FIELD PERFORMANCE OF CHOPPER HARVESTERS

By A. G. DE BEER and T. C. BOEVEY
South African Sugar Association Experiment Station

Abstract

An experiment was conducted on an estate in Swaziland to determine the losses of a sugarcane crop incurred when harvesting mechanically with two different machines, in comparison with those incurred when harvesting conventionally by hand and transporting the cane on self-loading trailers. Of the estimated 118,9 tons cane per hectare standing in the field, it was determined that 116,4 tons/ha were recovered when hand harvesting, 110,8 tons/ha when using machine A, and 100,7 tons/ha when using machine B. Because the cane had been treated with a chemical ripener, and because an excellent burn was obtained, the amounts of extraneous matter tended to be low in all treatments. For hand cutting they were 3,1%, for machine A 6,1% and for machine B 7,0%.

Introduction

The Experiment Station of the South African Sugar Association has been involved in testing chopper harvesters since 1975. Papers were read on the performance of these machines at the XVI ISSCT Congress[1] and at the 1978 SASTA Congress[2]. The 1977/78 Annual Report of the Experiment Station includes details of a further chopper test conducted in 1977 in Swaziland. This paper comprises a report on the tests carried out in 1978.

The 1978 tests were performed at Mhlume Sugar Company on two makes of sugarcane chopper harvesters, the performances of which had not previously been evaluated by the Experiment Station. Both machines were practically new, having only been used for demonstration purposes before the tests.

Machine A was in excellent condition, being under the supervision of and being maintained and adjusted by the manufacturer's representative. Machine B did not receive the same attention, being operated without the agent's presence. Two local chopper harvester operators, used to another make of machine, operated the harvesters but both had had adequate practice on the two machines in question before the tests began.

The aim of the tests was to observe the field losses incurred when each of the machines was used, in comparison with those incurred when the normal standard of hand cutting was practised by Mhlume Sugar Company. The tests were also regarded as a further opportunity to develop test procedures for sugarcane harvesters.

Experimental Procedure

When the experiments were being designed, consideration was given to obtaining the most meaningful results, but it was also realized that the testing procedures should not require unrealistic resources as far as manpower, testing equipment and time were concerned. To be relevant, the tests had to be done under actual infield harvesting conditions, but they could not be allowed to disrupt normal harvesting schedules to a significant extent.

The following test procedure was evolved from previous work done by the Experiment Station on chopper harvester evaluation. The determination of billet quality was based on procedures used by Australian researchers.*

Cane sample

The first factor to be considered in determining field losses was the amount of extraneous matter delivered to the mill with the harvested cane.

For hand-harvested cane, 11 random samples of 15 to 25 kg were taken from the windrowed cane before it was stacked. Samples were taken by removing stalks from all levels of the windrow to ensure that cane from all the rows included in that windrow was represented. The samples of stalks were weighed as they were taken from the windrow. All tops and other trash still adhering to the stalks were then carefully removed and the cleaned stalks were weighed again. This gave a measure of the extraneous matter content, which was then expressed as a percentage of the total sample, extraneous matter being defined as all material other than millable cane.

As the hand-cut cane was stacked manually and the stacks picked up by self-loading trailers, there was no chance that the cane could be contaminated by additional extraneous matter (such as soil) subsequent to sampling. Samples from chopper-harvested cane were taken directly from the machines. On a signal, the harvester operator stopped the elevator and the harvester, and the bin trailer was moved slightly forward to be out of the way. A canvas sheet was then held in position below the elevator and the operator started the elevator again. Between 15 and 25 kg of cane were caught on the sheet. During this operation all fans were kept going at normal operating speeds. The canvas sheet was large enough to catch all cane and extraneous matter delivered from the elevator. Care was taken, however, to ensure that trash did not get blown away. The machine then caught up with the trailer and continued to harvest normally. This procedure resulted in a minimum of delay to the harvester. Each sample was immediately analysed for cane and extraeous matter, the latter again being expressed as a percentage of the total. One sample was taken at random per row of cane in each test block.

Net cane delivered

The quality of net cane delivered at the mill was found by subtracting the estimated amount of extraneous matter, determined by means of the cane sample, from the gross mass of cane as determined on the weighbridge.

Gleaning after harvest

Handcut blocks were gleaned by the team of labourers normally used for this task. Gleaned cane was weighed in the field by a tractor-mounted grab fitted with a load cell. No gleaning of machine-cut cane occurred after harvest, but two field labourers worked with each chopper harvester and placed some left-over cane in the next row to be cut. The above gleaning procedures correspond to those normally used by Mhlume Sugar Company.

* John Allen, Director, Sugar Research Institute. Personal Communication.

Cane left in field

After all harvesting operations had been completed, three random sample plots were marked out in each lateral by means of pegs and string. These plots were 3 m square i.e. 9 m² each. All "millable" cane inside the demarcated sample plots was gathered and the mass determined. Millable cane consisted of all pieces of cane recognizable as such. Where topping was too low, that part of the top regarded as "millable cane" was broken off at the natural breaking point. Where base-cutting was obviously too high, the stubble was cut by hand. Any piece of millable cane lying across the plot demarcation line was cut at the line and the part left on the inside was collected.

The millable cane collected from each sample plot was expressed in terms of tons per hectare. In the case of chopper-harvested cane, care was taken to ensure that sample plots were marked out only on that part of the field traversed by both the harvester and the bin-carrying trailer.

Gleaning from loading zone

The loading zone where the hand-cut cane was transloaded was gleaned after the field had been completely harvested. The amount of cane to be gleaned from such a zone had been determined in previous tests to be 1% of the cane handled.

To estimate the amount of hand-cut cane that was harvested from the plots the mass sent to the mill was therefore increased by 1%.

Mill analyses

Approximately 40 tons of sugarcane were cut from each treatment block and delivered in one batch to the mill. This quantity of cane was adequate for mill sampling for sucrose and purity determinations.

Billet quality

Approximately 20 kg samples were taken from the cane delivered by the chopper elevator and analysed for extraneous matter content and billet quality as follows :

Damaged billets: all billets with splits longer than 40 mm in the rind, and totalling more than 80 mm per billet were considered to be damaged, but splits shorter than 40 mm in length were disregarded. Billets from which 400 to 2 000 m² of rind had been removed, thus exposing the interior of the stalk, were classified as damaged, as were billets less than 100 mm in length.

Mutilated billets : billets which had been broken, squashed and damaged so that there were numerous rind cracks and a portion of the cane was reduced to a pulpy condition, were regarded as mutilated. Billets with more than 2 000 mm² of rind removed were also classified as mutilated.

Sound billets : sound billets were undamaged sections of stalks longer than 100 mm. Included were those sections of stalks from below ground level which were developed to the full diameter of the immediate aboveground portions of the stalk, and the upper sections of the stalk up to the natural breaking point. Portions above this point were considered to be tops.

All sound billets were weighed and the length measured to the nearest 20 mm.

Extraneous matter : Extraneous matter was considered to be everything in the sample except the cane, and was sorted into :

Tops which were those parts of the stalks above the natural breaking point, plus any attached leafy material.

Trash, which was dead or green leaves and leaf sheaths, either free or attached to billets. Grass, weeds, etc. were also included in this category.

Roots, which consisted of true roots and also any fibrous pieces of material connecting the bases of two stalks, but not below-ground portions of stalk high in sugar content.

Dirt, which included all free soil, stones, etc., in the sample as well as similar material removed from the stools or billets.

Test particulars

The test was done on 39 sprinkler lateral blocks, with an average size of 0,37 ha, on the Ematsheni Section from 7 to 11 August 1978. The three treatments, Chopper A, Chopper B and hand-cut, were randomly assigned to each group of three lateral blocks. Fifteen replications were planned. All 15 of the hand-cut replications were harvested, but a ditch running across two of the replications (4 and 6) precluded mechanical harvesting, and reduced the number of available replications for these treatments to 13.

The whole field was burned at one time and harvesting commenced with five replications being hand-cut on Monday 7 August. This cane was hand-stacked for self-loading trailers to deliver the bundles to a transloading zone for further transport by road vehicle to the mill. Hand-cut cane was crushed on the day following cutting (see Table 1). Five additional replications were cut on August 8 and 9 respectively.

The chopper harvesters started cutting on Tuesday 8 August with the cane delivered directly from the field to the mill in 10-ton containers. Chopper-harvested cane was crushed within two hours of cutting (see Table 1). Only one machine operated at any particular time, allowing about 40 tons from each lateral to accumulate on the mill carrier for continuous crushing. Four replications were cut by each machine on the 8th, seven by machine A and one by machine B on the 9th, and the last two were harvested by machine A on August 10.

TABLE 1
Sequence of operations

Reps	*Cut*	*Crushed*
Hand-cut		
1–5	06.00–12.00 on Aug 7	10.12–16.55 on Aug 8
6–10	06.00–12.00 on Aug 8	10.21–16.10 on Aug 9
11–15	06.00–12.00 on Aug 9	08.50–14.41 on Aug 10
Machine-cut		
A 1, 2, 3 and 5 B 1, 2, 3 and 5	07.15–18.15 on Aug 8	08.41–18.51 on Aug 8
A 7–13 B 7	06.52–17.51 on Aug 9	08.21–19.10 on Aug 9
A 14–15	07.05–12.21 on Aug 10	08.45–12.53 on Aug 10

It soon became obvious that machine B was performing very badly and erratically. This was apparently due to a lack of proper setting and maintenance. This harvester was therefore withdrawn from the test after cutting only five replications.

Choppers A and B cut at average rates of 40,5 and 27,1 tons per field hour respectively. The cane was a fourth ratoon NCo 376 which was 12,7 months old. Because a cane ripener had been used, the quality of the burn was excellent. Recumbency was judged to be 25%, occurring in patches over the field. Field conditions were dry, and the average daily maximum and minimum temperatures were 28°C and 13°C respectively. Average relative humidities at 08h00 and 14h00 were 83 and 31 percent respectively. The cane rows were 216 m long, spaced 1,5 m apart, with the cane grown on a ridge of about 100 mm. Each lateral block consisted of 11 cane rows. Average yield for the field was 109,1 tons/hectare at 14,24% sucrose.

Results and discussion

The data collected during the test are presented in Tables 4, 5, 6 and 7.

Total millable cane

A measure of the total tons of millable cane on the field before harvest can be found by subtracting the extraneous matter from the hand-cut cane delivered to the mill, then adding what was gleaned and what was found left behind. The average for the 13 replications was 118,9 t/ha.

Net cane harvested

The amount of net cane normally harvested by Mhlume when hand cutting can be estimated as the total millable cane less that portion left behind in the field afer gleaning, i.e. 116,4 t/ha (118,9 – 2,5). For the chopper harvesters it would be the gross tons cane delivered at the mill less the extraneous matter. This was calculated to be 110,8 and 100,7 t/ha for machines A and B respectively.

Gleaning after harvest

By gleaning the hand-cut blocks, 0,9 t/ha of cane was retrieved. Gleaning of chopper harvested blocks was not deemed to be worthwhile.

Cane left in the field

Even after gleaning, 2,5 t/ha were still left behind in hand-cut blocks. Chopper A and chopper B left 3,0 and 6,1 t/ha behind respectively. Chopper A was clearly harvesting more cleanly and its base cutting was lower than that of chopper B.

TABLE 2

Harvesting losses, hand-cut cane

Replication	Gross t delivered	% E.M.	t E.M.	Net delivered + 1%*	Net t/ha	Gleaned /ha	Total harvest + gleaned	Left behind /ha	Total millable cane	S % cane	Purity %
1	44,85	2,5	1,12	44,17	120,03	0,57	120,60	1,11	121,71	14,00	89,56
2	47,30	2,7	1,28	46,48	126,65	1,24	127,89	2,07	129,96	14,00	87,42
3	39,95	3,2	1,28	39,06	106,14	0,65	106,79	3,22	110,01	15,00	88,99
4	44,05	2,3	1,01	43,47	118,45	1,82	120,27	—	—	—	—
5	40,75	2,8	1,14	40,01	108,72	0,55	109,27	1,04	110,31	14,75	88,81
6	45,70	3,1	1,42	44,73	121,88	—	—	—	—	—	—
7	42,50	2,6	1,11	41,80	113,61	1,02	114,63	3,26	117,89	13,40	88,30
8	43,95	3,1	1,36	43,01	117,19	0,89	118,08	3,00	121,08	14,03	87,34
9	41,10	2,9	1,19	40,31	109,54	0,76	110,30	1,19	111,49	14,05	87,99
10	43,96	3,9	1,71	42,61	116,10	0,93	117,03	3,41	120,44	14,37	88,04
11	42,95	3,4	1,46	41,90	113,86	1,02	114,88	2,30	117,18	13,90	87,08
12	46,30	3,3	1,53	45,22	123,22	0,86	124,08	2,74	126,82	14,30	88,92
13	41,10	3,8	1,56	39,93	108,51	0,85	109,36	1,78	111,14	14,85	88,70
14	46,15	2,9	1,34	45,26	123,32	1,53	124,85	4,00	128,85	14,90	89,19
15	42,90	3,4	1,46	41,86	113,75	1,27	115,03	3,74	118,77	15,00	89,88
	TOTAL				1500,64	12,14	1572,78	32,86	1545,64		
	MEAN	3,1			115,43	0,93	116,37	2,53	118,90	14,35	88,48
	S.D.	0,4			6,43	0,29	6,59	1,02	6,90	0,51	2,97

* 1% is added to allow for losses on transloading zone.

TABLE 3

Harvesting losses, machine A

Replication	Gross t delivered	% E.M.	t E.M.	Net delivered	Net per ha	Left behind per ha	Total /ha	S % cane	Purity %
1	44,6	7,9	3,52	41,08	111,63	1,63	113,26	14,28	87,81
2	47,2	8,0	3,78	43,42	118,31	2,78	121,09	13,60	86,39
3	44,3	3,2	1,42	42,83	116,39	2,81	119,20	14,76	89,65
4									
5	41,8	7,3	3,06	38,80	105,41	2,44	107,85	13,46	85,81
6									
7	41,25	5,0	2,06	39,19	106,49	3,39	109,88	13,62	86,80
8	47,55	7,5	3,57	43,98	119,84	3,35	123,19	13,70	87,12
9	38,60	4,2	1,62	36,98	100,49	3,09	103,58	14,86	89,48
10	46,85	6,2	2,90	43,95	119,75	4,37	124,12	13,54	86,86
11	38,80	6,2	2,41	36,39	99,02	3,59	102,61	13,80	87,33
12	43,55	5,7	2,48	41,07	111,91	3,72	115,63	14,10	87,84
13	40,45	6,6	2,67	37,78	102,66	2,43	105,09	13,90	87,00
14	45,25	5,9	2,67	42,58	116,02	2,44	118,46	13,47	85,27
15	43,40	4,9	2,15	41,25	112,24	3,53	115,77	14,28	88,24
	TOTAL				1440,16	39,57	1479,73		
	MEAN	6,05			110,78	3,04	113,82	13,95	87,35
	S.D.	1,45			7,30	0,72	7,43	0,47	1,27

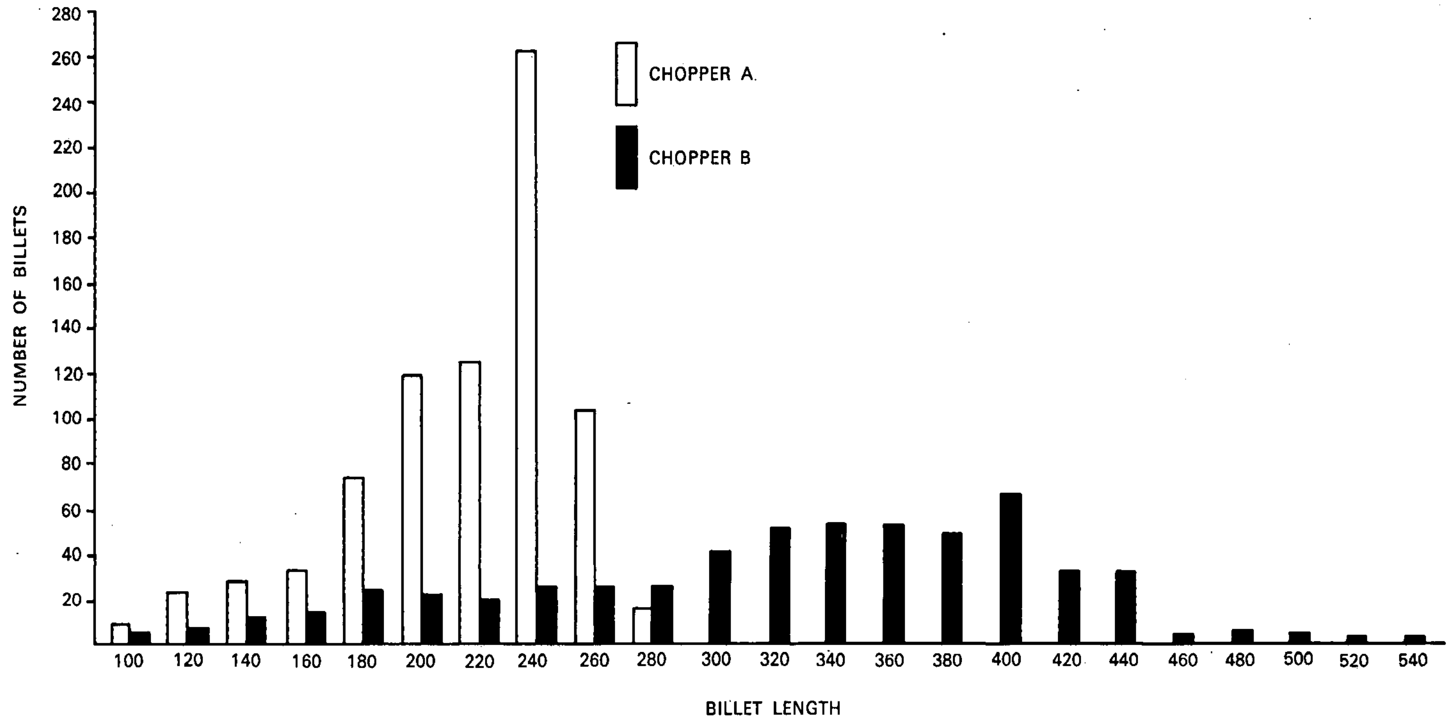

FIGURE 1 Distribution of billet lengths.

TABLE 4
Harvesting losses, machine B

Replication	Gross delivered	% E.M.	t E.M.	Net delivered	Net cane /ha	Left behind	Total cane/ha	S % cane	Purity %
1	39,95	8,2	3,28	36,67	99,65	5,17	104,82	14,30	88,36
2	47,55	8,0	3,80	43,75	119,21	9,24	128,45	13,16	85,46
3	35,95	6,7	2,41	33,54	91,14	5,89	97,03	14,73	88,66
4									
5	38,80	6,3	2,44	36,36	98,80	5,02	103,82	13,89	87,60
6									
7	37,00	6,0	2,22	34,78	94,51	5,09	99,60	13,68	87,63
	TOTAL				503,31	30,41	533,72		
	MEAN	7,0			100,66	6,08	106,74	13,95	87,54
	S.D.	1,0			10,92	1,80	12,54	0,60	1,25

TABLE 5
Sample analysis and billet quality

Sample No.	Tons* cut	Sample size (kg)	Roots %	Dirt %	Tops %	Trash %	BILLETS Damaged %	Mutilated %	Sound %
Machine A									
1	20	12,78	0,1	0,1	2,6	0,2	21,0	24,1	51,9
2	40	16,85	0,3	0,2	2,9	—	30,3	21,6	44,8
3	140	17,28	—	0,1	3,5	—	25,9	26,3	44,3
4	160	19,74	—	0,2	5,2	—	29,3	23,2	42,1
5	10	14,85	2,2	0,6	3,6	—	10,0	18,9	64,8
6	160	17,74	—	0,2	3,0	—	19,7	23,3	53,9
7	250	21,41	—	0,5	3,5	—	14,4	32,4	49,2
		Av.	0,4	0,3	3,5	—	21,5	24,3	50,1
Machine B									
1	20	24,98	0,1	0,1	3,4	0,5	22,3	30,6	42,0
2	40	16,57	0,1	0,1	3,9	—	26,3	36,0	33,6
3	125	27,66	—	0,1	3,0	—	30,4	18,7	47,8
4	150	24,82	—	0,1	4,4	—	26,7	19,4	49,5
5	155	24,18	—	0,1	3,4	—	25,4	26,3	44,8
6	194	17,94	—	—	4,3	—	18,3	22,6	54,7
		Av.	—	0,1	3,7	0,1	24,9	25,6	45,4

* The number of tons cut after setting the machine, sharpening blades, etc.

Mill analyses

Sucrose % cane was 14,35, 13,95 and 13,95 for cane cut by hand, by machine A and by machine B respectively, with juice purities of 88,5; 87,4 and 87,5 respectively.

Billet quality and extraneous matter

The low extraneous matter content of both hand-cut (3,1%) and chopper-cut cane (6,1% for A, 7,0% for B) must be ascribed to the excellent burn resulting from the prior use of chemical ripeners and the dryness of the weather.

Table 5 provides further evidence that machine A was cutting lower than machine B. This resulted in higher dirt and root percentages for machine A, but for both machines these values were negligibly small. Billet quality did not differ much between the two machines but machine A did show a marked improvement in sound cane (64,8%) after sharpening of blades. The lengths of the billets differed considerably, with machine A delivering shorter billets of more consistent length than those delivered by machine B (see Figure 1). In the case of Mhlume Sugar Company, the amounts of damaged and mutilated billets are probably not important, because chopped cane is usually crushed within two hours of cutting.

TABLE 6
Sucrose loss due to mechanical harvesting

Method	Gross cane delivered (t/ha)	Sucrose (%)	Sucrose (t/ha)	Difference (%)
Hand cutting	120,10	14,35	17,22	—
Chopper A	117,94	13,95	16,44	4,50
Chopper B	108,36	13,95	15,07	12,50

Field losses

Field losses are summarized in Table 7. Of the total amount of millable cane (118,9 t/ha), hand cutting resulted in a loss of 2,13%, chopper A caused a loss of 6,83% and chopper B a loss of 15,34%.

Compared to hand cutting with gleaning, as normally practised by Mhlume, mechanical harvesting resulted in a millable cane loss of 4,80% and 13,50% for choppers A and B respectively.

Mechanical harvesting resulted in a loss in tons sucrose per hectare of 4,50% and 12,50% for choppers A and B respectively when compared with hand-cutting and gleaning.

TABLE 7
Summary of field losses

	Hand	Chopper A	Chopper B
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 the hand-cut treatment is significant at 5% level.
** Difference from the hand-cut treatment is significant at 2% level.

Conclusions

In this test the treatment blocks were of adequate size and enough replications were included to show statistically significant losses in tons sucrose and tons millable cane when comparing chopper harvesters with hand-cutting as practised at Mhlume. Juice purities were also significantly lower when mechanical harvesting was practised.

The results obtained with chopper A, taking into account its high cutting rate, are nevertheless as good as those found previously by the Experiment Station for other machines. The results obtained using this machine are indicative of what can be expected with a chopper harvester when it is in good repair and with proper settings and maintenance.

The poor results obtained with chopper B should not be taken as typical for that make of harvester, but should rather serve as a warning of the deterioration in performance to be expected when a machine is neglected.

Acknowledgements

The Experiment Station received excellent co-operation from the staff of Mhlume Sugar Company in conducting these trials and our thanks are due to them.

REFERENCES

1. De Beer, A. G. and Boevey, T. C. (1977). Losses incurred when chopper harvesting sugarcane. ISSCT Proc **16:** 2115-2126.
2. De Beer, A. G. and Boevey, T. C. (1977). Field efficiency of chopper harvesters. SASTA Proc **51:** 19-20.