Sugar Research Australia

Harvesting Best Practice Manual

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Introduction

Introduction

Preface

This update to the 2002 *Harvesting Best Practice Manual* is timely given that the last decade has seen many practice and technological changes in farming, harvesting and milling.

By bringing together current research, innovations, and thinking, the manual provides new insights that should encourage the whole-of-industry to consider and adopt updated harvesting management practices.

The options presented in this manual reinforce the basic principle that there are no set 'recipes' for Harvesting Best Practice (HBP), but rather a set of guidelines which allow for the adoption of Best Management Practices (BMP). Depending on local circumstances such as burnt or green cane, crop size and factory set-up, HBP may differ regionally.

Overview of harvesting

Since the commencement of harvester mechanisation in the 1970s the Australian sugar industry has constantly sought to improve the efficiency of harvesting. A major challenge for the industry in the past has been finding the balance between minimising sugar losses, maintaining cane quality and optimising throughput to manage harvesting costs.

The adoption of green cane harvesting brought the advantages of improved moisture retention and better weed control without the need for constant cultivation. However, it has created the challenge of finding a balance between effective cane cleaning to minimise extraneous matter (EM) levels and excessive cane loss.

Customer expectations for high-quality sugar drive growers and harvester operators to deliver high-quality cane. However, this can push harvesting machinery beyond its capabilities, resulting in increased sugar losses.

Harvesting Best Practice

Quality cane product is characterised by good billet quality, a reasonably low EM level and minimal soil. Mill trials have shown that cane harvested green has a higher raw sugar quality in terms of ash levels and dextran compared to burnt cane.

Cane cleaning greatly improves at lower pour rates, which are achieved by reducing ground speed. The lower ground speed allows a reduction in fan speed, which in turn lowers cane loss, stool damage and soil in cane, but significantly increases the cost of harvesting. High-quality cane will have a higher Commercial Cane Sugar (CCS), improving grower returns but at current harvesting prices it is difficult to produce quality cane economically.

However, economic pressures on the harvesting sector have resulted in short billets, high cleaning losses and excess stool damage. This has led to a lower quality product being delivered.

To address this issue, a payment system that accounts for the extra costs to implement HBP is one way to encourage the uptake of HBP. The benefits provided by HBP will flow to all sectors of the industry, in particular, growers and millers through increased yields (due to reduced losses), better CCS and improved ratoonability.

Substantial negotiation is required before a new payment system can be implemented, thus it is essential that the value of the HBP benefits and the costs incurred by harvester operators are clearly defined.

This manual brings together current harvesting research and knowledge. It covers many aspects of HBP including: harvester set-up and operational settings; field conditions; farm layout; farm practices and their effect on harvester performance; cane quality; milling impacts and sugar quality; and overall profitability of the industry.

This manual provides a guide for sugarcane growers on how they can facilitate HBP through efficient farm layout and presentation of cane. It can also be used by harvest and transport operators in the set-up and operation of equipment to economically produce the best possible cane.

It is also a useful guide to facilitate the whole-of-supply chain discussion about the adoption of HBP.

Fundamental components of a harvester

Fundamental components of a harvester

Topper

The primary function of the topper is to remove and eject the leafy top of the cane stalk. Two types of toppers exist:

- Drum toppers have a single set of blades and are generally considered the most effective at gathering in the tops. However, the long tops can affect post-harvest operations.
- Shredder toppers have multiple banks of blades to shred the tops more effectively. This provides a more even ground cover for the leaf material and results in a faster rate of trash decomposition. Shredder toppers have higher power consumption, which can impact on machine productivity.

Toppers can rotate either left or right to throw tops away from the standing cane. Strong winds can reduce the ability of the topper to remove the tops and can blow ejected material back into the unharvested field.

Where possible, cane should be topped at the growing point to remove leaf material because tops comprise 40–45 per cent of total EM. Tops increase EM, depress CCS and reduce sugar quality through increased colour, ash and starch. Removing tops reduces the load on the extractors, allowing for improved cleaning, reduced cane loss, and less wear and tear on the machine.

This is supported by a trial conducted by Whiteing *et al.* (2002), which indicated that although topping reduced yield by 6 tonnes per hectare (t/ha), an improvement in CCS of 0.6 units increased growers' incomes by $110 per hectare ($/ha). In that trial, trash reduced by one per cent and tops reduced by five per cent. Grower returns increased by greater than $1 per tonne but harvester returns reduced.

Generally, only crops that are relatively even and erect can be topped effectively, with typical topping efficiency in a good erect crop being 75–85 per cent. In dual row and wide row crops grown at 1.8 m or greater spacing, the gathering discs have a much lower capture efficiency of tops. This effect can be mitigated by fitting larger diameter gathering discs to the toppers, with an appropriate modification to the mounting arms.

While there have been attempts to automatically control topper height, they have not yet been successful. The operator must therefore manually control topper height, and make appropriate adjustments when the basecutting height is adjusted.

The operation of the shredder topper with the top leaning forward will help reduce clog-ups. With both standard and shredder toppers, the rotation must always stop completely before the drum is reversed to avoid damage to hydraulic components.

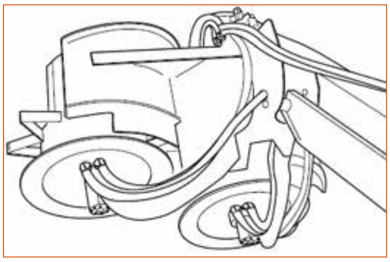


Figure 1: Drum topper (Case IH 2010).

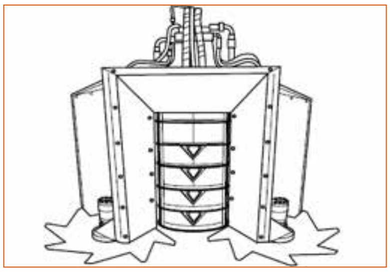


Figure 2: Shredder topper (Case IH 2010).

Gathering the crop

As the machine moves forward, the cane is guided into the front of the machine and aligned by the crop dividers. The crop dividers consist of a frame attached to each side at the front of the machine by a linkage which carries the gathering spirals, trimming saws and floating shoes. The gathering fronts have either a skid system for height control or, on newer machines, an 'active' height control system.

Gathering spirals

After topping, the gathering spirals make the first contact with the cane crop. The spirals rotate inwards to lift and align the cane for butt-first feeding. The spiral wrap (an upward helix flight) is welded onto the tapered cylinder and is designed to facilitate lifting of the cane. Ideally the surface velocity of the spirals should increase as the cane is lifted. This is facilitated by the tapered shape of the spirals. Research shows that the performance of the spirals is critical in setting up the even flow of material through the machine.

Typically, the configuration of the spirals on current model harvesters is optimised for forward speeds of around 6–8 km/h. As harvester power and processing capacity have increased, so too have harvesting speeds, even in lodged cane. This has resulted in increased cane and stool damage in lodged crops. Ideally, the rotational speed of the spirals should be linked to the machine forward speed to optimise the lifting and aligning effect.

An outer set of spirals is either fitted as standard or as an option on modern machines. The outer spirals help when cane from the adjacent row is encroaching into the row being harvested. Research indicates that in many situations the action of the outer spiral can be counter-productive. Some operators have fitted an additional valve to the outer spirals so that they rotate in the same direction as the main spirals. This can be of assistance in large, heavy crops.

The failure to pick up stalks that have lodged or been knocked down, and stalks that have broken or been dropped during the gathering process, contributes to cane loss in this section of the harvester. In practice it is difficult to measure these losses, because the material left in the paddock includes that dropped from all harvesting processes.

Ground losses are affected to a large extent by the presentation of the crop to the harvester.

Trimming saws

Under conditions of large lodged crops, or where the crop has a poor root system, the use of trimming saws can be the most practical method to assist the feed of cane into the machine. The saws prevent bridging of the cane stalks between the counter-rotating spirals, and the development of bundles of cane, which will cause feeding problems.

Manufacturers offer either fixed position or retractable systems. The latter allows the saws to be lowered into an operating position as required, however they do not interfere with the flow of the cane when not needed. Aftermarket manufacturers offer more aggressive saw kits.

Although trimming saws assist in the gathering and feeding of the crop, losses associated with the sawing process and cane stalk, which is not collected, increase. The damage to the crop stool is typically reduced by using saws under these harvesting conditions. Saws increase pick-up loss but reduce stool damage.

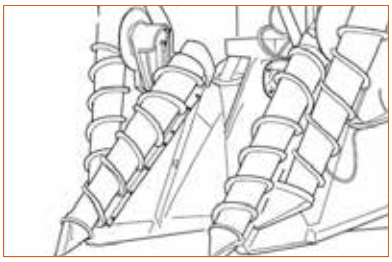


Figure 3: Components of fronts (Case IH 2010).

Floating shoes

Floating shoes pivot on the bottom of the crop dividers to follow the ground contour and help gather stalks that have fallen into the interspace. Correct set-up of the floating shoes is essential; as they may grade significant amounts of soil into the basecutters and cane bundle.

In farming systems where the cane is grown on a mound, the matching of the shape of the floating shoes to the profile of the mound can significantly reduce losses.

Above: Floating shoes.

Height control of gathering fronts

The crop dividers are connected to the chassis by two parallel linkage arms, to allow the crop dividers to move up and down to follow the row profile and allow the units to be lifted at the end of the crop row.

A range of systems have been used to help the operator control the height of the crop dividers relative to the soil surface and the machine frame.

Height control on the crop dividers is important. The tip should typically be operating on the soil surface to ensure proper gathering of the cane stalk. 'High' operation of the crop dividers allows lodged cane stalks to then be crushed by the harvester wheels/tracks.

Until recently, the most common height control system was simply the skid on the bottom of the crop dividers. The skid was often manufactured as an easily replicable component, because of wear. To enhance the height control offered by the skid:

- One manufacturer incorporated a spring system into the hydraulic ram that controlled the height of the crop dividers. This allowed the operator to manage the proportion of the weight of the units carried by the skid, and the proportion carried by the machine.
- Manufacturers also offered a pitch adjustment, to allow the crop dividers to run either tip down or heel down. On later model machines, this adjustment was made hydraulically from the cab.

More active height control systems have evolved. Wheels under the crop dividers, which are a significant aid for the driver, have been fitted by many growers and offered as an option by one manufacturer.

Most recently, another manufacturer has offered a fully electronic system where the control system of the fronts is linked into the control system for the automatic basecutter height.

Forward feed components

The forward feed components of the harvester control the cane prior to the basecutters. The effective forward feed ensures an even feed of the cane to the basecutters, and helps feed the cane over the basecutters, after it has lost the anchorage of being attached to the stool.

Poor gathering and forward feed result in high levels of stress being placed on the cane stool.

The other consideration relating to forward feed is damage to the cane stalk during the feeding process. More aggressive feed is a benefit in lodged crops but aggressive feed in erect crops will increase stalk breakage and stool damage.

How cane feeds or flows across the basecutters and into the feedtrain is referred to as front-end feeding or forward feeding. It is ideal for cane to flow across the basecutters evenly and consistently at all times. The effectiveness of any gathering system also depends on crop characteristics such as brittleness, degree of lodging and field conditions. Front-end pick-up losses are generally very low but may be up to 5 t/ha in adverse conditions.

In difficult feed conditions cane harvesters tend to bulldoze bundles of cane in the machine throat. That is, an enlarging ball of cane will be pushed up in front of the harvester, causing the choppers to be starved of cane. The bundle of cane will suddenly feed into the machine as a glut. This process is referred to as glut-starve feeding.

An even and consistent front-end feed is critical to achieving low cane loss and low EM levels. Any gluts or feed inconsistencies are transferred along the roller train, through the choppers into the extraction chamber.

When a glut of cane reaches the chopper box, additional effort is required to process it. Gluts of cane can be seen in chopper pressure data as pressure spikes. These spikes (see **Figure 4**) increase the amount of power required at the choppers and greatly increase the total maximum machine power required. Billet quality diminishes as a glut is processed. Poorer billet quality means more fragments of cane, which increase cane loss as they are easily removed by the extractors.

After the choppers process the glut, it enters the extraction chamber. The primary extractor's ability to remove EM is reduced because the glut is a large dense bundle.

An even and consistent flow of cane into the harvester means:

- lower horsepower requirements
- lower EM levels
- lower cane loss
- less stool damage.

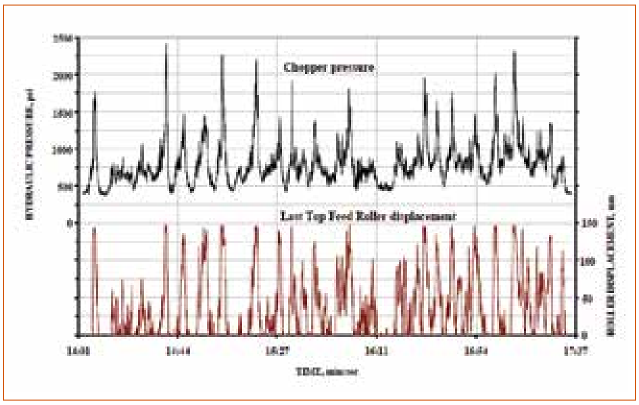


Figure 4: Typical chopper pressure data for glut-starve feeding (Norris & Davis).

Figure 4 refers to a standard gathering system travelling at 2 km/h in two-year old Q170⊕.

Knockdown roller

The knockdown roller positions the top of the cane stalks away from the harvester to achieve butt-first feeding and helps to align the stalk along the row. The knockdown roller assists front-end feeding in lodged or sprawled crops but does much less feeding in erect crops.

Correct adjustment of the knockdown roller is very important to reduce stool damage, soil in cane and extractor loss from stalk splitting. A hydraulically adjustable knockdown roller makes adjustment quick and easy.

Minimal crop damage should occur when the knockdown roller is correctly positioned. When set too low, it will split stalks.

- Have the knockdown roller up as far as crop conditions allow.
- Move the knockdown roller up as harvester forward speed increases.
- Move the knockdown roller up for brittle cane or insect-damaged cane.
- In erect crops, the knockdown and top roller can be fully up.
- In lodged or sprawled crops, it may be necessary to move the knockdown roller down to facilitate feeding.

Finned roller

In most harvesters, a second roller is mounted just in front of and above the basecutters. This roller aims to control the flow of material across the basecutters. On some machines, this roller is fitted with 'shark fins' to help with aligning and feeding material between the basecutter legs.

In wide row and dual row crops, getting the material to feed between the basecutter legs can be problematic. Some operators have found significant benefit in fitting spiral rollers to facilitate the feed between the basecutter legs. The smaller effective diameter of the shaft, rather than the flights, also reduces knockdown damage to the stalk and stool.

Above: Spiral wound knockdown roller and standard finned roller.

Basecutters

The basecutters sever the cane stalk at ground level and help feed the stalk, butt-first, into the feed train. Basecutters interact with the soil, the stool and the harvested stalk. They are a source of soil in cane, stool damage and stalk damage which results in reduced billet quality and increased cane loss.

Basecutter configuration

Almost universally, the basecutter configuration on modern harvesters is the 'leg box' configuration, where both basecutter discs are driven from above through legs attached to a gearbox. Basecutter blades are timed through the gearbox to pass under the adjacent disc and not contact the blades attached to the other disc.

Most harvesters sold in Australia utilise a basecutter configuration with 600 to 620 mm between disc centres although machines with both smaller and larger diameter basecutters are manufactured.

While robust and mechanically reliable, the disadvantage of the leg basecutter configuration is that the two legs restrict the flow of cane as it is forced to pass between them.

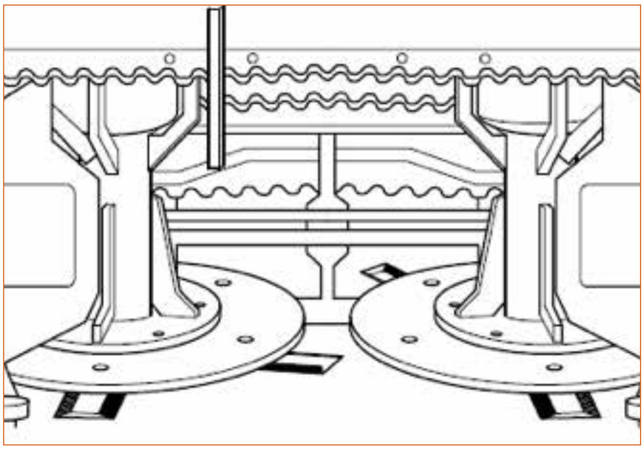


Figure 5: Leg basecutter box – most common (Case IH 2010).

An alternative design strategy is to use a gearbox system under the basecutter discs (underslung). While generally offering enhanced feed performance such as a wider flow of cane into the harvester, problems with operational reliability—particularly in wet conditions due to mud build-up which causes friction between the discs and the gearbox—has meant that manufacturers have generally moved away from that system.

Machines fitted with underslung basecutter systems are preferred for harvesting cane for billet planting, because of the reduced damage.

Basecutter discs

Modern basecutters typically hold five blades per disc, although discs with six blade slots are also available and are preferable at current high ground speeds. Manufacturers also supply discs with different diameters, to either increase or decrease the gap between the discs. This can assist in soil rejection.

Other options include dished discs, which increase the nominal angle of the blade, and scalloped discs. Scalloped discs can help with soil rejection, but are also useful in rocky conditions.

Basecutter dynamics

Although the basecutter is a mechanically simple system, the interactions that occur during the process of basecutting the cane are quite complex.

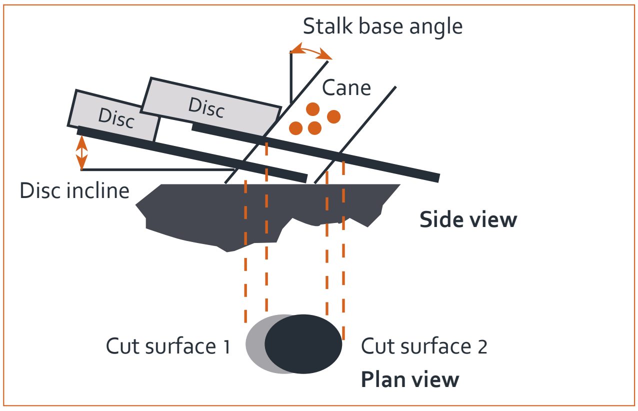


Figure 6: Disc incline and stalk base angle.

Research by Kroes – *Effects of cane harvester basecutter parameters on the quality of cut* 1994 – defined many of the parameters relating to basecutter performance. In simple terms, the main sources of stool damage are:

- The amount of 'preload' on the cane stalks just prior to cutting by the basecutter blade. High levels of pre-tension result in splitting into the stool.
- Blade smashing rather than cutting. This is a function of:
  - > the angle of the leading edge of the blade
  - > the sharpness of the cutting edge
  - > the relative contact speed of the blade contacting the cane stalk.
- Basecutter disc contact causing splitting of the stalk down the stool. This is a function of:
  - > blade effective length, number of blades and disc rpm
  - > blade sharpness.

To minimise damage to the crop stalk and stool, basecutter blades should have a sharp, square, cutting edge.

Blades require regular adjustment and replacement due to wear. Keep them as long and thin as possible. Blades are available in 4 mm, 5 mm and 6 mm thickness and can also be hard faced. Soils with medium or high levels of rock may bend and/or break blades, which increases operating costs and downtime.

Hard-faced blades are recommended in conditions with low levels of rock because the blades maintain a square edge. By maintaining a square cutting edge, stool damage is minimised.

Modelling shows that in good conditions—for example erect crop single row and dry soil—forward speeds of up to 9 km/h will cause minimal stool damage provided that the basecutter blades are new (**Figure 7**). To maintain negligible stool damage, harvester forward speed should reduce to 6 km/h when 25 mm of blade has been lost from its corner. As a blade wears, it not only loses length but also becomes rounded and therefore loses much of its cutting capability. At some point along the curve of the blade, the cane prefers to slide along the edge and tear, rather than be cut. Many factors will greatly reduce maximum forward speed, including wet conditions, stool tipping and insect damage.

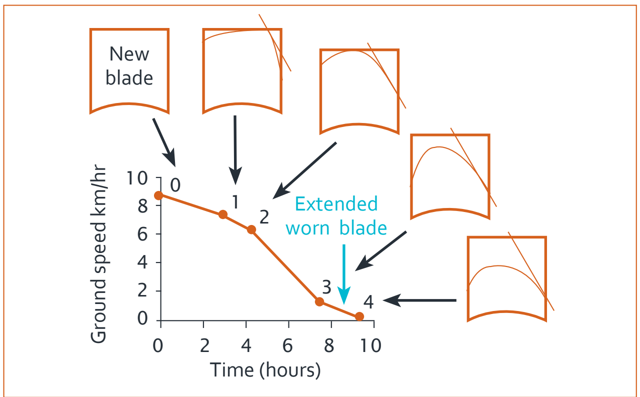


Figure 7: Basecutter blade wear and maximum forward speed.

Basecutter rpm and forward speed

To maintain optimal quality of cut and ratooning, the basecutter rpm should be variable to match harvester forward speed. Basecutters usually have a fixed rotational speed of between 580–650 rpm depending on year and model, which is best matched to 7 km/h.

For a given speed, an overly high basecutter rpm will result in stools being cut by the blades multiple times. This will reduce the ratooning of the stool and increase blade wear. Far worse than this is when basecutter rpm is too slow for the forward speed—it significantly reduces ratooning by tearing the stalk, and increases soil in cane supply. The disc tears off stalks before a blade reaches the stalk, causing severe damage to the stool. To minimise the effect of disc-to-stool contact, ideally basecutters should have six blades per disc. Having the extra blade per rotation leads to less disc-to-stool contact and improves the quality of the cut.

Basecutter angle

Leg basecutters are angled forward at 11°–18° (15°–25° for underslung basecutters) to facilitate butt-first feeding. This minimises dragging of the discs or gearboxes on the cut stubble. The basecutter angle should be adjusted to match hill height and shape and should increase as the hill height increases. A hydraulically adjustable basecutter angle is an advantage as it enables operators to quickly and easily match the basecutter angle to the stool profile at any time.

Basecutter height

Basecutter height is the distance between the tips of the blades and the bottom of the interspace. The harvester operator sets the basecutter height using a sight gauge in the cabin. This system offers no direct feedback to the operator on the appropriateness of the basecutter height to the desired height.

Basecutter blade tips should operate at or just below ground level. Modern machines face a compromise between good cane pick-up and dirt intake. If basecutters are set above ground level, pick-up losses increase and stalk shattering and feeding problems may occur. If they are set too deep, excess soil is fed into the machine.

Butt-lifter

The butt-lifter roller is mounted behind the basecutters guiding cane into the feedtrain butt-first. The butt-lifter tip speed is a compromise between maximising feed of the machine (by running at the same tip speed as other rollers in the feedtrain) and maximising soil rejection (by operating at a reduced speed).

Typically, best results will be achieved by operating the butt-lifter at a tip speed of 80–90 per cent of the tip speed of the other rollers in the feedtrain.

Butt-lifters were traditionally of solid design; however, more recently open designs have been widely adopted. The open designs maximise soil rejection, however tip speed must be at least 80 per cent of the tip speed of the other rollers to avoid cane wrap.

Above: Butt-lifter (solid) and open butt-lifter in the harvester.

Above: Butt-lifter (solid) and open butt-lifter out of the harvester

Roller train

The function of the roller train is to accept cane as it is being severed by the basecutters and deliver it to the chopper box in a consistent manner. Modern harvesters achieve minimal cleaning on the roller train even when different roller groups are running at different speeds. This is because the mat of cane is very thick and fast moving.

Tip speed is how fast the tip of the roller, chopper or butt-lifter is moving. Tip speed is also known as surface speed. Tip speed increases as rpm and diameter increase.

Tip speed = radius [metres] x rpm x 0.105

Where tip speed is in metres per second and radius is in metres. To convert tip speed to kilometres per hour, multiply by 3.6. Nominal roller radius is 0.110.

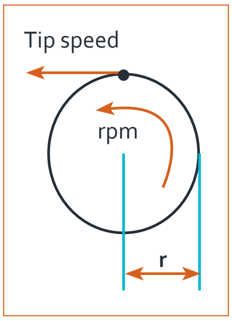


Figure 8: Tip speed (surface speed).

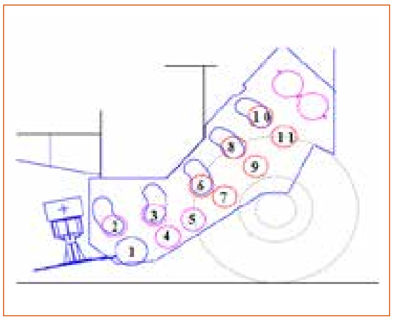


Figure 9: Schematic diagram of a roller train.

Roller train speed and feeding performance of the harvester

The feedtrain affects the feed of the harvester because the cane, when basecut, is no longer anchored in the ground. The action of the feedtrain then becomes critical to controlling the feed of the cane through the machine.

Research into the process of feeding cane through the machine has demonstrated that the feed roller speed should be as fast as practical, to maximise the feed effect and minimise baulking of the cane over the basecutters. This also reduces soil entrapment in the cane bundle.

Roller train speed and billet length

Adjusting the in-cab billet length dial varies roller train speed, which alters billet length. In doing so, the control either hastens or slows the rotational speed of the rollers (hence the cane bundle) relative to the tip speed of the choppers. While this does vary billet length, it also reduces billet quality and increases losses per cut.

In Case-Austoft harvesters, there are two groups of rollers in the feedtrain:

- The group closest to the chopper is adjusted in speed by the billet length adjuster.
- The lower group is set at a fixed rotational speed.

A similar arrangement was used for the Cameco 2500 series machines.

In the current John Deere machines, all the feed rollers are driven as a single group, so adjustment of roller speed applies to all rollers.

Research conducted using the BSES Chopper Test Rig (Norris *et al.* 2000) showed that all rollers should be run at the same speed with the roller tip speed in the range of 55–65 per cent of chopper tip speed. The butt-lifter tip speed should be approximately 80–90 per cent of the roller tip speed.

By operating within this range, billet quality is maximised and billets will be a consistent length. Maximising billet quality means that both chopper box and extractor losses are minimised as there are fewer, smaller fragments. Improved billet quality means reduced cut-to-crush deterioration, which improves cane quality and sugar quality.

Desired billet length should be achieved by choosing the number of blades that are fitted to the chopper box. This is a decision that needs to be made when purchasing a new machine or chopper box.

Cane bundle tension refers to the amount of 'pull' (tension) the cane bundle experiences in the roller feedtrain. The primary cause of this tension is the different groups of rollers running at different speeds. In effect, the rollers are working against each other and causing an unnecessary increase in horsepower requirements.

- For a 294 mm (12") chopper system operating at 195 rpm, the feedtrain rollers should be operating between 165 and 185 rpm.
- For a 368 mm (15") chopper system operating at 195 rpm, the feedtrain rollers should be operating between 200 and 233 rpm.

Rubber-coated rollers

Rubber-coated rollers provide a soft feed and are aimed at producing high-quality billets with sound eyes for planting. Rubber-coated rollers may also be used in a commercial cutting situation. It is vital to match roller speeds to chopper speeds where rubber rollers are used. There are two types of rubber coating available.

95 per cent natural rubber glued to the roller

The rubber is relatively soft, very well-wearing and provides good feeding in wet conditions. Life expectancy of the coating is not fully known. To date, machines have cut about 80 000 tonnes of cane and the rubber coating is not showing excessive wear.

Wet-pour process using polyurethane

Polyurethane rollers are cheaper than natural rubber. However, the level of satisfaction has also been more variable. Polyurethane roller coatings tend to have a poorer grip on the cane stalk in moist conditions, resulting in some feeding and billet length problems. If operation under damp trash conditions is not required, this will not be an issue. Life expectancy of this system is typically less than half of natural rubber coatings, especially in rocky conditions, where pieces break out.

Information sheets available on the SRA website:

Billet quality – a key element of planting success

Chopper systems

Since the early 1980s, the rotary chopper has been the preferred concept for billeting cane in modern chopper harvesters. There has been considerable evolution and development of the concept.

The system consists of two parallel cylinders fitted with replaceable cutting blades along the length of the cylinder. The system has an aggressive feeding action. 12-inch and 15-inch drum centres with four, five, or six blades per drum are available.

The initial designs had two equal diameter drums, with the blades extending radially from the centreline of the shaft. The first major development was the offset blades to give a 'hoe' effect. The most recent development was the differential chop, where the two chopper drums are of slightly different diameter and the blades are also offset from the centreline of the shaft. This has become the default standard.

The differential chop achieves a degree of self-sharpening of the blades because of the way they contact each other during the cutting process.

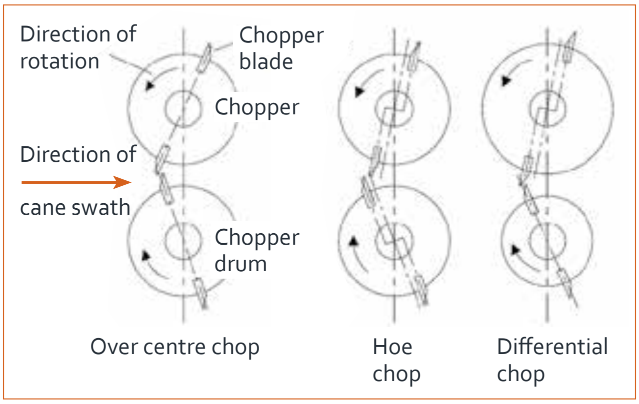


Figure 10: Rotary chopper configurations (Hockings and Davis 1999).

Billet length

Initially, chopper harvesters were designed to produce a billet length of about 300 mm. This was seen as a good compromise between the requirement for load density with burned cane, and the losses and deterioration associated with billeted rather than whole-stalk cane.

With the reduction in cut-to-crush times, and the impact of factors such as higher trash levels associated with green cane harvesting, there has been a consistent move to shorten billet lengths.

The impact of billet length on the density of the load is illustrated in **Figure 11**.

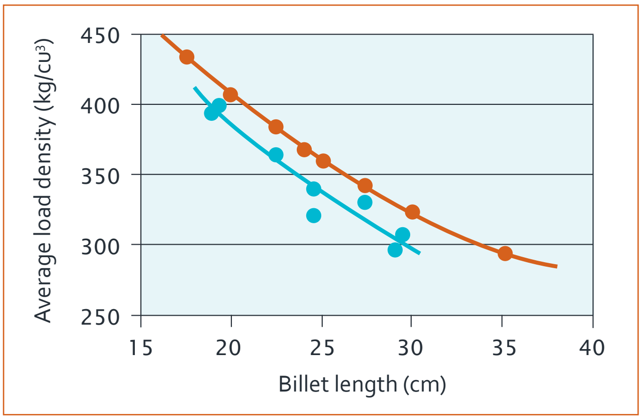


Figure 11: The impact of billet length on load density.

Since the development of the chopper harvester, manufacturers and research organisations have attempted to quantify the losses associated with cutting billets. Although a number of trials have been conducted, the results are not generally transferable to the field. In many of these trials the pour rate through the machine was not equivalent to realistic harvester operating pour rates.

The most recent and authoritative research – *Chopper systems in cane harvesters: A: Development of a test facility and Chopper systems in cane harvesters: B: Results of a test program* – on billeting losses was undertaken with a large scale test program using a full-size chopper test rig. Five different chopper systems were tested during the program.

Weighed quantities of cane and trash were fed through the test rig at controlled pour rates of 120 t/h and 240 t/h. Two different varieties—low fibre and high fibre—were used in the tests.

The trial program indicated that four factors had a significant impact on the degree of loss in the billeting process, the resultant billet quality, and the horsepower requirements of the choppers and feedtrain. These factors are:

1. The relationship between feedtrain roller speed and chopper speed
2. Pour rate
3. Blade sharpness
4. Variety and crop conditions.

The relationship between feedtrain roller tip speed and chopper tip speed

For all chopper systems, the losses are the product of the number of cuts in—for example one metre of cane stalk—and the loss per cut. For a given chopper configuration, the billet length is changed by adapting the feedtrain roller speed relative to the number of cuts/second the choppers are making.

The 'theoretical' billet length would then be derived simply by dividing the feedtrain speed by the number of cuts/second the choppers are making. In reality, this does not happen—when the feedtrain is slowed, the choppers actually pull the cane through the feedtrain rollers. The impact of the choppers pulling cane through the rollers is:

- variable billet lengths
- increased juice loss
- increased damage to the billets.

The optimum relationship between the blades and the cane bundle occurs when the cane bundle is travelling at approximately 60 per cent of the tip speed of the chopper blades. This relationship gives:

- lowest loss per cut
- highest billet quality
- longer chopper blade life.

The trial program indicated that for chopper systems using similar design (e.g. differential chop) the loss per cut was primarily related to the ratio between the chopper tip speed and the feedtrain speed. Based on the typical losses observed with the three different differential chopper units tested in the trial program, the relationship between billet length and losses for different chopper drums can be anticipated.

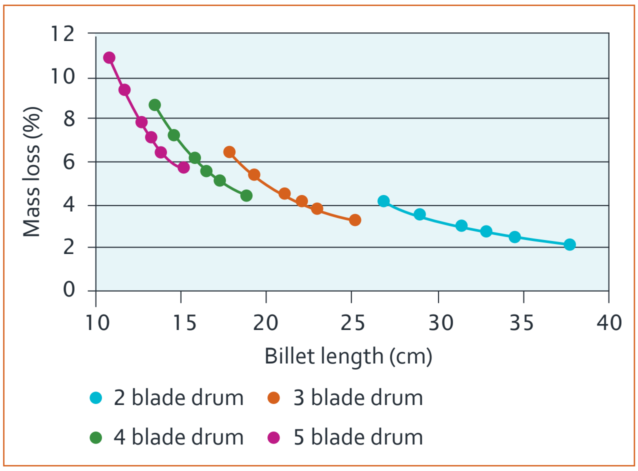


Figure 12: Billet losses (differential chop 120 tonnes per hour pour rate).

Gains can be made by optimising the roller train and matching roller speed to chopper speed—billet quality is maximised and losses are minimised. Roller tip speed should be 55–65 per cent of chopper tip speed. All rollers should have the same tip speed, and the butt-lifter tip speed should be at 80–90 per cent of the roller tip speed.

Reducing billet length is increasingly used as an 'easy fix' for load density—shorter billets equals high load density—but cutting shorter billets will result in more loss per cut and more cuts per stick. Juice loss can range from two to five tonnes per hectare.

Short billets are predisposed to accelerated post-harvest deterioration—a situation aggravated by billet damage. Shorter billets are more likely to split during chopping and be lost via the extractor.

Pour rate

As the harvester pour rate increases, the losses in the chopper system also increase. The exact processes are not fully understood, however it can be assumed that interactions between the cane stalk and the blade keepers would be a contributing factor.

The data from the chopper test rig indicated that doubling the very moderate pour rate from 120 t/h to the more typical 240 t/h increased loss per cut by at least 50 per cent.

Blade sharpness

Billet quality quickly reduces as blade sharpness deteriorates (**Figure 13**). Sharpness of the chopper blade and correct overlap is essential for chopping green leaf and trash, and minimising recycling of billets. Keep the blades as sharp as possible with a minimum knife overlap.

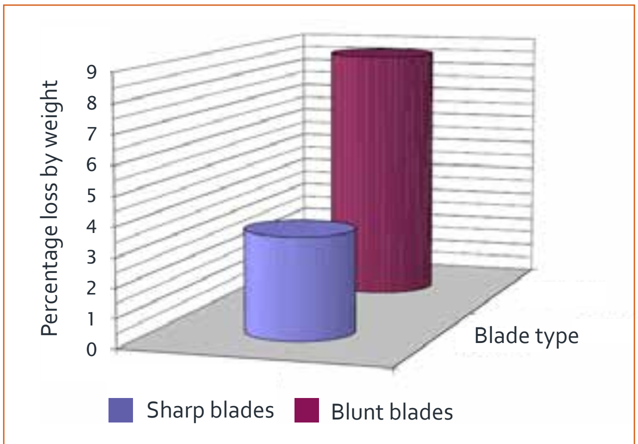


Figure 13: Effect of blunt chopper blades on cane and juice loss (Norris *et al.* 1999).

Variety and crop conditions

Variety has a significant effect on the losses of the chopper system. Losses are higher in brittle varieties. Crops that are lodged will have greater chopper losses.

Primary extraction chamber

The primary extractor is located behind and above the chopper box and works to clean the cane as it is ejected from the chopper box. The extractor fan holds four curved blades. These are designed as a compromise between the efficiency of a more complex blade and the cost of regularly replacing blades operating in a highly abrasive situation. The hub is driven by a vertical shaft, which has minimal impedance on air and trash flow. Older machines have the hub driven by a horizontal arm, which impedes the flow of air and cane.

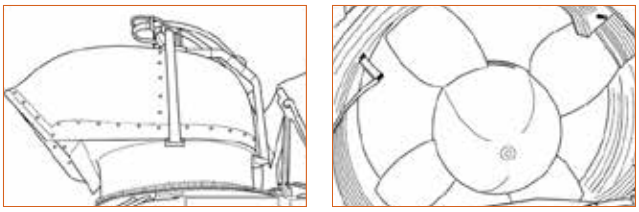


Figure 14: Primary extractor (Case IH 2010).

Increasing fan speed will increase primary extractor cane loss. Significant losses can occur at higher fan speeds. Refer to the Reducing harvester losses: Cane Cleaning section.

Fan speed setting is affected by many variables, including:

- pour rate
- green or burnt cane
- variety and crop conditions
- weather.

Ideally, the primary extractor should remove all EM from the cane without losing any cane. This is **not** possible and a compromise must be made.

As harvester design has evolved, pour rates have greatly increased. Modern harvesters have moved towards larger diameter chambers. The larger diameter increases the surface area on which the fan can work to remove EM. Smoothed curves have improved the performance of the hood by improving airflow. A larger opening reduces the backpressure on the fan.

- Larger blades generate higher air velocities and have a similar effect to speeding up the fan.
- Tip clearance is necessary to allow the flow of trash between blades and the wear ring without binding up. Excessive clearance reduces the efficiency of the extractor considerably, requiring higher fan speeds.
- The primary extraction chamber should be set up with air intakes that are unrestricted and be orientated to ensure incoming air flows from underneath and through the mat of cane.

The correct setting of primary extractor fan speed is critical to economic operation.

Deflector plate

The deflector plate controls the trajectory of the cane from the chopper relative to the extractor fan. The deflector plate needs to be set so that the flow of cane is parallel and close to the fan, but is never into the fan. Deflector plate height depends on pour rate.

Elevator

The elevator accepts cane as it falls from the primary extraction chamber and delivers it into a haulout. Elevators swing from side to side to allow delivery on either side. Different extension kits are available for harvesting dual rows or other specific row configuration. Worn flights can cause significant billet losses because billets are cracked under the flights and circulated.

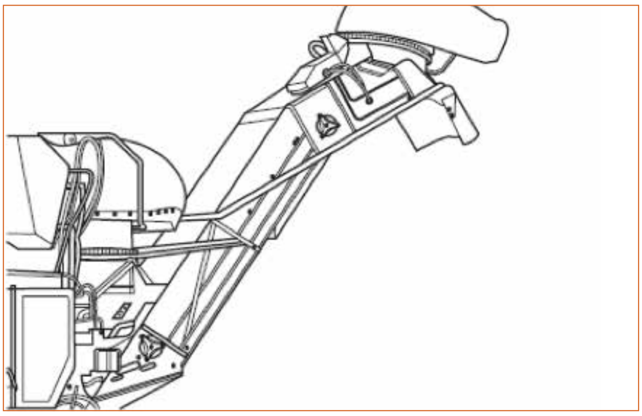
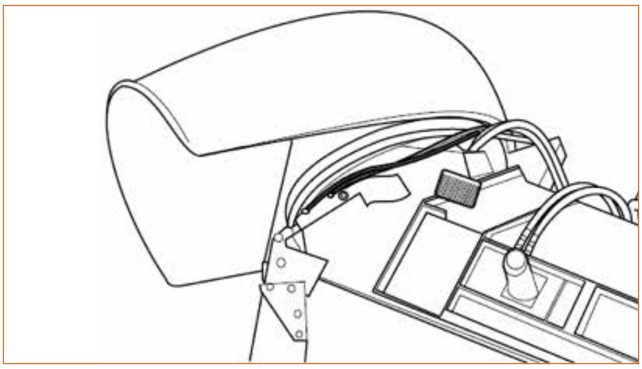


Figure 15: Elevator.

Secondary extractor

The secondary extractor is mounted on top of the elevator. The extractor is 920 mm (3 feet) in diameter and can remove around 50 per cent of the EM presented to it, depending on pour rate. Operators should aim to balance the cleaning workload between primary and secondary extractors. The secondary extractor should be used as a final clean up of the cane rather than for major trash extraction. Significant losses can occur in the secondary extractor. For this reason, full pitch blades are **not** recommended for use in the secondary extractor.



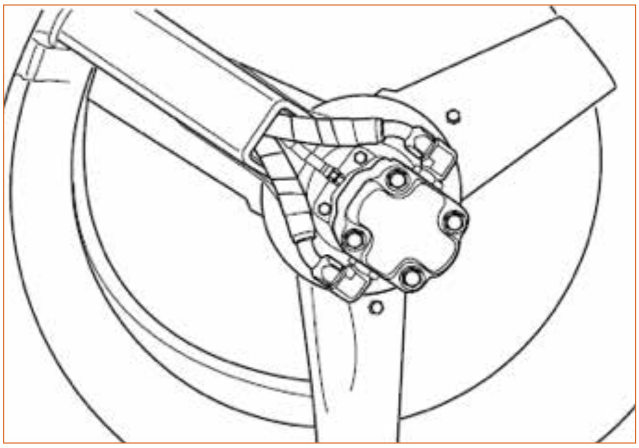


Figure 16: Secondary extractor (Case IH 2010).

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Farming practices and their impacts on harvesting

Farming practices and their impacts on harvesting

Growers can improve cane and sugar quality at a minimal cost through the management of cultural and crop factors.

Green cane versus burnt cane harvesting

Green cane harvesting	Burnt cane harvesting
Advantages	
• Reduced cultivation costs. • Greater harvesting flexibility in showery conditions when burning may not be possible, or if there is a danger of loss of burnt cane due to deterioration. • Improved trafficability in wet weather due to better soil-bearing capacity under controlled traffic. • In lower-rainfall districts, there is a moisture conservation benefit, giving better yields and reducing irrigation requirements. • Reduced erosion on sloping soils and minimised soil disturbance (bringing rocks to the surface) in stony ground.	• Lower trash and EM—three to seven per cent compared to five to 15 per cent for green cane harvesting. • Significantly cheaper than green cane harvesting. • Easier to harvest, especially with large crops. • Minimises harvester extractor loss in high cane-loss varieties. • Better for lodged crops.
Disadvantages	
• Cane loss during harvesting can be higher, ranging from five to 20 per cent, depending largely on extractor fan speed. • More expensive, as cutting rates are 60 to 70 per cent of those in burnt cane, and maintenance and fuel costs are higher. • Green cane trash blanketing may not be suitable for some situations, including: > poorly drained blocks, particularly under wet and cold conditions, leading to slower and poorer ratooning > furrow-irrigated blocks, especially those on heavier clay soils. • Difficulties in handling high-yielding crops where lodging has occurred. Harvesting capacity in green cane is only 50 to 80 per cent of that in burnt cane. However, this depends on crop size, variety, and the severity of lodging.	• Lower quality raw sugar as dextran develops once cane is burnt. • Harvest must be completed within 24 hours to avoid deterioration. Under hot and humid conditions, significant deterioration can occur within 10 hours, and within 16 to 20 hours if conditions are cool and dry. • Removes a valuable source of organic matter for the soil. • Increased erosion potential due to low ground cover. • In wet conditions, trafficability can be reduced.

Above: Green cane harvesting.

Above: Burnt cane harvesting.

Cultural factors

Farm layout

Improving farm layout increases the productive time for harvesters and reduces the time spent on headlands. Maximising row length, maintaining haul tracks and wide smooth headlands all improve farm layout.

Smaller blocks should be combined, where possible. If blocks cannot be joined, it may be possible to alter the farm routine to harvest two or three blocks at one time by crossing adjacent headlands.

Wide headlands allow for fast, smooth turning and ensure operator safety, especially near creeks and drains. Headlands should be clear of obstructions and washouts. They should be slightly lower than the field, which is important for drainage.

Hill-up

Hill-up must be consistent across the farm and must match the harvester. Talk to your harvesting contractor about their requirements for hilling-up.

A hill-up that is consistent and matched to the harvester's basecutter height and angle is vital for reducing stool damage, cane pick-up losses and soil in cane. Hill height and shape will vary depending on cultural practices and agronomic considerations. While it is not possible to stipulate a specific height and/or size, some general rules apply:

- Hill-up is **consistent** across the block or, preferably, the entire farm.

Above: Appropriately hilled-up cane.

- Ensure that plant cane is properly filled in. Start bringing in soil once there are eight to ten shoots per metre. If the filling in operation is left too long, soil will not flow properly into the centre of the hill, resulting in a volcano effect. The volcano effect causes high soil in cane supply and increased pick-up losses. Stools are more prone to damage as they are not properly supported by the soil.

Above: Volcano effect in plant cane created by poor hilling-up.

Above: Poorly hilled-up plant cane after harvest. *Note: The harvester operator cut high to avoid dirt, causing stool shattering and cane loss.*

- Flat or hollow profiles are unacceptable. Harvesters cannot pick up cane out of a hollow.
- Avoid excessive clods in the row as this increases soil in cane.
- Aim to produce a flat, smooth interspace free of tine marks to give the harvester a level platform to work from.
- Consistent row profile matching basecutter angle is the key to minimising stool damage.

Above: Well filled in and poorly filled in cane.

Research indicates that there is no yield impact from filling in early versus filling in late. However, filling in early leads to reduced stool damage due to the improved row profile (Whiteing pers. coms.)

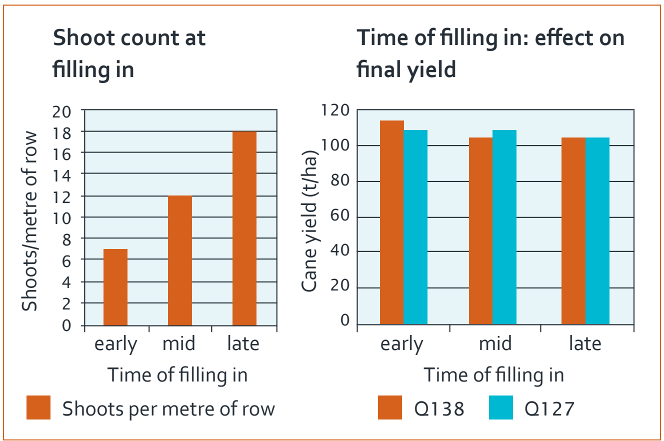

Figure 1: Shoot count at filling in and time of filling in, effect on final yield.

Row spacing

With row spacing, the most important consideration is consistency. If possible, plant using GPS guidance. Row spacing that is not consistent will cause cutting height variation and increase the possibility of the harvester running over stools. This leads to increased soil in cane and stool damage.

Conventional single rows

Conventional single rows are usually planted 1.5–1.65 m apart.

Controlled traffic

80 per cent of compaction occurs in the first pass. For a controlled traffic system to work optimally, each operation must be carefully controlled. Also remember that soil compaction problems will not be solved in one or two seasons of controlled traffic. Soil compaction is formed over many years and can extend to a depth of 600 mm.

Controlled traffic is the system of matching row spacing to the track width of the machinery used within the field. Rows spaced at 1.8–2 m will accommodate the machinery used in both farming and harvesting operations. This ensures compaction is confined to the interspaces, and stool damage is minimised. For this system to be fully effective, all machinery used in both the farming and harvesting operations needs to be fitted with GPS guidance where economically possible.

Controlled traffic can be achieved by using either a single wide row spacing or dual rows. For dual rows, the standard configuration is a pair of rows 500 mm apart with 1.8–1.9 m between centres.

Above: Dual row.

Soil compaction

The mismatch between harvester wheel tracks and row spacing causes substantial soil compaction. The economics of transport has seen the development of higher capacity infield cane transporters. The weight of modern harvesting and haulout equipment has increased to the point where compaction has become a serious industry issue.

Soil compaction increases cultivation costs, machine wear, erosion and run-off. It also causes poor infiltration, slow drainage and reduced aeration which limits root growth, nutrient uptake and crop yield. Braunack (1996) showed that soil compaction caused yield losses of 10–25 per cent in sugarcane.

There are three major ways to avoid soil compaction:

- reduce axle loads
- keep traffic in specific tracks
- keep off wet soils.

Harvesting operators must avoid running over the stool.

Planting depth

Planting depth and hill-up height may affect lodging and stool tipping. However, soil type, moisture level, crop variety, crop size and wind all have a large bearing on whether the cane remains upright even with adequate planting depth and hill-up.

Above: Example of planting depth in mound-planted cane. Note the billet is 10 cm above ground level. Not all mound-planted cane is done this way. Sometimes the billet is just on or above ground level.

Fertiliser regime

An adequate supply of plant nutrients is an important requirement for a large crop. However, when excessive fertiliser is applied, sugar quality and profitability can be lowered. Excess nitrogen causes increased colour formation in raw sugar. It can also cause lodging, which may reduce cane yield and CCS. High levels of potassium will increase ash levels in sugar.

Use soil tests to check soil nutrient levels. Adhere to the SRA SIX EASY STEPS nutrient guidelines for fertiliser recommendations in each region and take account of nutrients supplied by mill mud, ash, lime, legume crops, irrigation water and other amendments.

Irrigation management

Use good-quality irrigation water and test it regularly if in doubt. If water quality is poor, pay particular attention to drainage to reduce soil salinity. High salt levels can result in high ash levels in raw sugar and can hinder crop growth.

A stressed crop at harvest may have inconsistent CCS and poorer quality sugar. It may also fail to ratoon if damaged at harvest. A pre-harvest irrigation is desirable for cane that is stressed.

Under normal growing conditions, a drying off period of 30–60 days (60–100 days in the Burdekin), depending on soil type, is recommended to optimise CCS. Excessively long drying off periods should be avoided to prevent stress in ratooning cane.

Drainage management

Poor drainage results in uneven crop growth, suckering, lodging and increased impurities in cane. Wet conditions and lodging cause harvesting difficulties and soil in cane.

Good drainage improves soil trafficability and minimises compaction at harvest. Good surface and subsurface drainage is essential to maintain productivity. Subsurface drainage should keep the watertable at least 500 mm below the soil surface.

For further information on irrigation and drainage, refer to the Growing cane/Irrigation section on the SRA website www.sugarresearch.com.au

Weed control

It is easier and more cost efficient to control weeds when they are small. Poor vine control makes harvesting difficult. The cleaning system is unable to effectively remove weeds, therefore crops that are excessively weedy will increase EM and decrease sugar quality.

Keep headlands and haul roads slashed to reduce seed being transported into cane fields, and remember to clean down harvesters between farms.

For further information on weed control, refer to the SRA *Weed Management Manual*.

Pest and disease control

Inadequate pest and disease monitoring and control can weaken the crop and lead to increased stool removal, cane loss, EM and reduced sugar yield. Cane grub and Pachymetra root rot damage generally inflate soil in cane supply due to lodged and tipped stools, and stools which tear out easily at harvest. Pest and disease-damaged cane increases levels of dextran, colour and ash in raw sugar and lowers CCS.

For further information on pests and diseases, refer to the SRA *Pests of Australian Sugarcane Field Guide* and *Diseases of Australian Sugarcane Field Guide*.

Crop factors

Varieties

The SRA Plant Breeding Program selects varieties for release that have good harvesting characteristics and appropriate milling quality. Varieties that are more suited to harvesting are free or loose trashing, have a solid stool with a good root system, and are not excessively brittle or fibrous. Erect varieties can be readily topped to reduce EM and also feed better into the harvester.

Variety guides which outline the good harvesting characteristics of each variety are available for each district on the SRA website www.sugarresearch.com.au. Information about the seasonal sugar of each variety is also provided in the guides and can be used to develop harvesting schedules to maximise whole-farm sugar yield.

Crop class

Older crop classes can be more difficult to harvest. Soil in cane supply tends to increase because older ratoons generally have wider stools, especially in minimum tillage situations. The sticks are thinner in older ratoons and this requires adjustment of fan speed to reduce cane loss.

Crop size

Larger crops are often lodged and may be stool-tipped. Lodged crops are more difficult to harvest, do not feed as well and have higher EM levels than erect crops. If they have fallen in one direction down the row, then cutting one-way is an option to reduce EM, stool damage and cane loss. This, however, will reduce the efficiency of the harvesting operation. Harvester forward speed and pour rate should be adjusted according to crop size to facilitate good ratooning of the block (Refer to the **Reducing harvester losses** section).

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Reducing harvester losses

Reducing harvester losses

Cane cleaning

The introduction of mechanical harvesting to the Australian industry has brought many benefits, but also many challenges, in particular, the struggle to maintain a balance between containing harvesting costs and producing an acceptable product for milling. In order to overcome some of the current harvesting issues, the industry needs to firstly understand the limitations of current harvesting technology. It can then address existing system constraints that prevent maximum crop yields and cane quality.

Field conditions

One of the key learnings from green cane harvesting trials is that the main driver of cane quality is the field conditions faced by the harvester. The percentage of trash in the cane supply is determined by crop presentation factors such as lodging, wet/dry conditions, trashiness of the variety and row spacing/profile. Free-trashing varieties such as Q208[ⴲ] are much easier to clean than more tight-leafed varieties. Lodged or sprawled cane is more difficult to gather into the harvester, which reduces the efficiency of the cleaning system. Damp conditions cause the trash to clump together, making it harder to extract.

Figure 1 shows the percentage of EM in cane supply when harvesting the same variety under different field conditions. There is a significant increase in EM percentage when harvesting a lodged crop in wet conditions (>14 per cent EM) compared to harvesting erect dry cane (2 per cent EM). Increasing extractor fan speed has limited impact on trash levels as the harvester cleaning systems operate in a constant state of overload due to high machine pour rates.

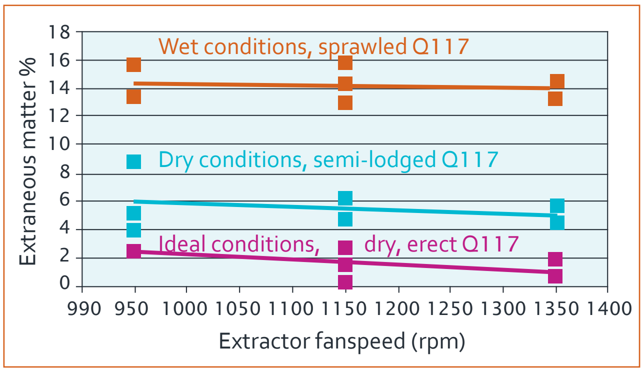


Figure 1: Impact of field conditions on EM levels.

Pour rate versus EM

One of the biggest problems for Australia's sugar industry is the high levels of EM entering factories. High EM levels:

- Reduce bin weights, which increases transport costs (**Figure 2**)
- Can reduce mill crushing rates due to high fibre levels
- Reduce CCS and extraction efficiency
- Have negative effects on sugar quality.

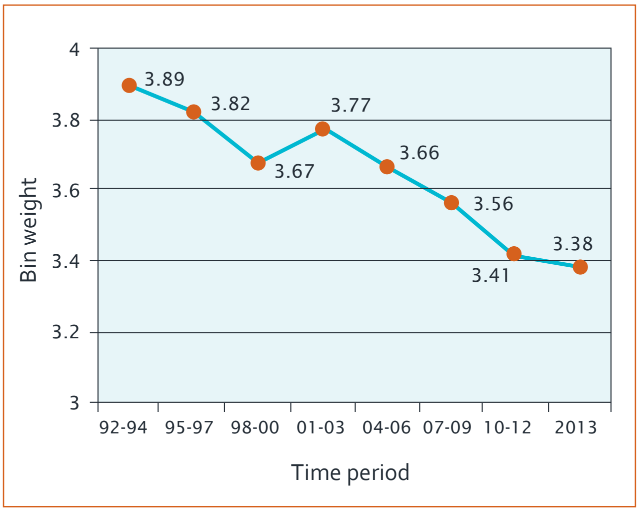


Figure 2: Bin weight trends for the Herbert region – nominal bin weight is four tonnes.

High EM levels are predominantly caused by a high harvester pour rate. In order to meet grower pressure to minimise harvesting costs, harvesting businesses have increased in size with many machines cutting >100 000 tonnes each season. To achieve this, typical elevator pour rates have increased from around 80 t/h in 1997 to in excess of 150 t/h in 2014.

Figure 3 shows how increasing pour rates affect EM levels in the cane supply. With EM levels at most green cane mills currently between 10 and 15 per cent, there is a need to rethink how the system can be better managed.

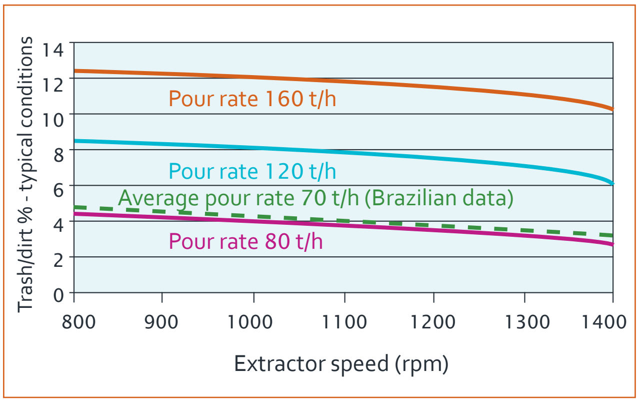


Figure 3: Impact of pour rates on EM levels.

Fan speed and cane loss

There are many sources of cane loss during harvesting, including pick-up loss, basecutter loss and chopper loss. But cleaning system losses have the biggest financial impact on the industry, costing millions in lost revenue each year.

Harvester operators are facing pressure to reduce EM levels and improve declining bin weights. In an attempt to better clean the cane supply while maintaining high pour rates, operators tend to increase primary extractor fan speeds. Unfortunately, cleaning system design hasn't kept pace with machine capacity. As a result, loss of millable billets extracted by the cleaning system can be extreme, with losses between 10 and 20 per cent being measured across regions.

The only real design changes to cleaning systems over the past 20 years have been an increased fan diameter and more aggressive fan blade design. The result is that current model cleaning systems can produce excessive cane loss at what used to be considered moderate fan speeds. **Figure 4** shows cane loss from a standard John Deere extractor chamber. Cane loss rises rapidly as extractor fanspeeds increase above 800 rpm. This is in contrast with older models; their losses start to increase rapidly above 1000 rpm (**Figure 5**).

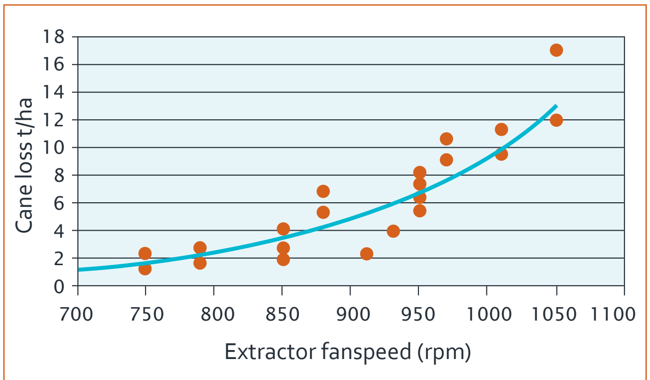


Figure 4: John Deere cane loss versus fanspeed.

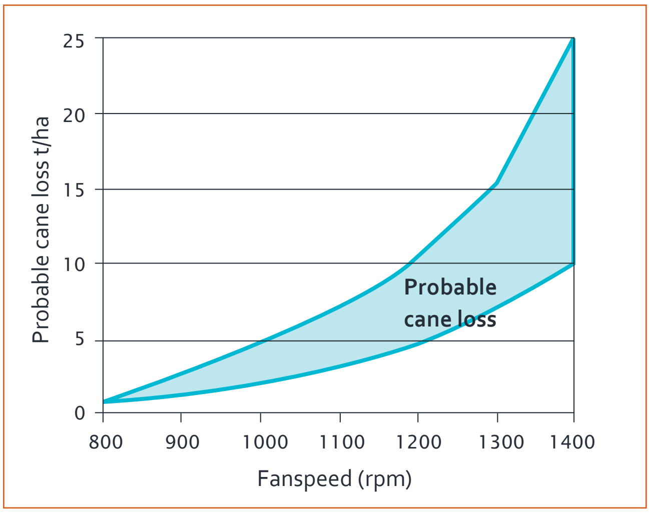


Figure 5: Fanspeed dictates cane loss, not EM levels.

The 'anti-vortex' extractor design is standard to the current model Case IH harvester but retrofittable kits are available to suit earlier machines. As with the John Deere system, losses increase exponentially above 800 rpm (**Figure 6**).

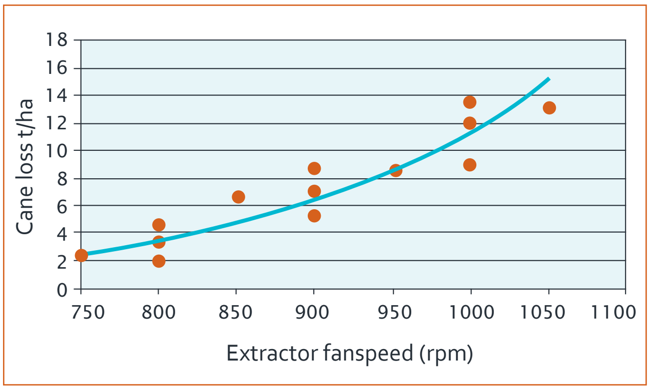


Figure 6: Anti-vortex cane loss versus fanspeed.

With losses of up to $1500/ha being measured in SRA field trials over recent years, it's important that operators are aware of the impact fan speed has on cane loss.

Measuring cane loss

For harvester trials in the past, the biggest problem was the lack of an accurate cane loss measurement technique. The traditional 'blue tarp method' of measuring cane loss and mass balance cane loss were two key measurement techniques that were used. A more accurate method that could provide rapid feedback to growers and operators was developed and is known as the 'infield sucrose loss measurement system'.

The blue tarp method of measuring cane loss

The destruction of billets as they are shattered into juice/ fragments by the extractor fan blades makes it very difficult to measure or even see infield cane loss.

Previously the 'blue tarp test' was used to give an estimate of cane lost via the cleaning system. This method involved collecting material ejected by the extractor onto a tarp placed adjacent to the row being harvested. This infield residue was then sorted, with billet fragments collected and weighed. As harvester research methods improved, mass balance trials revealed that the tarp method seriously underestimated the true magnitude of cane loss. With most of the billets being converted to juice and tiny particles, it was impossible to physically collect any more than 25 per cent of the actual cane lost. In many cases significantly less was able to be found. A more robust process for measuring cane loss is the mass balance method.

Mass balance cane loss

Mass balance cane loss is used in many trial situations. It is a labour-intensive and expensive process with data being available only after the cane is milled, which means feedback to operators can take days. Mass balance cane loss compares losses at different fan speeds against a 'no-fans' treatment in which all extraction equipment is turned off.

A field is selected with yield that is as consistent as possible. The field is divided into areas for each fan speed treatment. At least three replicates of each treatment are required to generate valid data.

The area of each treatment is measured to convert bin weights into tonnes per hectare yield. Harvester fan speed and ground-speed information are noted at the time of the trial, as are harvester set-up characteristics.

Large samples of cane product are collected from the bins at the siding. These samples determine per cent cane and per cent EM by weight for each treatment and are used to calculate the clean cane yield from each treatment.

No-fans treatments are conducted to determine the total clean cane yield available for harvest. In this treatment, the topper, primary, and secondary extractors are turned off so that cane loss is zero. This treatment delivers the total crop to the mill.

When the clean cane yield from each treatment was compared to the no-fans treatment, it was found that the clean cane yield decreased as fan speed increased.

The mass balance method is useful in providing a level of accuracy not found with the tarp method, however the effect of field variability and the slow/costly nature of the process left researchers seeking a quicker method that provided accurate data more rapidly. SRA researchers have now developed a mobile sugar loss measurement system capable of producing accurate results and immediate feedback to operators.

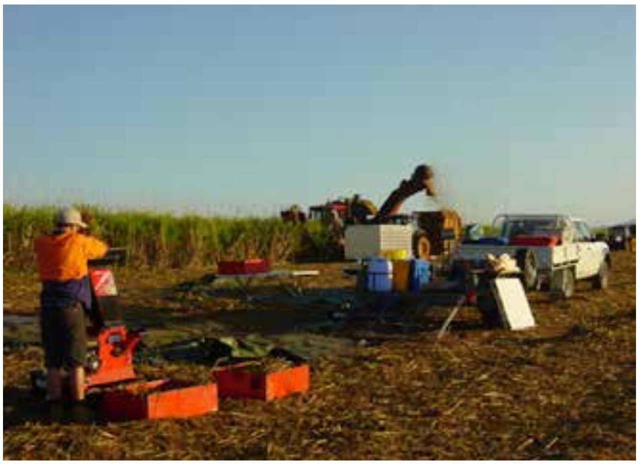
Infield sucrose loss measurement system

In 2010, the SRA engineering division developed a new system to measure harvesting losses. It was realised that measuring the sugar content of the entire trash blanket (infield residue) would provide a more accurate measure of sugar loss than attempting to find cane fragments that had passed through the cleaning system. The aim of the work was to develop a mobile sugar loss measurement system that could provide rapid and accurate feedback to operators. The methodology evolved from a lab-based system into a mobile system, which has now been proven in field trials over several harvest seasons.

The new approach measures the total t/ha of trash blanket extracted by the harvester and determines the total sugar content of this field residue. The total tonnes sugar/hectare can then be calculated to give a measure of the cost of harvesting losses ($/ha). By collecting, processing, and analysing samples at different fan speeds, the economic impact of extractor settings on yield and net returns can be accurately measured. This information is provided to operators within a few hours.

Field trial methodology

Large fields of relatively even cane were targeted for field trials. Two methods of gathering the field residue samples were used: 1) placing a tarp adjacent to the row being harvested and catching the trash/billet fragments and juice exiting the extractor; and 2) raking up the residue from within a measured area, or 'quadrat', following harvest. These samples were weighed to determine the density of the trash blanket (t/ha). When combined with the sugar content data it enabled sugar loss per hectare to be calculated. Field residue samples were then processed in a mulcher to give a homogenous blend of trash and billets. The mulched product was thoroughly mixed and a sub-sample taken and placed directly into a 12-volt freezer to preserve the sugars within the samples.



Above: Infield sucrose loss measurement system.

Field residue analysis

To release sugars trapped on leaves and within billet fragments, a weighed sub-sample of the field residue is taken and a measured quantity of water is added. The sample is then mixed and blended.

Above: Sample mixed then blended.

The sample is placed in a Carver press and held at 9 tonnes to extract the liquid containing the sugars present in the trash blanket. A handheld, digital brix refractometer is used to test the brix level of this sample before the remaining liquid is frozen and sent to the SRA Brisbane laboratories for high performance liquid chromatography (HPLC) analysis to determine the actual sucrose/glucose/fructose levels. These are then compared to the original brix readings.

Left: Carver press and brix refractometer.

Results of the sample analysis

For this method to be useful in measuring the sugar content of trash blankets following harvest it required a good correlation between brix levels as measured with the digital brix refractometers, and the total sugar content of the samples as determined using the extremely accurate HPLC system. The analysis of hundreds of liquid samples has built a strong correlation between brix values measured in the field and actual sugar content measured in the lab, as shown in **Figure 7**.

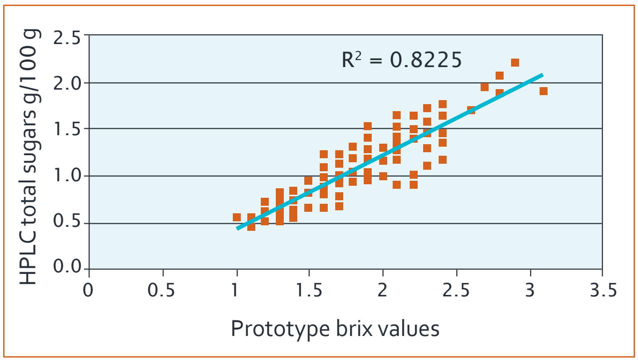


Figure 7: Prototype brix versus HPLC total sugars.

The outcome of this project is a fully functional sugar loss measurement tool which is being used by researchers to boost awareness of harvesting losses, and generate data on harvester performance to provide guidelines for the industry to reduce harvesting losses. The same method can be applied to measure the juice transferred onto trash in the billeting process, which forms the basis of an upcoming project focused on assessing the cost of moving to shorter billets.

Finding a balance between cane loss and cane cleaning

Avoiding excessive cane loss

As discussed previously, the big challenge for the industry is trying to achieve a balance between cane cleaning and cane loss. Data generated using the mobile sugar loss measurement system combined with EM sampling from rail bins indicates that high fan speeds cause excessive cane loss with minimal improvement in cane quality. This costs all sectors of the industry—so awareness of this information could prevent thousands of tonnes of millable cane being left infield. **Figure 8** shows that increasing fanspeed from 830 rpm to 1030 rpm tripled cane loss with a <2 per cent reduction in EM levels.

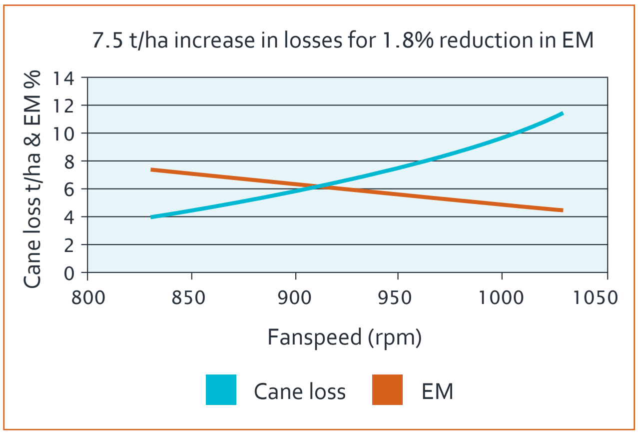


Figure 8: John Deere fanspeed versus EM and cane loss.

Case IH anti-vortex cleaning systems exhibit the same performance characteristics, as shown in **Figure 9**.

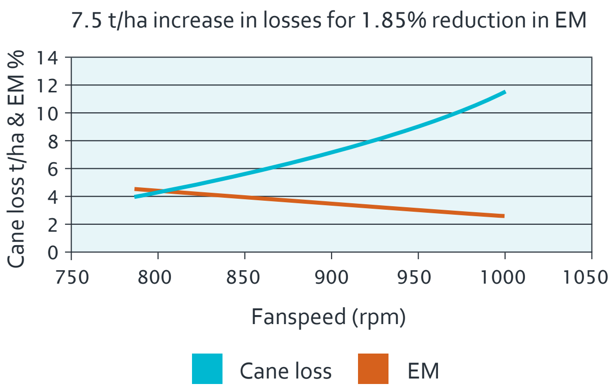


Figure 9: Anti-vortex fanspeed versus EM and cane loss.

The key message is that as fan speed increases over 800 rpm, losses increase dramatically with minimal improvement in cane quality. Unfortunately, if operators attempt to reduce losses further by running even lower fanspeeds, trash levels rise to a point where bin weights create transport/milling issues and the economic benefit of the extra yield gained is eroded by the CCS loss caused by high EM levels.

Note: All the above information refers to extractor systems running factory standard fan blades. Emerging data suggest that the use of more aggressive aftermarket fanblades increases airflow at lower fanspeeds, meaning it is possible to sustain high levels of cane loss even at fan speeds <800 rpm. Ongoing research is gathering data on these aftermarket systems to provide new guidelines to operators who fit them.

Table 1 shows the percentage loss, $/ha loss to industry and the cost of losses from a single harvester cutting 1000 ha (typical commercial harvester operation). The first two data lines show the trial result from two identical John Deere harvesters, both cutting Q208[⌽] at nearly the same fan speed. The machine running at 780 rpm* was cutting in wet Q208[⌽] due to rain and had more than double the losses of the machine cutting at 800 rpm in dry Q208[⌽]. Wet trash becomes clingy and difficult to extract, resulting in a large increase in the volume of billets being taken out via the extractor fan with the wet trash. This is an important consideration when selecting appropriate fan speeds for wet conditions. The middle data line shows the high level of loss measured from a Case IH harvester running the anti-vortex extractor at 1050 rpm, resulting in over a $1 million loss to industry in one harvest season.

Table 1: Percentage cane loss and financial loss at different fanspeeds.

Fanspeed rpm	% Loss	$/ha loss	Loss $/1000 ha
780JD* (wet conditions)	9.5%	$475	$475 000
800JD (dry conditions)	4.4%	$155	$155 000
1050CIH	16.0%	$1080	$1 080 000
650JD**	10.0%	$505	$505 000
800JD**	19.8%	$1115	$1 115 000

The last two data lines (650JD** & 800JD**) are from a trial using aftermarket blades, which have a very aggressive pitch and flow more air at low fan speeds compared to standard blades. As can be seen, the losses were extremely high considering the low fan speeds being tested. Even at 650 rpm, losses were 10 per cent and increased to nearly 20 per cent at 800 rpm, which represented over $1.1 million in lost income to the industry.

Other approaches to reducing EM

The key to moving forward as an industry is to recognise the limitations of current harvesting technology and to accept that effective cane cleaning isn't possible without excessive cane loss in harvester cleaning systems. Other options need to be seriously considered to maximise the percentage of crop that makes it to the mill. Evaluation of the cost/benefit of cane cleaning plants is just beginning in Australia and may provide opportunities to break down some of the system constraints that have been driving the industry towards ever-increasing chopper and extractor losses.

Measuring pour rate

Pour rate and forward speed

Pour rate is an important performance measure in the sugarcane harvesting system. Pour rate is defined by the speed that cane flows through the machine, and is measured in tonnes per hour (t/h). Crop size and harvester forward speed determine pour rate.

There are four different pour rate definitions commonly used within the harvesting sector:

- throat pour rate
- elevator pour rate
- delivery rate
- engine hour pour rate.

Throat pour rate

Throat pour rate is the gross material-processing rate of the chopper system. That is, the gross tonnes of material processed by the choppers per hour of continuous cutting. Gross material includes millable cane, trash, tops and everything that enters the roller train.

Throat pour rate is a function of crop size and ground speed, and is a measure of the 'work load' of the harvester. It is not affected by field efficiency and will typically average over 180 tonnes per hour. When the harvester is experiencing glut-starve feeding, instantaneous flow rates can exceed 400 t/h.

Throat pour rate is calculated using the total tonnes of material the harvester processes. It is difficult to measure the total material standing in the paddock and therefore throat pour rate is usually used only in harvester research trials.

Elevator pour rate

Elevator pour rate is the tonnes per hour delivered off the end of the elevator while the machine is continuously cutting. Elevator pour rate is a measure of harvester performance while it is cutting. It is a function of crop size and ground speed, and does not take into account any downtime.

Elevator pour rate is calculated either by using the Flow Rate Ready Reckoner (**Table 2**), or by dividing daily bin weights (in tonnes) by daily cutting time (in hours) as measured by an elevator hour meter (**Equation 1**). For more information, refer to the **Measuring cutting time – the elevator hour meter** section.

Equation 1: Calculating elevator pour rate

$$\textbf{Elevator Pour Rate} = \frac{\textbf{Total tonnes delivered}}{\textbf{Total cutting hours}}$$

The Flow Rate Ready Reckoner is available on the SRA website www.sugarresearch.com.au. Open the Flow Rate Ready Reckoner document. Enter the paddock row width, then press enter to calculate the range of flow rates at different ground speeds to crop size.

Delivery rate

Delivery rate is the tonnes delivered to the mill pick-up point per harvesting hour. The delivery rate uses total harvesting hours, which include downtime such as servicing, no-haul transport, repairs and turning (**Equation 2**).

Delivery rate is a good measure of the overall efficiency of the harvest-haul system. For more information, refer to the **Measuring total harvest hours** section.

Equation 2: Calculating delivery rate

$$\textbf{Delivery Rate} = \frac{\textbf{Total tonnes delivered}}{\textbf{Total harvest hours}}$$

Engine hour pour rate

Engine hour pour rate is tonnes processed per harvester engine hour. It is also referred to as tonnes per engine hour.

Engine hour pour rate is based on the total time that the harvester is operating, which accounts for turning, backing, moving between blocks and no-haul transport. It does not account for downtime, such as late mill bins, servicing and repairs.

Engine hour pour rate is another performance measure commonly used by harvesting contractors. In practice, it is calculated by dividing daily bin weights by daily engine hours (**Equation 3**). This is done by simply recording the reading from the engine hour meter at the start and end of the day. For more information, refer to the **Measuring engine hours** section.

Equation 3: Calculating engine hour pour rate

$$\textbf{Engine hour pour rate} = \frac{\textbf{Total tonnes delivered}}{\textbf{Total harvest engine hours}}$$

Table 2: Flow Rate Ready Reckoner for 1.63 m row spacings. Note a change in row width will significantly change pour rates.

Cane Harvester Flow Rate - Ready Reckoner (Tonnes/hour)

Row Width

1.63

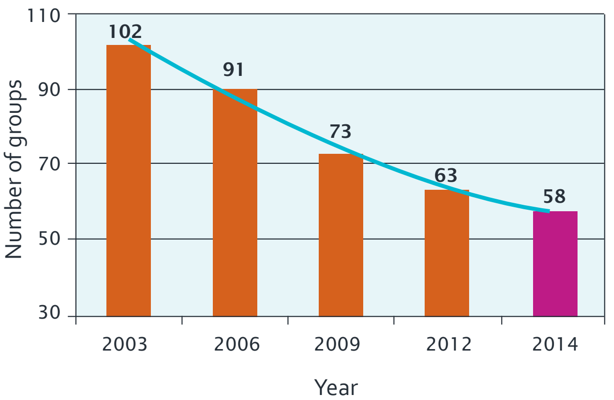
Crop Size - Tonnes Per Acre	20	24	28	32	36	40	45	49	53	57	61	65	69	73	77	81	85	89	93
Crop Size - Tonnes Per Hectare	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**	**140**	**150**	**160**	**170**	**180**	**190**	**200**	**210**	**220**	**230**
Ground Speed (kph)																			
3	24	29	34	39	44	49	54	59	64	68	73	78	83	88	93	98	103	108	112
4	33	39	46	52	59	65	72	78	85	91	98	104	111	117	124	130	137	143	150
5	41	49	57	65	73	82	90	98	106	114	122	130	139	147	155	163	171	179	187
6	49	59	68	78	88	98	108	117	127	137	147	156	166	176	186	196	205	215	225
7	57	68	80	91	103	114	126	137	148	160	171	183	194	205	217	228	240	251	
8	65	78	91	104	117	130	143	156	170	183	196	209	222	235	248				
9	73	88	103	117	132	147	161	176	191	205	220	235	249						
10	82	98	114	130	147	163	179	196	212	228	245								
11	90	108	126	143	161	179	197	215	233	251									
12	98	117	137	156	176	196	215	235	254										
13	106	127	148	170	191	212	233	254											
14	114	137	160	183	205	228	251												
15	122	147	171	196	220	245													

Flow rate is cane processed by the harvester continuously cutting. Actual delivery rates will be less depending on row length/turning/stoppages and transport availability.

Effect of pour rate and forward speed on crop ratooning

This section addresses the effect of pour rate and forward speed on crop ratooning and the factors which have driven the increase in pour rate.

Generally, pour rates have doubled since 1997. This has been caused by a number of factors, including declining group numbers (see **Figure 10**) and bigger harvesters. Higher pour rates and ground speed have led to higher levels of stool damage and EM.



Note: Harvester capacity versus mill crush capacity issues are emerging in many regions.

Figure 10: Harvest rationalisation trend – Herbert region.

Damage to ratoons increases as a function of speed and pour rate.

Spatial analysis in the Herbert cane-growing region using GPS (Global Positioning Systems) and GIS (Geographic Information Systems) has enabled the industry to begin to quantify the effect of pour rate on the ratoon cycle. The process collected two years of cane block productivity data and ground speed from harvester GPS units. Averaging the change in yield from one year to the next at various pour rates from thousands of cane blocks shows that pour rates and/or ground speed appear to have a predictable impact on subsequent ratoon yields. These trends have been replicated in different years and regions, **Figures 11** and **12** indicate that as the pour rate increases, on average, the following ratoons decline.

However, determining the impact of pour rate and forward speed on the following ratoon can be confounded by a number of complex factors, including operator experience, pests, diseases, rainfall events, time of harvest and harvester modifications.

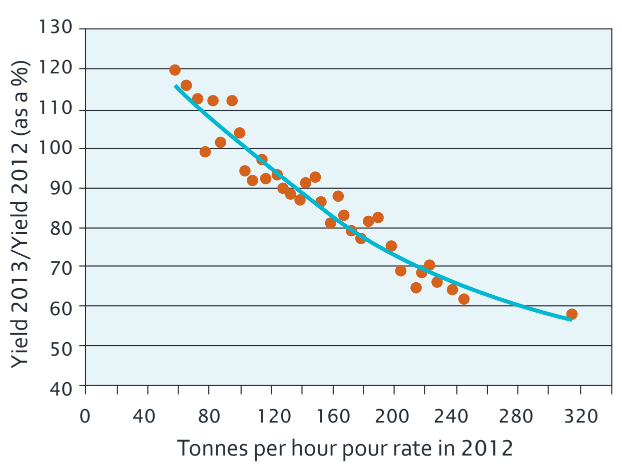


Figure 11: The impact of pour rate in 2012 on productivity in 2013 – Burdekin region.

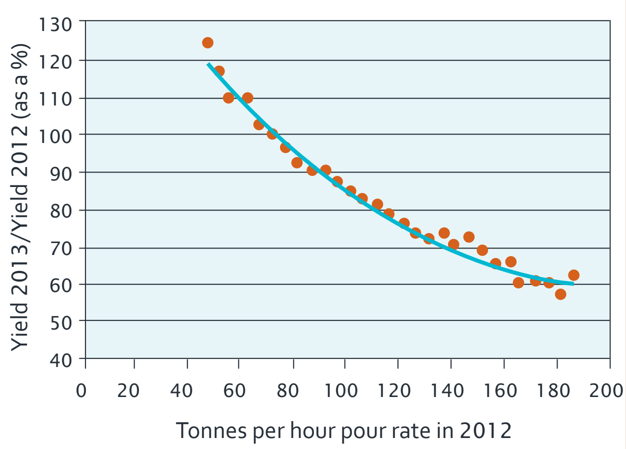


Figure 12: The impact of pour rate in 2012 on productivity in 2013 – Herbert region.

Forward speed also affects ratooning. **Figure 13** shows that as forward speed increases, the yield of the following crop is reduced. The figure also shows the average ground speed was almost 8 km/h for the Herbert region. The Brazilian sugar industry has long realised the impact of harvest speed on ratooning, and controls the speed of their harvesting fleets between 5 and 7 km/h. This has been achieved through the vertically integrated nature of their sugar industry (grower, contractor and miller are one entity) compared to the Australian industry where these are often separate entities.

Industry conditions, including low prices and poor seasons, have reduced the number of harvesting groups and increased pressure on remaining groups to keep prices low. Harvesting groups have adapted to the squeeze on harvesting price and have maintained margins by significantly increasing both the contracted cane area and pour rates. As a consequence, Australia now has the highest harvest pour rates in the world. This has led to a range of transferred, hidden and not immediately obvious costs. Higher milling costs and ratooning losses are just some examples.

The benefit of implementing HBP is improved cane quality and better ratoons.

The harvesting and growing sectors must work cooperatively if the industry is to remain viable. Operators can't implement HBP without the support of the entire industry. Given that the crop is a shared asset, there are big stakes in getting the entire harvesting system settings right.

Getting the harvesting settings right, including payment and incentives, may be critical to attracting new entrants to the harvesting sector.

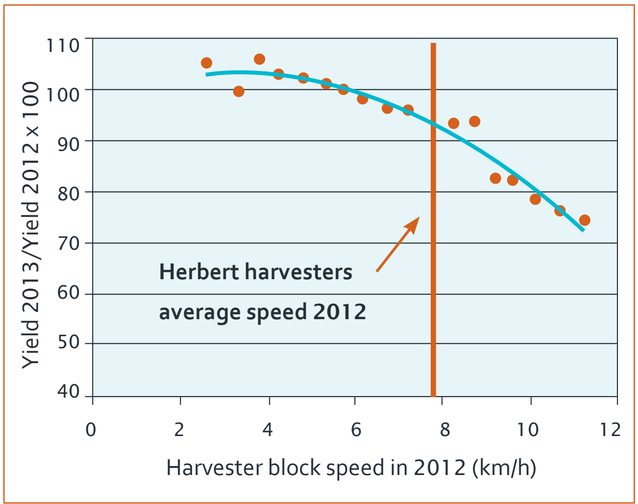


Figure 13: The impact of forward speed in 2012 on productivity in 2013 in the Herbert region.

Other strategies for harvesting and milling

Unfortunately, current harvester designs are unable to meet grower and miller expectations at current pour rates.

In the long term, enhanced harvesters that can increase pour rates with minimal stool damage and improved cane quality may be the solution for the industry. Although there are some alternatives and promising outcomes from multi-row harvesting and various prototypes, the reality is we must ensure the viability of all sectors while working with current designs.

GPS guidance

The use of new technologies, such as GPS guidance, yield monitors, automatic basecutter height adjusters and cameras, are all recent developments.

Anecdotal evidence from operators shows the use of GPS guidance on harvesters increases yields by a few tonnes per hectare as less cane is left behind in the paddock. Further research needs to be done in this area to quantify the benefits. If this proves to be correct then larger groups may well justify the additional capital cost of this technology. In some areas the capital cost is shared between the harvest operator and growers. This funding model has the potential to allow the rapid rollout of this technology in the harvest fleet.

In other industries, auto-steer has been shown to reduce driver fatigue. Given the increase in group size and the long hours required of operators, any technology that reduces fatigue, as well as having business benefits, is welcome.

Yield monitors

The emergence of yield monitors that show variability of yield within a paddock need to be considered, in conjunction with the entire productivity system and complex spatial data processing requirements to create the yield maps.

Digital cameras

Digital camera monitors are an increasingly popular and affordable option for the driver to see parts of the harvest that traditionally have been out of view (such as behind the basecutters). Their use can increase efficiency and contribute to better workplace health and safety standards by reducing fatigue and improving safety.

Automatic basecutters

The ongoing development of these devices will continue to be of interest to the industry. It is driven by the potential to improve returns in the current and subsequent harvests as well as reducing driver fatigue.

Other factors

- The combination of increased forward speed not being matched to basecutter rpm leads to significant damage to the ratooning crop.
- Harvester forward speed and rotational basecutter speed are not linked, so at higher speeds, cane may be ripped out. This design issue has long been flagged as a concern by industry.
- The sharpness and thickness of the blades affect ratooning but this is difficult to quantify on a large scale.
- Harvesting groups are showing signs of going faster with the advent of high-speed wheel motors.
- In general terms, sharper and thinner basecutter blades contribute to improve ratooning. Anecdotal evidence is emerging that the hard facing of blades may lead to poorer ratooning. More research on the impacts of various blade configurations needs to be conducted.

Harvesting wide and dual rows

When harvesting a single row, two basecutters cut and feed the cane into the roller train. When a standard harvester is used to cut dual rows 500 mm apart, each dual row is cut by the front of a single basecutter. When a single row is cut in the centre of the harvester, any side-to-side rocking of the harvester has little effect on the cutting height, but this is not the case for dual rows where tilting of the machine will raise one basecutter while lowering the other. It is important to have smooth inter-rows and well-formed hills to allow the correct cutting height of dual rows to be maintained.

Cutting cane on the front of the basecutter disc rather than between two discs will affect cane feeding as well. The total width of the stool and throat of the harvester needs to be considered to see if any modifications need to be made to enable the cane to feed.

Above: Attached elevator extensions.

Harvesting damaged stools

Cane stools in the cane supply causes extreme increases in soil levels. Removing stools limits the productive life of the ratoon and contributes to premature planting.

Stools that are insect-damaged, diseased or tipped require particular care. Harvest this cane only in optimum conditions, reduce ground speed and follow the recommendations below.

Minimising stool damage and soil in cane

- Wet-weather harvesting markedly increases levels of soil in cane.
- Avoid harvesting in wet soils, where possible, and aim to harvest lighter soils and erect cane in wet conditions.
- A consistent hill-up must match the harvester—talk to your contractor to manage this.
- Match the basecutter angle to hill height.
- Have the knockdown roller up as much as crop conditions allow. Keep it fully up in erect crops; drop the knockdown roller only in lodged cane.
- If possible, match the basecutter rpm to forward speed. Increase basecutter rpm as ground speed increases above 7 km/h.
- Check ground job to ensure that a minimum amount of soil is disturbed.
- Travel at a ground speed that allows time for the operator to respond to changes in the row profile.
- Keep the blades as long and thin as possible and keep the cutting edge of the blades square.
- Have all rollers running at the same speed and matched to chopper speed.
- Increased ground speed could increase soil in cane. Trials have demonstrated increases of soil of around one per cent for every 2 km/h increase in ground speed, under some conditions.
- Reduce forward speed when the stools are in poor condition, such as when diseased or insect-damaged.
- CCS levels reduce in the order of 0.2 units of CCS for every one per cent increase of soil in cane.
- In Australia, soil levels in cane of around two per cent are typical although levels may be above 10 per cent in some situations.

Harvester sterilisation

Harvesters can transmit diseases such as Ratoon Stunting Disease (RSD) and spread weeds. To prevent the spread of pests, weeds and diseases, clean and sterilise the harvester between farms and, wherever possible, between blocks.

If RSD is present in a group it may be best to cut infected blocks prior to a rostered day off to allow for thorough cleaning and sterilisation of the machinery before entering clean farms.

References

Sandell, G. & Agnew, J. (eds) (2002) *The harvesting best practice manual for chopper-extractor harvesters*, BSES Limited.

Whiteing C and Norris CP (2002) Facilitation of best practice to reduce extraneous matter and cane loss. *SRDC final report* SD02009, 1–33.

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Introduction

Fundamental components of a harvester

Farming practices and their impacts on harvesting

Reducing harvester losses

The economics of Harvesting Best Practice

Implementing Harvesting Best Practice

Milling and sugar quality

Trash separation and recovery systems

Appendices

Improving harvester efficiency

Improving harvester efficiency

Field efficiencies are an important measurement in the analysis of harvest cost and the harvest transport system.

Row length and haulout turnaround time are two of the most important factors affecting operating costs, and efficiency gains can be made from improving the farm layout.

Harvester field efficiency is the percentage of the total harvest time that is actually spent cutting cane.

Harvester field efficiency =

$$\frac{\text{Total time that the choppers process cane}}{\text{Total time spent harvesting}} \times 100$$

Total harvest time includes time spent servicing and repairing the machine, turning and other downtime, such as haulouts not being available. It does not include wet weather or idle times. Refer to **Appendix 1: Harvester field efficiency definitions**.

Total time spent harvesting is measured using an elevator hour meter.

Record keeping helps to assess harvest field efficiency by providing feedback on the harvest and measuring the effectiveness of the plan.

Record keeping

Record keeping is important because it enables the contractor to calculate the cost of harvest for each block in the contract. Once this is known, profit and loss blocks can be identified and inefficiencies rectified. The record keeping process requires the operator to complete a paper logbook as the harvest progresses.

At the start and completion of each block or day, the following variables are recorded:

- date
- farm number
- block number
- engine hours
- elevator hours.

Optionally, these variables can be recorded:

- green/burnt
- number of bins
- haul conditions
- crop conditions
- downtime
- consumables
- comments.

Record fuel use at the end of each day or as the harvester leaves the farm. Time sheets are used to calculate total harvest time. It is important that the time sheets are accurate—they must properly account for rest time. Mill data is also required. Haul distance and row length are calculated using mill maps. Rake weights by block are required.

All of the above data is entered into a database. For each block, these variables can be calculated:

- total cutting time
- total harvest time
- field efficiency
- elevator pour rate
- tonnes per engine hour
- total cost of harvest.

Measuring cutting time – the elevator hour meter

Time spent cutting is simply measured by the elevator hour meter. It will record cutting time while the elevator is operating and the harvester is cutting cane.

Use a logbook to record elevator hours at the start and completion of each block or part thereof.

There are times when the elevator is running and the machine is not cutting cane, such as at the end of the row. Conversely, the harvester may be cutting cane with the elevator off, for example, cutting into a new row or changing haulouts. Studies have shown that these types of errors do, in fact, cancel out on average.

An SRDC-funded project – *A participatory approach towards improving industry sector profits through improved harvesting efficiency* 2002 – gives a breakdown of one day of harvesting in a Mackay farm trial in 1999, as shown in **Figure 1**.

The figure shows the proportion of the day consumed by each activity. The harvesting field efficiency was 45 per cent (6.15 hours out of 14 hours). Total harvest time includes time spent servicing and repairing the machine, turning and other downtime, such as no haulouts. It does not include wet weather, moving or idle times.

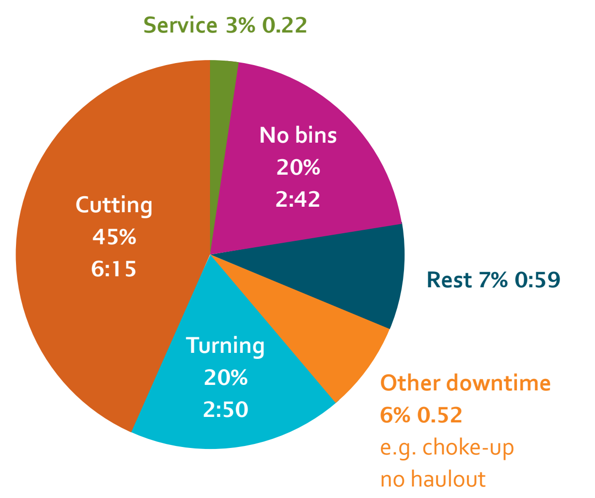

Figure 1: Breakdown of one day of harvesting in a Mackay farm trial in 1999 (Sandell and Agnew 2002).

Measuring engine hours

Use a logbook to record the value shown on the standard engine hour meter at the start and completion of each block or part thereof.

Measuring total harvest hours

Use time sheets to record total harvest time. It is important that time sheets are accurate and properly account for rest periods. Total harvest hours include all of the operating states, as listed in **Appendix 1: Harvester field efficiency definitions**, except wet weather and idle time. Total harvest time is the amount of time spent on all activities related to the harvest.

What can be done to improve harvester efficiency?

Record keeping

Harvest records should always be kept—then informed economic decisions can be made because the cost of harvest for each block is known. Record keeping can become quick and routine for harvester operators.

Record data for each block with the date, time, farm and block number. Record fuel use by refilling daily and for each farm. Record accurate start and finish engine hours and elevator hours for each block each day.

The information derived from this data, together with bin weights and accurate time sheets, can help contractors to identify dollar costs block by block.

Improve farm layout

Improving farm layout always makes large improvements in harvester field efficiency. Row length and haulout turnaround time are the two most significant variables. Changing farm layout requires careful consideration, capital investment and labour. Efficiency gains made by improving farm layout will always remain and will help make harvesting viable in the long term.

Analysis and action

Once you have an accurate measurement of where time is spent, take a critical look at the factors that waste time. The big losses are turning time, servicing, backing (one-way cutting), waiting for haulouts and waiting for bins. What factors cause these times to blow out? Who controls these factors? What can the grower, harvester operator and miller do to manage these factors better?

Avoid cutting one-way

One-way cutting is a common practice in the Burdekin region. A trial conducted by Sandell during the 2001 harvesting season investigated changes to infield efficiency, harvest time and cost made by changes in turning practice.

In the trial, daily bin allocation was divided into three. Three turning practices were investigated: cutting in a circuit; cutting two-ways; and cutting one-way. The time taken for turning, cutting, backing, servicing and all other activities was manually recorded as the trial progressed. The harvester was fitted with a data logger.

The crop was burnt Q96, first ratoon and yielded 118 t/ha. Total harvest was 639 tonnes. Row length was 550 metres; the field had square ends, smooth headlands and rough field entry/exit conditions. Four trucks each with two 5-tonne bins carted 3 km return.

Results for each turning practice were extrapolated to show the effect of cutting the entire block using each turning practice. Downtime such as shifting, service and choke were held constant for each scenario. Service time is made up of: warm-up, five minutes; basecutter blade change, 14 minutes; clean down, 14 minutes; and fuel and grease, 40 minutes.

The data in **Table 1** demonstrates that if the block was cut two-way, total harvest time would reduce by 13.7 per cent compared to cutting one-way.

By avoiding one-way cutting, significant time and financial savings can be made. Savings in harvest time realise savings in labour, diesel and machine wear. Research indicates that by avoiding one-way cutting time, financial savings in the order of 10 and 20 per cent can be made.

Table 1: Time analysis of turning practices.

	One-way		Circuit		Two-way	
Shifting 1	0.09	2%	0.09	2%	0.09	2%
Shifting 3	1.13	12%	1.13	14%	1.13	14%
No haulout 5	0.13	2%	0.49	10%	0.42	8%
Change haulout 6	0.15	3%	0.17	3%	0.14	3%
Choke 7	0.02	0%	0.02	0%	0.02	0%
Turning 10	2.00	20%	2.00	18%	1.14	20%
Backing 11	1.44	18%	1.33	0%	0.00	0%
Cutting 12	4.15	43%	0.00	55%	4.28	53%
Total harvesting time	9.51	100%	8.35	100%	8.30	100%
Time saved over one-way	0.00		1.16		1.21	
Elevator pour rate t/hr	150		150		150	
Tonnes per engine hour t/hr	74		85		88	
Delivery rate t/hr	65		74		75	
Field efficiency %	43		55		53	

However, in some cases, one-way cutting is the only option. For example, where heavily lodged cane blocks exist and cutting two-ways will cause stools to be ripped out of the ground. This information is only suitable where two-way cutting is an option without affecting other factors of the harvesting process.

Ten tips on improving harvester efficiency

1. **Improve farm layout**

   The aim is to increase the proportion of actual cutting time. Pay particular attention to row length and appropriate headland space. Headlands that are wide and smooth increase the efficiency of harvester and haulout turning.

2. **Ensure row spacing is consistent and rows are parallel by using GPS at planting**

   GPS guidance systems can also be used to keep harvesting and haulout over the cane rows. This contributes to improved ratoonability by minimising soil compaction and physical damage to stools.

3. **Ensure row profile is consistent across the farm and matches the harvester**

   Poor row profiles increase cane losses at harvest as well as causing stool shattering and splitting that hinders subsequent ratooning. The damage caused also encourages the development of fungal rots. Consistent row profiles that match basecutter set-up significantly reduce stool damage during harvesting. Remember that damage to hill shape during harvesting cannot be effectively corrected by cultivation in ratoons. Also use ripper tines carefully to avoid having large clods of soil present in the rows.

4. **Select varieties carefully and tailor agronomic practices to the variety**

   It is best to match vigorous varieties to appropriate soil types. Highly vigorous and productive varieties grown on good soil may create problems with lodging and stool tipping. This may require deeper planting, better hilling-up, and reduced nitrogen fertiliser applications. High-yielding erect cane well presented for harvesting significantly increases harvesting efficiency, particularly given the high pour rates of existing harvesters. Also, controlling weeds within the crop reduces the quantity of potential EM in the harvest.

5. Develop a harvesting plan to maximise cane maturity at harvest

Plan the order in which blocks will be harvested according to maturity, layout, predicted peak in CCS and seasonal weather conditions.

6. Pay attention to harvester set-up and operation

Harvester maintenance, particularly the condition of basecutters and chopper blades, has a significant impact on harvester damage and sugar loss. Research has shown that losses can be tripled if blades are not correctly maintained. In the feedtrain, optimise feed roller speeds to chopper rotation speeds to reduce juice loss in the billet-cutting process. Avoiding high fanspeeds (>850 rpm) will lower losses. However, if the fanspeed is reduced further, excess trash levels affect bin weight and CCS to a point where transport/milling requirements are not met.

7. Have a wet-weather harvesting plan in place

Growers should discuss the best harvesting options for wet periods with their harvesting contractor. For example, it may be best to cut plough-out blocks in preference to damaging younger crops. Also use trash blanketing and minimum tillage, where appropriate, as these improve trafficability in wet weather compared to conventional cultivation.

8. Ensure appropriate harvester hygiene

Avoid the spread of RSD by sterilising harvesters between blocks wherever possible. Pay special attention to the crop dividers, basecutters and choppers.

9. Plan ahead to ensure a sufficient supply of bins

This minimises the time lost during harvesting operations.

10. Maintain appropriate records

Use a logbook for all harvesting operations.

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The economics of Harvesting Best Practice

The economics of Harvesting Best Practice

Economics is used to evaluate the financial costs and benefits of HBP for the purpose of providing information to encourage its adoption and to improve industry profitability.

Four main principles concerning the economic viability of HBP are recognised as:

1. Improved farm layout can reduce the cost of harvesting.
2. HBP reduces cane loss and provides additional revenue to the sugar industry.
3. The costs and benefits of HBP do not accrue uniformly to each sector within the industry and therefore presents a barrier to adoption.
4. Each harvester payment system has advantages and disadvantages.

Harvesting field efficiency and farm layout

Harvester field efficiency is the ratio of time spent cutting cane to the total time spent harvesting. Total harvesting time includes cutting, turning, infield service and maintenance, downtime, waiting for bins and rest breaks.

Infield research suggests that there is a large variation in harvester field efficiency between farms, blocks and harvester groups as well as between years (SRDC, 2007; Tabone Harvesting Group, 2007; Muscat & Agnew, 2004). A comparison of the time spent harvesting by two harvesting groups in the Burdekin is shown in **Figure 1**.

The total cost of harvesting includes two components: variable costs and fixed costs.

Fixed costs related to harvesting include expenses such as depreciation, interest, storage costs, taxation and insurance. Those costs that are variable include fuel, repairs and maintenance and labour.

Variation in harvester efficiency amounts to large differences in the variable cost of harvesting between different farms and harvesting groups. Low field efficiency implies high labour and fuel use per tonne of cane harvested, and vice versa.

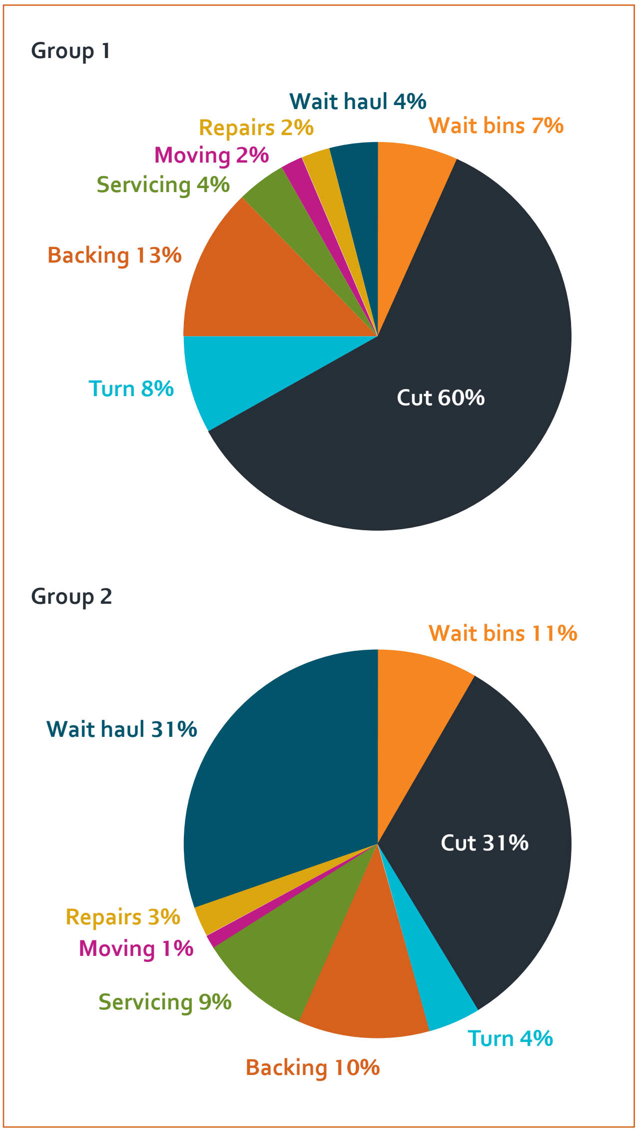

Figure 1: Comparison of time spent harvesting by two harvesting groups. *Source: SRDC 2007, p.4–5.*

The average fuel use per tonne of cane harvested across ten different farms is shown in **Figure 2**.

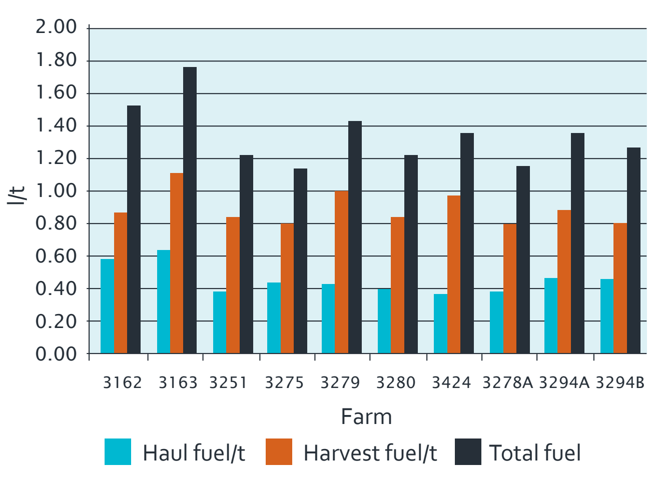

Figure 2: Average fuel use per tonne of cane for harvester, haulouts and total for farms harvested by a harvester group. *Source: Willcox et.al 2005, p.31.*

The difference in harvester field efficiency and the variable cost of harvesting between farms and blocks is impacted by differences in farm layout.

The BSES Harvest/Transport Model was used to assess the relative impact of farm layout on the cost of harvesting. Modelling shows that turning within blocks accounts for a significant proportion of time spent harvesting. This implies that increasing row length and therefore reducing the number of turns will decrease the variable cost of harvesting. Increased hauling distance was also shown to increase the variable cost of harvesting (Sandell & Agnew, 2002).

Harvesting losses

HBP seeks an acceptable balance between cane cleaning and cane loss. Cane cleaning is primarily achieved by the harvester's primary extractor fan, which removes EM from the cane supply. At very low fan speeds, EM is excessive, causing a reduction in sugar recovery at the mill and an increase in transport costs. At very high fan speeds, excessive cane loss may occur (SRA, 2013).

Economics can be used to evaluate the ideal fan speed for harvesting. From an economic perspective, the optimal fan speed is the speed at which the marginal dollar value of cane lost is equal to the marginal additional value of clean cane. This figure will be affected by the price of sugar and the cane payment formula as well as the efficiency and cost to the mill of cleaning and transporting cane.

Cane and sugar loss may also be reduced by optimising the harvester roller train. Optimising the roller train has been shown to reduce chopper losses by up to seven per cent (Whiteing, 2004). An economic cost-benefit analysis may be used to weigh up the additional revenue gained by roller train optimisation against the additional cost of modification.

Economic modelling of Harvesting Best Practice

Economic modelling can be used to determine how the costs and benefits of HBP adoption are distributed between harvesters, millers and growers.

The costs and benefits of HBP adoption include changes in cane loss and CCS as well as changes to harvester operating practices, such as fuel use and labour. The sharing of proceeds between growers, harvesters and millers can be calculated using the cane payment formula, an assumed sugar price and harvester pay rate.

In 2003, economic modelling of HBP was conducted at a sugar industry workshop (see Jones [ed.], 2004), the results of which are presented here. The modelling was based on actual data from two mill areas referred to as mill A—a central district mill of about 2 Mt annual crushing capacity; and mill B—a wet tropics mill of about 1 Mt crushing capacity. Key assumptions that were used in the modelling are described in **Table 1**.

Table 1: Model assumptions. *Source: Jones (ed.) 2004.*

	Mill A		Mill B	
	Base Case	HBP	Base Case	HBP
Crop delivered to mill (Mt)	1.91	1.95	1.15	1.18
CCS (units)	13.84	14.92	13.23	14.21
Season length (weeks)	19.01	19.01	20.32	20.32
Row length (m)	400	400	200	200
Group size (t)	60,000	61,315	33,000	33,865
No. of haulout units active	3	3	2	2
Average forward speed harvesting (km/h)	8	5	8	5
Average infield haulout distance (km)	3	3	1.5	1.5
Haulout bin capacity (t)	10	11	10	11
Average haulout ground speed (km/h)	25	25	25	25
Sugar price paid to grower ($/tc)	23.34	25.85	21.94	24.21
% cut as green cane	98	98	98	98
Average crop size (t/ha)	92	92	98	98
EM (%)	13.0	6.7	13	7.1
Cane loss (%)	16.5	8.5	16.5	8.5

The change in grower income, miller gross margin and harvesting costs under HBP for mill area A and mill area B is summarised in **Table 2**.

Table 2: Financial model results: Mills A and B – HBP compared to base case. *Source: Jones (ed.) 2004, p.26.*

	Mill A	Mill B
Grower income	$6.00 m	$3.30 m
Miller margin	$2.00 m	$0.75 m
Harvesting costs	$0.80 m	$0.83 m

Aggregate revenue across the supply chain (growers, millers and harvesters) was predicated to increase in both mill areas.

Of this aggregate revenue, grower income increased by $6 m for mill A and $3.3 m for mill B due to more tonnes (lower cane loss) and increased CCS (cleaner cane).

The remainder of the increase in total revenue accrued to the mill. This increase in revenue, combined with a decrease in milling costs, resulted in an increase in the miller's margin of about $2 m for mill A and $0.75 m for mill B. Harvesting costs rose for both mill areas due to the slower harvesting speed required to achieve clean cane at low cane loss.

Sandell and Prestwidge also used economic modelling to determine the impact of HBP adoption in the Mourilyan sugar mill region. Results showed that while the region as a whole gained from HBP adoption, returns within the harvesting sector decreased (Sandell & Prestwidge, 2004).

Payment system

Currently, the most widely accepted payment system is an agreed price per tonne. As demonstrated, the benefits of adopting HBP do not accrue uniformly to each sector within the industry. For example, the benefits of improving cane and raw sugar quality are largely gained by growers and millers, while potentially imposing additional costs on harvester operators. The current harvester payment system also influences the adoption of improved farm layout. It has been shown that well laid-out farms are significantly cheaper to harvest than poorly laid-out farms (Sandell & Agnew, 2002). However, if all farms are charged at the same price for harvesting per tonne regardless of their layout, there is little incentive to improve farm layout.

The harvesting payment system is a key driver for HBP adoption. An alternative payment system, one that is cost reflective and provides the appropriate rewards and incentives to growers, harvesters and millers, may be warranted for improved harvesting efficiencies to be achieved. Advantages and disadvantages of proposed alternative payment options are presented in **Table 3**.

Data from harvester operator logbook information was used to compare the cost of harvesting for several different payment methods (Willcox *et al.*, 2005). The results indicated that the method of pricing by the hourly rate was sensitive to factors such as farm layout, field conditions, haul distance and crop size. Payment systems that are based on fuel use were found to be largely driven by farm layout and crop yield. Notwithstanding, the method of pricing using a base rate plus fuel provided very weak signals.

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Table 3: Alternative harvesting payment options, consequences and incentives. *Source: Jones (ed.) 2004 p. 34–36.*

Payment system	Advantages and disadvantages (advantages in bold)	Consequences	Feasibility and attractiveness
1. Dollars per tonne cane	• **Widely known system.** • **Easy to administer as relates to tonnage along supply chain—not open to abuse.** • Inbuilt HBP disincentive rewards high speed harvesting. • Heavy cross-subsidisation of poor productivity. • No incentive for extra work or harvest quality. • Does not encourage improvements in farm layout. • Discounts the importance of the key parameter, namely, capturing the total tonnage of available sugar.	• Harvester will not perform a quality harvest as there are no incentives. • Grower will lose sugar in the field and may suffer stool/ field damage. • Miller will receive higher EM and incur higher costs.	• Currently feasible but results in significant losses along supply chain. • Does not create net incentives to maximise economic sugar. • Limited attractiveness.
2. Dollars per hour	• **Enables full HBP economic incentives to capture 'economically viable' sugar to flow to harvester and grower.** • **Allows automatic accounting for variable yield.** • **Enables full economic incentives to flow to growers from better farm design.** • **Encourages improved crop presentation.** • **Promotes closer pre-harvest planning between harvester and grower.** • Penalises growers distant from receival pads/ sidings, especially in wet weather. • Requires detailed accurate time recording by machine operators and authorisation by growers. • Opportunity for human error in recording of time. • Opportunity for unscrupulous charging of time by harvest operators.	• Harvester has power to agree to specific commercial incentives with grower and miller. • Grower faces greater risk of poor administration and time keeping, but will capture added revenues if arrangements are clear on contractual terms. • Miller will receive increased volume of clean cane with positive impact on net revenue.	• Currently feasible and commercially attractive. • Requires enhanced pre-harvest planning and contractual arrangements between the parties to agree on how time will be managed and risks and returns allocated.

Payment system	Advantages and disadvantages (advantages in bold)	Consequences	Feasibility and attractiveness
3. Base price + fuel ($/t + fuel supplied by grower)	• **Easy to manage for both fuel and tonnage.** • **Partially accounts for farm layout variations.** • **Introduces flexible fuel pricing options.** • **Enables partial economic incentives to flow.** • Some cross-subsidisation of poor productivity. • Partial disincentive for extra work or harvest quality. • Limited incentive for improvements in farm layout.	• Harvester will focus on cost management rather than quality. • Grower assumes more cost risk without guarantee that harvester will capture maximum sugar. • The miller's cane supply and quality will not be improved.	• Currently feasible. • Focus will be on cost competitiveness, not on incentives to maximise sugar. • Limited attractiveness.
4. Quoted price using BSES Harvest/ Transport Model	• **Provides verifiable economic quotations.** • Significant effort required to understand and use the model the first time. • Needs annual review, possibly between harvest rounds to recognise changes in yield estimates.	• Uncertain, subject to components of model.	• Uncertain, subject to components of model.
5. Dollars per hectare	• **Easy to administer based on agreed field areas** • **Makes harvester budgeting easier as revenues are known.** • **Grower's costs are known.** • Inbuilt disincentive rewards high speed harvesting. • Enables cross-subsidisation of poor productivity. • Limited incentive for extra work or harvest quality. • Limited incentive to improve farm layout.	• Harvester will focus on cost management. • Grower will lose sugar in the field. • Miller's cane supply and quality will not be improved.	• Currently feasible. • Focus will be on cost competitiveness, not on incentives to maximise sugar. • Limited attractiveness.
6. Floor price	• **Enables some flexibility as rate reverts to an hourly base if t/ha is low.** • **Uses the BSES Rate Calculator Model as a starting point.** • A bet each way—implications are likely to be too complex and risky for growers and harvesters. • Requires prompt and accurate tonnage and area feedback and monitoring to work.	• Harvester will focus on cost management. • Grower will lose sugar in the field. • Miller's cane supply and quality will not be enhanced.	• Currently feasible. • Focus will be on cost competitiveness, not on incentives to maximise sugar. • Limited attractiveness.

Payment system	Advantages and disadvantages (advantages in bold)	Consequences	Feasibility and attractiveness
7. Dollars per tonne of sugar	• **Directly links maximum whole-of-chain revenue to harvester incentives for harvest quality.** • Difficult to manage as sugar varies across mill areas. Geographic harvest options required. • Growers fear loss of harvest equity from geographic harvesting. • Technology constraints—difficult to accurately measure and monitor sugar at the harvester. • Complicated by delay in delivery to the mill and loss of quality—24-hour transport scheduling.	• Would deliver optimum net incentives to all parties but only where the payment system was reset to better allocate benefits.	• Feasible, subject to payment system realignment. • Most attractive option.
8. Pay direct economic incentive for adoption of HBP ($0.5/t + share of net revenue gains)	• **Establishes a clear, pre-agreed, attractive economic reward for harvest performance based on specified field practices and maximum sugar recovery.** • **Amenable to current cane payment arrangements.** • **Allows flexibility for parties to agree locally in mill area.** • Needs to be negotiated by parties on a mill area basis, including sharing of net gains to growers, and millers. • Does not fix all the inadequacies of the current payment system.	• Will result in immediate positive change in practice, quality of harvest, and economic flow on to growers and millers. • May result in additional harvest tonnage and extension of season length.	• Currently feasible and commercially attractive. • Focus will shift from cane pricing to revenue maximising.

Implementing Harvesting Best Practice

Implementing Harvesting Best Practice

Origins of Harvesting Best Practice

Research conducted in the area of harvesting over a number of years has investigated many aspects of cane harvesting. Some key findings included:

- Harvester cane loss is strongly linked to extractor fan speed (see the **Reducing harvester losses** section).
- EM is controlled by harvester pour rate (see the **Reducing harvester losses** section).
- Field conditions have the most impact on EM and cane loss (see the **Reducing harvester losses** section).
- Pour rate and ground speed have a direct impact on ratoonability (see the **Reducing harvester losses** section).
- High basecutter speed at low forward speed reduces ratooning and increases blade wear (see the **Fundamental components of a harvester** section).
- High forward speed at low basecutter speed significantly reduces ratooning and increases soil in cane supply (see the **Fundamental components of a harvester** section).
- To minimise damage to the crop stalk and stool, basecutter blades should have a sharp, square, cutting edge and be kept as long and as thin as possible (see the **Fundamental components of a harvester** section).
- Reducing billet length is increasingly used as an 'easy fix' for load density but cutting shorter billets will result in more loss per cut. It also produces billets that are predisposed to post-harvest deterioration and are more likely to split during chopping and be lost via the extractors (see the **Fundamental components of a harvester** section).
- Billet quality quickly reduces as blade sharpness deteriorates (see the **Fundamental components of a harvester** section).
- Where possible, cane should be topped to reduce the load on the extractors, for improved cleaning and less wear and tear on the machine (see the **Fundamental components of a harvester** section).
- Maximising row length, maintaining haul tracks and wide smooth headlands all improve farm layout (see the **Farming practices and their impacts on harvesting** section).
- Hill-up needs to be consistent and matched to the harvester's basecutter height and angle to minimise stool damage, cane pick-up losses and soil in cane supply (see the **Farming practices and their impacts on harvesting** section).

Harvesting losses

Cane production is affected by both harvesting and field issues, which can impact on raw sugar quality and quantity. Both harvesting efficiency and crop presentation affect cane yield, cane quality and crop ratooning. The biggest area of losses is in the harvesting of cane.

Losses through tops

As mentioned in the **Fundamental components of a harvester** section, cane should be topped, where possible, at the growing point to remove leaf material because tops increase EM, depress CCS and reduce sugar quality.

Losses through leaf

Harvest best practice research has shown that crop and field conditions, weather conditions and pour rate determine EM levels. The operator lowers EM by lowering the pour rate—fanspeed dictates cane loss levels, not EM—however, this increases the cost of harvesting.

Stalk losses

Stalk losses occur in almost every part of the harvesting process—when they are gathered and as they pass through the basecutters, chopper box and extractors—as outlined in the **Fundamental components of a harvester** and **Reducing harvester losses** sections. However, the greatest source of sugar loss is through the harvester's cleaning system (see the **Reducing harvester losses** section). Field trial data in **Table 1** shows the percentage of the crop lost at different fanspeeds and the financial cost of losses for a 1000-hectare harvesting group (e.g. at a 100 t/ha average yield, this would represent a 100 000 tonne harvesting group).

Simply reducing fanspeed from 1050 rpm to 900 rpm can reduce the crop loss by 6.4 per cent as more cane is picked up. This can be seen as increased clean cane yield. By accompanying this with a reduced pour rate, cane loss can remain significantly low and cane quality high, providing the grower with an increased net income.

Table 1: Percentage cane loss and financial loss at different fanspeeds.

Fanspeed rpm	% Loss	$ Loss/1000 ha
950	7.1%	$475 000
1050	16.0%	$1 080 000
720	3.6%	$210 000
900	9.6%	$560 000
760Primary	3.4%	$220 000
760Primary and secondary*	10.5%	$680 000

** Bigger secondary blades can cause excess cane loss.*

Note: Some losses are unavoidable. On average, the process of cutting cane (basecutters and chopper knives) results in losses of three to five per cent.

Due to increasing costs, pour rates have doubled since 1997, resulting in higher levels of stool damage and EM. Research has shown that reducing pour rate and ground speed will improve ratoonability and reduce EM levels. However, with the current payment system, an incentive needs to be put in place for this to be appropriately feasible.

To make more efficient use of the cane transport system, mills have been encouraging higher bin weights, which pushes operators towards shorter billet length. The downside of this is that shorter billets are prone to more damage, resulting in higher cane and juice losses as well as potential deterioration problems. Trials conducted in the past showed that a longer billet (204 mm versus 175 mm) produced 10 per cent lighter bins but CCS was increased by 0.22–0.32 units and sugar yield was 0.5 t/ha higher. However, penalties for 'low' bin weights are at odds with this strategy.

Crop ratooning losses

With an ever-increasing pour rate and ground speed due to decreasing harvester numbers and increasing group size, a new form of loss is emerging with yield reductions in the following season.

The improved monitoring of harvesting activities through the use of GPS and GIS has enabled the industry to quantify the effect of pour rate on the ratoon cycle.

Two years of cane block productivity data and ground data was collected from harvester GPS units. Averaging the change in yield from one year to the next (at various pour rates from thousands of cane blocks) it can be seen that pour rates and/or ground speed have a predictable impact on subsequent ratoon yields (**Figure 1**).

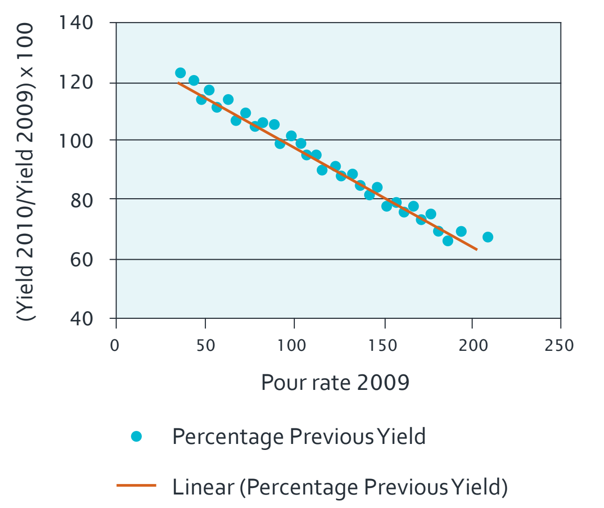

Figure 1: Pour rate versus subsequent productivity.

Note: The vertical axis is an index, not a yield figure. It was obtained by dividing the yield in 2010 by the yield in 2009 and multiplying the result by 100.

If this correlation can be shown to be valid over a number of seasons, it would indicate that a 25 per cent reduction in pour rate from 120 t/h to 90 t/h would result in a 10 per cent increase in yield in the following season. Although this relationship requires verification over a number of seasons to be reliable, it provides an insight into the detrimental effect that high pour rates have on the ratoon crop.

Economics of implementing Harvesting Best Practice

As mentioned in the **Economics of Harvesting Best Practice** section, the costs and benefits of HBP adoption include changes in cane loss and CCS as well as changes to harvester operating practices, such as fuel use and labour. The sharing of proceeds between growers, harvesters and millers can be calculated using the cane payment formula, an assumed sugar price and harvester pay rate.

In 2003, economic modelling of HBP was conducted at a sugar industry workshop (see Jones [ed.], 2004), the results of which are presented here. The modelling was based on actual data from two mill areas referred to as mill A—a central district mill of about 2 Mt annual crushing capacity; and mill B—a wet tropics mill of about 1 Mt crushing capacity. Key assumptions that were used in the modelling are described in **Table 1** (from the **Economics of Harvesting Best Practice** section).

Table 1: Model assumptions. *Source: Jones (ed.) 2004.*

	Mill A		Mill B	
	Base case	**HBP**	**Base case**	**HBP**
Crop delivered to mill (Mt)	1.91	1.95	1.15	1.18
CCS (units)	13.84	14.92	13.23	14.21
Season length (weeks)	19.01	19.01	20.32	20.32
Row length (m)	400	400	200	200
Group size (t)	60 000	61 315	33 000	33 865
No. of haulout units active	3	3	2	2
Average forward speed harvesting (km/h)	8	5	8	5
Average infield haulout distance (km)	3	3	1.5	1.5
Haulout bin capacity (t)	10	11	10	11
Average haulout ground speed (km/h)	25	25	25	25
Sugar price paid to grower ($/tc)	23.34	25.85	21.94	24.21
% cut as green cane	98	98	98	98
Average crop size (t/ha)	92	92	98	98
EM (%)	13.0	6.7	13	7.1
Cane loss (%)	16.5	8.5	16.5	8.5

The change in grower income, miller gross margin and harvesting costs under HBP for mill area A and mill area B is summarised in **Table 2** (from the **Economics of Harvesting Best Practice** section).

Table 2: Financial model results: Mills A and B – HBP compared to base case. *Source: Jones (ed.) 2004, p.26.*

	Mill A	Mill B
Grower income	$6.00 m	$3.30 m
Miller margin	$2.00 m	$0.75 m
Harvesting costs	$0.80 m	$0.83 m

Aggregate revenue across the supply chain (growers, millers and harvesters) was predicated to an increase in both mill areas.

Of this aggregate revenue, grower income increased by $6 million for mill A and $3.3 million for mill B due to more tonnes (lower cane loss) and increased CCS (cleaner cane).

The remainder of the increase in total revenue accrued to the mill. This increase in revenue, combined with a decrease in milling costs, resulted in an increase in the miller's margin of about $2 million for mill A and $0.75 million for mill B. Harvesting costs rose for both mill areas due to the slow harvesting speed required to achieve clean cane at low cane loss.

Currently, the most widely accepted payment system is an agreed price per tonne. As demonstrated, the benefits of adopting HBP do not accrue uniformly to each sector within the industry.

The current harvesting payment system is a barrier against HBP adoption. An alternative payment system, one that is cost reflective and provides the appropriate rewards and incentives to growers, harvesters and millers, may be warranted for improved harvesting efficiencies to be achieved. Advantages and disadvantages of proposed alternative payment options are presented in the **Economics of Harvesting Best Practice** section.

Implementing Harvesting Best Practice

Applying best practice is not simple. For example, there are no sliding rules or databases that determine HBP payment rates. Longer crew hours due to lower pour rates aren't easy to negotiate for compliance with workplace health and safety guidelines. A tonnage-based payment system for harvest contractors and employees in some cases may not facilitate a best practice harvest operation. The fluctuations of crop yields and prices make analyses of best practice harvesting scenarios difficult.

An ideal harvest will strike a profitable balance between harvest price and harvest job quality. The first step to achieving HBP is to plan the harvest. The harvest plan should be developed jointly by the growers and the harvest contractors, and it is important that all parties be clear and upfront on the plan.

The following should be addressed:

- Clear definition of the harvesting job the growers expect from the contractors.
- Harvest price quote from the contractors based on the harvesting description outlined by the growers.
- Assess the cost of harvest.
- Negotiations between the growers and contractors to find the optimum balance between the harvesting job, price and grower returns.

Points to consider are:

- field conditions
- farm harvest efficiency
- daily harvester allocation
- season length
- harvest days.

The above points are all related to:

- crop yield
- farm layout
- haul distance
- mill crushing capacity
- group tonnage
- area tonnage
- rostered days off.

The main questions for the group to consider when adopting a harvest plan include:

- Is the quality of the planned job satisfactory?
- Does the planned harvest comply with workplace health and safety guidelines?
- Does the planned harvest allow the crew an opportunity to carry out HBP?
- Is the harvest price reasonable for the quality of the job?

The key to implementing the plan on the farm is to ensure that it has the support of the harvest crew. Generally, harvest plans that have realistic expectations of job quality and crew work conditions will be received well by the harvest crew.

Record keeping completes the planning and harvest management circle by providing feedback on the harvest and measuring the effectiveness of the harvest plan.

Planning the harvest

Planning the harvest will ensure that:

- The harvesting contractors knows what job quality the growers expect
- This standard is obtainable
- This standard is affordable.

To develop a harvesting plan, the group needs:

- A clear definition of the harvesting job the growers expect of the contractors
- An estimate of the impact of field conditions on harvester productivity
- A harvesting price quote based on the harvest job description.

Points to consider when developing a harvest plan:

- daily harvester allocation
- season length
- harvest days
- field conditions
- workplace health and safety compliance
- mill scheduling compliance.

These points are also related:

- mill crushing capacity
- group tonnage
- crew rostered days off.

Develop a number of harvest plans by:

- Using harvest logbook data
- Using the experience of harvester owners/operators, growers, and mill staff
- Using local productivity data and the experience of productivity services.

Rate the plans against the following criteria:

- Harvest job quality provided
- Workplace health and safety compliance
- Cost
- Mill scheduling compliance.

Select the harvest plan that provides the highest possible job quality with fair and safe working conditions for the crew at a price that is acceptable.

Record harvest performance with logbooks/data logging systems to measure the actual performance compared to the planned performance. This method will allow more accurate planning in the future.

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Milling and sugar quality

Milling and sugar quality

Refiners require a reliable supply of consistent, quality, raw sugar. The Australian sugar industry has a long-held reputation among refiners around the world for its consistent supply of high-quality raw sugar. However, it must be recognised that the sugar quality of other countries continues to improve, and that for various reasons they can produce sugar with characteristics that suit many customers.

For instance, ethanol production allows numerous Brazilian mills to produce a high-purity sugar from a lower quality material. This type of sugar appeals to some customers, and suitably equipped Brazilian millers can produce it with less concern for higher sugar losses to molasses as these enhance yield in the production of ethanol. Other countries are able to produce sugar with lower colour and ash content due to the nature of the cane supply.

Queensland Sugar Limited (QSL) has a Raw Sugar Quality Scheme that categorises raw sugar into two categories.

- Premium Customer Grade – meets all 10 quality criteria and attracts a premium bonus payment.
- Below Premium Customer Grade – fails to meet one or more of the quality criteria. This sugar attracts the pool price and in some cases may incur a price discount.

This scheme aims to encourage the production of a high-quality and consistent product to enhance marketing and logistics with the aim of improving outcomes for participants. Any sugar marketing arrangements outside QSL will also typically have sugar quality agreements between millers and customers, which may have a financial component.

Regardless of the marketing mechanism used, any reduction in sugar payment through sugar quality deficiency may result in a reduction in the value of cane. In a competitive world sugar market, it is important that the Australian sugar industry continues to produce sugar that can be differentiated from other countries in its overall quality and consistency.

The quality of cane supply can have a significant impact on the value chain. Mechanised cane harvesting in Australia has increased the amount of tops, trash and soil in the cane supply. EM in cane supply can have a negative effect on factory operations, which can flow on to equipment wear rates, transport efficiency and cost, lost factory time and season length, and sugar quality. Many of these issues can be influenced by and can affect growers.

This chapter discusses the impact of cane quality on factory operations and the potential implications for growers.

Milling throughput and efficiency

The throughput of cane through the mill is related to the cane solids that can be processed. An increase in the volume of fibre processed because of higher EM reduces the crushing rate of the mill and can be a factor in prolonging the crushing season.

High dirt loading causes severe wear to shredders, rollers, carriers and boiler station equipment, reducing efficiency and increasing maintenance costs. Higher wear rates increase the time required to maintain equipment during planned stops and increase the likelihood of failure resulting in unplanned stops. Failures in the feeding, crushing and boiler stations are often long and costly.

Clarification can be adversely affected by excessive dirt content and deteriorated cane. It is also overloaded by excessive quantities of dirt in the cane supplied for crushing. Poor clarification can affect raw sugar quality and increase the fouling rate of the evaporators to the point where they become factory-rate limiting. More frequent and longer stops are required to chemically clean the evaporators, with the additional expense of extra steam consumption.

High soil loadings can cause the capacity of mud handling and filtration equipment to be exceeded, resulting in a reduction in milling throughput. Large amounts of soil can reduce the separation efficiency of bagacillo collectors, which can further diminish the capacity of mud filtration equipment. The combustion efficiency of the boiler station is reduced with high soil loadings in bagasse, which can lead to furnace instability resulting in steam generation issues and lost crushing time. Soil is a primary cause of boiler wear, which increases maintenance needs and costs, and can result in significant lost time events.

Sugar loss in bagasse, mud and molasses is greater as levels of EM and soil increase in the cane supply. Industry profitability is reduced by increased sugar losses.

Sugar quality parameters

Pol

Pol is a measure of the sucrose content of the raw sugar. It is a primary characteristic of interest to sugar buyers and is a significant determinant of sugar price. Buyers will have a preference for the pol of sugar they receive according to their business needs and/or trade restrictions. Some refiners seek high pol sugar because it is more likely to have lower concentrations of impurities (such as ash and dextran) which will decrease their refining costs. Others will prefer sugar within a lower pol range in order to satisfy the trade requirements of the country they are operating in.

High levels of EM can have a negative effect on factory processing, which, in turn, limits the ability to make higher pol sugars, and can make pol control on other sugar pol levels more difficult.

Colour

Colour is ranked highly by customers when determining sugar quality and price. Colour in raw sugar must be removed during refining, because residual colour in refined sugar lowers its value.

Primary sources of colour are pigments and other compounds produced within the plant. These may interact during processing to produce more coloured compounds, or increase the colour intensity of those already present.

EM contains considerable amounts of colour. On average, tops and trash have, respectively, about seven and 36 times as much colour as the cane stalk. While the colourants involved are readily removed in conventional clarification processes, high amounts of these and other impurities can overload the clarification process. This results in increased colour in processed materials and, hence, in the sugar.

Ash

Ash is the inorganic component of raw sugar. Soluble ash is primarily related to materials taken up by the plant during growth (such as soil nutrients), and is not readily removed in clarification. It increases the loss of sugar in molasses in both mills and refineries, and is seen as a characteristic of high importance by refiners. Cane tops have been shown to have a higher ash per unit impurity than cane, and high topping of cane can increase soluble ash in sugar.

Insoluble ash is primarily related to soil in cane that was not removed in clarification. It can affect the separation of the crystal and molasses in mills, and affination and filtration processes for refiners. While most soil types can be effectively removed during clarification, excessive soil can overload clarification and filtration equipment, resulting in poor clarification and soil in juice flowing on to become insoluble ash in sugar. Care should be taken to minimise soil in cane supply.

Dextran

Dextran is a natural polysaccharide produced by bacteria that infects the sugarcane billets after cutting or damage. The bacteria is present in soil and infection occurs at the time of harvest. The processes that result in dextran formation decrease CCS.

Dextran bonds to one face on the crystal and stops it from growing. As a result, the crystal shape changes to become longer and finer. As the number of affected crystals increases, impacts on pol control in raw and refined sugar manufacture are seen. Dextran-affected crystals also decrease the efficiency of impurity removal for refiners during affination. Dextran and related degradation products increase the viscosity of process materials, resulting in greater sugar losses in raw and refined sugar processing.

The level of bacterial action increases with available surface area for the bacteria to infect. Greater surface areas are provided by shorter billet lengths, and split and damaged billets. The risk of dextran formation can be minimised by maintaining adequate billet length, good basecutter blade and chopper knife condition, and a basecutter speed appropriate for the harvester ground speed. Action should be taken to correct issues resulting in billet damage or splitting as soon as practicable after it is noticed.

Cane that is damaged by lodging, rodents or insects can become affected by the bacteria and have elevated dextran levels. Burnt cane can deteriorate faster than green cane, and dextran could form before harvest in cane that has been burnt.

Starch

Starch levels are important to sugar refiners. High levels of starch increase the cost of refining by slowing the filtration of sugar syrups. In raw sugar manufacture, natural enzymes and enzymes added to the process break down starch to simpler carbohydrates. Higher starch levels require additional enzyme treatment, which increases costs.

The leaves and tops contain significantly more starch than the cane stalk. Minimising excessive leaves and tops in cane supply makes achieving appropriate starch levels in raw sugar easier.

Filterability

The test primarily responds to the presence of insoluble impurities (such as insoluble ash) and some soluble impurities such as dextran, gums and soluble phosphates.

Poor clarification and deterioration products such as dextran are typically the two biggest variables affecting filterability. Green cane harvesting improves filterability through being less susceptible to the formation of dextran and other degradation products.

The maintenance of adequate filterability levels are aided by low levels of soil and other EM in cane supply, and undamaged billets of appropriate length.

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Trash separation and recovery systems

Trash separation and recovery systems

Background

Sugarcane trash separation or cane cleaning is a complementary technology to mechanical harvesting, particularly where the move to machine harvesting is being driven by environmental or regulatory conditions.

Cane burning has been used in many industries as a means of eliminating a large proportion of EM prior to harvest. In hand-cut industries, this strategy is used to significantly enhance cutter productivity and minimise health and safety issues with vermin. In machine-harvested industries, a pre-harvest burn enhances machine feed capability in larger crops.

Despite these nominated benefits, pre-harvest (and post-harvest) burning of crop residues is rapidly becoming an unacceptable practice for environmental reasons, both in the Australian sugar industry and internationally. Conversely, green cane harvesting eliminates the pollution issues associated with burning, but also offers the potential for the crop residues to be utilised for agronomic benefit or to be utilised as an additional resource.

Losses associated with green cane harvesting

Loss of cane is an inevitable part of the process of separating trash from cane **on the harvester**, because of the significant constraints which are inherent in the design of modern high performance harvesters. Whilst harvester manufacturers use the best technology available, fundamental issues relating to space constraints and material presentation to the extraction chamber mean that:

- Some cane loss is unavoidable as intertwined leaf is drawn from the clumps of billets traversing the extraction chamber. Data indicates that around 50 per cent of the trash can be removed with minimal loss of cane, however, as the aggressiveness of the extractor settings and pour rate increase, cane loss increases dramatically.
- Even under ideal harvesting conditions, harvester extractor systems can remove only a proportion of the leaf material. As field conditions deteriorate and harvester pour rates increase, higher levels of leaf remain with the cane, even at aggressive extractor settings.

Results from a large number of cane loss trials and the parameters impacting on cane loss are discussed in the **Reducing harvester losses** section in this manual. This data is highly consistent with international experience.

In **Figure 1** below, the relationship between harvester extractor settings and both cane loss and trash levels in delivered product is demonstrated. The pour rate of the harvester in these trials was approximately 80 t/hr, which is very conservative and facilitates good cleaning.

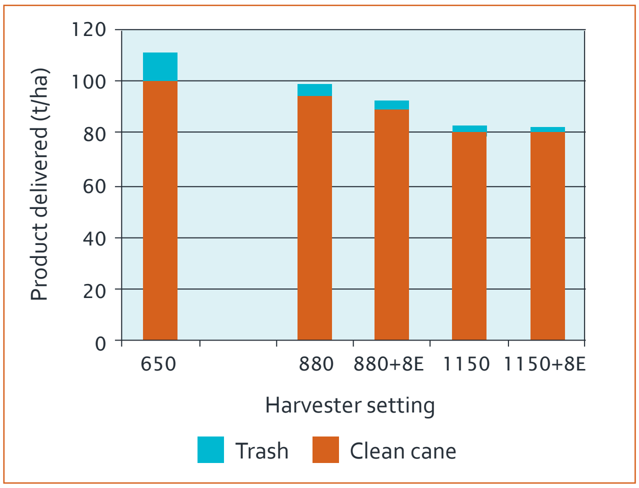


Figure 1: Results of an evaluation trial on a current model harvester in Papua New Guinea, indicating the increase in cane loss (as indicated by reduced delivery of clean cane billets) associated with increasing harvester extractor fan settings.

Figure 1 illustrates that:

- The trash levels at the low fan speed setting '650' indicated that approximately 50 per cent of the leafy trash was extracted at that extractor setting, with approximately 9 t/ha of leafy trash delivered to the mill. A similar amount was left in the field.
- As the harvester extractor settings became more aggressive, trash levels were reduced, but the reduction in delivered cane was more dramatic. Increasing extractor fan speed reduced trash levels by approximately 7.5 t/ha (to <2 t/ha in the product delivered to the mill) however approximately 20 t/ha of cane was also extracted.

Cane loss is essentially invisible, as billets are generally dissociated as they pass through the extractor fan. Several well-conducted studies have shown that less than 20 per cent of the cane lost through the harvester extractor will be typically found as 'visible' cane stalk components in the trash after harvest. More recently, measurement of the sucrose left in the field on leaf and as small particles has allowed cane losses to be positively determined, and correlates with measured reductions in cane yield.

Relative to a reference of common contemporary harvester operation, each additional tonne of trash, sent with cane to the mill as a result of reduced extractor fan speed, has an associated increased cane recovery of between two and five tonnes, depending on harvest conditions.

The inclusion of a separate cleaning operation between the harvester and the mill allows a substantial increase in total industry value. The post-harvest cleaning allows the harvester operator to utilise settings of the extractor system which minimise cane loss whilst still achieving an acceptable level of trash on the field for a viable trash blanket. The combination of higher total cane delivery and the improved cleanliness of the cleaned cane means the losses are reduced and total sugar recovery increases.

The more significant benefits of post-harvest cane cleaning in the cane production system include:

- Reduced harvesting losses, as the trash extraction system does not have to be operated aggressively to achieve clean cane.
- Increased sugar recovery because of the reduced cane loss on the harvester and the increased recovery of sucrose from the cane being milled.
- An increase in the biomass available as a fuel for co-generation or as a feedstock for higher value processes.

Post-harvest cane cleaning provides:

- **Reduced harvesting losses**
- **Increased sugar recovery**
- **Increased biomass for fuel or feedstock.**

These benefits will be discussed further in this section which will also cover the following topics:

- Overview of trash separation and recovery processes
- Overview of trash separation and recovery systems development
- Impacts of trash separation on the overall cane production system, including harvesting, transportation, and milling functions
- Benefits that trash separation has had on other countries
- The benefits of trash separation for the Australian sugar industry.

The process of sugarcane trash separation and recovery systems

The process of sugarcane trash separation and recovery, as applicable to machine harvesting, can be divided into three options:

- separate collection and delivery systems
- integrated delivery systems
- hybrid systems.

Separate collection and delivery systems

For separate collection and delivery systems, the following sequence of activities is performed:

- Sugarcane is cleaned by the harvester.
- Billeted cane is transported to the mill.
- Trash is separately baled and transported to the mill.

The option of separate collection and delivery of trash, while providing maximum flexibility for trash collection, is subjected to harvester cane losses, EM delivered with the cane, and additional field operations, when compared to the integrated and hybrid types of delivery systems.

Although post-harvest trash recovery using a separate collection and delivery system is undertaken in some overseas industries such as Brazil, Argentina, the Philippines and South Africa, this system has not been considered a cost-effective option in Australia. Examples of both separate collection and trash delivery systems are shown below.

Above: Post-harvest collection in Brazil.

Above: Loose trash transport in Ubombo, Swaziland, after mechanical loading.

Integrated delivery systems

For integrated delivery systems, the following sequence of activities is performed:

- Minimal or no cleaning of sugarcane is performed by the harvester.
- Cane and trash are transported together to the mill.
- Cane is cleaned from trash at the mill.

The integrated delivery system requires a trash separation or cane cleaning system at the mill. With this option the additional field operations of separated trash collection are avoided, however there are associated cane transport cost increases due to the lower product density of cane and trash being transported together to the mill.

Hybrid systems

For hybrid systems, the following sequence of activities is performed:

- Minimal or no cleaning of sugarcane is performed by the harvester.
- Cane and trash are separated near the field.
- Billeted cane is transported to the mill.
- Trash is separately transported to the mill or other location.

The hybrid system aims to mitigate the disadvantages of both the separate collection and integrated delivery systems. It does this by avoiding harvester extractor losses while providing a cleaner cane product to the mill, and alleviating load density issues inflicted on the cane transportation network.

Development of trash separation and recovery systems

1st generation systems

Cane cleaning stations for mechanically harvested cane were developed in Cuba in the mid-1960s in the face of acute labour shortages. The dry-cleaning stations, or *centros de acopio*, took sugarcane loaded mechanically at the fields, sorted it and removed EM.

The Cuban cleaning stations were designed to take in green machine-cut cane or green manually cut cane, where trash is removed from the stalk and blown out into a storage area while the clean cane stalks travel along a conveyor to awaiting rail cars (Larson, 1994).

The 'supplementary' leaf separation at cane cleaning stations was introduced to compensate for the limited performance of the harvesting fleet, by further cleaning the cane prior to transportation to the mill. Towards the end of 1970s, nearly 500 of these stations were operating and by the early 1980s, there were 607.

At their peak, Cuba had more than 1000 cane cleaning stations that processed all of the cane crushed in its 156 factories.

The cleaning stations are generally not located adjacent to the mills, but are connected to the mills by a rail network. They are essentially a hybrid system. The cane cleaning stations are used in conjunction with chopper harvesting to improve the quality of cane being delivered, while minimising cane loss on the harvester, as shown below.

Above: Cuban cane cleaning plant.

2nd generation systems

In Brazil, 2nd generation trash separation and recovery systems arrived in the late 1990s, coinciding with its transition from burnt hand-cut to green hand-cut cane. These systems were full feeder table-width systems; many of the initial designs attempted to be suitable for both hand-cut (whole stalk) and chopper-harvested cane. Although useful in cleaning up the cane supply, actual trash separation efficiency was low and power consumption was high.

3rd generation systems

The 3rd generation of trash separation and recovery systems also originated within the Brazilian sugar industry. One of the most intensive efforts to understand and design trash recovery, transport and advanced electric power generation systems was carried out in Brazil from 2000 to 2008 by the Copersucar Technology Centre (CTC).

A Brazilian paper titled, 'Análise de seis sistemas de recolhimento do palhiço na colheita mecânica da cana-de-açúcar' or 'Analysis of six systems of trash recovery in mechanical harvesting of sugarcane' (Michelazzo & Braunbeck, 2008), states that the recovery of sugarcane trash faces high recovery costs, which are related to the gathering, baling, transportation, and residue utilisation technology.

The same paper's results find that 'integral harvesting' has the lowest cost for trash recovery, over other options such as baling, pellet, and briquette systems. The integral harvesting method is synonymous with low-loss harvesting (of cane and trash) and separation of the trash, whereby the gathering and baling phases of trash are not required.

The need for factory-based trash separation was driven by co-generation and identified through research from organisations such as CTC. Several 3rd generation systems are installed throughout Brazil to capitalise on the value of trash for co-generation and to enhance the throughput and sugar recovery performance of the mills. Examples of these trash separation and recovery systems are shown in the Raizen-owned mills below.

Above: Trash removal systems at four Raizen sugar mills in Brazil.

Brazilian mill's 3rd generation trash separation systems are large 'double-drop' installations, which were developed to operate on the cane carrier. The images below and to the right show an example of such a system at a Brazilian mill.

Above: Double-drop trash separation at a Brazilian mill.

Above: Trash recovery chamber at a Brazilian mill.

Current (4th generation) trash separation systems

The current or 4th generation of trash separation technology is aimed at maximising trash extraction efficiency while essentially eliminating loss of cane during the cleaning process. The current technology systems incorporate the following processes to achieve high levels of separation and efficiency:

- Mechanical pre-separation of the leafy components as it enters the extraction or separation chamber by the action of the kicker unit.
- 'Complementary flow' technology which maximises the efficiency of the pneumatic separation process of trash and soil from the cane stalk.
- A high-energy air jet to maximise component separation (of trash from cane stalk).
- High levels of induced airflow to scavenge the separation chamber and transfer separated trash out of the chamber.

The latest generation provides a 'downsizing' of trash separation system technology, and as such has resulted in two applications:

- Mill-based trash separation system and recovery systems.
- Field-edge trash separation system and recovery systems.

4th generation mill-based trash separation systems

The 4th generation trash separation systems can achieve similar or superior separation performance compared to larger double-drop systems and 3rd generation systems, at a fraction of the installation and operating costs.

The smaller footprint of 4th generation systems allows existing mills and cane yards to retrofit high-performance pneumatic trash extraction systems into current mill facilities, with minimal rearrangement of cane receival layouts compared to the much larger 3rd generation systems.

4th generation cane cleaning systems achieve very high levels of trash removal from the cane supply (greater than 85 per cent under most conditions) with very low levels of cane loss (typically greater than 0.3 per cent), whilst having very conservative power consumption when compared to 3rd generation systems.

4th generation separation technology has been installed at several mills overseas. The system depicted in the images below is located in Pakistan and processes 250 tonnes per hour (of cane after cleaning) and provides the trash for co-generation purposes.

Above: Trash separation system, Pakistan.

Above: Trash recovery system, Pakistan.

Another example of 4th generation trash separation technology is installed at Ubombo Sugar Mill in Big Bend, Swaziland, as shown in the image below.

Above: Trash separation system at Ubombo Sugar Mill, Swaziland.

Trash separation systems are not new, although:

- **Drivers for such systems have evolved over time.**
- **Separation efficiencies have improved over time.**

4th generation field-edge trash separation systems

Hybrid systems for trash collection and delivery avoid the disadvantages incurred by using either separate trash collection methods or integrated delivery systems. Field-edge separation provides a hybrid system solution. Examples of a field-edge separation system are shown in the images below.

Above: Field-edge trash separation unit.

Above: Field-edge separation unit in operation.

Drivers for trash separation and recovery systems

The main drivers for trash separation and recovery systems include:

- Reducing harvesting losses
- Reducing fibre levels from green cane harvesting and the associated effect on mill cane crushing rates and recovery
- Maximising sugar recovery per hectare
- Avoiding transportation load density issues associated with green cane harvesting.

Increased fibre effecting crushing rate

As shown in **Figure 7** in the **Reducing harvester losses** section, the EM in green cane has increased dramatically in recent years. Increased amounts of EM delivered to the mill, and subsequent high fibre levels, are effectively slowing the cane rate during the mill crushing process.

The impact of total EM on the milling rate of the delivered product, expressed in terms of the milling rate of the clean cane component, is demonstrated in **Table 1** which details a dataset from trials at the Mossman Mill in North Queensland (Collie, 2000).

Increased sugar recovery

Increasing trash levels reduce the milling rate and the total sugar recovery. The quality and value of the sugar produced is also degraded. By using low harvester fan speeds alone, the gross yield (tonnes/ha) is increased, but the reduction in CCS—as a result of the increased EM—reduces the benefit. Increasing levels of EM, including soil and trash in cane supply, is a problem for both growers and millers.

The freshness and cleanliness of cane are essential to maximising sucrose recovery and sugar quality. Leaf material in the product being milled increases the 'non-sucrose' components in the juice, thereby increasing losses to molasses and potentially reducing filterability. Ash and colour levels in the sugar also increase. The elevated fibre level from leaf matter reduces effective milling capacity and increases losses to bagasse.

Recent international work suggests that much of the benefit, of simply reducing cane loss on the harvester by reducing trash extraction, is lost at the mill.

This is due to reduced sugar recovery attributable to increased levels of fibre and non-sucrose components in the juice.

Green cane harvesting systems incorporating post-harvest trash separation increase the freshness and cleanliness of the cane, whilst reducing the amount of fibre, to well below that typically achieved through harvester based separation using extractors. The composite effect is higher factory throughput and significantly higher total sucrose recovery per hectare harvested than can be achieved from either green cane harvesting without post-harvest separation or from burned cane harvesting.

In recent Australian trials, low harvester extractor fan speeds plus cleaning of the cane significantly increased sugar recovery because of the increased CCS of cleaned cane.

Trash separation reverses the impact of elevated trash levels associated with typical 'commercial' harvester settings on fibre levels and the ratio of recoverable sugar and fibre milled. Using only 'low cane loss' harvester extractor settings reduces obtained CCS compared to commercial practice due to the increased fibre levels. It is only when a low cane loss harvester operation is coupled with a trash separation system—'low cane loss + cleaning'—that maximum CCS is achievable.

Trash separation in conjunction with low harvester extractor fan speeds maximises CCS of the cane delivered and total sugar recovery.

Mitigate transport load density issues

The increased trash levels associated with green cane harvesting in the cane supply reduces load density, which then impacts on transport costs and often on the capacity of the cane receival system at the mill. Cane transport systems for billeted cane are primarily volume-limited transport systems with bin volume determined to give close to maximum allowable axle loadings with 'typical' product.

In the initial move to chopper-harvested cane, the crop was burned prior to harvest and the early harvesters typically produced a billet length of approximately 300 mm. This resulted in load densities in the order of 360 kg/m^3 in 'average' crops. The mill transport system, along with field transport systems, were devised to achieve design payload with this load density.

Table 1: Effect of clean cane on factory crushing rate.

	Experiment 1		Experiment 2		Experiment 3		Experiment 4		Experiment 5	
	Clean	Dirty	Clean	Dirty	Clean	Dirty	Clean	Dirty	Clean	Dirty
EM %	12.59	13.60	1.93	12.51	6.07	12.56	2.52	8.95	2.85	11.92
Fibre %	18.52	18.55	13.32	16.37	15.03	17.69	13.43	16.42	14.28	16.22
CCS	9.56	9.14	12.11	11.42	10.74	10.27	11.23	10.68	12.26	12.02
Crushing rate t/hr	361.0	331.0	395.0	349.0	363.0	342.0	384.0	348.0	336.0	318.0
Fibre rate t/hr	66.9	61.4	52.6	57.1	54.6	60.5	51.6	57.1	48.3	51.6
Crushing increase t/hr	30		46		21		36		20	

The move to green cane harvesting resulted in a downward trend in load density associated with increased EM levels in the delivered product. The strategy adopted by the industry has been to reduce billet length to increase load density. While reduced billet length does potentially give some limited enhancement in trash separation efficiency, it can also increase losses through the extractor system, based on the increase in aerodynamic drag associated with billet ends.

As billet length is reduced, even more significant losses are incurred through the billeting process on the harvester, and loss of recoverable sucrose through accelerated deterioration of the shorter billets. The move to shorter billet lengths (see **Figure 2**) shows the relationship between billet length and achieved bin weights.

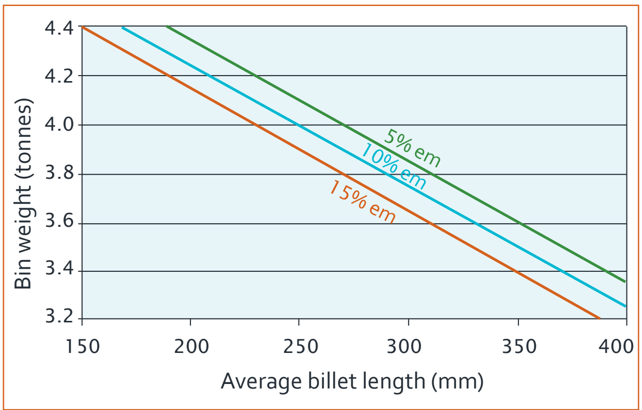


Figure 2: Impact of billet length and EM level on bin weight at South Johnstone. Note that only a proportion of the EM material is leaf.

Reducing trash levels increases load density in cane sent to the mill. The use of a hybrid system, such as 4th generation field-edge cleaning, can potentially allow an increase in billet length while maintaining bin payloads within desirable parameters. **Figure 3** shows load densities achieved with varying levels of trash content using commercial practice harvesting, low loss harvesting and low loss harvesting in conjunction with field-edge cleaning trash separation.

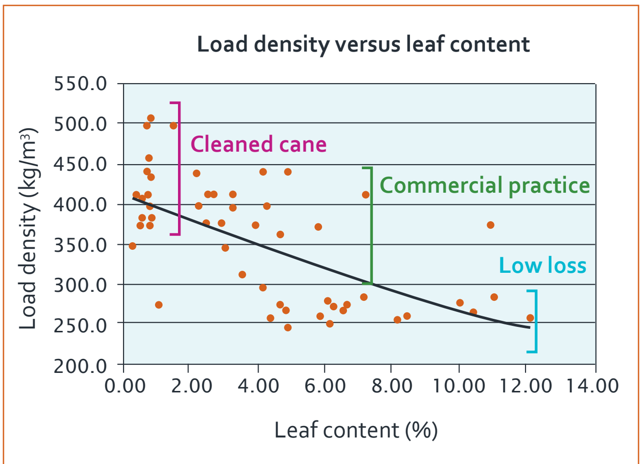


Figure 3: Load density versus leaf content.

Very high transport load densities are achieved with field-edge trash separation due to the absence of leafy material in the load.

The benefits that trash separation has had in other countries

Sugarcane trash separation is becoming an increasingly attractive proposition in countries where energy and labour costs are increasing or where pre-harvest burning of the crop is becoming more difficult due to environmental or regulatory conditions.

The problem of cane loss is more significant in developing countries. Typically the expectation is that the machine-harvested crop will be of similar characteristic—Pol, fibre etc.—to that of traditional hand-cut burned cane. The typical response to the higher leafy trash levels in machine harvested green cane is to maximise extractor speed.

Especially in industries forced to move away from burned-cane harvesting, the new requirement to manually detrash is a significant additional cost in the production of sugarcane and may affect industry viability. The benefits of incorporating trash separation into the cane production system of these countries' industries include:

- Reduced harvesting costs, as canecutters need only cut and top the green cane
- Reduced requirement for labour for harvesting due to increased cutter productivity
- An increase in the biomass available as a fuel for co-generation or as a feedstock for higher value processes.

Reduced manual handling costs

Approximately half the effort expended by a canecutter when cutting, stripping and windrowing green cane is used in the actual detrashing movements. This significantly reduces the potential productivity of a cutter and is especially noticeable in industries that may have been able to burn previously.

Where trash separation is used in hand-cut industries, the manual harvest requirement is having the cutter only cut and top the cane, therefore approximately doubling its output relative to cutting and stripping. A cutter's productivity cutting and topping green cane is only marginally reduced relative to burned cane. In industries which are moving towards semi-mechanical harvest aids, these units also mean that there is little difference between the harvesting rates of green versus burned cane.

Reduced requirement for labour

The implementation of trash separation in the industries using hand-cut or semi-mechanical harvesting aids allows cutters to direct their efforts towards cutting and topping the crop. This potentially doubles the productivity of a workforce or halves the workforce requirement in labour-scarce environments.

Increased biomass availability

Although the amount of leaf on the sugarcane crop at harvest varies widely depending on crop variety and other factors, datasets from a number of industries indicate that on average the total energy contained within a crop of sugarcane is approximately equally shared between the sucrose content, the fibre content of the residual bagasse and the fibre content of the trash (leaves).

The available energy from leaf and tops and green leaf is similar to the energy from the bagasse, however approximately 70 per cent of the energy is in the dry leaf at time of harvest. Taking dry leaf to the mill with the cane therefore significantly increases the energy available for co-generation, while minimising the actual tonnage and volume of material sent to the mill. Often this increased energy can approximately double the actual co-generation output. Dry leaf trash is considered a good quality boiler fuel as it has very low levels of alkali metals, which can cause problems in the boilers.

The benefits of trash separation for the Australian sugar industry

Cane cleaning for fibre crushing rate and sucrose recovery are the immediate benefits to the Australian sugar industry, even without taking into account the value of trash as a byproduct. The overall benefits of trash separation and recovery are as follows:

- Improves milling efficiency and sugar recovery.
- Provides an economically viable method to supply fuel to boilers.
- With 4th generation mill-based technology, integration of trash separation systems into existing mill infrastructure can be achieved more easily than with previous generations of the technology.
- With 4th generation field-edge technology, transport logistics post-harvest are improved by increasing load densities, which maximises productivity and efficiency.

The benefit of trash separation for the Australian industry is best described using an economic analysis of 'current/commercial practice' versus 'low loss' and 'low loss plus cleaning' harvesting practices.

The figures used were obtained from trial results in the Isis region SRDC-funded project – NET001 'Quantification of the potential to reduce harvesting losses with field edge trash separation technology'. The assumptions for operating parameters are listed in **Table 2**.

Table 2: Commercial practice and low loss harvesting parameters.

Commercial practice	Low loss harvesting
Current harvester daily allocation of 850 t	Reduction in forward speed by 15-20 per cent
Cost/t $8.50 delivered to siding	No change
Extractor fan speed 950–980 rpm	Extractor fan speed reduced to 600 rpm
Use of two 13 t double bin haulouts	Initially increase the number of standard haulouts rather than buy units optimised for application
Typical pour rate of 150 t/hour (80 to 85 t/engine hour)	Actual total pour rate will remain similar due to increased biomass (cane and trash)
10 hours per day harvester operation	10 hours per day harvester operation

The resulting impact of the economic analysis with respect to the harvesting operation in isolation is shown in **Table 3** below.

Table 3: Impact on harvesting operations.

Harvesting costs	Current practice	Loss loss	Low loss + cleaning
Harvester cost ($/ha)	$561	$688	$688
Haulout cost ($/ha)	$289	$462	$462
Trash separator cost ($/ha)			$139
Total harvest cost ($/ha)	$850	$1150	$1289

Analysis of the costs in **Table 3** indicates that the total daily payment for harvesting operations increases due to the additional cost of ownership and operating an additional haulout. Note that the area harvested per harvester over the season will actually reduce, but profitability remains. However, the resulting benefit in terms of overall farm economics is shown in **Table 4**.

Table 4: Impact of trash separation on farm economics.

Grower income	Current practice	Loss loss	Low loss + cleaning	Per cent change
Grower sugar payment ($/ha)	$4162	$4496	$5347	+28
Total harvest cost ($/ha)	$850	$1150	$1289	+51
Net after-harvest costs ($/ha)	$3312	$3345	$4058	+23%
Relative income (%)	100	101	123	
Crop production cost ($/ha)	$1500	$1500	$1500	-
Gross margin ($/ha)	$1812	$1845	$2558	+41%
Impact on gross margin (%)		+2	+41	

Based on the Isis figures, grower income increases by approximately 23 per cent relative to current practices. The overall benefit, inclusive of increased total harvest costs, is that the grower gross margin increases by approximately 41 per cent.

Grower benefits

- **Increased sugar per hectare.**
- **Gains higher portion of recovered sugar (higher % CCS).**
- **Very significant increase in returns per hectare after adjustment for harvesting and haulage costs.**
- **No change to current practice.**

The factors that need to be considered are the additional activity at siding, and increased harvest and haulout costs—which negate relative to the increase in sugar payment.

Miller benefits

- **Reduced ash.**
- **Improved transport density.**
- **Reduced fibre per tonne of sugar.**
- **Potentially improved sugar quality (reduced colour and ash levels).**
- **Increased revenue per hectare, attributed to reduced cane loss.**

Appendices

Harvester field efficiency definitions

Appendix 1

Code	Name	Explanation	
1	Shifting	Shifting between blocks.	High ground speed, zero fanspeed and elevator off.
2	Wet weather	Harvester is halted due to adverse weather conditions.	
3	Servicing	Regular scheduled servicing is being performed.	e.g. blade changes, fuelling and greasing.
4	Repairs	The harvester is not operating and non-scheduled repairs are being performed.	e.g. hose replacement.
5	No-haul transport	Harvester is waiting due to non-availability of infield haulouts.	Begins when ground speed is less than 66 per cent of cutting speed and ground speed is reduced to zero.
6	Change haul	Harvester is not cutting while the full haulout leaves and an empty haulout moves into place.	Begins when ground speed is less than 66 per cent of cutting speed and ground speed is reduced to zero.
7	Choke	The feeding components or choppers are stalled.	Begins when ground speed is less than 66 per cent of cutting speed and the choppers are stalled.
8	No bins	Harvest is halted because bins were not delivered to the siding by the scheduled time.	Begins when ground speed is less than 66 per cent of cutting speed and all available bins have been filled.
9	Rest	Harvest is halted as the crew take a rest break.	Begins when ground speed is less than 66 per cent of cutting speed and the harvest crew is resting.
10	Turning	The harvest is turning from one row to another.	Begins when ground speed is less than 66 per cent of cutting speed and the harvester will complete a turn.
11	Backing	The harvest is moving back to the end of the row during one-way cutting.	Begins when: 1. The harvester has completed a turn and ground speed is rapidly increased. 2. Ground speed is less than 66 per cent of cutting speed and harvester will commence reversing down the drill.
12	Cutting	The harvester is cutting cane.	Begins when the harvester reaches 66 per cent of cutting speed.
13	Idle	All harvest activities have ceased.	This is usually overnight and the crew are not present.
14	No data	No data is available.	

How to assess billet quality

Appendix 2

Billet quality is an important determinate of cane quality. Ideally, billets should be cut cleanly at both ends (no squashed ends, no splits and no rind removed) and should be uniform in length. A low level of eye damage is important for billets used for planting.

The billet quality definitions presented here have been ratified by the International Society of Sugarcane Technologists (ISSCT) and are used as the international standard.

Billet sampling

Collecting a sample is the most critical step in the assessment process. It is important that the sample represents the performance of the harvester. For research trials, large samples are required; five samples, each of 20 kg, are recommended by ISSCT. Much smaller samples may be used to assess billet quality 'infield'.

Mixing of the cane product is important. It is preferable to collect a sample from the siding as elevator tippers provide some mixing of the cane product. For roll-on roll-off systems, collect a sample of billets from the bin siding.

Billet length

Sort the billets into length categories of 0–100, 100–150, 150–200, 200–250, 250–300, and greater than 300 mm. Weigh each category.

Averaging billet lengths of 50, 125, 175, 225, 275 mm and an estimate of the average length of billets greater than 300 mm are used for each category. Average billet length is calculated as follows:

Billet quality

Sort each of the above length classifications into sound, damaged or mutilated categories according to the definitions below. Any billets less than 100 mm in length are classed as mutilated.

The suggested method for rating quality is to calculate the percentage of sound billets of acceptable length. Where only billet quality is required, sorting by billet length may be ignored and the sample sorted only by quality.

Sound

- Longer than 100 mm.
- No splits longer than 80 mm. Small rind splits shorter than 40 mm and growth cracks are not regarded as splits.
- Not more than a 400 mm² section of rind removed.
- No squashed ends.

Damaged

- Longer than 100 mm.
- Splits totalling more than 80 mm per billet.
- Sections of rind between 400 mm² and 2000 mm² removed.
- No squashed ends.

Mutilated

- Billets that are squashed, broken or damaged so that a portion of the cane is reduced to a pulpy condition.
- More than 2000 mm² of rind removed.
- Any billet that is shorter than 100 mm.

$$\text{Mean billet length [mm]} = \frac{50W_1 + 125W_2 + 175W_3 + 225W_4 + 275W_5 + (\text{Average length of} >300\text{ mm billets})\, W_6}{\text{Total weight of sample}}$$

* Where W_1 to W_6 represents the weight of each category.

Glossary

Appendix 3

Harvester fundamentals

Topper

The topper cuts off the leafy top of the cane. The operator manually controls topper height. Cane should be topped, if possible, to reduce the cleaning load of the extractors and to reduce final EM levels.

Crop dividers

The crop dividers separate lodged cane and direct the cane (and potentially soil) to the basecutters and into the harvester. Pick-up losses occur here.

Knockdown roller

The knockdown roller assists front-end feeding in lodged cane. The knockdown angle is important in achieving a consistent feed while minimising stool damage.

Finned roller

The finned roller feeds cane butt-first to the basecutters and roller feedtrain.

Basecutters

The basecutters sever the cane stalk at ground level and feed it butt-first into the roller feedtrain. Correct basecutter set-up and consistent hill-up are essential in minimising dirt in cane.

Butt-lifter

The butt-lifter accepts the cane stalk butts from the basecutters and feeds them into the roller train.

Roller feedtrain

The roller feedtrain feeds the cane butt-first to the choppers. The bottom rollers are fixed to the chases while the top rollers pivot in a cradle.

Chopper box

The chopper box cuts the cane into billets and propels the cane/trash bundles under the primary extractor. Juice loss and cane loss occurs in the chopper box.

Primary extractor

The primary extractor causes a strong, upward air stream, which separates the trash from the billets. The majority of cane loss occurs here. Billets fall into the elevator while trash and lost cane are ejected through the hood.

Elevator

The elevator conveys the billeted cane under the secondary extractor and into the haulout.

Secondary extractor

The secondary extractor also causes a strong air current that separates the trash from the cane and is also a potential source of cane loss.

Fundamental definitions

Cane loss

Cane loss is the millable cane that is available to be harvested but is not delivered to the mill. It includes cane and juice loss. Sources of cane loss include: gathering and pick-up, basecutter, chopper box, primary and secondary extractor, and spillage losses. Primary extractor cane loss is the greatest source of loss.

'Cane loss' in this manual refers to extractor cane loss, unless stated otherwise.

Extraneous matter (EM)

EM is anything that is not millable cane and is sometimes called trash. Extraneous matter constituents are defined as follows:

$$\% \text{ EM} = \left(1 - \frac{\text{Weight of millable cane}}{\text{Total weight of sample}}\right) \times 100$$

Millable cane

All sound millable stalks below the growing point. This includes suckers but excludes dead and rotten cane. All adhering trash, roots and soil will have been stripped away. Stools will be broken up into millable cane, dirt and roots.

Tops

The upper section of the stalk above the growing point, which can be readily broken by hand, plus any attached leafy material. This will include tops that come from suckers.

Trash

Dead and green leaves and leaf sheaths either free or removed from billets. This also includes grass and weeds and anything else of an organic nature not covered by the definitions of millable cane or tops such as dead or rotten cane.

Dirt

Dirt present as lumps, attached to roots and removable from billets and leaves.

Roots

Roots and fibrous pieces of tissue connecting the stalks that are free of dirt.

Dead/rotten and other

Dead or rotten cane billets and any other organic material not included in the definitions of millable cane, tops, or trash.

Fanspeed

Fanspeed is the rotational speed of the primary extractor expressed in revolutions per minute (rpm). The primary extractor fanspeed is variable.

Ground speed

Ground speed, also known as forward speed, is the speed of travel of the harvester relative to the ground. It is usually expressed in kilometres per hour (km/h) but sometimes metres per second (m/s).

Pour rate

Pour rate is the speed at which cane flows through the machine, and is measured in tonnes of cane per hour. Crop size and harvester forward speed determine pour rate. There are four different pour rate definitions commonly used.

Throat pour rate

Throat pour rate is the gross material-processing rate of the chopper system. That is, the gross tonnes of material processed by the choppers per hour of continuous cutting. It is difficult to measure the total material standing in the paddock and therefore throat pour rate is usually used only in harvester research trials.

Elevator pour rate

Elevator pour rate is the tonnes of cane per hour delivered off the end of the elevator while the machine is continuously cutting.

Delivery rate

Delivery rate is the tonnes of cane delivered on the line, pad or other mill point per harvesting hour.

Tonnes per engine hour

Engine hour pour rate is the tonnes of cane processed per harvester engine hour. It is also referred to as tonnes per engine hour.

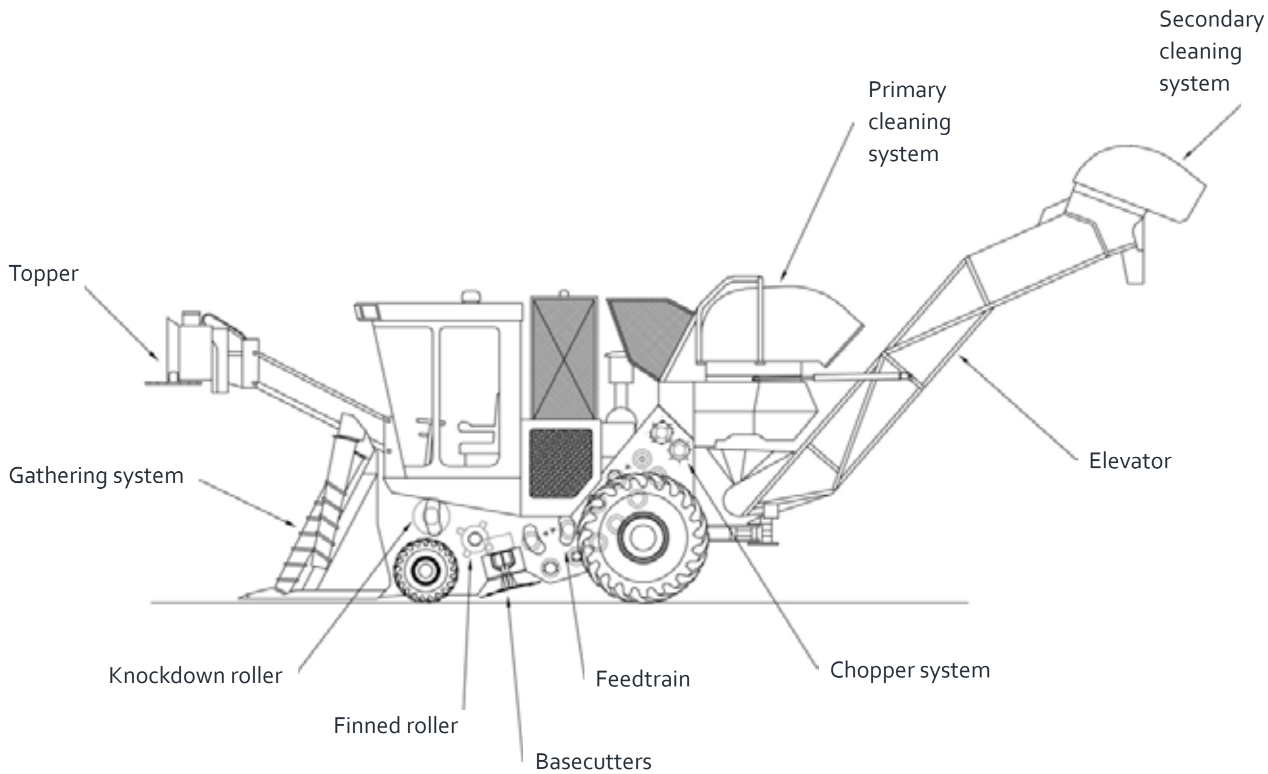
When this manual mentions pour rate it is referring to elevator pour rate, unless stated otherwise.

Soil in the cane supply

Soil present in cane sent to the mill is termed soil in the cane supply.

Fundamental components of a harvester

Appendix 4



Information sheets Appendix 5

Billet quality – a key element for planting success

Planting is a major cost to the industry. It is important to get good plant establishment, as it affects your ongoing returns through the crop cycle. Careful attention to the many components of the billet planting system will ensure a successful strike.

For optimal germination rates the following items need to be assessed:

- seed cane quality
- harvester set-up to minimise damage
- planting rates
- effectiveness of fungicides
- placement of billets
- press-wheel set-up.

Seed cane quality

Above: Good quality billets.

Above: Poorly cut billets.

You should only plant good quality, disease-free cane from an approved seed source.

Plan ahead:

1. Determine what varieties and volumes of cane will be required for planting.

2. Grow cane specifically for plants. Cane should:

- Be erect with short internodes, this can be achieved through reduced fertiliser rates.
- Have at least two buds per sett.
- Be less than one-year old.
- Be no more than three years off hot water treatment.

Note: Approved seed is already one year off hot water treatment when purchased. New approved seed should be introduced onto the farm at least every second year.

Harvester set-up for cutting good quality billets

For billet planting, it is best to use a modified harvester to cut undamaged billets between 250 and 300 mm long. Samples of planting billets should be taken and inspected for split or crushed ends and damaged eyes.

Many commercial cane harvesters have variations in feed roller speeds and aggressive 'teeth' on rollers. This causes highly variable billet length and damage to eyes, which in turn will reduce germination rates. Modifications such as rubber coating rollers and feed-train optimisation to match all roller speeds to chopper speed can significantly improve the quality of planting billets.

Left: Modified harvester – rubberised rollers.

Left: Commercial harvester – aggressive feed-train.

Quality assessments to determine the quantity of viable billets have shown:

- Whole stick planter – 80 per cent viable billets
- Modified harvester (optimised/rubberised) – 70 per cent viable billets
- Commercial cane harvester – 30 per cent viable or less.

Cutting lodged cane for plants significantly reduces the level of viable billets, even with a fully modified harvester. It is also important to reduce speed when harvesting for billet planting. This minimises trash levels and avoids overloading the choppers, which can cause billets to become squashed on the ends and split.

Planting rates

The target planting rate is four to six eyes per metre to establish three primary shoots per metre. Key points to remember for planting rates include:

- Higher planting rates will not guarantee a suitable plant stand.
- Excessive tillering may mean unnecessary use of nutrients and moisture.
- For lower planting rates good-quality billets are essential.
- Assess the number of viable eyes prior to planting to ensure a good strike.
- Need an even feed of billets with no gaps.

Increasing the amount of cane (depth of cane) covering the elevating slats will increase the billet metering rate. Whilst billet planters don't have a consistent metering system, it is important to ensure that the depth of cane remains constant which will allow for a more even billet distribution.

Calculating Planter Output (t/ha)

Step 1

Run the planter over 10 metres, collect the billets and weigh.

Step 2

Planter output (t/ha) =

$$\frac{(\text{Sample weight kg}/10) \times (10{,}000/\text{row spacing m})}{1000}$$

Effectiveness of fungicides

Effective fungicide application is necessary to prevent Pineapple sett rot. Pineapple sett rot is caused by a fungal infection which is favoured by planting damaged billets and/or by cold, dry or wet soil conditions. Billets must be cleanly cut and protected with an appropriate fungicide or other cane sett treatments. Planters that use fungicide sprays must be correctly set up to ensure that both ends of the billet and any growth cracks on the billet are covered. If there is insufficient coverage, check nozzles for correct positioning and to ensure no nozzles are blocked.

If the planter uses a dip to apply fungicide, the dip must be kept clean. Mud in the dip will reduce the effectiveness of the fungicide.

Placement of billets

The amount of soil cover over the sett, soil temperature, and moisture content influence the speed of germination. With good soil moisture, 25 to 50 mm of firmed soil is sufficient coverage.

Press-wheel set-up

Correctly set press-wheels enhance crop establishment. It is best to use large diameter pneumatic wheels, with wheel width matched to the planting furrow width. Significant press-wheel forces are required to create adequate sett-to-soil contact. Down force should be in the range of 2 to 4 kg per cm of wheel width. For example, for a 15-cm wide press-wheel, down force should be in the range of 30 to 60 kg. This can be easily checked using bathroom scales.

Assessing the sugar content of a crop for managing the harvesting sequence

The Commercial Cane Sugar (CCS) of a crop can vary due to the variety, age of the crop, arrowing, moisture, nutrient or temperature stress. Growers can use a refractometer prior to each harvesting round to enable them to select blocks to harvest with potentially higher CCS to maximise whole-farm sugar yield.

A portable refractometer (or hand held Brix meter) is a useful tool to use when planning your block harvesting sequence on your farm.

A refractometer can measure brix in cane juice. Brix is a measure (in degrees) of the amount of dissolved solids (or sugar) in a liquid. A higher brix reading indicates a higher sucrose content.

The refractometer measurements taken from stalks of cane in the field can be used as estimates of the relative sucrose content between blocks. The brix readings are not equal to CCS of the cane crop at the mill but can be used as an indication of relative crop sugar content. The brix measured in the field is different to CCS for many reasons, including sampling error, fibre content, harvesting process and environmental factors.

Juice sampling equipment

A proper juice sampling device or dibbler (see the image below) makes the process easy. Pliers can be used to squeeze juice out of the stick, but this is slow and each stalk will be destroyed.

Above: Juice sampler – dibbler.

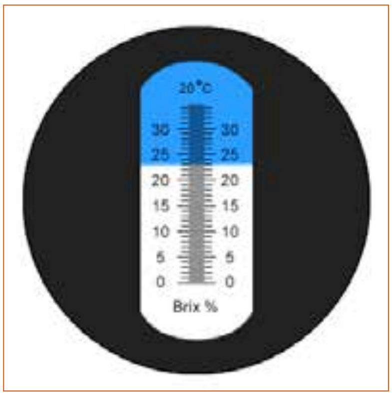
When taking juice samples, pierce the rind with the dibbler. Push the dibbler firmly into the stalk and twist it a few times to get the juice to flow into the collector.

Practice good farm hygiene and ensure that the juice sampling equipment is cleaned and sterilised with 70 per cent methylated spirits/water mixture between blocks. This ensures that any diseases that might be present are not spread.

Refractometer

Above: A refractometer.

- Follow the manufacturer's instructions for refractometer reading, maintenance, cleaning and calibration.
- Take readings in natural light and ensure the sample has time to reach the ambient temperature.
- Clean the instrument (both the cover plate and the top of the prism) using a soft, damp cloth.
- Make sure the prism and cover plate are dry. Any remaining water will dilute the juice sample.
- Place two to three drops of juice on top of the prism.
- Close the cover plate and take your reading through the eyeglass. The image below shows how to read the refractometer.



Left:
View through the refractometer with a juice sample brix reading of 23.

To assess block average sucrose content

- Make sure you get a representative sample of the block by sampling at least five locations spread across the block and at least 10 m in from the edge/ends.
- Sample the juice from 10 to 20 sticks of cane at each location. Accuracy improves when more sticks are sampled.
- Take the sample at the same height from the ground, such as waist height, on each stalk.
- Take one brix reading from the collected juice sample at each of the locations and then average the five readings to give an overall brix for the block. If one of the five brix readings varies by greater than 10 per cent from the average, discard it from your calculation.

To assess the maturity of the block

The sugar content varies throughout the stalk and the lower internodes will have higher sucrose content than the upper ends of the stalk on an immature plant. Basal internodes of the stalk fill with sugar while the top of the stalk is still actively growing. With stalk maturation, more internodes reach maximum CCS.

You can use this characteristic to assess whether a sugarcane crop has reached its maximum CCS by sampling the stalks separately at the top, middle and bottom. Use the same technique above, but at each site collect CCS samples from the three positions along the stalk length.

A crop with more similar readings at the top and bottom of the stalk will be more mature and a limited increase in overall crop CCS will result from delaying the harvest.

A crop with a bigger difference between the brix reading at the top of the stalk compared to the bottom will be less mature and a higher overall crop CCS may result if harvest is delayed till the next round.

Above: A refractometer with a digital readout.

Above: Harvesting for maximum sugar yield.

Maximising the sugar yield on each block by planning the harvester sequence will improve whole farm productivity.

Reduce harvester losses: Dollars in your pocket, not in the paddock

Harvesting losses are a major cost to the sugar industry; in particular the loss of millable cane via the cleaning system during green cane harvesting. Losses as high as 20 per cent have been recorded, but 5–15 per cent are more common.

For harvester trials in the past, the biggest problem was the lack of an accurate cane-loss measurement technique. The traditional 'blue tarp method' of cane-loss measurement underestimated cane loss. A more accurate method that could measure juice loss during harvesting was required.

Infield Sucrose Measurement System (ISMS)

A five-year harvesting project, which developed a mobile harvesting-loss measurement system, has significant benefits for the industry.

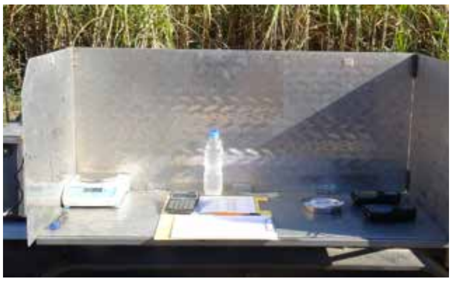
The ISMS prototype has been used industry-wide over recent seasons by SRA's engineering team to measure losses. Losses of $200/ha to in excess of $1500/ha have been measured.

The process

Samples containing trash, billets, juice and tops are collected, either directly from the harvester or from a measured area (quadrat), and weighed to calculate total tonnes per hectare of residue.

Left: Collection of residue.

The field residue is then mulched and processed to obtain a liquid extract which is analysed using a digital brix refractometer to measure sugar content.



Left: Field lab for infield sucrose measurement system.

From this information, the dollar value of sugar losses at different extractor fanspeeds can be calculated.

Sugar loss in tonnes per hectare, and mill CCS are used to calculate how many tonnes of cane are being lost.

The field trial data in Table 1 shows the percentage of the crop lost at different fanspeeds and the financial cost of losses for a 1000-ha harvesting group (e.g. at a 100 t/ha average yield, this would represent a 100 000 tonne harvesting group).

It is important to note that some losses are unavoidable. The process of cutting cane (basecutters and chopper knives) results in losses of three to five per cent.

Table 1: Percentage cane loss and financial loss at different fanspeeds.

Fanspeed rpm	% Loss	$ Loss/1000 ha
950	7.1%	$475 000
1050	16.0%	$1 080 000
720	3.6%	$210 000
900	9.6%	$560 000
760Primary	3.4%	$220 000
760Primary and secondary*	10.5%	$680 000

** Bigger secondary blades can cause excess cane loss.*

Figure 1 shows that as fanspeed increases, cane loss triples while EM is reduced by less than 2 per cent. Excessive fanspeed severely reduces income to all sectors with minimal improvement in cane quality. It is important that the impact of reducing fanspeed on EM levels is managed carefully. At very low fanspeeds the extra trash reduces sugar recovery at the mill and increases transport cost.

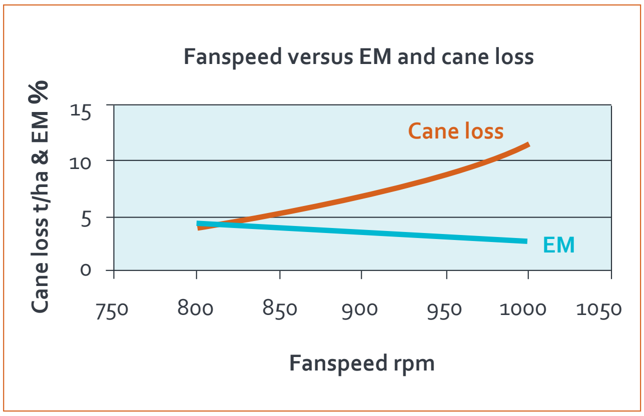


Figure 1: Indicates how harvester fanspeed can affect cane loss and EM. This shows a 7.5 t/ha increase in losses for 1.85 per cent reduction in EM.

Benefits of the ISMS

- Reduced harvesting losses
- Rapid/accurate feedback on losses
- Improved dollar returns to the grower, operator and miller
- More cane to the mill
- Ability to assess the performance of aftermarket modifications
- 5–15 per cent increase in harvested cane would benefit the entire industry.

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