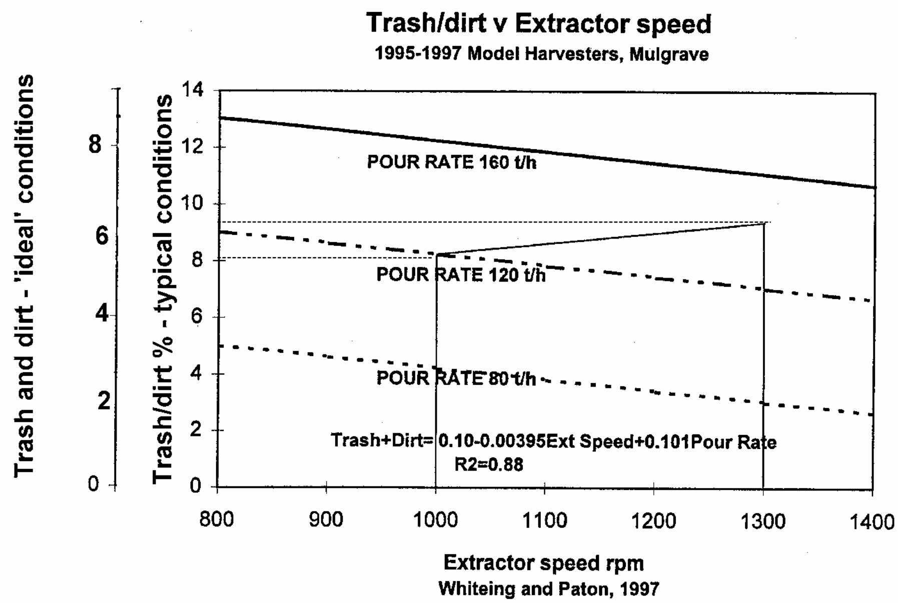


Figure 1 - EM vs Pour rate and extractor speed. A harvester operating at 1300 rpm extractor speed and 140 t/h (eg 130 t/ha crop at 7 kph) would achieve lower EM levels, at 1000 rpm fan speed at 6 kph (120 t/h)

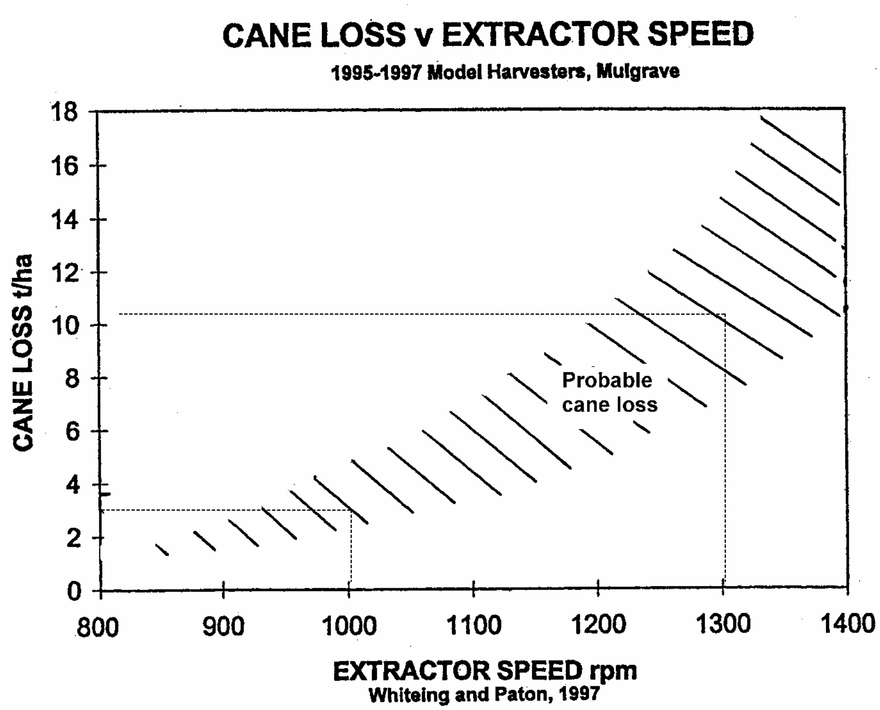


Figure 2 - Cane loss vs extractor speed. Reducing the extractor speed from 1300 rpm to 1000 rpm in the example in Figure 1 significantly reduces cane loss. This benefits all players in the industry.