ASSESSING THE VIABILITY OF A FULLY MECHANISED HARVESTING OPERATION FOR A LARGE SUGARCANE ESTATE

E MEYER[1], K DOMLEO[2], J BLISS[2] AND GW MAHER[1]

[1]South African Sugar Association Experiment Station Private Bag X02, Mount Edgecombe, 4300,
[2]Illovo Sugar Ltd, Private Bag 501, Dalton 3236,

Abstract

A desk top analysis was conducted to assess the feasibility and economics of introducing a fully mechanised combine harvesting system on several farms of a miller cum planter estate located in the KwaZulu Natal Midlands of South Africa. Machinery and equipment costing exercises based on row length, haul-out distance and harvester forward speeds were investigated.

The outcome of the study indicated that the success and economic viability of introducing a fully mechanised combine harvesting system is largely dependant on the harvester's output, reliability and the overall management of the proposed system. The study furthermore showed that if the contractor is afforded a reasonable management fee and profit margin the cost of the fully mechanised harvesting system was comparable to that of the existing manual harvesting system currently employed on the estates.

Introduction

At present sugarcane on the Illovo Sugar farms– situated in the Noodsberg area is burnt, manually cut and windrowed. Mechanical grab loaders are used to load the windrowed cane into single axle 5 ton rear tipping trailers coupled to 55kW two wheel drive (2WD) tractors. The infield transport vehicles haul the cane an average distance of one kilometre from the fields to several strategically positioned transloading zones located on the various properties. The whole stalk cane is dumped on the transloading zones in a loose form. The infield haulage operation is carried out during daylight hours only. The whole stalk loose cane on the transloading zone is transloaded by the same grab loaders used in the field, into commercial 30 ton spiller vehicles. These vehicles transport the cane to the Noodsberg mill, 24 hours a day over a six day week delivery period. The harvesting, infield loading and infield transport operations are carried out over a six day working week.

The miller-cum planter approached the South African Sugar Association Experiment Station (SASEX) to undertake a desktop assessment into the feasibility of mechanically harvesting approximately 50% of the cane area on the various farms. These selected areas would be harvested mechanically during daylight hours and the remaining areas (steep and rocky areas) would be harvested and transported using the existing manual harvesting system. The chopped cane would be transported from the field to suitable transloading zones or sites using 2WD tractors coupled to high lift bin trailers. The cane would be tipped directly into a contractor's dual-purpose road haulage vehicles, which would deliver the cane to the mill during the

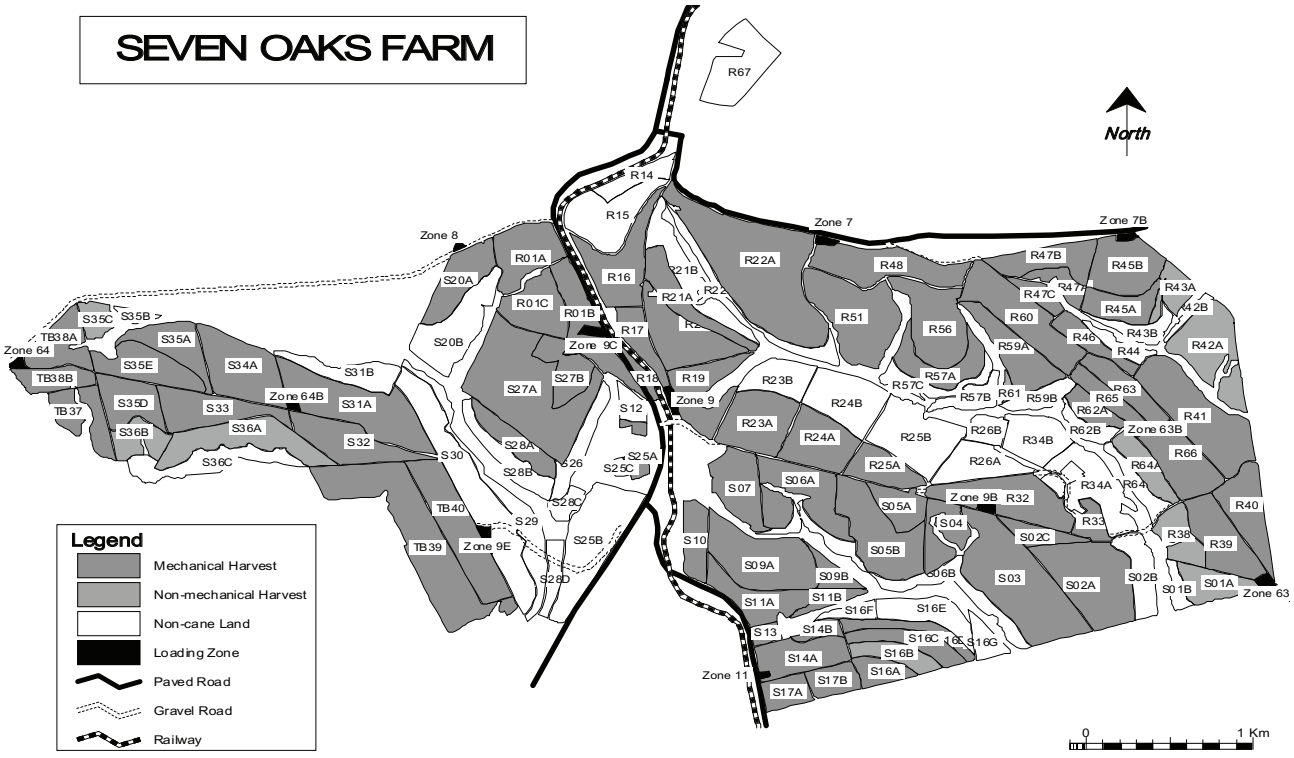

Figure 1. Map of the Seven Oaks farm indicating fields suitable for mechanical harvesting.

Table 1. Cane distribution.

Farm name:	Area (ha)	Annual tonnage
Boekenhout	27,65	2098
Burleigh	161,60	12266
Jaagbaan	98,90	7507
Ryhill	219,05	16627
Smidtshoek	50,40	3827
Sutton	203,70	15461
T.E.B. Hill	74,90	5686
Total	836,20	63472

day. The manually harvested cane is to be stockpiled on the transloading zones during the day and transported to the mill by the same contractor's road haulage during the night.

This paper summarises the outcomes of the desktop analysis.

Materials and method

Field and crop data collection

The miller-cum-planter staff undertook to investigate the area and annual tonnage on all the farms supplying sugarcane to the Noodsberg mill that could be mechanically harvested with a combine harvester. The main criteria in the selection of suitable fields was slope. Other factors that were considered were row length, infield haulage distance and rocks.

Computer software which included Digital Orthophoto's, Digital Terrain Modelling and a Mapping Tool (MapMaker) was used for field selection and data collection. A digital terrain model (DTM) was used to produce a slope map of various categories of slope from 2½ to 20% using different colours for each slope category. The map was then super-imposed over the field boundary map. All fields on the different farms with slopes less than 20% were identified and considered for mechanical harvesting (see Figure 1). A further criteria of rocky terrain was then applied and those fields known to have a high percentage of rocks were excluded. The Map Maker desktop software which was originally purchased to measure areas accurately was found to be useful in measuring row lengths for each field. Random row length measurements were measured to obtain the average row length for each field. Distances from each field to the transloading zone were also measured using this software. A central point was taken from the field via the road that will be normally used to the transloading zone.

Figure 1 Map of the Seven Oaks farm indicating fields suitable for mechanical harvesting The cane areas and annual tonnages for the various farms are shown in Table 1.

An example of the individual farm, field and crop data including row lengths, infield haulage distances as well as road haulage distances from individual transloading zones are given in Table 2. Utilising the pivot table function available in Microsoft Excel, the estimated annual area, cane tonnages, average weighted row lengths and infield haulage distances transported to individual transloading zones were extracted. An example of the area, cane tonnages, row lengths and infield haulage distances associated with the individual transloading zones where chopped cane would be transloaded are summarised in Table 3.

Machinery and transport equipment

Combine harvester:

The self-propelled combine chopper harvester chosen for this assessment was the Claas CC 3000. The two wheel drive har-

Table 2. Farm, field and crop data.

Farm name	Field No	Area	Variety	Zone No	Field to zone (km)	Zone to mill (km)	Row Width (m)	Row length (m)	Tons cane
Boekenhout	BH01	27,0	N12	BH1	0,91	27,00	1,00	574	2049
Burleigh	B05A	11,6	N12	BR 1	1,48	32,00	1,00	446	880
Jaagbaan	J01D	8,0	N12	JB	0,50	1,10	1,00	275	607
Jaagbaan	J02A	6,6	N21	JB	0,50	1,50	0,85	356	501
Ryhill	R16	15,9	N16	9	1,03	22,00	1,00	568	1207
Smidtshoek	SH41	12,7	N16	111A	0,98	20,00	1,00	563	964
Sutton	S02A	24,7	N12	9B	1,09	25,00	1,00	641	1875
T.E.B. Hill	TB37	9,7	N16	64	1,13	27,00	1,00	170	736

Table 3. Summary of area, tonnages, row lengths and haulage distances associated with each transloading zone.

Zone No:	7	7B	9	9C	64	64B	111A	BR2	BR3	JB
Total area	58,7	40,3	87,3	48,9	30,5	36,6	43,6	59,8	40,0	98,9
Total tons	4452	3059	6626	3712	2315	2778	3306	4539	3032	7507
Av.row length (m)	706	317	320	374	323	439	374	377	402	311
Av.field/zone dist.(km)	1,40	1,51	1,25	1,13	1,13	0,70	1,17	1,14	1,13	0,50
Av.zone/mill dist.(km)	25,00	28,00	22,00	22,90	27,00	28,70	20,00	34,00	37,00	2,50

vester is powered by a 179kW engine and weighs 11,5 tons. The harvester's fixed discharge elevator is located on the left hand side of the machine which means that it is only capable of harvesting in one direction. The reasons why this harvester was selected is that it is capable of harvesting two rows of sugarcane in a single pass, has good ground clearance and with its 3,0 m front wheel track it is relatively stable on slopes.

Sugarcane is predominantly grown at 1,0 metre row spacing on the miller-cum planter's estate. However the relationship between the stool width at various stages throughout the crop's life cycle was uncertain. A survey was therefore carried by Illovo Sugar field staff to assess this row/interrow relationship. The results of this survey is shown in Figure 2.

As can be seen from Figure 2 cane stool width steadily increases with each ratoon. However, it would appear a maximum stool width of 400 mm is reached after the third ratoon. The relationship of the Claas harvester's base cutter assembly and cane row spacing is illustrated in Figure 3.

Infield transport:

The assessment was based on using three 55kW wheel tractors coupled to 6 ton capacity, single axle, high-lift trailers. The trailers are equipped with twin hydraulic lifting rams and have

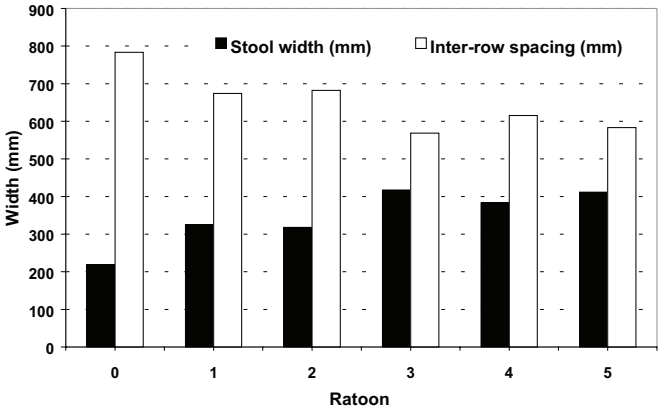

Figure 2. Cane stool width vs. inter-row space at 1,0 m row spacing.

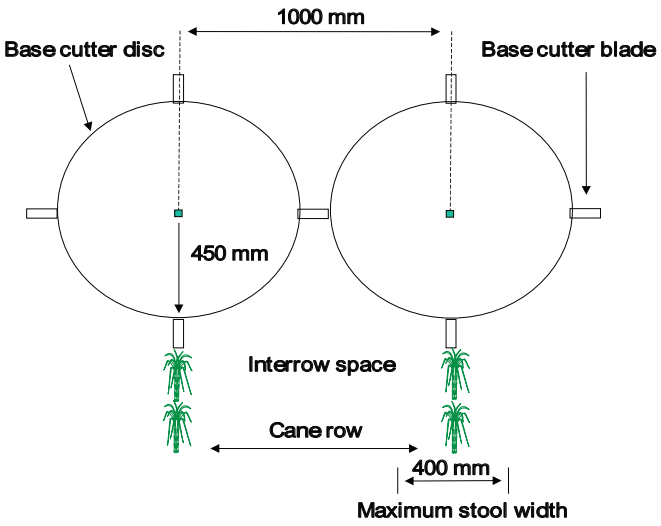

Figure 3. Harvester base cutter arrangement relative to 1,0m row spacing.

an off-loading reach of 4,4 m. These haulage units transport the cane from the field to the nearest transloading zone where the billeted cane is tipped directly into the waiting road transport vehicles.

Road transport:

A commercial haulier will transport the billeted cane to the Noodsberg mill during daylight hours. The hauliers vehicles comprise of 6x4 truck tractors coupled to tri-axle spiller trailers capable of handling both chopped and whole stalk cane.

Results and discussion

The computer based combine harvesting and infield transport analysis programme, developed by the South African Sugar Association Experiment Station (SASEX) (Meyer, 1998), was used to estimate the average combine harvesting and infield transport costs for the entire fully mechanised harvesting operation. The estimated harvesting costs were based on an annual crop of 63 472 tons, an average yield of 76 t/ha, an average row length of 396 m and an infield haulage distance of 1,09 kilometres. Harvester forward speed was based on observations made by the harvester agent and harvesting contractor currently employed by the miller-cum-planter as well as results of time and motion studies conducted by SASEX (Meyer, 1999).

Using the harvester simulation programme the harvester and infield transport units performances were calculated based on varying the harvester's forward speed. This was done to show the effect of varying sugar cane and infield conditions on harvester and infield transport performance and cost. The results of this exercise are given in Table 4 and graphically illustrated in Figure 4.

It can clearly be seen in Table 4 that harvester forward speed, which is dictated by numerous crop and field conditions such cane yield, cane recumbency, field layout and operator proficiency, has a significant effect on overall mechanical harvesting performance and costs.

To assess the viability of the proposed mechanical harvesting system it was compared to the existing miller-cum planter's manually based harvesting operation. Machinery costs were based on SASEX's classical costing method, which include depreciation and interest on capital invested. The miller-cum planter's current manual based harvesting costs consisted of

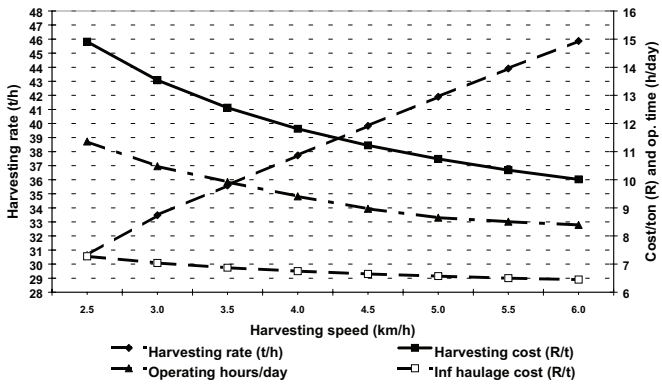

Figure 4. Harvesting rate, harvesting and infield transport cost and operating times.

Table 4. Harvester and infield transport performance and costs based on varying harvester forward speeds.

Harvester Speed (km/h)	Harvesting Rate (t/h)	Harvesting Cost (R/t)	Operating hours/day	Infield. haulage cost (R/t)	Total cost (R/t)
2,5	30,63	15,55	11,36	7,28	22,83
3,0	33,48	14,10	10,48	7,04	21,14
3,5	35,59	13,06	9,92	6,87	19,93
4,0	37,73	12,27	9,41	6,75	19,02
4,5	39,83	11,64	8,97	6,65	18,29
5,0	41,90	11,13	8,65	6,57	17,70
5,5	43,91	10,71	8,51	6,50	17,21
6,0	45,87	10,35	8,39	6,45	16,80

R10,34 for manual harvesting, R4,29 for infield loading and transloading and R7,51 for infield transport per ton respectively. The average weighted road transport cost for both the existing and proposed harvesting system was based on R17,65 per ton.

The comparative costs between existing manual and the proposed mechanical harvesting system based on harvester forward speeds varying between 2,5 and 6,0 km/h is illustrated in Figure 5.

Costs for the fully mechanical harvesting options do not include a management fee or profit margin. However, allowing for a 30% combined management and profit margin (M&P), the mechanical harvesting system cost is only equal to the manual harvesting system costs when the harvester achieves a average harvesting rate of about 37 t/h. Only after this point is the mechanical system cheaper than manual harvesting system.

Conclusions

The mapping software proved to be an easy to use and useful tool in providing field and crop data. Accurate field and crop data, such as cane yield, slope and row lengths is a prerequisite when estimating combine harvester as well as infield haulage vehicle performance and costs.

The desk top analysis clearly shows that harvester forward speed plays a significant role in determining harvester output which in turn will dictate overall costs for the proposed mechanical harvesting system.. The study furthermore showed that if the contractor is afforded a reasonable management fee and profit margin there appeared to be little difference in total harvesting costs between the existing manual and the proposed fully mechanical harvesting systems.

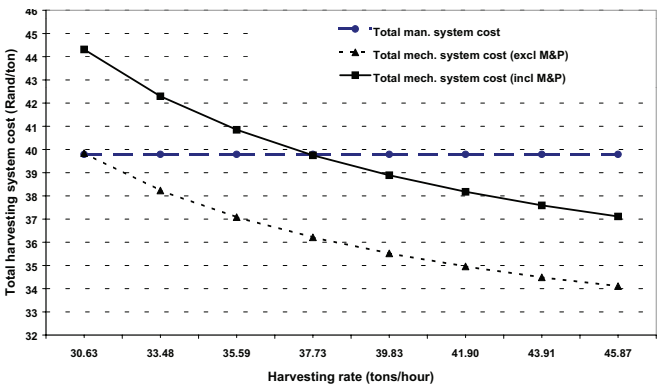

Figure 5. Comparative harvesting costs – Existing manual vs mechanised harvesting systems.

After considering the results of this investigation as well as, the added benefits of improved cane quality (less soil and double handling), the possibility of green cane harvesting and the long term labour implications of cutting cane it was decided to engage a commercial contractor to harvest the selected cane areas on the various farms as from the beginning of the 2000/2001 harvesting season. The miller-cum-planter will monitor the harvesting and infield transport actual performances and costs and this data will be compared to the estimated performances and costs estimated in this assessment. This comparison will prove invaluable in verifying harvesting and infield transport operational standards and future fully mechanised harvesting assessments.

Acknowledgements

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