MECHANICAL GREEN CANE HARVESTING

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ABSTRACT

Green cane harvesting is preferred by many sugar cane growing countries despite the fact that harvesting unburnt sugar cane is more arduous and slower than harvesting burnt cane. Many attempts have been made throughout the world to develop acceptable mechanical green cane harvesting systems and the results of some of these are described. In South Africa green cane harvesting has distinct advantages and the Experiment Station of the South African Sugar Association has, for some years, been involved in the development of appropriate mechanical harvesting alternatives. The so-called Sasaby forms the basis of a completely mechanical wholestalk harvesting system which, by December 1981, was approaching commercially acceptable levels of performance. The second system is semi-mechanized and incorporates a simple cutter with a manual retrieval and stacking system. The quality of cane harvested by both these systems compares favourably with that of manually harvested cane while total cane losses are also acceptable.

INTRODUCTION

Many cane growing countries have found that there are distinct advantages in harvesting unburnt cane, one of which is increased yields. The effect of trash on yield depends on factors such as soil type, slope and rainfall, and yield responses of 9 t/ha/year have been achieved. A trash blanket reduces water runoff significantly and the moisture available to cane cultivated under marginal rainfall conditions would therefore be increased. Thompson showed that there was an eight-fold decrease in runoff from trashed fields compared with that from burnt fields during six month periods in late summer. Moisture is also conserved during the period of incomplete canopy since evaporation from bare soil is reduced.

Burning cane could have adverse effects. According to Hudson, sugar cane production in Barbados fell by 20% when burning was implemented in the early 1970s. Hudson estimated that in 1975, 32,000 t of sugar out of a potential production of 177,000 t was lost. This was reduced to an 8,000 t loss in 1976 when burning was prohibited. Yields from 6,800 ha of burnt cane and 1,150 ha of trashed cane on the South Coast of Natal were compared during a six year period. Trashed cane yielded 17% more than burnt cane and differences were greatest during years of drought.

Cane deteriorates faster once it is burnt so well-trashed cane should be of a higher quality. A good trash blanket can suppress the growth of weeds, making weed control measures unnecessary. Factors such as pollution as a result of burning and the difficulties associated with controlled burning, may eventually end this practice.

There are, however, disadvantages with green cane harvesting. A trash blan-
ket may decrease soil temperatures in some areas to such an extent that ratoon
growth is impaired. Fewer shoots developed and the number of harvestable stalks
will also be reduced. Payload densities of trashed cane are less than those of
burnt cane, therefore transportation costs are higher. The greatest disadvantage
of green cane harvesting is that the output of all harvesters is reduced. Mill
crushing rates might also be decreased because of high levels of extraneous matter.

Those growers using manual cane cutters for harvesting unburnt sugar cane will
be the first to be affected should cutters become scarce. There is therefore, a
considerable need to develop mechanical alternatives to manual green cane harvest-
ing. Some alternative harvesting methods and the progress towards the develop-
dment of whole stalk green cane harvesting systems in South Africa will be revi-
wed in this paper.

Green Cane Harvesting by Means of Chopper Harvesters

Modern chopper harvesters perform well with burnt cane but their success
with harvesting green cane is questionable from a practical and economic point of
view (De Beer 4). In 1977 the Rio Grande Valley Sugar Growers 13 in Texas used
8 different choppers to harvest green cane. The result was a reduction of 68% from
66 t/h in pour rate for burnt cane. In Australia, Fuelling 7 found that the
Class 1400, MF 205, Toft 400 and Toft 6 000 were all capable of harvesting erect
green cane but pour rates were reduced by between 30 and 40% of those for burnt
cane.

Performance studies of a number of chopper harvesters operating in green and
burnt cane were recently done in Texas (Rozeff and Crawford 14). The amount of
trash and cane left behind in the field after green cane harvesting, increased.
Compared with burnt cane, 7.4% less sugar was recovered in green cane and
production costs increased by 9.2% since efficiency of the harvester, transport and
milling was reduced.

In Florida chopper harvesters were used in burnt and unburnt cane and it was
found that 23% of unburnt cane was lost. Fuel consumption was 200% while
pour rate was 40% of that when harvesting burnt cane (Eiland and Clayton 9).

Modern chopper harvesters are powerful, high capacity machines and although
their performance in green cane is not satisfactory at present it can be expected
that it will be improved to a commercially acceptable level.

Wholesalk Mechanical Green Cane Harvesting

The development and performance of the BSPA cane cutter for green cane
was described in a 1974 ISSCT paper by Hudson. 8 It was a simple, tractor-
mounted device which topped and cut the cane into sausage-like windrows which were
later retrieved manually. This machine was regarded as the first step towards
mechanized green cane harvesting and the manual part of the operation would be
substituted in the future with another machine.

In the subsequent McConnel multipass green cane harvesting system three
machines were introduced as labour became scarcer. First a loader, then a har-
vesting aid (the BSPA cutter now developed into the McConnel Stage 1 machine)
and then, a pickup cleaner-bundler, the Stage 2 machine. Cane is cut by the
Stage 1 machine. The cut cane is then gathered by hinged sweeps which run
along the ground into the Stage 2 machine, tops first, for cleaning and top-
ping. The stalks accumulate in a bin before being dumped onto the ground.
Prototypes of the Stage 2 machine were tested and developed further in the Caribbean (Hudson) and in South Africa. In 1977 (Boast) predicted delivery rates of 20 t/h and with trash counts of less than 7%. In an ISSCT paper by Scott and Hudson in 1980, details of refinements to this system were described and announced that the project would continue directly through the Barbados Sugar Producers' Association. The Stage 1 machine is known as the Carib and has been accepted by Caribbean and Far Eastern countries.

Another approach to wholestalk mechanical green cane harvesting was adopted by Japanese companies such as Bunmei who developed a small cutter behind which the operator walked. These machines are limiting because they can operate only in straight, erect cane of less than 90 t/ha. Once cut, the stalks are topped, detrashed and bundled manually. In 1973, 100 of these machines were brought to Okinawa but by 1976 only ten were still operating.

In 1976 Hanshin demonstrated a self-propelled green cane chopper harvester in Taiwan. If successful a whole-stalk version was to follow. This project has since been abandoned.

The well-known soldier type cane cutters from the United States of America were designed to cut wholestalk green cane in Louisiana. No detrashing systems other than burning of the cane in the piled windrows has been developed for these machines.

Mechanical Green Cane Harvesting in South Africa

Fully Mechanised Harvesting

Further reports of the development of the McConnel machines can be found in Annual Reports of the SA Sugar Association Experiment Station. By the end of the 1977-1978 season problems were still being encountered, especially when cane was being cut on steep slopes. It was decided that a completely different machine should be designed. A McConnel Stage 2 was converted into a stationary test bed where investigations into the feasibility detrashing and topping green cane were made. Results were encouraging and led to the construction of a self-propelled harvester, known as the Sasaby which incorporated the essential principles of the test rig. Field trials commenced in October 1978. Figure 1 shows the Sasaby as it appeared at that stage. The cleaning section is shown in Fig. 2.

The cane is cut at its base, is lifted by pick-up rollers and fed through scuff rollers over a topper and through draw rollers into a bin. The peripheral speed of the scuff rollers is four times as fast as that of the others. This causes leaves to be loosened from the cane stalk and a blast of air from a centrifugal blower frees the trash and helps to force the tops into the blades of the topper. The angle at which the cane is drawn out of the scuff rollers is such that the cane tops are brought into contact with the topper blades and are cut off. The air blast clears the tops from the machine.

A two row harvester was built for extra stability on slopes and to provide adequate space for 3-4 t bundles to be dropped. A Deutz V8 130 KW air-cooled diesel engine was the power source and hydrostatic transmission provided speed variation. All components of the machine were driven hydraulically so that the speed of individual components could be varied as desired. Pilcher and Boast provided a comprehensive description of this machine in a 1980 SASTA paper.
Figure 1. First prototype of Sasaby harvester.

Figure 2. Diagrammatic representation of cleaning section.
It became apparent that the available power was inadequate for harvesting two rows of cane at an acceptable speed. The maximum bin capacity was 1 t only and this meant that the original target of dumping 3-4 t bundles which could be loaded by self-loading trailers could not be achieved. A loader had to make stalks of the desired size from the smaller bundles which were being dumped. Total extraneous matter was less than 7% but even with gleaning, cane losses were still as high as 9.5%. Other shortcomings in the design were identified and by the end of 1979 it was clear that this concept would be more effective if the same principles were applied to a single row operation. Stability could still be achieved if the machine was wide but the advantage of being able to cut in either direction on a cane face would be lost.

A second Sasaby prototype (Fig. 3), incorporating the experiences gained from the double row harvester, was built and put into operation in September 1980. After many modifications, by December 1981 it could be stated that the Sasaby was approaching the performance of a commercial harvester.

Figure 3. Second prototype of Sasaby harvester.

The principle of operation of the latest Sasaby is unchanged but the form of the machine has. The two row Sasaby I was a machine with a front wheel drive and rear wheel steering. The base cutters were mounted on a separate frame in front of the driving wheels. The Sasaby II has the conventional rear wheel drive and front wheel steering design of a chopper harvester. The height of the base cutter on the new machines can be adjusted by raising or lowering the front of the machine on oleo legs.

A single base cutter for each row was used on the old model but the new model
has twin overlapping base cutters driven by separate hydraulic motors. The chassis of the Sasaby II forms part of its hydraulic oil reservoir and the components handling the cane has been reduced in size from 1300 mm for a two row operation to 750 mm.

The cane in the receiving bin at the rear of the machine is unloaded by a crane into trailers running alongside. A separate operator is necessary to drive the crane. Detailed modifications have been made to individual components and to their relative positions. Considerable attention has been given to eliminating trash-wrap around components and bearings. The centrifugal fan used to clear trash and tops from the topper-scuff rollers has been replaced by an aerofoil axial flow fan which provides more air at less pressure and power.

The difficulty in achieving an even feed of cane into the machine is attributed largely to inter-stalk friction caused primarily by the interaction to the tops. To alleviate this and to reduce the amount of material fed into the machine, an external topper has been fitted to the Sasaby II. The topper is set in such a way that the stalk is cut just above the meristem driven roller fitted with teeth and long swept-back tines is fitted above and the remaining part of the top is removed by the internal topper. A roller, known as a comb, serves to knock down cane, align it, assist with feeding it into the machine and to loosen trash on the stalks. The base cutters have each been fitted with two small augers which lift the cane butts onto the pick-up roller and then into the machine. The feed and draw rollers have remained unchanged but the lower scuff roller has been replaced by a cylinder on which twelve pieces or flat bar have been welded radially to it to reduce stalk bounce before the topper.

Figure 4 shows the relative positions of the cane engaging components of the Sasaby as they were in December 1981.

The cleanliness of the harvested crop was of prime importance and efforts were initially directed towards minimising the amount of extraneous matter. Results of such efforts were gratifying, with levels of extraneous matter of less than 5% (Table 1).

Aggressive cleaning can result in cane being broken and therefore lost. Possible under-topping by the internal topper can be measured but it is impossible to determine whether harvested stalks are over-topped. To determine the amount of cane lost to topping, the length of all stalks from a 15 m length of row was measured. This was done from ground level to the third node below the meristem which is considered to be the ideal topping height. After harvesting the cane with the Sasaby, the total length of cane stalks inside the bin was compared with
Table 1. Extraneous Matter Content of Cane Harvested by the Sasaby

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>1</th>
<th>2</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>kg</td>
<td>%</td>
</tr>
<tr>
<td>Tops</td>
<td>7.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Leaves</td>
<td>8.5</td>
<td>2.2</td>
</tr>
<tr>
<td>Cane</td>
<td>362.7</td>
<td>95.8</td>
</tr>
<tr>
<td>Total</td>
<td>378.7</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 2. Losses From 15 m of Cane Harvested by the Sasaby; Stalk Length Measured in Metres

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length of stalk, before harvest</td>
<td>228.62</td>
<td>307.03</td>
</tr>
<tr>
<td>Total length of stalk in bin</td>
<td>224.82</td>
<td>285.39</td>
</tr>
<tr>
<td>Loss of stalk</td>
<td>3.80</td>
<td>21.64</td>
</tr>
<tr>
<td>% Loss</td>
<td>1.7</td>
<td>7.1</td>
</tr>
</tbody>
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that of the standing cane. Losses varied from 1.7-7.1% (Table 2). The content of extraneous matter of Sample 2 was 4.2%.

The performance of the Sasaby harvester was tested by varying the setting and operation of the different components and altering their speed or clearances. Some of these results are shown in Table 3. After this study it was decided to operate the Sasaby with both the internal topper and the fan, and with the scuff rollers set wide apart and running at 680 r/min.

Table 3. Effect of Component Setting on Extraneous Matter Content

<table>
<thead>
<tr>
<th>Setting</th>
<th>Extraneous Matter (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both toppers operating, scuff speed 280 r/min</td>
<td>Tops: 4.4  Leaves: 3.2  Total: 7.6</td>
</tr>
<tr>
<td>External topper only, scuff speed 280 r/min</td>
<td>Tops: 5.2  Leaves: 4.2  Total: 9.4</td>
</tr>
<tr>
<td>External topper only, scuff speed 280 r/min and rollers wide apart</td>
<td>Tops: 2.5  Leaves: 3.5  Total: 6.0</td>
</tr>
<tr>
<td>Same as 3, but scuff speed 680 r/min</td>
<td>Tops: 2.6  Leaves: 4.0  Total: 6.6</td>
</tr>
<tr>
<td>Same as 4, but without fan</td>
<td>Tops: 3.5  Leaves: 8.5  Total: 12.0</td>
</tr>
<tr>
<td>Same as 4, but both toppers and fan operating</td>
<td>Tops: 2.2  Leaves: 2.9  Total: 5.1</td>
</tr>
</tbody>
</table>

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The harvesting rate of the Sasaby was established while cutting NCo 376 which yielded 90 t/ha. Average row length was 154 m. The average harvesting rate was 22.5 t/operating hour or 14 t/field hour when the time spent waiting for trailers was included.

The limiting factor on harvesting rate in this particular study was found to be the speed of unloading with the crane. There was an average of 7.5% of extraneous matter and cane loss measured over a specific length of row as described earlier, was 5.6%. When harvesting was done immediately after a midday downpour, the amount of extraneous material increased to 11.5% (3.8% tops, 7.7% leaves) and the losses to 6.5%. In comparison with the mill group averages for burnt and green cane cut manually over the same period, the fibre percent cane for the Sasaby was 16.15% compared with 16.77% and the juice purity was 86.81% compared with 81.52%.

Conclusions at the end of 1981 were that the Sasaby could harvest cane with amounts of extraneous matter as low as those from manual cutters and with total cane losses comparable with those of chopper harvesters (de Beer). Harvesting rates were still relatively low and were limited by the crane output and available power of the present machine.

Semi-Mechanized System

A different approach to green cane harvesting is to cut and remove the tops mechanically and to do the cleaning and handling manually. At the beginning of the 1980/1981 season the Experiment Station investigated this possibility; unburnt cane was cut with a simple tractor-mounted mechanical cutter.

The machine had no difficulty with cane yielding 80-90 t/ha but clogged frequently in cane yielding more than 100 t/ha. This problem was aggravated where cane had lodged. The density of the standing cane caused the stalks to be pushed forward and out of reach of the topper, resulting in poor topping efficiency. The sausage-shaped windrow left by the machine was extremely neat.

Cane retrieval from the windrow was manual. Tops and some trash were removed before the cane was stacked at a rate of 2 stacks per man per day. Twelve men stacked a total of 398 t and averaged t/man-day.

The stackers preferred to lift the cane out of the sausage and to remove the trash with a cane knife, rather than to pull the stalks tops first, out of the sausage: a process which would have removed most of the trash. Trashing improved during the trial and the total amount of extraneous matter reduced from 11.4% over a three week period.

It was feared that much of the cane would be lost in the trash and losses were therefore measured before gleaning. Excluding what was left as stuble as a result of high base cutting, 1.9% of the cane was left in the field.

Table 4 shows quality analyses for cane cut mechanically and handled green:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Sucrose %</th>
<th>Fibre %</th>
<th>Purity %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvested green</td>
<td>13.5</td>
<td>18.7</td>
<td>82.5</td>
</tr>
<tr>
<td>Harvested burnt, same field</td>
<td>15.4</td>
<td>14.4</td>
<td>87.0</td>
</tr>
<tr>
<td>Mill group average</td>
<td>13.6</td>
<td>17.2</td>
<td>83.1</td>
</tr>
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</table>
for cane that was burnt in the same field and for the average of all cane delivered to the mill while the trial was in progress. The quality of the cane harvested during this time was lower than that of burnt cane from the same field but was not much worse than the mill average, which included data for both green and burnt consignments.

In a poor crop yielding 85 t/ha the cutter achieved an output of 34 t/ha when cane was erect but this dropped to 22 t/ha in 100 t/ha of lodged cane. The conclusion from this project was that a simple cutter can be used effectively to cut green cane. In heavier cane, the topper will need to be modified. The productivity of stackers was reasonable and would improve if all the cane of an estate were harvested in this way. Cane quality and cane losses were considered to be acceptable.

**Future Plans**

During the 1982-1983 season the operation of the Sasaby will be refined so that the optimum component speeds and relative position can be established. After this, the design of the machine will be analysed thoroughly to establish what cleaning mechanisms are required for acceptable cane quality. A decision will then be made as to whether a third, simplified prototype should be constructed. All superfluous cane handling and cleaning components will be eliminated so as to produce a commercially acceptable green cane harvester.

Further trials for the semi-mechanised green cane harvesting system are planned for the 1982-1983 season. The cutter will be modified to partially remove leaves from the stalks and this will reduce the task of the labourers who must complete the harvesting operation.

**CONCLUSIONS**

Once it is accepted that a mechanical harvesting system need not deliver cane containing less extraneous matter than is the case with manual cane harvesting, mechanical or semi-mechanical alternatives are feasible. In addition, if it is accepted that cane losses equal those of present commercial chopper harvester in burnt cane, the Sasaby appears to be a reasonable proposition for completely mechanized green cane harvesting.

Semi-mechanized systems such as the Carib or those developed in South Africa are also possible, and could be used in conjunction with manual labour. For many countries this would be a cheaper alternative than completely mechanized systems.

**REFERENCES**


RÉCOLETE MÉCANISÉE DE LA CANNE VERTE

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RÉSUMÉ

Maints pays producteurs de canne à sucre préfèrent récolter la canne verte, même si les travaux sont plus ardu et plus lents lorsque la canne n'est pas brûlée avant d'être coupée. Dans le monde entier, une somme considérable d'efforts a été consacrée à la mise au point de systèmes adaptés à la récolte mécanisée de la canne verte. Les auteurs présentent les résultats de quelquesuns de ces travaux. En Afrique du Sud, la récolte de canne verte présente des avantages bien définis; depuis plusieurs années, la Station expérimentale de l’Association du sucre d'Afrique du Sud essaie de mettre au point des techniques de récolte mécanisées. Le Sasaby est la base d'un système de récolte complètement mécanisé où les tiges sont coupées entières et qui, en décembre 1981, egressait des niveaux de rendement acceptables commercialement. Le deuxième système est semi-mécanise; il s'agit d'une simple coupeuse munie d'un élément manuel de ramassage et
COSECHA MECANIZADA DE CAÑA VERDE

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RESUMEN

La cosecha de caña verde es preferida por parte de muchos países cultivadores de la caña de azúcar, a pesar de que el cosechar la caña sin quemar es una tarea más ardua y lenta que cuando se cosecha la caña quemada. Se han hecho muchos intentos en todo el mundo para desarrollar sistemas mecanizados para cosechar caña verde que resulten aceptables; aquí se describen los resultados de algunos de ellos. En África del Sur la cosecha de caña verde tiene ventajas definidas y la Estación Experimental de la Asociación Azucarer de Africa del Sur ha estado, durante algunos años, enfrascada en el desarrollo de alternativas apropiadas en cuanto a mecanización de las cosechas. El denominado Sasaby forma la base de un sistema completamente mecanizado para las cosechas a tallo entero, el cual, en diciembre de 1981, se aproximaba a niveles de rendimiento comerciales aceptables. El segundo sistema es semimecanizado e incorpora una simple cortadora con sistema manual de recogida y apilamiento. La calidad de la caña cosechada mediante estos dos sistemas se compara favorablemente con el de la caña cosechada a mano, en tanto que las pérdidas totales de caña también resultan aceptables.