

# EXPERIENCES WITH MECHANIZED CANE PRODUCTION SYSTEMS AT LA MERCY

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## Abstract

Mechanization standards established by the Experiment Station over the first four years of the La Mercy exercise are presented. Both long term average performances based on field records and those determined during more detailed time-and-motion studies have been given. Experiences gained with mechanical planting are also discussed.

## Introduction

Standards are essential for meaningful programme planning and tasking of operations by sugarcane growers. Available standards for mechanized operations are based mostly on overseas data or refer to other crops and experience has proved these standards to be most inapplicable to the South African sugar industry. Standards may be established by time-and-motion studies on individual farms, but results will always be dependent upon local factors such as management and topography. The acquisition of the La Mercy farm afforded the Experiment Station the opportunity to measure the performance of a range of equipment under reasonably standard and well defined field conditions. This paper is a first report on experiences gained with mechanized sugarcane production systems.

## Method

The La Mercy exercise entailed all cane growing operations, including the eradication of the previous crop, the re-shaping of fields, and the construction of new roads and conservation structures. Practical standards for all of these operations could thus be established. All standards were determined on a field-hour basis (i.e. total time spent away from the headquarters, including travelling and down-time). More detailed and more accurate time-and-motion studies were performed additionally on selected operations to establish factors such as machine efficiency and output per operating hour.

A clerk noted the relevant data from machine logbooks, the farm manager's diary and labour records. Fuel and materials used and tractor hours were allocated daily per operation and per field. This information was analyzed by means of a computer service offered by the South African Cane Growers' Association. Field staff wrote additional comprehensive reports on experiences gained while implementing each phase of the La Mercy operation. <sup>1, 3, 4, 5, 6, 7, 8, 9.</sup>

## Results and Discussion

### Long term averages

Lists of some of the operations performed on areas 3, 4, 5 and 6 of the La Mercy farm (see Fourie and de Beer<sup>2</sup> for a full description of these areas); with the average output attained over a four-year period, are given in Tables 1 and 2. These data include the performances of commercial and prototype machines. Operators were quite often unfamiliar with machines or techniques being used. Initial performances were thus necessarily poor, but were nevertheless included when calculating the averages. When evaluating these results, it must be remembered that the figures were obtained over

an extended period. They were based on the total time a machine spent on an operation, measured from the time it departed from the headquarters until it returned.

TABLE 1

Long-term average mechanization standards expressed in tractor hours per hectare

Operation	h/ha
Removal of scrub	8,7
Harrowing	2,8
Ripping	6,1
Land levelling	6,1
Ploughing	4,7
Waterway construction	7,6
Infield structure construction	9,7
Ridging	1,7
Mechanical planting	8,2
Herbicide application	1,1
Mechanical cultivation	2,4
Fertilizer application	1,3

It is interesting to note in Table 1 that the construction of conservation terraces to Experiment Station specifications, using only 2-wheel drive tractors with two-furrow, reversible disc ploughs, required nearly ten tractor hours per hectare. The use of the same equipment for waterway construction required nearly eight tractor hours per hectare. The high figure for scrub removal (8,7 tractor hours per hectare) included the time required for rock, stump and old cane stool removal.

Table 2 gives more specific information on the performance of a number of cane cutters and loaders, measured in terms of tons per hour. The average output of the Edgecombe cutter illustrates the effect of operator training and machine improvement on performance. While the average output was relatively low (18 t/h), this machine eventually cut as much as 30 t/h. Topping efficiencies for all cutters appear to be low, but it must be appreciated that 18% of all stalks were regarded as "untoppable". Untoppable stalks were defined as short stalks located amongst the longer stalks such that the operator could not adjust the machine's topping device quickly enough to be able to top them. Patches of recumbent or lodged cane also reduced the topping efficiency of the cutters.

TABLE 2

Long-term average performances of mechanical cane cutters and loaders

	Total tons	Av. tons per field hour	Topping %
<i>Cutters</i>			
Edgecombe	7 376	18,1	48,6
Sasex	5 900	15,1	50,2
Midway	1 037	15,5	44,2
Bell (cut and stack)	2 957	5,5	43,1
<i>Bell loader</i>			
Load box trailers from sausage windrow	6 409	11,0	
Stack from sausage windrow	4 226	11,4	
Load box trailers from windrow	2 211	17,0	

It may be seen in Table 2 that a Bell loader, picking up cane from a sausage windrow, cut by machines such as the Sasex, had nearly the same output when loading into box trailers (11,0 t/h) as when stacking for self-loading trailers (11,4 t/h). When loading took place from hand-made windrows, the output increased by more than 50% to 17 t/h.

#### Time-and-motion studies

Selected operations were carefully timed to establish machine and system efficiencies. Field conditions pertaining during these tests were noted. The results of these studies provide an indication of standards which should be well within the reach of South African cane growers. These studies were conducted not only on areas 3, 4, 5 and 6 but also on other fields on the La Mercy farm.

The first operation to be studied in detail was mechanical planting. Observation time totalled 44 hours during the normal planting of an area of 12 ha. Results are shown in Table 3. A 4-wheel drive Ford County tractor with a Waletz cane planter was used. Row spacing was 1,5 m and the seed cane was pre-trashed. Nine people were involved in this operation, namely, one driver, two feeders on the planter, two followers to check on consistent seed delivery to the furrow and four loaders, who also pre-trashed the seedcane. Planter efficiency was 49% when loading of seed consumed 35% of the total time. A further analysis quantified the effect of row length on planter efficiency, as shown in Figure 1. For maximum planter efficiency rows should be at least 200 m long. When obtaining the data used in Figure 1, six loaders were used and this increased planter efficiency to 58% for rows longer than 200 m, because filling time was then reduced to 30% of the total field time.

TABLE 3  
Field efficiency of a mechanical planter

Area under test (ha)	Ave. row length (m)	Operating time %	Turning time %	Filling time %	Down-time %	Output	
						ha/field hour	ha/op hour
12,1	202	49,0	12,4	35,0	3,6	0,29	0,55

The siting of seedcane and fertilizer stations played an important role in reducing downtime and unnecessary travelling. According to the results shown in Table 3, it should be possible to plant as much as 2 ha per 8 h day. Over two

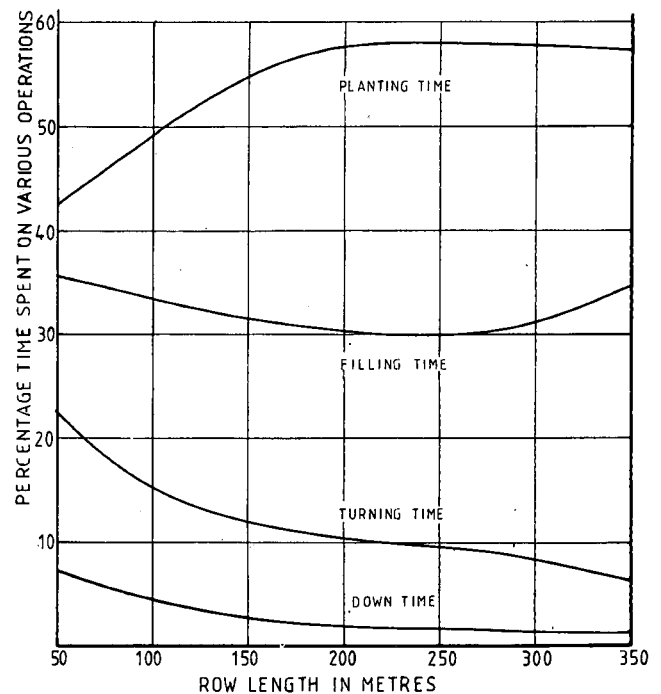


FIGURE 1 Results of time-and-motion study on planter efficiency.

planting seasons, planting a total of 160 ha at an average seedcane rate of 9 t/ha, we averaged only 0,8 ha/day, but this was counting all planting days, including those interrupted by rain and breakdowns.

The second intensive study concerned the handling of the cane after it had been cut. Various handling systems, requiring varying amounts of labour, were used in conjunction with different mechanical cutters while harvesting cane from 135 ha. Labour requirements, cane left behind in the field and cane quality are shown in Table 4. "Labour required" included all field labour but excludes machine operators and trailer conductors. For systems 1 to 8 the Sasex, Edgcombe and Midway cutters were used. These machines leave the cane in "sausage" windrows. A Bell cutter/loader was used to cut the cane for systems 9 to 11. Burnt NCo 376 was harvested in all these trials at a rate of 50 to 100 tons per day.

The first system comprised stacking the cane from the "sausage" windrows manually. Tops and other extraneous matter in the windrows were thus generally left in the field. This should have resulted in the cleanest possible cane, containing a minimum of soil, being delivered to the mill. Productivity was 6,5 t/man day. By stacking mechanically from

TABLE 4

Labour productivity for various handling systems of burnt sugarcane cut mechanically by machines such as the Sasex, Edgcombe and Midway (systems 1 to 8) and Bell (systems 9 to 11), with field losses and cane quality

System	Tons/man/day	Losses before gleaning tons/ha	Losses after gleaning tons/ha	Fibre % cane	Purity
1. Manual stacking, self-loading trailers	6,5	2,09	NR	15,57	84,00
2. Forming small bundles manually, mechanical stacking,* self-loading trailers	9,8	NR	NR	NR	NR
3. Manual windrowing and topping,** mechanical loading into box trailers	6,0	6,16	2,38	14,74	79,23
4. Manual windrowing, mechanical loading into box trailers	10,0	4,16	2,08	15,69	82,83
5. Mechanical stacking* after manual topping** in the sausage, self-loading trailers	6,2	13,36	5,86	15,43	83,69
6. Mechanical stacking,* some manual cleaning of stacks, self-loading trailers	11,7	4,31	NR	18,30	82,30
7. Mechanical stacking,* self-loading trailers	14,9	NR	NR	17,60	81,80
8. Mechanical windrowing,* manual topping,** mechanical loading into box trailers	10,2	9,01	2,69	15,94	83,13
9. Bell cutting and stacking, self-loading trailers	13,6	6,43	4,42	15,88	81,47
10. Bell cutting and stacking, hand cleaning and topping, self-loading trailers	8,7	NR	NR	16,01	83,23
11. Bell cutting and loading into box trailers	26,5	1,23	1,19	16,91	82,41

\* by Bell loader.

\*\* large number of tops missed by mechanical topper due to lodged cane, removed by hand.

small manually prepared bundles, the productivity per man-day was increased to 9,8 tons in system 2. For this operation a loader of the "Bell" type was required. Changing from self-loading to box-type trailers, and loading mechanically from manually prepared windrows, as in system 4, gave results similar to those in system 2, viz 10 t/man-day. It should be noted that, when dealing with recumbent cane, topping during the windrowing was required to remove the tops missed by the topping device on the cutting machine (system 3). This reduced productivity to 6 t/man-day.

By stacking mechanically with a Bell loader directly from the sausages, as was done in system 7, productivity increased to 14,9 t/man-day. Again there was a reduction in productivity when manual topping or cleaning of stacks was required (systems 5 and 6).

The final system to be evaluated from the sausage windrowed cane was that of mechanical loading by the Bell loader from the windrow into box trailers (system 8). While waiting for a trailer to return from the loading zone, the loader prepared "windrows" of cane. This resulted in faster loading of the trailers without affecting the labour requirements. Productivity was 10,2 t/man-day. This included manual topping. Unfortunately this system could not be tested in erect cane. Had this been possible, the effect of manual topping on productivity could have been established. From experience gained when using the other systems, a production of 15 t/man-day could be expected if manual topping was avoided.

For systems 9, 10 and 11 a Bell cutter/loader was used to harvest the crop. A single machine could handle a maximum of 50 tons per day. Straight upright cane was required for the Bell cutter to operate efficiently. When cutting and stacking for self-loading trailers (system 9), labour productivity was 13,6 t/man-day. Manual cleaning and top removing (system 10) reduced this output to 8,7 t/man-day. System 11 proved to give the best labour productivity results of all the systems tested. The Bell cutter/loader formed small bundles from the cut cane. When a box trailer arrived, it was loaded by the Bell from these bundles. Labour productivity was 26,5 t/man-day. By comparing the amounts of cane left behind in the field before and after gleaning, it is clear that gleaning reduced field losses by about 50% (from an average of 6,7 to 3,1 t/ha). The values for "fibre % cane" and "purity" should not be compared between systems, because field conditions varied considerably at different times of harvest. The data are included only for general interest.

During the 1978/79 harvesting season, the performance of a slewing type push-pile loader was evaluated<sup>3</sup>. Cane was loaded from windrows prepared from either two or four rows of cane into two five-ton capacity box trailers for transport to a loading zone. Average loading rates from a four-row

**TABLE 5**  
Operating efficiency of slewing push-pile mechanical loader

No. of rows per windrow	Total observed time (min)	Loading (operating) time (min)	Total tons cane	Tons per field hour	Tons per operating hour	% Time operating	Distance to loading zone (km)
4	402	264	159	24	36	66	0,5
2	91	35	18	12	31	38	0,6

windrow (Table 5) were 24 t/field hour and 36 t/operating hour. Time lost while waiting for the trailers reduced loader efficiency to 66%. When loading from windrows consisting of cane from two rows only, the loading rate decreased to 31 tons/operating hour. These results indicate that if no time is lost waiting for trailers, the capacity of such a machine could be nearly 300 tons per 8 hour day.

The next aspect of cane handling to receive attention was the haulage operation. Box trailers were compared with self-loading trailers over a period of 25 hours. The box trailers were loaded by slewing and non-slewing loaders while the self-loading trailer picked up stacks made manually or by machine. From the data in Table 6 it is clear that self-loading trailers should transport more cane in a given period than box trailers. The average payloads of the mechanically loaded trailers were, however, higher than the average for the self-loading trailers. The amount of time spent on fixing and removing chains, expressed as a percentage of the total loading/unloading time, was 38 and 67% for box and self-loading trailers respectively. Time required to off-load box trailers was longer than that for the self-loading trailers. This was due to the double lift required to tighten the chains around the mechanically loaded cane.

A more detailed breakdown of the percentage of time spent on various phases of the total transport cycle, travelling included, is given in Table 7. During this study it was established that the average speed to travel to and from the loading

**TABLE 6**  
Loading and unloading times for box and self-loading trailers

Total time spent on chains (min)	Loading time (min)	Time spent unloading (min)	Total (min)	Average payload (tons)	Total load and unload time/ton
Box trailer with slewing loader					
4,57	5,40	2,32	12,3	4,12	3,0
Box trailer with non-slewing loader					
5,02	5,50	2,57	13,1	4,02	3,3
Self-loading trailers, mechanically and hand-stacked bundles					
5,89	1,16	1,79	8,8	3,75	2,4

**TABLE 7**  
Results of time-and-motion study on cane trailers

% Time chains l/zone	% Time travel empty	% Time chains loading	% Time loading	% Time chains loaded	% Time travel loaded	% Time crane	% Down time	Average payload	Average distance (km)
Box trailers with slewing loader									
5,3	13,5	7,2	28,4	11,5	12,9	12,4	8,8	4,12	0,8
Box trailers with non-slewing loader									
4,7	13,2	6,1	27,8	12,2	16,6	12,4	7,0	4,02	1,0
Self-loaders — hand and machine stacked									
5,8	19,4	18,5	6,0	7,8	23,4	10,3	8,8	3,75	1,4

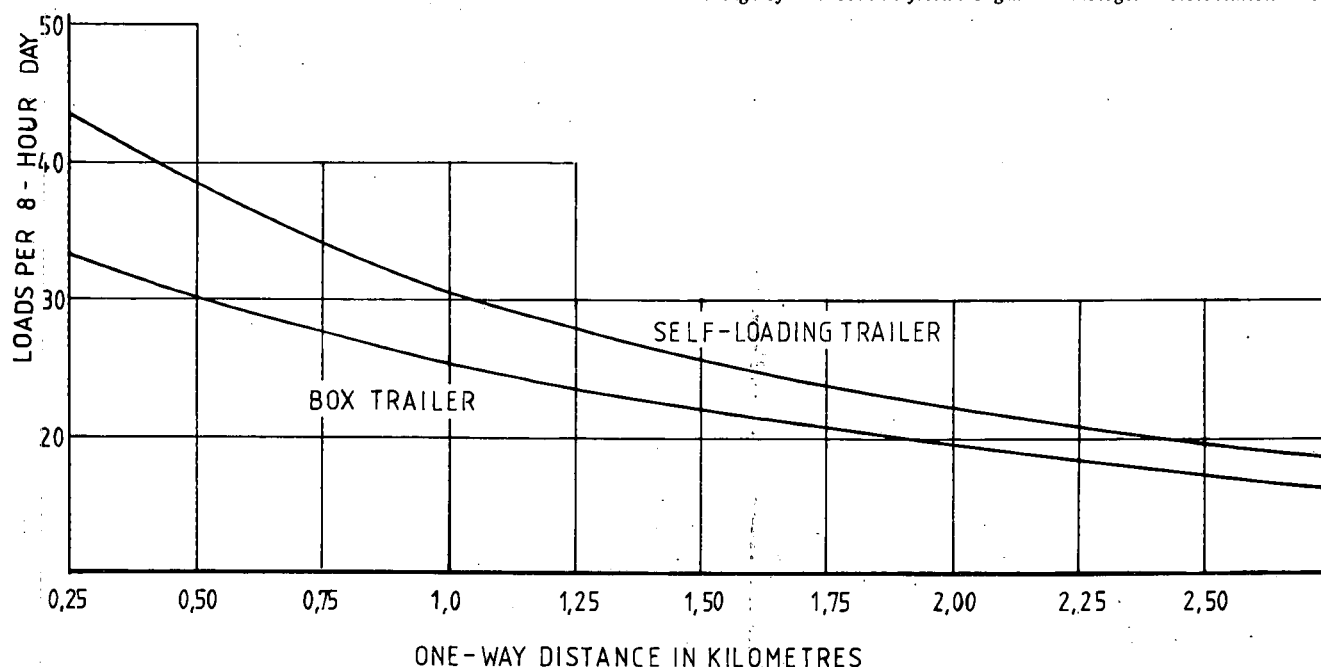


FIGURE 2 Number of loads per 8-hour day with box and self-loading trailers as a function of distance to the loading zone.

zone was 19,6 km/h. From these data the number of loads it would be possible to haul in an 8-hour day can be calculated as a function of haulage distance, as shown in Figure 2. Payload, of course, also helps to determine the amount of cane transported per day.

#### Other results

Two important lessons were learnt about mechanical planting. The first was that compaction of the soil over the setts might decrease germination under certain field conditions. Planting on steep slopes, the upper wheels of the tractor were allowed to travel in the furrow previously planted. This assisted greatly in maintaining constant row spacings and in stabilizing the tractor/planter. From the germination data shown in Table 8, it would appear that this

practice should be discouraged as it could lead to large areas needing replanting. Soil type and soil moisture content will, however, affect the results obtained, poor germination being more likely to occur in heavy soils.

The second lesson was that planting in spring and early summer is preferable to planting in late summer and autumn (see Table 9). Provided that soil tilth conditions were good, soil type played only a small part in germination efficiency.

#### Conclusion

The La Mercy exercise is providing the Experiment Station and the sugar industry with a wealth of information on practical mechanized sugarcane farming under typical South African conditions. One of the most important features of this exercise is the establishment of basic mechanization standards. After the first four years a large number of operations have been evaluated, some in great detail. The results will be continuously augmented and updated as more experience is gained.

It is to be expected that the standards presented in this paper will be steadily improved upon as management, machine operators and labour become more proficient.

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TABLE 8  
Germination results as affected by compaction

Planting period	Total rainfall (mm)	Field	Hectares planted	Soil type	Replant hectares
1/9/75 to 1/1/76	466	301	1,00	50% Dolerite	0
		304	6,35	50% Middle Eccla	
		601	4,44	50% Dolerite	
		602/1	2,78	50% Middle Eccla	
Percent replant of total: 0					
1/1/76 to 1/4/76	767	410	1,93	Dolerite	0
		404	1,35	Middle Eccla	
		603	2,00	Middle Eccla	
		605	3,65	Middle Eccla	
Percent replant of total: 37					

TABLE 9  
Effects of planting dates on germination

Season	Planting period	Rainfall (mm)	Area planted (ha)	Replant		Total — season replant
				ha	%	
1975/76	1/9/75—1/1/76	466	40,54	0	0	—
	1/1/76—1/4/76	767	50,34	15,27	30	17%
1976/77	1/9/76—1/1/77	375	51,04	0	0	—
	1/1/77—1/4/77	543	17,70	3,10	18	5%