A REVIEW OF MECHANISED CANE HARVESTING SYSTEMS IN SOUTHERN AFRICA

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Abstract

Manual harvesting has predominated in the South African sugar industry since 1948, when sugarcane was first cropped at Compensation on the north coast of KwaZulu-Natal. However, as successive generations of labour have attained higher levels of education and their living standards have improved, employment aspirations have risen above the strenuous but monotonous hand cutting of sugarcane, and this is now less favoured as a means of earning a living.

Over the years there has been a continual quest for a reliable and economically viable mechanised harvesting system which could be successfully implemented under local conditions. This paper summarises the evaluation and development of harvesting equipment over the past two decades by the Agricultural Engineering Department of the South African Sugar Association Experiment Station (SASEX). An assessment of the operating costs of various mechanised harvesting systems relative to manual harvesting methods is also given.

Keywords: Sugarcane harvesting, labour costs, systems

Introduction

The search for a whole stalk sugarcane cutter by the South African sugar industry began in 1948. It was at this time that the first Mechanisation Committee was established. SASEX first became associated with the activities of the Committee in 1950. Following a tour of several overseas countries by members of the Mechanisation Committee in 1963, several harvesters were imported for evaluation. The most important lessons learned from this exercise were that these machines were unable to operate on steep slopes, in recumbent cane and in fields not specifically prepared for mechanisation.

In 1972, the South African Sugar Association established a Subsidy Fund for the development of new concepts in mechanical harvesting, with the Agricultural Engineering Department of SASEX being closely associated with all projects supported by this scheme. Several private enterprises and growers were prompted to develop harvesting machines under this scheme, and these included the Stevenson, Johnstone and Cane-Sny cutters and the Mecane harvester. Many of the subsidised machines were unsuccessful because they were limited to harvesting burnt cane, could only operate on flat terrain or because they were too expensive when compared with the cost of manual methods. Interest soon faded when the fund was discontinued in 1983. Manual cane harvesting, during this period, remained the preferred option.

Background

Research during the early seventies indicated that overseas entrepreneurs showed no real interest in developing whole stalk harvesting machinery or harvesting equipment capable of operating on steep slopes. It was therefore clear that any future development in this area would have to be initiated locally (de Beer, 1974).

In the early seventies SASEX embarked on a research programme to investigate alternative mechanical harvesting systems. The programme included the evaluation of commercially available machines as well as the design and development of machines which would be able to operate under local conditions.

The South African industry's mills and transport systems were and still remain, with the exception of three mills, organised to handle whole stalk sugarcane. Priority was therefore given to investigating the viability of whole stalk sugarcane harvesting machinery and harvesting systems. However, some development was carried out during this period on a chopped cane harvester, and extensive research was done on chopped cane quality, cane loss and the field efficiency of chopper harvesters.

The Agricultural Engineering Department of SASEX researched two main aspects of mechanised harvesting and harvesting systems:

- Partial mechanisation in burnt and green cane, primarily to ease the burden of manual harvesting and reduce the cost of harvesting operations.
- Total mechanisation.

This paper summarises the development of mechanical chopped cane and whole stalk harvesters and harvesting aids by the Agricultural Engineering Department of SASEX over the past twenty years. The relevant machines are briefly described, and manual cane handling systems, labour performance, cost standards, infield loading and transport systems are explored. Finally, an attempt is made to estimate the operational costs of some of the systems relative to current manual harvesting methods.

Review of harvesting machinery

A summary of the characteristics and performances of the harvesting equipment developed and evaluated by the Agricultural Engineering Department at SASEX since the early seventies is given in Appendix 1.

The machines can be grouped into four categories:

- Whole stalk transverse windrowing machines
- Whole stalk linear windrowing machines
- Whole stalk bundling machines
- Chopped cane harvesters.

Whole stalk transverse windrowing machines

The following machines harvested a single row of cane per pass. The cane stalks were placed in a windrow at right angles to the row direction, either mechanically or manually. Stalks were topped by the machine, or by hand in a subsequent manual operation.

Santal (Anon, 1974)

The Santal whole stalk cane harvester was imported from Brazil at the beginning of 1973. The machine cut and topped both burnt and green cane, and laid up to five rows of cane in a single windrow. Green cane had to be subsequently burnt.

Bell cutter (Anon, 1981)

Bell Equipment Company of South Africa fitted a reciprocating blade type of base cutter and a sickle bar topper to their popular three wheeled cane loader. The cutter base cut and windrowed a single row of cane per pass. The windrowed cane was then push-piled and loaded into a basket trailer or stacked in the conventional manner.

Mini-Mech (Anon, 1979a)

A 3,5 kW petrol engine with vertical crankshaft powering a 450 mm base cutter was mounted onto a lightweight wheelbarrow-like frame supported by 500 mm bicycle wheels. The cut stalks were manually directed into a windrow.

Whole stalk linear windrowing machines

This category of machines base cut and topped the cane stalks and formed a linear windrow ('sausage') of cane parallel to the row direction.

McConnel Stage I (Anon, 1975)

The components of the McConnel were imported in 1973 from Barbados and mounted on to a conventional agricultural tractor. A single burnt or green cane row was topped and the stalks pushed forward and under the tractor before being base cut at the rear of the tractor.

Sasex cutter (Pilcher and van der Merwe, 1976)

The Sasex cutter concept originated from a machine known as the 'Cane-Sny', designed by Mr F Snyman of Nkwaleni. The three point mounted machine topped and base cut a single cane row. Various models of the Sasex cane cutter were developed between 1974 and 1977.

Edgecombe cutter (van der Merwe *et al.*, 1978)

The Edgecombe cutter was a further development of the Sasex cutter. This cutter topped and base cut two rows simultaneously, placing both rows of cane into a single large linear windrow.

Midway cutter (Meyer, 1984)

The Midway cutter was again a further development of the Sasex cutter that located the base cutter between the front and rear wheels of the tractor for better height control. A single row of cane was base cut and laid down in a linear windrow. A bin, fitted to the front of the tractor, collected the shredded tops which were dumped into the interrow at intervals along the row.

Sasex-Bell two row cutter (Boast, 1986a)

Twin base cutters and toppers were mounted on to a Bell three wheeled loader, one on each side of the chassis. The machine cut and topped two rows at a time, forming a double linear windrow centrally beneath the machine.

Front mounted cutter (FMC) (Boast, 1989)

The development of an automatic ground following device for the base cutter (Boast, 1986b) enabled SASEX to mount an updated base cutter and topper assembly to the front of a standard agricultural tractor. The machine base cut and topped one row per pass and placed the cane in a linear windrow.

Green cane FMC (Anon, 1990)

This machine was a further development of the FMC. The topper and detrashing rotors removed the tops and the trash on the adjacent standing row, while the base cutter mounted on the front of the tractor cut the previously topped and detrashed row in a single pass operation.

Whole stalk bundling machines

This category of machines topped, base cut and collected the cane stalks in a bin at the rear of the machines. The cane in the bins was either dumped at intervals along the cane row or was transloaded into following basket trailers.

Gobbler (Anon, 1976)

Two prototypes of this whole stalk harvester were built and tested during 1973 and 1974. The tractor mounted machine topped and base cut a single row of cane, with the stalks being propelled by a set of rollers, butt first, into a collecting bin at the rear of the machine.

McConnel Stage II (Hudson *et al.*, 1976; Boast, 1977)

Two models of the McConnel Stage II were imported from Barbados. These were designed to pick up, detrash and bundle the cane left behind by the McConnel Stage I machine.

Toft J150 (Anon, 1978)

In 1977, an old Toft J150 whole stalk harvester was loaned to SASEX for development purposes. The machine topped and base cut a single row of cane and conveyed the stalks in an upright position by means of a chain (looped belting) into a horizontal collecting bin.

Sasaby 1 & 2 (Pilcher and Boast, 1980; de Beer *et al.*, 1983)

SASEX designed and built two prototype self-propelled machines to base cut, detrash, top and place the clean cane in a large bin. The second machine was equipped with a crane fitted with a grab which transferred the cane from the bin directly into following transport.

Mini-Sasaby (Boast, 1985)

A simpler version of the Sasaby I and II was designed using the same principles as those of the bigger machines. The tested components of the Sasaby II were fitted to a modified tractor which was used as the prime mover. This machine harvested unburnt cane and made bundles of 200-300 kg.

Ngwenya (Boast, 1994)

In 1991 work began on the Ngwenya green cane harvester. This project arose because of the success obtained using the prototype detrashing rotors that had been developed for a mechanical pretrashing device (Anon, 1990). The principle of detrashing cane was incorporated into a 'soldier' type harvester which would cut, top, detrash and produce bundles of green cane of between 200-300 kg.

Chopped cane harvesters

Mini Rotor (de Beer and Adey, 1985; Pilcher, 1983)

The design and development of the Mini Rotor was a joint project with Santal of Brazil who at that time had developed and patented a similar concept. The aim of the project was to simplify the conventional chopper harvester design, in particular the mechanisms for chopping and conveying chopped cane. In place of the conventional cane elevators used by chopper harvesters, this machine used the swinging blade of the chopping mechanism to 'throw' the cane billets into transport moving alongside.

Evaluation of chopper harvesters (de Beer and Boevey, 1977; Boevey and de Beer, 1977; de Beer and Boevey, 1979; de Beer, 1980)

Between 1975 and 1978, extensive experiments were conducted on different estates in Swaziland to determine field performances, efficiencies and cane losses incurred when harvesting sugarcane with chopper harvesters.

An extract from the results of time and motion studies for two typical harvesters is given in Table 1.

Table 1

Chopper harvester time and motion study results

Parameter	Machine A		Machine B	
	Minutes	%	Minutes	%
Cutting	228,3	35,4	2 043,7	54,5
Turning	184,6	28,7	373,6	10,0
Waiting	20,5	3,2	844,4	22,5
Maintenance & repair	-	-	23,0	0,6
Other	210,5	32,7	465,4	12,4
Total field time	643,9	100,0	3 750,1	100,0
Average row length	200 m		460 m	
Burn	Good		Good	
Recumbency	2%		40%	
Variety	NCo376		NCo376	
Ratoon	2,1		2,3	
Yield	95 t/ha		98 t/ha	
Tons cut	239		131	
Tons per field hour	22,3		21,0	
Tons per cutting hour	62,8		38,4	
Hectares cut	-		14,9	

It can be seen from Table 1 that row length has a marked effect on harvester performances when the time spent turning on headlands is taken into account. The effect of insufficient infield transport on harvester output is clearly illustrated by machine B's high percentage waiting time.

In 1978 tests were conducted at Mhlume Sugar Company on two makes of chopper harvester. Machine C was maintained in an excellent state of repair and adjustment, whereas machine D was not maintained at the same level. The aim of the tests was to observe the field losses incurred by these two machines when compared with the traditional hand cutting harvesting system. The results of the tests are summarised in Table 2.

The results obtained with machine C are representative of what could be expected from this type of harvesting machine at that time. The results shown in Table 2 also clearly indicate the importance of maintenance and adjustment of machinery on output and on quality of the cane delivered to the mill.

Table 2

Summary of field losses, Mhlume Sugar Co, 1978

Parameter	Hand	Chopper C	Chopper D
Gross cane delivered (t/ha)	120,10	117,94	108,36
Extraneous matter %	3,10	6,05	7,00
Net cane delivered (t/ha)	116,37	110,78	100,66
Left behind in field (t/ha)	2,35	3,04	6,08
Loss vs total millable cane (%)	2,13	6,83	15,34
Loss vs hand cut + gleaning (%)	-	4,80**	13,50**
Sucrose % cane	14,35	13,95*	13,95*
Purity %	88,48	87,35**	87,54**
Sucrose (t/ha)	17,22	16,44*	15,07
Loss in tons sucrose vs hand-cut + gleaning (%)	-	4,50	12,50

* Difference from hand cut treatment significant at 5% level
** Difference from hand cut treatment significant at 2% level

Cane handling systems

There are numerous methods of handling whole stalk sugarcane following full or partial mechanised harvesting.

Linear windrowing systems

The linear (sausage) cane windrows produced by the mechanical cutters can be handled manually using the methods below:

1. Two labourers work as a team, incorporating four sausage rows into one row of 150-200 kg bundles placed at right angles to the rows. The labourers then remove the tops.
2. The operation is the same as above, except that the tops are not removed by the labourers. Topping is done during the loading process, by a topper fitted to the mechanical loader.
3. The operation is the same as above, except that the tops are removed by an additional labourer whose sole function is to remove tops. This method requires one extra labourer to serve three teams of bundlers.
4. Each labourer builds 3-6 ton stacks from the sausage and removes the tops by hand.

Note: In green cane, manual trashing would be required in all the above methods.

Bundle systems

Mechanically bundled cane can be handled as follows:

1. Cane bundles can be piled into 3-6 ton stacks, either manually or using a Bell loader.
2. Using grab loaders, cane bundles can be mechanically loaded directly into basket type trailers.

Infield loading and transport systems

Stacked cane

Cane is stacked manually or using non-slewing loaders. The 3-6 ton stacks are transported directly from the field to the mill or are delivered to transloading sites using tractor and self-loading trailer combinations.

Windrowed or bundled cane

Non-slewing grab loaders or slewing type push-pile loaders are normally used to load the cane into tractor and conventional basket or rear tipping basket trailer combinations. These haulage units either transport the cane directly to the mill, or to transloading sites where the bundles are transloaded onto road haulage by mobile cranes, or by grab loaders if the cane has been loosely tipped at the transloading point.

SASEX developed a slow speed, disc type topping attachment for the popular Bell three wheeled loader. This means that the performance of labour windrowing or bundling cane can be increased significantly because they need not top the cane, as this task can be successfully performed during the loading operation.

Table 3

Labour performance for cane handling systems 1 and 2.

Cane condition	Harvesting option	System No	Activity	Output (t/man/day)
Green cane	Manual cutting	1	cut, top, trash, bundle cut, top, trash, stack	7,5 3,3
	Mech. cutting (sausage)	2	top, trash, bundle top, trash, stack	10,4 6,2
Burnt cane	Manual cutting	1	cut, top, bundle cut, top, stack	8,2 5,5
	Mech. cutting (sausage)	2	no topping, bundle top, bundle top, stack	22,8 14,7 9,7

Labour performance and costs

Labour performance

A summary of labour performance for manual and semi-mechanised cane handling systems, based on results achieved during extensive control tests conducted on the SASA La Mercy farm, is given in Table 3 (Anon, 1979b; de Beer *et al.*, 1989; Meyer and Worlock, 1979).

Two of the systems mentioned previously are elaborated on:

System 1: manual cutting, topping and bundling

System 2: a semi-mechanised system where cane is mechanically base cut, and manually topped and bundled.

Labour costs

Labour costs per ton, based on the mean labour performance figures given in Table 3 (as well as performances 30% below and above the mean) are given in Table 4, for both burnt and green cane Systems 1 and 2.

Manual and mechanical harvesting systems

An attempt has been made to assess total labour and machinery costs for various cane handling systems. The systems selected for evaluation are:

System 1 Cane is manually cut, topped and windrowed as previously described (small bundles).

System 2 Cane is mechanically cut using the Front Mounted Cutter (harvesting rate: 25 t/h burnt, 20 t/h green cane). The cane in the linear windrows is manually topped and placed into small bundles as previously described.

System 3 Cane is mechanically cut using a hypothetical mechanical harvester which tops, base cuts and deposits the cane in a neat 300-400 kg bundle (harvesting rate: 25 t/h burnt, 15 t/h green cane). No manual operations are required and this system therefore does not appear in Tables 3 and 4.

In the above three cane handling systems a non-slewing grab loader is used to load the cane (loading rate: 22 t/h in burnt cane, 20 t/h in green cane) into 55 kW tractor basket trailer combinations (payload: 6 tons in burnt cane, 5 tons in green cane) which transport the cane 1,0 kilometre to a transloading zone.

Machinery and equipment operating costs

Machinery and equipment operating costs are calculated using the standard SASEX costing method. Machinery and equipment values used in the costing exercises are given in Appendix 2.

Table 4

Labour costs for cane handling systems 1 and 2.

Burnt cane						Green cane					
System 1: Manual cut, top and bundle						System 1: Manual cut, top, trash and bundle					
Labour performance (tons/man/day)		Percentage of typical labour costs				Labour performance (tons/man/day)		Percentage of typical labour costs			
		85	100	115	140			85	100	115	140
		Cost per ton						Cost per ton			
Low	5,74	3,69	4,36	5,03	6,03	Low	5,25	4,03	4,76	5,49	6,59
Medium	8,20	2,58	3,05	3,52	4,22	Medium	7,50	2,82	3,33	3,85	4,62
High	10,66	1,98	2,35	2,71	3,25	High	9,75	2,17	2,56	2,96	3,55
System 2: Mech. cut, manual top and bundle						System 2: Mech. cut, manual top, trash and bundle					
Low	10,29	2,06	2,43	2,80	3,36	Low	7,28	2,91	3,43	3,96	4,75
Medium	14,70	1,44	1,70	1,96	2,35	Medium	10,40	2,03	2,40	2,77	3,33
High	19,11	1,11	1,31	1,51	1,81	High	13,52	1,56	1,85	2,13	2,56

The cost of machinery operators and trailer conductors are included in the machinery costs. However, peripheral costs such as burning of the cane, gleaners, supervisors, transloading and a management fee have not been taken into account.

Manual and mechanical harvesting systems costs

The estimated machinery and labour costs for the various burnt and green cane handling systems over a range of annual tonnages based on three scenarios of labour performance standards and cost structures, are graphically illustrated in Figures 1 to 6.

The scenarios evaluated are:

Scenario 1: Medium labour output (see Table 4) and medium labour cost (medium = 100%).

Scenario 2: Low labour output (see Table 4) and high labour cost (140%).

Scenario 3: High labour output (see Table 4) and medium labour cost (medium = 100%).

The conclusions that can be drawn from the results are as follows:

Scenario 1

These results are based on obtaining medium labour output at a medium labour cost, i.e. System 1 - R3,05, R3,33/ton and System 2 - R1,70, R2,40/ton for burnt and green cane respectively, as shown in Table 4. System 3 does not involve any labour costs (operator productivity is not a subject of discussion in this paper).

There is a marked reduction in total cane handling costs for all three systems between 6 000 and 18 000 tons of annual production. This is primarily due to increased utilisation of equipment.

System 1 (Figure 1) is the cheapest option over the entire range. System 3 compares favourably with the other two systems when handling 16 000 tons/annum and above.

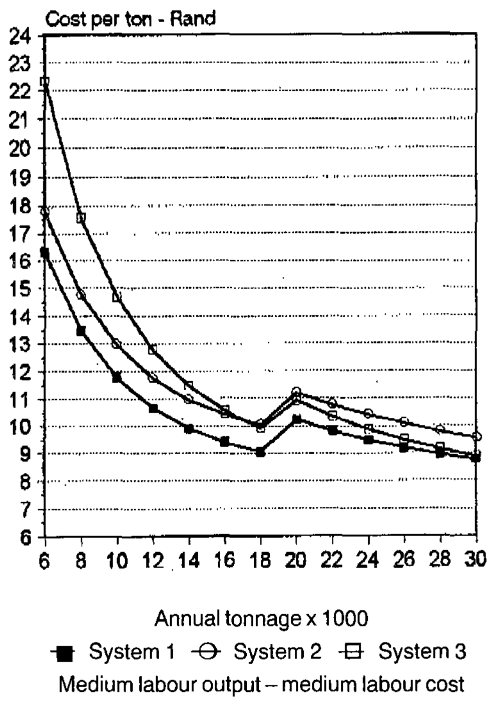

FIGURE 1 Burnt cane harvesting systems

In green cane (Figure 2), costs are generally higher and cost differences between the three harvesting systems become greater. Manual cutting remains the cheapest option over the entire tonnage range. Systems 2 and 3 have limited production in a single shift operation in green cane.

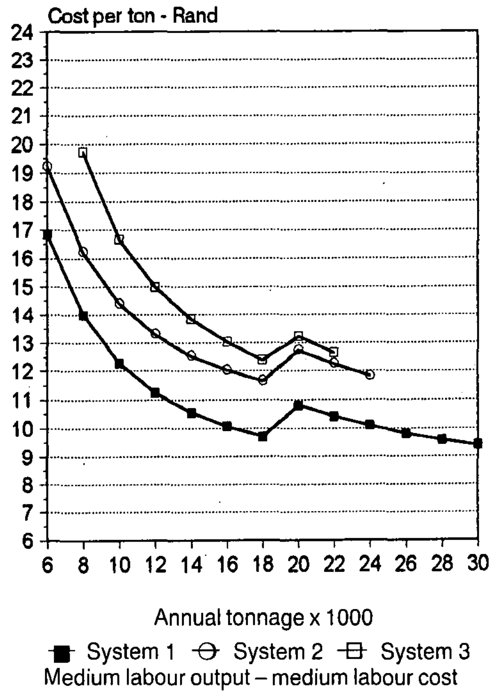

FIGURE 2 Green cane harvesting systems

Scenario 2

Low labour output, high labour cost, i.e. System 1 - R6,03, R6,59/ton and System 2 – R3,36, R4,75/ton for burnt and green cane respectively.

In burnt cane (Figure 3), Systems 1 and 2 have similar cane handling costs over the entire tonnage range. System 3 becomes the cheapest option above 12 000 tons cane annual production.

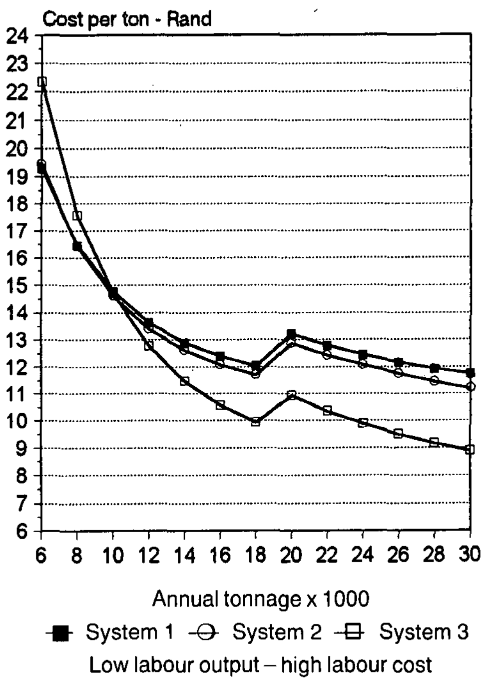

FIGURE 3 Burnt cane harvesting systems

In green cane (Figure 4), the mechanical cutting option never really competes with the manual system. The fully mechanised system again only competes with the manual system at about 14 000 tons cane annual production.

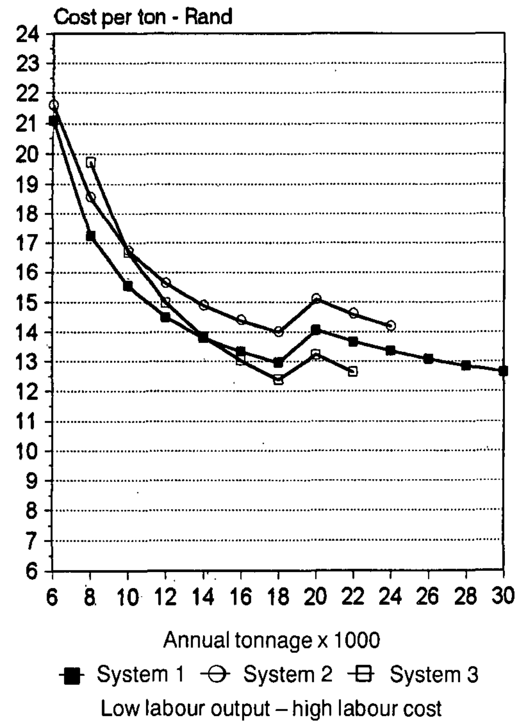

FIGURE 4 Green cane harvesting systems

Scenario 3

High labour output, medium labour cost, i.e. System 1 - R2,35, R2,56/ton and System 2 - R1,31, R1,85/ton for burnt and green cane respectively (Figures 5 and 6).

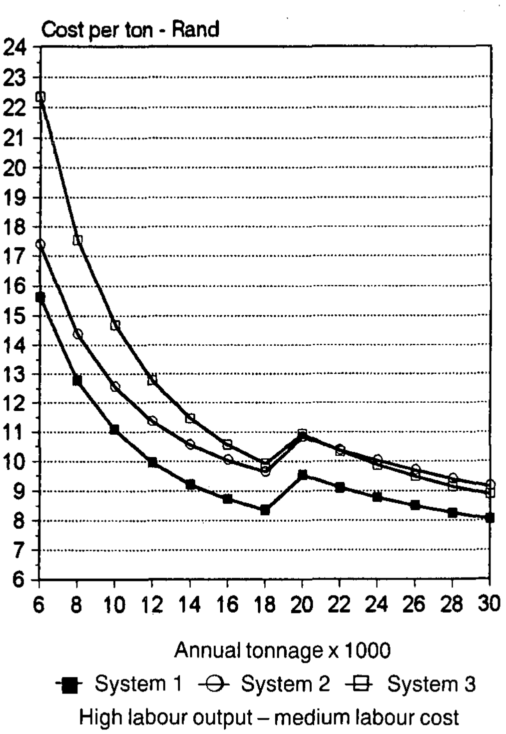

FIGURE 5 Burnt cane harvesting systems

If labour performance is increased and labour costs remain relatively static, cost differences between the three harvesting systems will be similar to those shown in Figures 1 and 2. However, the cost advantage of the labour based system over the mechanised system will be even greater.

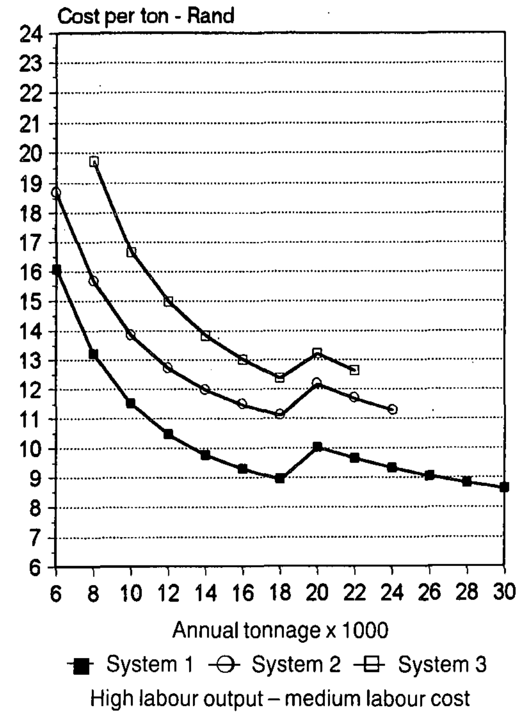

FIGURE 6 Green cane harvesting systems

As can be seen from the information given in Table 4, labour performance and labour cost will have a significant impact on total cane handling costs. The higher the labour productivity achieved, the less competitive the mechanical loading or harvesting options become.

Conclusions

Topography, field layout practices, cane transport systems, mill receiving facilities and, in particular, labour productivity have made it difficult to develop cost effective mechanised harvesting machinery for the South African industry. However, recent increases in labour wages may reduce the cost difference between mechanised and manual harvesting systems.

Manual harvesting labour performance varies widely within the sugar industry, and there appears to be tremendous scope for improving productivity. Measures for improvement include selection of free-trashing varieties, improved cutting tools, harvesting aids, incentives and training.

Some of the harvesting equipment developed by SASEX has resulted in reducing the use of labour, and some harvesting systems have the potential to reduce the harvest labour force by as much as 60-70%. However, because of the increased swing towards mechanical loading in many regions and/or the resistance of labour to handle linear windrows, there is a perceived need for a 'whole-stalk bundling machine' which will base cut, top and detrash cane (if harvested green) under a wide range of conditions.

At present there is no viable green cane harvester which can perform successfully under South African conditions. The advantages of green cane harvesting are well known and this, together with increasing pressure from environmentalists to limit the burning of cane, may accelerate development of a whole stalk green cane harvester that will be able to cope with the undulating terrain which makes up a large portion of the local industry.

The effect that labour performance and labour costs have on overall cane handling costs has been clearly illustrated. Furthermore, the economic viability of using a mechanical cutting aid or loader, or of changing to a fully mechanised harvesting system, will depend on machine hourly output and total annual tonnage handled.

The formation of harvesting syndicates or contracting groups may stimulate the use of and improve the viability of sophisticated and expensive harvesting aids or complete cane harvesting machinery. It is a well established fact that increased annual utilisation of harvesting machinery will result in improved efficiencies and lower costs. However, for cane produced on the steeper slopes, it may never be economically viable to harvest with mechanical equipment. Furthermore, to improve the commercial viability of mechanisation, special attention will have to be paid to field conditions, field layouts and row spacings to ensure higher machinery throughput and efficiency.

The knowledge and experience gained by SASEX over the past two decades will undoubtedly contribute meaningfully to future development of cane harvesting machinery and cane handling systems in the South African sugar industry.

Review Paper No. 11 entitled, 'The development of cane harvesting machinery and systems in Southern Africa' is in press and will soon be available through the South African Sugar Industry Agronomists' Association. The document assesses the various options reviewed in this paper and deals also with various other manual and semi-mechanised harvesting systems.

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Appendix 2

Machinery and equipment purchase prices

55 kW 2WD tractor	-	R98 000
Front mounted cutter attachment	-	R25 000
Single stack self-loadig trailer	-	R36 000
6 ton basket trailer	-	R33 000
Bell 120 hi-capacity loader	-	R154 000
Hypothetical burnt cane harvester	-	R230 000
Hypothetical green cane harvester	-	R270 000

Appendix 1

Summary of harvesting machinery performance

Machine	Period	Power (kW)	Machine type*	B-burnt G-green	Operation				Min. row spacing	Rows /pass	Slope (%)	Lodging tolerance	E.M. (%)**	Losses (%)	Output tons/hour	Problems or major limitations
					Cut	Top	Trash	Load								
Whole stalk transverse windrowing machines																
Santal	1973-75	50	PA	B	Yes	Yes	No	No	1,4 m	1	<10	None			15-25	Poor stability on slopes, requires upright cane
Bell cutter	1978-79	45	SP	B	Yes	Yes	No	Yes	1,0 m	1	<12	Low			6-10	Cane stool damage in lighter soils, requires upright cane
Mini-Mech	1978-80	3,5	MO	B	Yes	No	No	No	1,0 m	1	NA	Low				Difficult to handle, low output, requires burnt upright cane
Whole stalk linear windrowing machines																
McConnel Stage 1	1973-79	58	PA	B & G	Yes	Yes	No	No	1,2 m	1	<25	High			15-25	Stool damage, poor topping and base cutting
Sasex	1974-77	58	3PT	B & G	Yes	Yes	No	No	1,2 m	1	<20	Low			15-25	Side draught, uneven base cutting
Edgecombe	1976-78	58	PA	B & G	Yes	Yes	No	No	1,0 m	2	<25	Moderate			15-35	Uneven base cutting height, poor operator comfort
Midway	1978-83	58	PA	B & G	Yes	Yes	No	No	1,2 m	1	<25	Moderate			15-30	Dedicated machine
Sasex-Bell	1984-86	50	SP	B & G	Yes	Yes	No	Yes	1,0 m	2	<25	Moderate			25-40	Uneconomical as a cutter/loader combination
Front mounted cutter (FMC)	1986-90	55	DT	B & G	Yes	Yes	No	No	1,0 m	1	<25	Moderate			20-35	
Green cane FMC	1988-90	55	DT	G	Yes	Yes	Yes	No	1,0 m	1	<25	None			20	Cane, tops and trash mixed, requires even row spacing, erect cane
Whole stalk bundling machines																
Gobbler	1973-74	58	3PT	B	Yes	Yes	No	No	1,2 m	1	NA	Mod-high			NA	
McConnel Stage II	1975-77	58	PA	B & G	Yes	Yes	Yes	No	1,4 m	1	<20	Mod-high	3,0	3,6	15-20	Unreliable, low output, two-pass operation
Toft J150	1977	30	SP	B	Yes	Yes	No	No	1,4 m	1	<15	Mod-high			12	Unstable, under-powered, requires erect cane
Sasaby 1 & 2	1978-82	130	SP	G	Yes	Yes	Yes	Yes	1,5 m	1	<25	Mod-high	8,0	7,0	30	
Mini-Sasaby	1982-85	58	PA	G	Yes	Yes	Yes	No	1,2 m	1	<25	Mod-high	9,2	3,3	15	Under-powered, problems with collection bin
Ngwenya	1991-93	80	SP	G	Yes	Yes	Yes	No	1,5 m	1	NA	None	10,0		20-25	Excessive cane losses (design problem with conveyor)
Chopper harvester																
Mini Rotor	1981-84	112	PA	B	Yes	Yes	No	Yes	1,5 m	1	<18	Mod-high	10,4	5,7	20-25	Relatively poor output, poor billet quality

* Machine type
- 3PT Three point mounted to tractor
- MO Manually operated
- SP Self-propelled
- PA Permanently attached to tractor
- DT Detachable from tractor

** Extraneous matter

Cane quality tests were mainly conducted for green cane harvesting machines