THE BSPA CANE CUTTER

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ABSTRACT
There has been a rapid decline in the numbers of workers willing, or able, to cut cane in Barbados. Pre-harvest burning and mechanical loading have temporarily alleviated the labour shortage but yields have fallen seriously as a result of the burning.

A simple, tractor-mounted machine has been developed to cut and top unburned cane. The cut cane is manually sorted from the trash into piles which can be loaded with existing equipment. This piling can be done by all classes of worker, including those who could not normally engage in harvest work. One estate, in 1973, reaped its entire crop with the machine and without burning. For areas where burning is not objectionable a very high output per person can be achieved by burning the windrow of cane left by the machine.

Base cutting exploits the weak point of the stalk at ground level, whilst topping exploits the weak point in the "coot". Because there are no sharp edges or fast-moving mechanisms, the machine can deal with the hazards of rocky and sloping fields, cut cane planted in a furrow or on a ridge, and top cane of irregular stalk lengths and degrees of lodging.

INTRODUCTION
In common with many other countries producing sugarcane, Barbados is faced with a rapid decline in the number of men able, or willing, to cut cane. Several imported cane harvesters have been tried with the result that we were made aware of the shortcomings of our field preparation and managerial skills, the shortcomings of the machines, and the unsuitability of much of our land. Even more worrying was the requirement of pre-harvest burning to secure even moderate outputs from the machines. Local experience and experiment have repeatedly demonstrated that burning results in lowered yields (Eavis and Chase; Hudson); in fact production has recently fallen by about 20% with pre-harvest burning whilst weeding costs have soared.

The Barbados Sugar Producers' Association (BSPA) have adopted a double attack on the problem of mechanical harvesting. On the one hand there has been a wholehearted trial of controlled burning, push-pile loading, and the use of 3 Don Mizzi harvesters on a contract basis. On the other hand we are developing harvesting machinery which can work in undulating and stony fields and which eliminates the need for pre-harvest burning. This development, which has been carried out in association with an English manufacturer, F. W. McConnel Ltd, is attracting fairly wide interest, and machines have been purchased in 10 other countries for evaluation.

In an age with the technological competence to reach the moon, it is certainly mechanically possible to create a single machine which will enter a field of unburned sugarcane and deliver clean cane to a transport vehicle. Ramp reported such a machine for wholtsick cane, at the 1965 ISSCT Congress, Creber and Mizzi have developed green cane chopper units in
Australia, and most modern combines can be operated for a time in green cane if challenged. But it appears that the productivity of these expensive machines is uneconomically low (Clayton and Whittemore) except in favourable circumstances. While appreciating that there are many cane industries where burning is acceptable and existing harvesters produce good results, we join with Vallance, Bartlett and others (e.g. Leffingwell) in believing that new thinking is needed. It must, however, also be admitted that this paper owes a great deal to old thinking of the early pioneers of mechanical harvesting in Australia and Louisiana!

The purpose of this paper is to (a) describe our approach to a simple harvesting system with emphasis on green cane, (b) describe the machine which is central to the success of this approach, (c) elaborate on 3 novel aspects of this machine.

THE STRATEGY AND TACTICS OF A GREEN CANE HARVESTING SYSTEM

The main problems to be overcome with a green cane harvesting system are as follows:

a) Vision — especially setting, and seeing obstacles in the path of, the base-cutter; row-following in lodged cane.

b) Chokes — the volume of trash and tops usually exceeds the volume of cane, thus requiring high capacity mechanisms and special steps to eliminate trash wrap.

c) Cleaning — existing methods (pneumatic, roller-beds, stripping fingers) only work efficiently with a thin mat of cane and trash. If the machine also contains topping and gathering mechanisms, base cutter, etc., it may be too expensive in relation to the throughput permitted by this cleaning mechanism.

d) Fire risk — mostly associated with dry trash settling around hot exhaust manifolds.

e) Soil compaction and row-management — modern cane harvesting machinery, especially where it relies upon accompanying transport, can produce considerable soil compaction. Many harvesters also depend upon some row-management subsequent to harvest, for example off-barring. Although decompacting cultivation can be carried out through trash, other row-management could be impractical and a green cane harvester must deal with wide stools and unmanaged rows.

This is a formidable list of difficulties but we have evidence that they can all be overcome by a stepwise approach. Complete mechanical harvesting must include; base cutting, topping, cleaning and placement into transport. The first step in mechanization is usually to deal with the last of these, loading. This has frequently been done with the push-pile loader which, though an excellent machine, requires the cane to be burnt. However, with a rotating grab and wider arc of loading, it is possible to mechanize loading of unburnt cane by using the dwindling loading force to make heaps of clean cane which is much easier work than carrying it onto transport.

A logical second step is to mechanize the first 2 operations — base cutting and topping. This takes most of the hard work out of manual harvest, leaving only the cleaning and piling to be done by the remaining ex-loaders and ex-
There are a number of machines already available which can cut-and-top, including the Louisiana harvesters and simpler machines like the Scorpion, Santal and Agrolic. Unfortunately from our point of view these machines make demands on cane type, land-preparation and terrain which we can not guarantee to satisfy. They also have the weakness that they do not specifically envisage a third step — the eventual introduction of a mechanical retrieval/cleaning machine — if required. Since cleaning is the most difficult of the 4 operations listed above, it is logical that it should be the last operation to be mechanized, but it would be dangerous to venture on the first 2 steps without knowing what the third would look like.

A formal statement of this step-wise approach is shown in Table 1, where it is compared with an alternative.

**TABLE 1.** The two approaches to mechanised harvesting being tried in Barbados. The second results in a much more gradual evolution from the point of view of the land, management, labour, factory, and capital input.

<table>
<thead>
<tr>
<th>Typical Introduction of Mechanical Harvesting</th>
<th>Step-Wise Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>( Burning)</td>
<td>(No Burning)</td>
</tr>
<tr>
<td>1. Hand cut</td>
<td>1. Hand cut</td>
</tr>
<tr>
<td>hand load</td>
<td>hand load</td>
</tr>
<tr>
<td>no burning</td>
<td>no burning</td>
</tr>
<tr>
<td>2. Hand cut</td>
<td>2. Hand cut</td>
</tr>
<tr>
<td>push-pile load</td>
<td>hand pile</td>
</tr>
<tr>
<td>burning</td>
<td>grab load</td>
</tr>
<tr>
<td></td>
<td>no burning</td>
</tr>
<tr>
<td>burning</td>
<td>hand pile</td>
</tr>
<tr>
<td></td>
<td>grab load</td>
</tr>
<tr>
<td></td>
<td>no burning</td>
</tr>
<tr>
<td>machine pile</td>
<td>machine pile</td>
</tr>
<tr>
<td>or chop-load</td>
<td>or chop-load</td>
</tr>
<tr>
<td></td>
<td>no burning</td>
</tr>
</tbody>
</table>

A step-wise approach like this also has the advantage of a gradual evolution (Baxter6) in the demands made upon the farmer and his land preparation, the local mechanical resources, the factory reception and processing, the labour supply, and the availability of capital. The last point is most important if relatively small farms are to retain their independence.

In order to implement the approach outlined on the right hand side of Table 1 we needed 3 machines. The first was a low-cost loader capable of picking up hand-piled, unburned, cane on small farms and awkward terrain. Secondly a machine to cut and top canes under a wide range of conditions, free the trash as far as possible, and leave a convenient windrow from which the cane can be manually assembled. Thirdly a machine to imitate the hand retrieval operation when labour supplies dwindle even further. The loader has been described elsewhere and the third machine is only in the prototype stage. The rest of this paper deals with the second machine.
THE BSPA/McConnel cane cutter

The purpose of this machine, then, is to reduce a standing crop of cane to an orderly swath of cut and topped stalks, freed from adhering trash. The more important demands which it has to satisfy are that it must be:

a) Able to cut unburned cane of up to 100 tons per hectare.
b) Tolerant of rough-and-ready field preparation.
c) Able to cut cane from furrows, ridges, tied-furrows or flat-planting.
d) Able to work in stony conditions.
e) Competent to cut cane from any slope which can be negotiated by a wheeled tractor for other operations (spraying, manuring, etc.).
f) Tolerant of variable row spacings and of wide ratoon stools.
g) Able to negotiate difficult headlands, in-field ditches, etc.
h) Rugged in construction, and undemanding in operator skill, maintenance, and local back-up capacity.
i) Priced within the capability of a 100 hectare farm.

We believe that the clue to satisfying the first 6 requirements lies in abandoning sharp cutting edges and exploiting the 2 structurally weakest points of a cane stalk — 1 at ground level and the other in the "coot". Although the machine has been called a cane cutter it has not yet in fact cut a single cane. To satisfy the last 3 requirements, the machine is mounted on a range of standard wheeled tractors using a common front-end loader mounting and the standard 3 point linkage.

The general layout of the machine is shown in Fig. 1.

During operation, cane is first engaged by the pusher bar in front of the topper unit. Taller canes are pushed forward whilst lodged or short canes pass directly underneath. Thus the tops of canes of different height are attacked by
the downward-sweeping rubber flails at approximately the same height. The speed of the reel, on which these flails are mounted, can be varied as well as the number of flails attached to each bar. Leaves are stripped from the upper part of the canes and tops are broken off. Some canes slip round the pusher bar, and are brought inwards and upwards by the spirals, entering the topper reel from the side (or even from the rear). The topper is pivoted and counter-balanced so that it adjusts its height according to the resistance of the canes on the pusher bar.

Conventional spiral dividers are mounted on a hollow-section beam which is slotted along the back. Two pairs of wheels run inside each beam, allowing the dividers to float up and down as the ground contour demands. The divider units are mounted on a front-end loader jib which fits a range of medium horsepower tractors (e.g. MF 165, Ford 5000, IH 574). Topper, spiral dividers, and rams, are powered from a tractor-mounted pump of about 60 litres/minute capacity.

The canes are then knocked forwards and downwards by a crossbeam on the jib and pass under the tractor. In tangled cane and if the cane is not firmly rooted in the soil, a roller or pressure plate can be attached to the jib as shown. This holds the cane against the ground whilst the dividers disentangle it. Two flexible pillars tidy the canes away from the rear wheels of the tractor. The passage of the tractor or roller over the canes results in a high proportion of the stalks breaking, or half-breaking, at ground level. The action of combing the cane into an orderly array of parallel stalks also frees most of the adhering trash.

Breakage of the canes at ground level, and further loosening of the trash, is completed by 2 contra-rotating sets of sweeps, powered by the tractor PTO. This unit is attached to the 3-point linkage and floats over the ground on a weight transfer arrangement and height control wheels. In addition each sweep is hinged and spring-loaded so that it follows the soil surface, whether this is prepared in furrows, flat planting, or ridges. For ridges higher than about 10 cm the drums can be angled to help the sweeps to travel up the side of the ridge. There is no need to sharpen the sweeps and if they strike a rock the implement and tractor PTO are protected by a pre-set, and audible, slipping clutch.

The rear implement can be quickly unhitched to free the tractor for other duties during the crop. The topper, dividers and hydraulics can easily be dismounted at the end of crop.

Since the topper, dividers, and base sweeps feel their own way through the crop, the operator is left with only the work of row following and taking action if the slipping clutch is heard. On reasonably well-prepared land the unit is also self-steering and under these conditions agile operators have left the machine to work itself!

The machine is relatively safe by cane harvester standards. There are no fast-moving or sharpened edges. By passing the cane under the tractor, the centre of gravity is kept low. However there is a fire risk with trash from the topper settling round the exhaust of one of the makes of tractor and this must be suitably protected.

So far the main limiting factor to output has been tractor overheating. Trash, dust and cane arrow fluff block the grill and radiator fins. Various solutions to the problem have been found and 5 different methods were used on the

Next in importance as a limiting factor was vision whilst cutting opening rows in lodged cane. Long-term solutions are easy to envisage, for example planting lines of different-coloured varieties at intervals across the field. Otherwise an assistant is sometimes required to guide the driver.

Although the machine has been designed primarily to cut unburned canes it will also cut burnt cane satisfactorily. In fact, since row-following is much easier, and far less power is required, the machine has handled quite heavy tonnages of burnt cane (over 160 tons/hectare) and the output goes up appreciably.

Further details of the machine are summarised in Table 2.

**TABLE 2.** Details of the BSPA/McConnel Cane Cutter.

<table>
<thead>
<tr>
<th>Item</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>Front end 1 194 kg</td>
</tr>
<tr>
<td></td>
<td>back end 1 092 kg</td>
</tr>
<tr>
<td>Suitable tractors</td>
<td>power 60 - 80 hp</td>
</tr>
<tr>
<td></td>
<td>tyres as suited to local conditions</td>
</tr>
<tr>
<td></td>
<td>clearance under tractor 40 cm minimum</td>
</tr>
<tr>
<td>Row widths</td>
<td>usual 1,45 m - 1,80 m</td>
</tr>
<tr>
<td></td>
<td>possible 1,20 m - 2,20 m</td>
</tr>
<tr>
<td>Suitable culture</td>
<td>normal setting of basecutter furrows to 12 cm deep</td>
</tr>
<tr>
<td></td>
<td>flat</td>
</tr>
<tr>
<td></td>
<td>special setting ridges to 10 cm height</td>
</tr>
<tr>
<td></td>
<td>ridges to 20 cm height</td>
</tr>
<tr>
<td>Power on hydraulic motors</td>
<td>spiral dividers up to 7 hp</td>
</tr>
<tr>
<td></td>
<td>topper up to 14 hp</td>
</tr>
<tr>
<td>Speeds</td>
<td>topper 0 - 350 rpm</td>
</tr>
<tr>
<td></td>
<td>dividers 0 - 150 rpm</td>
</tr>
<tr>
<td></td>
<td>base cutter 120 - 160 rpm</td>
</tr>
<tr>
<td>Forward speed</td>
<td>good conditions around 3 kph</td>
</tr>
<tr>
<td></td>
<td>reasonable conditions around 2 kph</td>
</tr>
<tr>
<td></td>
<td>difficult conditions around 1 kph</td>
</tr>
<tr>
<td></td>
<td>(reduction gear box advised for tractor)</td>
</tr>
<tr>
<td>Typical outputs</td>
<td>green cane in difficult 7 - 8 tons/hr</td>
</tr>
<tr>
<td></td>
<td>conditions</td>
</tr>
<tr>
<td></td>
<td>green cane, average</td>
</tr>
<tr>
<td></td>
<td>10 - 15 tons/hr</td>
</tr>
<tr>
<td></td>
<td>conditions</td>
</tr>
<tr>
<td></td>
<td>burnt cane</td>
</tr>
<tr>
<td></td>
<td>10 - 25 tons/hr</td>
</tr>
</tbody>
</table>

**NOVEL ASPECTS OF THE SYSTEM**

1. *Labour content*

   From the outset, the need to involve labour in all stages except the last one (Table 1) has been the most controversial aspect. Many cane farmers adopt mechanical harvesting only when driven to it by an impossible shortage, or expense, of labour. Usually by that time relationships between labour and management are so strained that management will countenance nothing
other than the exchange of an excessive reliance on labour for an excessive reliance on machinery. The results can be as unpleasant for management as for labour (e.g. in massive increases in extraneous matter, Humbert, Symes).

In our own situation we are being driven to mechanisation by an acute shortage of young and able-bodied workers, but there are still large numbers of older men and women who need (and want) work, provided that it is dignified and remunerative. The cane cutter plus mechanical loading has taken the hard work out of harvesting leaving relatively light work which suits these people.

There is a close analogy here with the introduction of the mechanical potato spinners and elevator-diggers in Europe in the face of a shortage of men able or willing to dig potatoes. A hard job was exchanged for a lighter sorting and gathering task to the mutual benefit of farmers and labour, including casual workers (cf a recent editorial in the Agricultural Machinery Journal).

For Barbados the avoidance of burning is worth about $120 US per hectare so that we can well afford to pay $1 US per ton for heaping unburned cane left by the machine. One farm in Barbados changed last year from burning and hand cutting with immigrant labour, to machine cutting and hand heaping of unburnt cane with the remnants of the local labour force only. Earnings of these people went up by 30% compared with the previous season and there was actually a small labour surplus.

We have also had some experience with the piling of canes burnt before, or after, cutting with the new machine. In this case the rate of piling doubled and labour earned good wages at 55c US per ton. Assuming a five-year depreciation for the cane cutter, this burnt cane system was cheaper than any other harvest method in Barbados due to the higher outputs from the machine and the lower cost of manual piling.

Various ideas are being tried to improve the appearance of the unburnt sausage and to facilitate hand retrieval. The most successful aid so far is a simple hand-tool (Fig. 2). The hooked part helps to sort cane from trash. The straight edge is sharpened and used for cutting off any bits of stumpy material. The hooked edge is sharpened and used for cutting off any tops missed by the machine. Since it weighs only 340 g it can easily be handled by women.

### FIGURE 2
Simple hand tool to aid retrieval of cane from the swath left by the Cane Cutter.

2. **New method of base cutting**

As far as we know this is the first cane cutting machine which exploits the fact that the weakest point of a cane stalk is usually at ground level. It is however a well-known fact to manual cane cutters and is utilised in Madeira as the normal method of harvest (Leffingwell). Most varieties in which the machine has worked have been harvested satisfactorily in this way, including most varieties tried in Puerto Rico, Fiji, South Africa and Barbados as well as
a wide range of breeding material at the Central West Indies Cane Breeding Station.

However, although the method has so far been found to be of wide application, it will probably not be universally applicable because it depends upon the cane being firmly held in the soil. For example in very wet conditions, and in muck, or light sandy soils, stools may be uprooted. One Barbados variety forms very small stools in primavera planting and has shown a tendency to uproot when the clay soils are moist. Bad attacks of root-eating pests can also lead to appreciable amounts of stump material being removed.

Ratooning has generally been good with two exceptions. One concerns circumstances mentioned in the last paragraph where stools are turned out of the ground. The other has been noticed in fields which were burnt and then suffered from heavy jumping borer attack (Elasmopalpus lignosellus). Because the shoots with growing points at or near ground level continue to grow after hand cutting they are relatively resistant to this pest; but the machine knocks these shoots off and the new tillers, though more numerous, are more susceptible to attack.

Although the hinged sweeps will deal with quite deep furrows and high ridges, the best performances have been in fields of more or less level culture. Rough field preparation results in a slower operation only in the first year of cutting since the action of the sweeps prepares a smoothed soil surface for future cutting.

Casual estimates of additional sucrose retrieved, compared with hand cutting, indicate increases up to 500 kg/ha since no stubble is left.

3. The new method of topping

For a number of reasons it is impossible to produce stands of uniform cane in Barbados. Therefore a method of topping was sought which was both simple and able to cope with a wide range of stalk lengths and cane condition within a single field. Rotating blades, scissor-bars, or high speed flails, did not seem to offer a good approach.

Leaves emerge from the stalk at an acute angle and are therefore good targets for downward-sweeping rubber fingers (Ramp3). Furthermore the strength of the coot is so much less than the cane that there is a good chance of breaking off the immature top as it runs the gauntlet of the flails. Such selective topping can be very effective and cane cut with the machine and then hand-assembled recorded a lower percent of top material than any other method in routine factory sampling last year (Gittens11). During prototype trials in the previous year counts of over 10 000 stalks showed a 76% topping success judged by the removal of coot, and most of the remaining 24% had been at least partly defoliated. However some tops are missed entirely when cane falls directly forward of the machine under the influence of other canes. Attempts at reducing this tendency are continuing.

Although the method might be used on other harvesters it has limitations. One problem is that the flailed-off leaves and tops fall directly back into the cane to be cut, presenting an additional quantity of material to any subsequent clearing system. Secondly there is a large volume of leaf shreds etc., which can blow back and foul the grill and radiator fins of the tractor. Thirdly, a flail tip speed of more than about 1 000 m/min can damage the stalks of some
varieties. This fact will limit the forward speed of a machine depending upon
the arrangement and number of flails; for example the present topper arrange-
ment seems to be limited to just over 3 kph which would be too low for some
types of harvester. On the other hand one Barbados variety has a very strong
coot (protected by highly-fibrous leaf sheathes) and flail tip speeds of about
1200 m/min were required to top it effectively.

Ramp found that rubber fingers, rigidly mounted and working hard
against the cane, had a rather short life. We have not encountered this problem,
presumably because of the counter-balance and the fact that the cane is not
held rigidly against the flails.

CONCLUSION AND SUMMARY

Recalling the analogy with root-crop harvesting, the machine described
in this paper represents an intermediate step towards the complete mechanical
handling of the crop. It replaces an arduous task for which few people are
fitted, by an easier task for which many people are suited. As with the potato
elevator-digger, the harvested crop is left in a form which does not prejudice
its eventual complete mechanical handling in a multi-stage system.

The most important step taken to achieve the desired strength and versa-
tility of operation was to abandon the use of sharp edges for base-cutting and
topping. This exploitation of the two weakest points in a cane stalk by karate
methods might have wide application in cane harvesting.

By separating the harvest of green cane into distinct stages we believe
that a simple and economic system can be developed. At the same time it
allows a more gradual evolution of mechanisation to the mutual benefit of
management and labour and the availability of capital and local mechanical
experience.

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La cortadora de caña BSPA

J. C. Hudson

RESUMEN

En Barbados hay una continua merma en el número de trabajadores disponibles o con habilidad para cortar caña. La quema de la caña antes de cortarse y el llenado mecánico ha servido para aliviar esta merma de trabajadores, pero el resultado de esta práctica ha sido un descenso en el rendimiento.

Se ha desarrollado una cortadora de caña la cual es instalada en un tractor. La misma está diseñada para cortar caña verde y cortar el rabo también. La caña así cortada puede separarse fácilmente de la paja para ser recogida con llenadora de caña. El apilamiento puede hacerse por cualesquier trabajador no comprometido con la zafra. En la cosecha de 1973 una hacienda recolectó toda su caña con la máquina y sin quemar. Para aquellas áreas donde todavía la quema no es objetable se puede conseguir un alto rendimiento por persona, quemando la caña apilada una vez ésta ha sido cortada por esta máquina. El cortar de la caña a nivel del terreno con esta máquina permite obtener el mayor rendimiento posible y el mismo es aumentado al poder cortar el rabo. Debido a que la máquina tiene muy pocos componentes con filos agudos o componentes de rápido movimiento, permite que ésta trabaje con eficiencia en terrenos rocosos y escarpados. Puede también cortar caña sembrada en el lomo como caña sembrada en el surco, como de diferentes tamaño y de diferentes grados de producción.