DEVELOPMENT OF A PROTOTYPE CANE CUTTER FROM A BELL LOADER

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Abstract

This paper describes the modifications that were required to convert a standard, high capacity Bell loader to a cane cutter and the use of this machine in various harvesting systems. Base cutter assemblies that had been previously tested were mounted in the best position for this machine. Two rows of cane were cut simultaneously which enabled the machine to open a field at any convenient point and cut any chosen face of the field in any direction without damaging the cane which was still standing or had already been cut into a 'sausage' windrow. Time studies were done to establish the output of the machine when used as a cane cutter fitted with Sasex-type toppers. The results were compared with the output of the machine when cane was cut without topping and the tops were removed with a sickle-bar topper during the loading operations. The weaknesses and disadvantages of the system were identified and the necessary modifications were either carried out or they were recorded for future reference. The cutting operation had a high forward speed which necessitated the development of 'ground-following' base cutters, which automatically follow the ground profile.

Introduction

The Bell loader was introduced into the South African sugar industry 18 years ago and although the basic 'tricycle' configuration which gives it manoeuvrability and versatility has been retained, it has changed in strength, reliability and performance. Its versatility was increased when cane cutting attachments were introduced in 1974, and it was field tested by the South African Sugar Association Experiment Station during 1978.

The type of base cutter initially used was not commercially acceptable, but it seemed from further trial results that a conventional rotating disc type of base cutter could be useful in a mechanical cane cutter/loader combination. A project to develop such a cane cutter was planned by the SASA Experiment Station in 1980 and in 1984, Bell Equipment Co assisted with this project. The Bell cutter was designed to cut two rows simultaneously and its construction was similar to the Edgecombe cutter (van der Merwe *et al*).[3] A pair of base cutter assemblies was manufactured by the Experiment Station and supplied to Bell Equipment Co to attach to a modified Bell loader. The prototype Bell cane cutter was ready for testing by 30 November 1984.

Description of the prototype Bell cane cutter

A standard, high capacity loader was used as the basic unit and a 4-cylinder Deutz engine with a developed power of 50 kW was used to supply the extra power needed to drive the base cutters and toppers. A second set of driver controls and a seat were mounted above the engine, facing the single castor wheel (Figure 1). A new fuel tank was fitted onto the chassis and a cooling air intake screen and duct replaced the original fuel tank above the air intake of the engine.

An additional hydraulic pump was coupled to the crankshaft pulley to supply the oil for the base cutters. The base cutter assemblies were mounted on each side of the chassis and two conventional Sasex toppers were mounted on a Tee-beam attached above the castor wheel (Figure 1). A sickle-bar topper was attached to the main axle, in line with the right-hand side of the grab (Figure 2).

Testing Procedures

The machine was only operated in burnt cane and while cutting it was driven in the opposite direction to the normal loading direction (i e the castor wheel was at the front).

Cane cutter only

The Sasex-type toppers were fitted in front of the base cutters and the cane tops were removed and directed to the outer edges of the rows being cut. The base cutters cut the

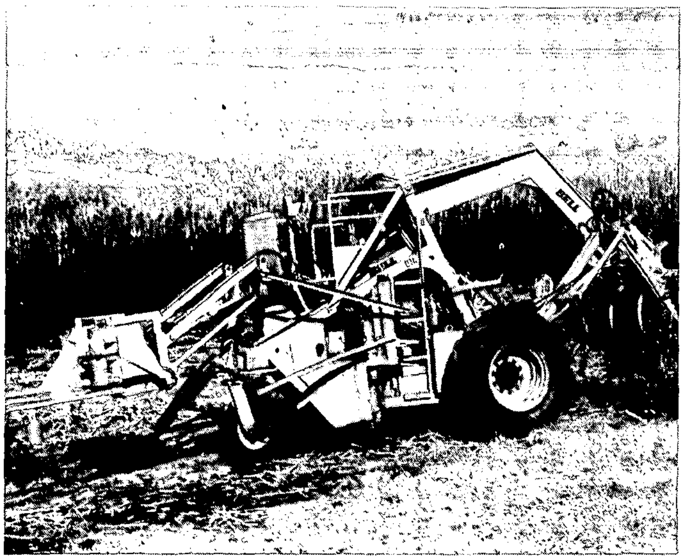

FIGURE 1 Bell cutter with attachments.

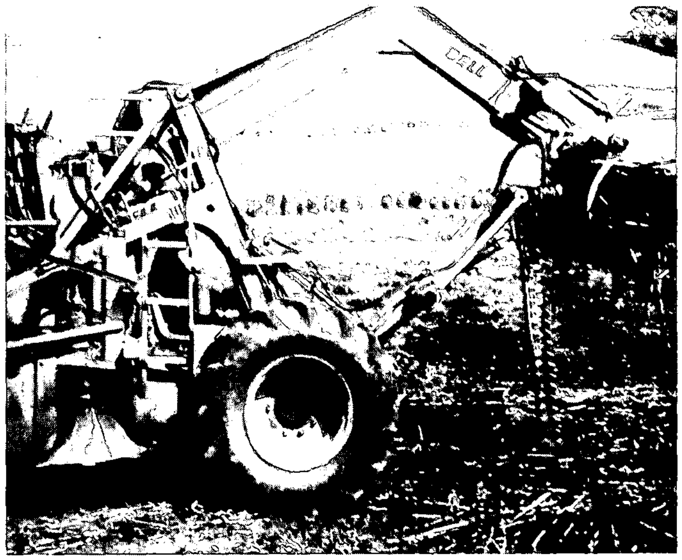

FIGURE 2 Bell cutter with a sickle bar.

two rows and directed the cane towards the centre of the machine, forming a sausage in the interrow and leaving the stubble exposed. An average of 33 tc were harvested per hour (Table 1).

TABLE 1

Production figures for cutting cane

Area (ha)	Tons cane cut	Tons cane ha^{-1}	Hours		Fuel (ℓ)	Tons cane h^{-1} (in-field)	Hours ha^{-1} (in-field)	Litres h^{-1} (operating)	Litres t^{-1}	Litres ha^{-1}
			Operating	In-field						
13,27	1 249	94	33,1	26,7	333	46,8	2,0	10,1	0,3	25,1
5,38	281	52	17,6	14,3	154	19,6	2,7	8,8	0,5	28,6
Average		73				33,2	2,4	9,4	0,4	26,9

Bundles of 150 to 250 kg were gathered manually from the sausage and placed across the interrow, which gave a rate of 12 tc man-day^{-1}. These bundles were mechanically loaded by a loader into box trailers to be transported to a transloading zone.

The new Sasex toppers worked adequately and they did not impair the overall performance of the machine. Some of the cut tops were however drawn back into the sausage by the base cutters. Lodged cane cannot be topped with these toppers and in erect cane mechanical topping normally gives only a 60 % topping efficiency.

The results of time studies showed there was no advantage in using the Sasex toppers on the Bell cutter under the conditions tested so they were removed. In cane where heavy green tops are present after an incomplete burn, the Sasex toppers are useful but using the same machine to load is difficult because the toppers reduce manoeuvrability.

Cane cutter and loader

To use the sickle-bar topper it was necessary to use the machine for loading purposes. Two rows of cane were cut into a sausage as previously described, but with the tops still attached. Bundles were made manually and while they were being loaded by the machine, the tops were cut by the sickle-bar topper (Figure 2). This system functioned best when the cutter cut cane from 06h00 to 07h00, loaded until 12h00 and then cut again until 13h00. This procedure allowed time during the afternoon for the machine to be serviced for the following day. Although the times for cutting were flexible, the aim was to cut for 2 h and load for 4 h, so the rest of the time was available for operator rests, repairs and servicing.

This method produced an average of 75 tc d^{-1}, i e 12,7 tc h^{-1} cut and loaded (Table 2). When cane yielding 100 tc ha^{-1} was harvested it was possible to cut and load 120 tc d^{-1}.

TABLE 2

Production figures for cutting and loading with a single machine

Area (ha)	Tons cane cut & loaded	Av tons cane ha^{-1}	Hours		Fuel (ℓ)	Hours ha^{-1} (operating)	Tons cane h^{-1} (in-field)	Litres t^{-1}
			Operating	In-field				
64,8	3 047	47	256,7	239,6	2 293	3,7	12,7	1,3

Cutting limitations

- **Land slope**
  It was found that production declined when a 30 % gradient was reached and the machine is therefore not recommended for steeper slopes.
- **Power**
  An increase in the forward speed was required to improve the output in cane that was low yielding. This increase in speed caused the base cutters to dig-in frequently which in turn required more power from the engine. Furthermore, as the surface of the fields was uneven, the machine bounced excessively and the base cutters ploughed into the ground, causing the machine to stall at speeds greater than 3 km h^{-1}. To overcome this problem, without increasing the size of the engine, automatic 'ground-following' base cutters were required. Once these base cutters had been developed (Boast)[1] they enabled the machine to cut at speeds of up to 6 km h^{-1}. A comparison between the cane yield, the output of the machine and its speed before and after automatic 'ground-following' base cutters were installed is shown in Table 3.

TABLE 3

Effect of automatic height control on speed and output for various cane yields

Without auto-control			With auto-control		
Yield (tc ha^{-1})	Av speed while cutting (km h^{-1})	Net working rate (tc h^{-1})	Yield (tc ha^{-1})	Av speed while cutting (km h^{-1})	Net working rate (tc h^{-1})
85	2,5	63,8	92	3,1	85,6
53	2,5	39,8	34	4,3	43,9
46	2,9	40,0	22	5,4	35,6

Reliability

The Bell cutter was found to be as reliable as the conventional Bell loader, but there was a problem with transmission mounting bolts which constantly vibrated loose, and tightening these bolts daily did not prevent the transmission pump from vibrating out of its mounting, which led to cracking of the mounting flange. The continual movement of the base cutter assembly beams caused excessive wear to assemblies and a better design will be necessary to improve its durability.

The initial structural and hydraulic problems with the sickle-bar topper were corrected and no further repairs were needed. It was economical on blades and no blades were replaced during the topping of 3 000 tons of cane.

Brakes

The brakes are inefficient and 'fail-safe' brakes should be fitted.

Results

The reduced output that occurred with a low yielding crop is shown in Table 1. An average of 33 tc h^{-1} was achieved before the automatic 'ground-following' base cutters were fitted which indicates that an average of 40 tc h^{-1} could be expected with automatic 'ground-following' base cutters under all field conditions.

It can be seen from Table 2 that cutting and loading with a single machine gave an average of 12,7 tc h^{-1}, but if a loader is equipped with a sickle-bar topper, without base cutters, it could be expected to load at a rate of 25 tc h^{-1} (Table 4).

TABLE 4
Production figures for topping and loading only (sickle-bar topper)

Area ha	Tons cane loaded	Tons cane ha^{-1}	Hours		Fuel (ℓ)	Tons cane h^{-1} (in-field)	Litres t^{-1}
			Operating	In-field			
8,6	765	89	33,9	29,8	228	25,7	0,3

The cost of the various elements of the harvesting system per ton can be calculated separately from Tables 1, 2 and 4 (Figure 3). The cost per ton can be calculated using any combination of elements.

Example 1:

Using a Bell cutter to cut, load and top with sickle-bar (15 000 tons annual quota)

Cost to cut, top and load (Figure 3) = R3,00 t^{-1}
Cost to bundle (by hand) (Table 5) = R0,64 t^{-1}
Total cost = R3,64 t^{-1}

Example 2:

Using a Bell cutter to cut only and two separate loaders fitted with sickle-bar toppers (60 000 tons annual quota)

Cost to cut only (Figure 3) = R0,85 t^{-1}
Cost to bundle (by hand) (Table 5) = R0,65 t^{-1}
Cost to top and load 30 000 tons = R0,91 t^{-1}
Total cost = R2,40 t^{-1}

TABLE 5
Cost of making bundles by hand

Pay (R d^{-1})	Food, etc (R d^{-1})	Total (R)	Tons	Cost (R t^{-1})
5,50	2,20	7,70	12	0,64

When loading directly from the sausage it is possible to load at a rate of 8 tc h^{-1} (de Beer and Fourie)[2] which gives an annual output of 12 000 tons.

Example 3:

Using a Bell cutter with Sasex toppers to cut and top cane and a separate loader to load directly from sausage (12 000 tons annual quota)

Cost to cut and top only (Figure 3) = R2,03 t^{-1}
Cost to load at 8 tc h^{-1} = R2,54 t^{-1}
Total cost = R4,57 t^{-1}

Loading directly from the sausage is an extremely untidy method which results in poor quality cane being delivered to the mill. It is not recommended if alternative methods are available.

Conclusions

The Bell cutter is recommended as a commercial cane cutter for quotas of 200 to 300 tc d^{-1} when cutting cane only, and 60 to 75 tc d^{-1} if used for cutting and loading. It can operate on slopes up to a 30 % gradient and the base cutters can be adjusted to operate on row spacings from 1,2 to 1,5 m.

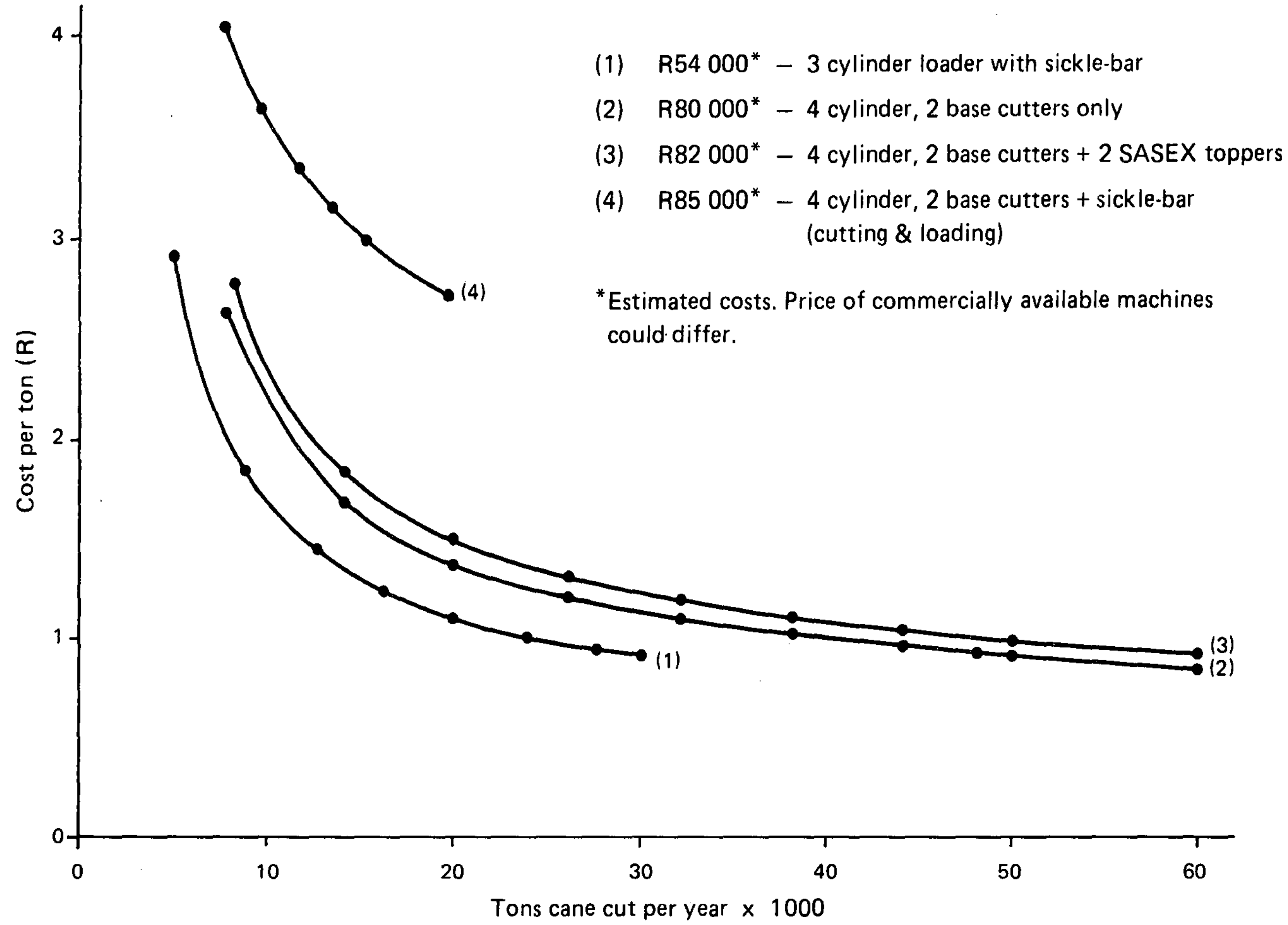

FIGURE 3 Cost per ton for various operations

TABLE 6
Cane quality (extracted from Maidstone mill returns)

Months harvested 1985	Source	Tons cane harvested	Av yield of area cut (tc ha⁻¹)	Average sucrose (%)	Average purity (%)	Average fibre (%)
May/Jun/Jul	Bell cutter	1 507	92,0	13,7	83,4	15,0
	Mill average	—	—	12,5	82,6	16,0
Aug/Sep/Oct	Bell cutter	1 438	46,2	13,0	81,1	16,0
	Mill average	—	—	13,5	82,9	16,8
Nov/Dec	Bell cutter	611	43,0	11,6	80,8	17,3
	Mill average	—	—	11,0	81,2	17,9
May/Dec (season)	Bell cutter	—	60,4	12,7	81,8	16,1
	Mill average	—	—	12,3	82,2	16,9

If cane cut by the Bell cutter is bundled into approximately 200 kg bundles for mechanical loading, or hand-stacked for a self-loading trailer, cane of a satisfactory quality can be supplied to the mill (Table 6).

The various cane cutting and loading systems that are offered by the Bell cutter make this machine a valuable addition to the range of cane harvesting machinery already available to the South African sugar industry.

Acknowledgements

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REFERENCES

1. Boast, M. M. W. (1986). Hydraulic sensing for height control of ground-following base cutters or mechanical cane cutters. *Proc S Afr Sug Technol Ass* 60 (in press).
2. De Beer, A. G. and Fourie J. P. (1984). The La Mercy Project. *Proc S Afr Sug Technol Ass* 58: 173–178.
3. Van der Merwe, G; Pilcher, JR and Meyer, E. (1978). The Edgecombe cane cutter. *Proc S Afr Sug Technol Ass* 52: 169–173.