THE EDGECOMBE CANE CUTTER

By G. v.d. MERWE, J. R. PILCHER, E. MEYER
South African Sugar Association, Experiment Station, Mount Edgecombe

Abstract

The reasons for attempting to design and develop a whole stick sugarcane cutting or harvesting machine specifically suitable for South African conditions are described. The thinking which led to the final form of the machine is given and the development of the machine during a full season of working under commercial conditions is discussed in greater detail. Results of performance tests done during this period are described and discussed.

Introduction

For many years cane harvesting machinery for wholestick and chopped cane has been commercially available in the sugar world. These machines are invariably very expensive, particularly the choppers, and well beyond the needs of the average cane grower in South Africa who cuts less than fifty tons of cane per day. In 1967 a Toft J 150 was imported from Australia for evaluation and in 1973 a Santal from Brazil. The Experiment Station even built a machine closely resembling the Australian Crichton machine in 1966. All these machines suffered from a common limitation. They were "soldier" harvesters, which means that the cane is cut and passes through the machine in an upright position. To do this the standing cane has to be upright, and this is not always the situation in the field. Secondly the Toft, and to a larger extent the Santal, were very narrow and top heavy and therefore much too unstable to negotiate the hillsides which are a feature of the South African sugar belt.

It has become apparent throughout the world, that the only way to cut recumbent cane mechanically is to take it into the machine butt first.

In recent years (prior to the slump in the economy which hit South Africa in 1976/77) there has been a scarcity of labour willing to cut sugarcane. It was therefore desirable to find a cheap machine which could negotiate hillsides, handle around 50 tons a day and cut recumbent cane if necessary, preferably using the ubiquitous farm tractor as a power source. It was not considered necessary to eliminate labour completely from the farm. An aid to cutting would therefore suffice.

In 1973/74 the Experiment Station took up the challenge and designed and built a machine called the "Gobbler." It consisted of a topper, a base cutter, a chopper harvester intake system and a bin at the back to collect the whole stalk cane into bundles which were subsequently dropped onto the ground. The machine was side-mounted on a Ford 5000 and showed great promise. Further development of this concept was held in abeyance pending progress with other machines.

At the same time a very simple cane cutter had been built on a farm in the Nkwalini Valley. On this machine a plough disc, which was driven off the belt pulley of the tractor, operated as a base cutter. It was mounted on the three-point linkage of the tractor with the machinery behind and to the right of the right-hand rear wheel of the tractor. The cut cane was left in a sausage windrow behind the machine.

The idea had great potential in straight burnt cane and the Experiment Station's Sasex machine was based on the same concept but with refinements such as a depth wheel to control base cutting height, a topper to top the cane and crop lifters to deal with recumbent cane (Pilcher and van der Merwe[2]).

It can be understood that if each row of cut cane is left on the ground, as the tractor moves to the right to cut subsequent rows, unless the row spacing is exactly right, there is a possibility of the tractor wheels, to a lesser or greater extent, running over cane already cut. This effect is accentuated when operating on hillsides where the sausage tends to slide out of position. The other big disadvantage to the side-mounting was the drag imposed when attempting to cut recumbent cane. This would slew the tractor and steering was made difficult and sometimes impossible.

To over come these two disadvantages of the side-mounted Sasex, it was decided to build an in-line machine using the already proven components of the Sasex machine. Thus the Edgecombe cane cutter was born.

Description and Operation

An attractive feature of the Sasex was the ease with which it could be attached and removed from a tractor. An attempt was made with the Edgecombe cutter to retain this feature and the cutting part of the machine was mounted on a quickly detachable frame. The machine was mounted on a John Deere 2120 2-wheel drive tractor. It had croplifters, a topper and base cutters from the Sasex but was mounted on a new frame. The machine was intended to cut single rows more than 1,3 m apart and double rows at lesser spacings. The base cutters, toppers and croplifters were all driven hydraulically and the oil tanks and pumps were mounted on a frame carried on the three point linkage, in order to counterbalance, to a degree, the weight of the machine on the front wheels.

It very soon became apparent that the heavy steering and lack of traction was unacceptable and the machine was then built onto a 4-wheel drive County 754 tractor. This, with power steering and driven front wheels, was a great improvement and the main problem became one of visibility for the driver. This was a very real problem in cane which was so recumbent that even on foot it was difficult to follow the row. However, the machine did perform adequately although standard tractor gearing was much too fast for such conditions.

Further fields trials led to the conclusion that the function of the scrolls could be fulfilled quite satisfactorily by the base cutter drums, even in badly recumbent cane. This resulted in a much simpler design. Operator visibility was, however, still very poor and it was decided to rebuild the machine on the rear of a two-wheel drive tractor for the 1977 season.

The present Edgecombe cutter is a double row, burnt cane machine which tops and base cuts the stalks, and leaves them in a single "sausage" windrow parallel to and between the two rows which have been cut. The machine can nevertheless cut green cane and could be used to open fire breaks.

The Edgecombe cutter comprises five major units; two base cutters, two toppers and an hydraulic-drive assembly. These components are mounted on a Ford 5000 tractor with the tractor controls reversed. The tractor is fitted with a County reduction gearbox to provide a wider range of speeds when travelling in reverse (see Figure 1).

The base cutter assembly consists of two independent base cutters, adjustable for height and width, which are fixed onto a toolbar. The toolbar is mounted onto the tractor's three-point linkage and can be raised and lowered to traverse obstacles.

The toppers are carried on an A-frame mounted on the rear axle of the tractor. The topping heights are individually adjustable. The hydraulic drive unit is mounted on the front of the tractor and is driven by a shaft from the engine crank-pulley. Both base cutters and toppers are powered from this unit. Steering of the machine is completely hydraulic with the oil being taken from the tractor hydraulics and fed into a Charlyn orbital

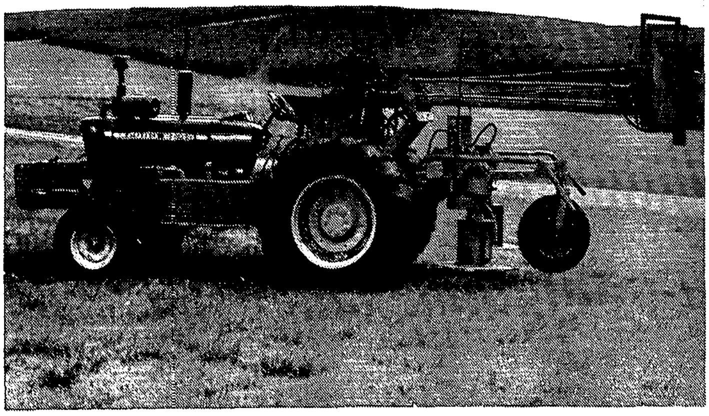

Figure 1: Edgecombe cane cutter, general view

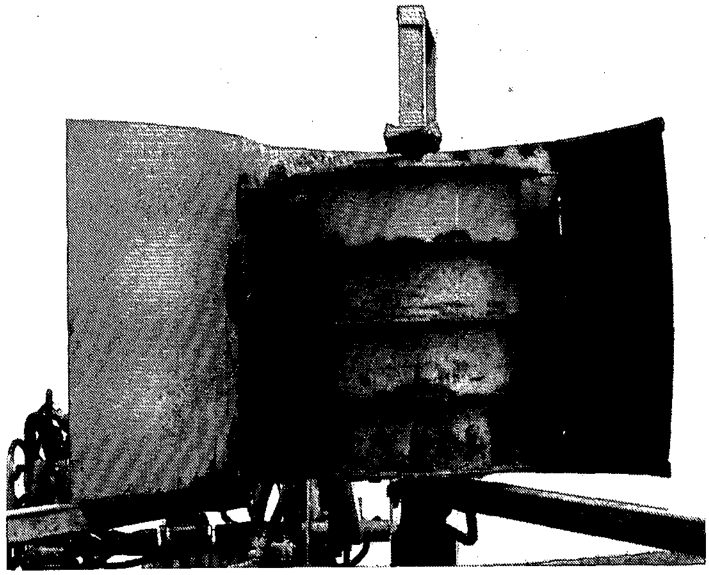

Figure 2: Chopping topper of the Edgecombe cutter

steering motor, which in turn feeds oil to an hydraulic ram mounted between the steering arm on the tractor and the frame.

Modifications During Year

Base cutters

The operator found it very difficult to maintain good depth control on each base cutter while maintaining a reasonable cutting speed. This limitation reduced capacity considerably. Halfway through the test period, a depth control wheel was fitted between and ahead of the base cutters. This depth wheel ran in the centre of the interrow between the two rows being cut and base cutting height was controlled by the levels of this wheel and the rear wheels of the tractor. A further refinement was the fitting of an automatic device for lifting the base cutter in the event of its absorbing excessive power. This would usually be due to the base cutter digging into the ground. These modifications made the base cutting operation much easier, gave better control of the cutting height and faster speeds were attained.

Toppers

Initially twin disc toppers were used and topping efficiency was fair. These toppers cut off whole tops and, while most of them fell, as planned, into the interrow, some fell into the sausage. Unfortunately some of the correctly placed tops, being whole, would be caught up by the base cutters and incorporated into the sausage. If, as described later, mechanical loading straight from the sausage is done with a Bell loader, the loader inevitably collects tops whilst picking up the cane. Thus far too many tops may be sent to the mill.

A new type of topper was designed to cut the tops into short pieces. Each topper now consists of a vertical drum with four rings of mower blades. By cutting the tops into 150 mm lengths, drying rate is increased and those few pieces caught by the base cutters and dragged into the sausage are much less in mass than whole tops (see Figure 2).

When loading with the Bell loader, these short pieces tend to fall out more readily than whole tops and thus often remain behind in the field. These modifications thus resulted in more efficient topping and cleaner cane.

Performance

The performance of the Edgecombe cutter while cutting nearly 5 000 tons during the test period is shown in Table 1.

Fuel consumption

The relatively low fuel consumption of 5,5 ℓ/h indicates that only about 50% of the tractor's total available power was utilized. A less powerful tractor would have been adequate but its mass and size would have been insufficient to carry the cutter with the stability and manoeuvrability required.

Output

The average output per field hour was 15,6 tons. This figure included time lost in travelling back and forth to the fields. Output increased steadily, especially from September onwards when the depth wheel was fitted. The performance in field 406 in November, cutting 33,2 tons per field hour, is indicative of the potential performance in well prepared fields, with good burns and on reasonable slopes with upright cane. Under these conditions, daily output could be up to 200 tons. It seemed that row length and recumbency were the most important factors affecting output. The total hours worked per day were limited and it can be expected that considerably more cane could be cut if a larger quota were available to the machine.

Reliability

The hydraulic drive to the various components worked very satisfactorily and time lost due to breakdowns was insignificant. From Table 2 it is clear that maintenance and repairs were acceptably low over the test period.

Manoeuvrability and stability

Manoeuvrability and stability were good. The machine is well balanced with the cutting attachment carried mostly by the large rear wheels of the tractor. The hydraulic oil tanks are mounted centrally and low down on either side of the tractor. While operating along the contour on slopes of 30%, the steering wheels tend to break away, thus causing crabbing. Under these conditions the brakes had to be used to stay on the row. The turning circle is quite tight and similar to that of the tractor alone because the complete base cutter assembly can be lifted by the three point linkage to avoid obstructions.

Base cutting

An important problem was the loss of base cutter blades in stony fields. The best solution so far has been to weld the blades onto the base cutter disc in addition to bolting them on. Quality of base cutting was good in light and heavy soils with no discernible stool damage.

Ridges were more of a problem than an advantage, especially in lodged cane where the base cutters were unable to retrieve recumbent stalks lying right next to the ridge. Ridged fields were also a distinct impediment to across-the-row mechanical loading

TABLE 1
Test results, Edgecombe Cutter

Month	Field	Cane condition	Area cut (ha)	Hours	Fuel (ℓ)	ℓ/h	Tons	t/h	t/ha	ha/h
April	80	Totally lodged	4,15	31,0	173	5,6	395	12,7	95	0,13
April May	303	Patches lodged	5,59	49,0	268	5,5	686	13,1	123	0,11
May	301	Patches lodged	7,68	54,0	326	6,0	785	14,5	102	0,14
May June	602/2	Patches lodged	1,50	15,0	81	5,4	169	11,3	113	0,10
June	602/1	Patches lodged	1,30	12,0	40	3,3	141	11,7	108	0,11
June	81	Mostly lodged	2,50	15,0	83	5,6	238	15,9	95	0,17
June July	601	Upright	4,40	25,0	170	6,8	418	16,7	95	0,18
Aug	11	Patches lodged	0,50	4,0	25	6,2	45	11,3	91	0,13
Aug Sept	13	Upright	5,72	32,7	162	5,0	533	16,3	93	0,17
Sept	5D	Upright	3,50	22,0	117	5,3	344	15,6	98	0,17
Sept	16H	Patches lodged	1,15	9,1	50	5,4	118	13,0	103	0,13
Oct	19	Upright very short	5,88	20,3	104	5,1	380	18,7	65	0,29
Oct	14	Upright	1,20	5,3	22	4,3	100	18,9	83	0,23
Oct Nov	13	Upright	3,20	14,3	77	5,4	295	20,6	92	0,22
Nov	406	Upright	3,30	10,0	54	5,4	332	33,2	101	0,33
	TOTAL		51,57	318,7	1752		4979			
	Average					5,5		15,6	96,5	0,16

and more cane was left behind by the loader in ridged fields than in fields with a flat culture.

Loading Systems

Growers will normally be advised to hand-stack from the sausages left by the Edgecombe cutter. Stacks can then be removed by self-loading trailers. If, however, a completely mechanical loading system is required, a Bell loader can be used to load into basket trailers or to stack for self-loading trailers. All cane cut by the Edgecombe cutter during the test was handled mechanically by a Bell loader. (Table 3).

Cane left behind in the field

Mechanical handling from the sausage windrows by a Bell loader was found to be quite feasible, but gleaners picked up an additional 9 tons cane/ha (see Table 3).

Two gleaners reduced the amount of cane left behind in the field from 9 to 1,9 tons/ha (Table 4). These figures were obtained from samples taken over an extended period with the cane averaging nearly 100 tons/ha. The figure for "after gleaning" will of course depend on the number of gleaners and on management. From work done by the Experiment Station on chopper harvesting losses, it is known that for hand-cut, push-pile loaded, burnt cane, pre- and post-glean figures for cane left in the field were about 5,4 tons/ha and 3,2 tons/ha respectively (de Beer and Boevey[1]).

Quality of sample

In Table 5 it can be seen from the four samples analysed that the average proportion of tops sent to the mill was 3,6%. This consisted of tops from cane topped correctly, cane topped too high or too low, or cane not topped at all.

A measure of topping efficiency can be found by comparing the average figure for "untopped cane" of 20,2% to the number of stalks in the field regarded as "untoppable." Untoppable stalks were defined as short stalks in between the longer stalks being such that the operator could not adjust the toppers in time to cut them. From a count made before harvesting, it was determined that 18% of all stalks in the experimental field were untoppable. Since 20,2% of all stalks were, in fact untopped, only 2,2% of "toppable" stalks were missed by the machine. This extremely good result can, of course, only be obtained in straight, upright cane.

Labour requirements

Cutting with the Edgecombe cutter, loading with the Bell and transporting 100 tons per day with two tractor/trailer units to a transloading station 1 km away, requires ten workers (Table 6). If box trailers are used, only nine workers are necessary.

TABLE 2

Repairs and maintenance

	Time (h)	Labour cost(R)	Spare part cost(R)	Total cost (R)
CUTTER COMPONENTS				
Weld steering bracket	1,50	11,25		11,25
Replace taperlock on base cutter shaft	1,00	7,50	3,93	11,43
Weld topper frame	1,50	11,25		11,25
Replacing base cutter blades	5,00	37,50	144,00	181,50
Replace steering ram	0,25	1,87	50,00	51,87
Weld topper anvils	1,00	7,50		7,50
Replace base cutter pressure hose	0,50	3,75	20,00	23,75
Weld base cutter shaft and brake fluid supply line	3,50	26,25		26,25
Repair hydraulic drive shaft	3,00	22,50	15,00	37,50
Repair hydraulic drive shaft	3,00	22,50	15.00	37.50
	20,25	151,87	247,93	399,80
TRACTOR COMPONENTS				
Fit reconditioned generator	0,25	1,87	36,83	38,70
Fit new RPM cable	0,75	5,62	9,00	14,62
Replace battery	0,16	1,25	166,25	167,50
Replace fanbelt	0,33	2,50	3,00	5,50
Fit 4 rim bolts	2,00	15,00	1,28	16,28
Repair cylinder head gasket recondition and check top	7,20	54,00	79,00	133,00
	10,69	80,24	294,36	375,60

TABLE 3

Cane left in field after loading with the Bell loader (tons/ha)

	Sample								
	1	2	3	4	5	6	7	8	mean
Whole sticks	6,9	7,9	6,0	3,2	4,3	8,7	6,7	4,1	6,0
Broken sticks	2,7	2,1	1,9	1,9	1,4	4,9	2,9	1,9	2,5
Stubble	0,9	0,1	0,8	0,8	–	–	–	–	0,3
Cane from tops	0,4	0,4	–	–	0,2	0,5	0,3	0,3	0,3
	10,9	10,5	8,7	5,9	5,9	14,1	9,9	6,3	9,1

TABLE 4

Cane left behind in field after loading with the Bell loader and after manual gleaning by two gleaners (tons/ha)

	sample		
	1	2	Mean
Whole sticks	0,7	0,9	0,8
Broken sticks	0,9	0,4	0,7
Cane from tops	0,4	0,5	0,4
	2,0	1,8	1,9

Handling systems used

Cane was either transported by box trailers or self-loading trailers. When using box trailers, the Bell loader "raked" across the sausages until it had a good grab full of cane. This cane was then laid down into a windrow. As soon as a box trailer arrived, it was loaded with the Bell from the windrow. This system gave faster loading rates than when loading directly from the sausages. Cane in the box trailers was chain-bundled as usual.

From the experience gained during the test period it is clear that one Bell loader working as described above with the Edgecombe cutter should handle up to 100 tons/day.

Costs

Cutting costs will depend on annual tonnage, machine output (determined by field conditions) and factors such as actual maintenance and depreciation. Estimated hourly costs based on limited experience with the machine, are given on the graph in Figure 3. The use of this graph is illustrated by the following examples:

	Grower 1	Grower 2
Total annual tonnage	30 000	12 000
Expected output (t/h)	25	25
Total hours per annum	1 200	480
Cost per hour (from graph)	R8,30	R13,50
Cost per ton	R0,33	R0,54

To these costs must then be added that of mechanical or manual loading, or stacking.

TABLE 5

Quality of cane sent ot the mill

	Sample			
	1	2	3	4
	%	%	%	%
NET CANE				
topped correctly	42,4	39,8	54,4	41,7
topped too high	30,4	27,7	21,5	14,0
untopped	12,5	19,7	15,2	35,3
short piece	10,2	10,4	2,0	1,2
TOTAL	95,5	97,6	93,1	92,2
NET TOPS				
topped correctly	1,8	0,5	0,6	1,2
topped too low	1,4	0,8	0,5	0,2
topped too high	0,2	0,1	1,0	1,2
untopped	0,8	0,6	1,1	2,6
TOTAL	4,2	2,0	3,2	5,2
Other extraneous matter	0,3	0,4	3,7	2,6
TOTAL	100,0	100,0	100,0	100,0

TABLE 6

Labour requirements for 100 tons per day

Operation	Number
Edgecombe cutter operator	1
Cutter assistant (stone remover)	1
Bell loader operator	1
Loader assistant*	1
Gleaners	2
Tractor drivers	2
Trailer conductors**	2
TOTAL	10

* Digs cable furrows when stacks are built

** Stay behind in the field, helping gleaners after attending to bundle or stack chains.

Conclusions

The Edgecombe cutter proved to be a viable proposition as a commercial cane cutter for quotas up to 200 tons/day. Its stability allows operation on slopes up to 30% and the width adjustment of the base cutters caters for all normal row spacings. If cane cut by the Edgecombe cutter is hand-stacked for self-loading trailers, virtually all tops and other extraneous matter can be eliminated.

A fully mechanised system is possible by incorporating a Bell loader. Such a system can handle quotas of up to 100 tons/day per loader. In this case, field losses will depend on management and on manpower used for gleaning. Extraneous matter content of the cane delivered to the mill will depend largely on the quality of the burn. Poor burns will inevitably lead to more tops and trash being picked up by the loader.

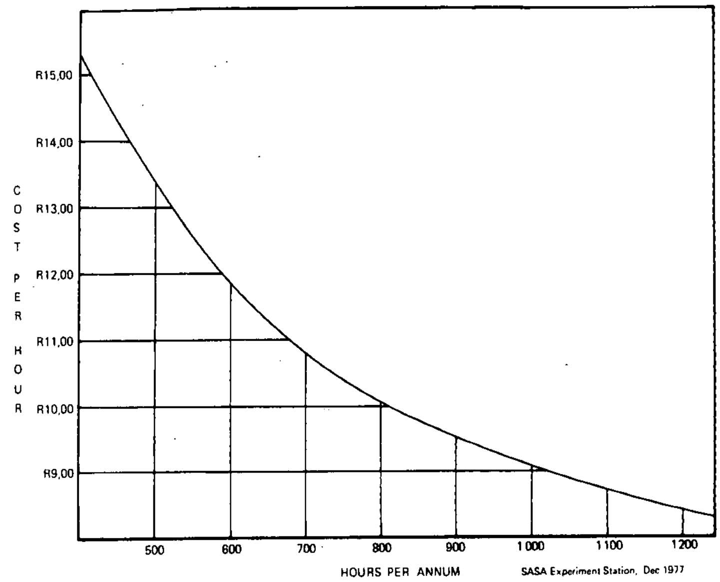

Figure 3: Estimated cost per hour of the Edgecombe cutter on a Ford 6 600 tractor (including driver and assistant).

REFERENCES

1. de Beer, A. G. and T. C. Boevey (1977). Losses incurred when chopper harvesting sugarcane. ISSCT Proc **16** (in press).
2. Pilcher, J. R. and G. van der Merwe (1976). The development of a simple cane cutter. SASTA Proc **50** : 1-5.