

THE OPERATION OF A SEMI-MECHANIZED HARVESTING SYSTEM AT LA MERCY

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Abstract

A harvesting system used at La Mercy during the 1981/82 season is examined in detail and peak performance standards established for the machinery used. The efficiency of various extraction systems is compared. Time taken for each phase of the operations is tabulated. Labour requirements and output are recorded. Costs of operating the Midway cutter and Bell loader are estimated. The need for further integrated man-machine studies is discussed.

Introduction

The La Mercy farm is used as a proving and testing ground for machinery. However, there are areas which are reserved for commercial operations. In these areas individual implements and various systems are evaluated.

Experiences gained with individual cane cutters, loaders and hauling methods, enabled the staff at the farm to employ a semi-mechanized harvesting system during the 1981-82 season. It was possible to operate various units at or near peak performance and achieve a balanced system to handle the daily cane allocation. The farm's daily allocation is between 50 and 60 tons but to valuate the capacity of the system more thoroughly delivery rates to the transshipping zones exceeded 100 tons per day for selected periods.

Method

Harvesting and handling equipment included the following:

- Two tractor-drawn water tenders.
- Midway cane cutter: the cutting attachment is mid-mounted on a conventional Ford 5000 tractor with the rear wheel track extended.
- Conventional Bell loader.
- Hauling shuttle unit — Ford 4600 (39 kW) and two box trailers, one of which was always parked in the field for loading while the other was on its way to and from the field.
- Hydrostatically driven Zulu crane.

All the cane was burnt prior to harvesting to accommodate the Midway cutter. Since strip cropping is practised at La Mercy, watercarts are essential to control burns and two fire-fighting tenders were used for this purpose.

The Midway cutter is a single row cane cutter which tops and base cuts the stalks and leaves them in parallel sausage windrows between the cane rows. At La Mercy tops were collected in a bin on the front of the tractor. The tops were either dumped in windrows across the field or emptied in piles when the bin was full.

Cane from four rows was then combined into one windrow using hand labour. As the cane tops were collected they were prevented from becoming entangled with the cane sausage. Therefore the labourers doing the windrowing did not have to sort out many tops from the cane. The daily task was set at 12 tons per man and the length of row to be windrowed by one man was calculated from the

estimated yield and the length of row per hectare. A simple measuring wheel was used to set out the task for each labourer.

Once the labourers had windrowed the cane, the Bell loader loaded directly from the windrows into one of the box trailers parked in the field. The piled cane tops which were normally spread out after the haulage operation was completed, were easily avoided by the loader.

Using only one tractor to haul two trailers required frequent switching of trailers. The hitch on the hauling tractor was modified to speed up coupling and uncoupling. It is normally difficult to hitch tractors and trailers on steep terrain, but the modified hitch made this easier. Once the trailer was hitched, a labourer from the hauling and gleaning gang had only to raise the stand which supported the trailer during the loading operation. Trailers were positioned to reduce the travelling time of the loader. Under dry conditions this shuttle method was used on slopes up to 20%.

When fields were wet or the terrain too steep, two tractors and trailers were used to transport cane from the field. The hauling units then followed the loader along the windrowed cane. In this way compaction of the soil on patches of land was avoided during the wet weather and the risk of runaway trailers was reduced on the steeper terrain.

The weekly cane allocation was hauled in two to three days from the field to one of three loading zones, where the cane was off-loaded and stock-piled by means of a self-propelled Zulu crane. These zones were situated to reduce the hauling distance to less than 1,5 km. Cane deliveries to the mill were normally spread over three or four days.

Results and Discussion

Electronic hour meters were installed on all vehicles except the Bell loader which has a vibratory hour meter. The electronic hour meters are operated via the engine oil sender unit. The ordinary hour meter is dependent on the number of engine revolutions per unit time whereas the electronic hour meters record actual hours. The hauling tractor was fitted with a tachograph. The operators always recorded times of arrival in and departure from the field to provide an accurate record of hours worked daily in the field.

Details of the performance of the various machines are given in Table 1. The results are based on the readings from the electronic hour meters. Discrepancies between tractor hours and clock hours under various conditions are apparent. Tractor hours were 43% higher than clock hours for the mechanical cutter which operated at high revolutions per minute. For haulage tractors tractor hours are only 79% of clock hours. The fuel consumption of the transloading crane was high and it used only 27% less fuel per ton than the Midway cutter.

Performance for different extraction systems is given in Table 1. The haulage tractor with two trailers is far more productive than either of the tractors with its own trailer. The single tractor with two trailers consumed less fuel per

TABLE 1
Machine performances

Machine	Tractor h	Ratio to Clock h	Litres per ton	Litres per ha	Clock hours /ha	Tons/ clock h	Tons/ infield* clock h	l/ton gross /km†	Average distance
Fire tender tractors	1	: 1	0,03	3,4	0,6	—	—	—	—
Midway cutter	1,43	: 1	0,29	22,3	2,7	27,9	30,6	—	—
Zulu crane	1	: 1	0,21	16,3	2,7	25,1	31,4	—	—
	1 Tractor plus 2 trailers								
Bell loader	1	: 1	0,22	16,6	3,4	22,5	23,8	—	—
Ford 4600	0,80	: 1	0,21	15,8	3,8	20,3	22,3	0,150	1,04
	2 Tractors plus 2 trailers								
Bell loader	1	: 1	0,21	13,8	2,9	22,6	25,9	—	—
Ford 4600	0,78	: 1	0,26	17,1	4,2	15,4	16,7	0,195	1,02
MF 165	0,75	: 1	0,22	14,9	5,7	12,0	13,6	0,161	1,02

* excluding time lost travelling to and from the field
† including mass of trailer

ton/km than two tractors and trailers. Cost per ton delivered to the zone is reduced with a single tractor but the cost per hectare of loading is increased and cane delivered per hour reduced.

Percentage time spent on various phases of harvesting is given in Tables 2, 3 and 4. From the data obtained from

TABLE 2
Midway cutter: time spent on various operations

Turning (%)	Cutting (%)	Cleaning (%)	Down time (%)	Infield travel (%)	Total time min.	Average cutting speed km/h
9,4	85,1	1,0	3,5	1,0	899,8	3,3

time and motion studies, it can be seen that one tractor hauling one trailer and then another trailer spends 50% of the time travelling, which is productive work, compared to 35% of the time when hauling with a single trailer. The tractor and trailer spent about 33% of the time being loaded when only one trailer was used.

The labour output is detailed in Table 5. Man days include all operators and drivers for each task. A total of 3 334 tons were delivered, requiring 598 man days or 13,63 man days per hectare for harvesting, loading, transport and transloading. The performance of labour at trans-shipment could be improved if larger quantities were being handled. The crane driver also weighed the cane. Average hilo load over this period was 22,8 tons.

The operating costs for the Midway cutter and Bell loader are shown in Table 6. Fuel cost was assumed to be

TABLE 3
Operational details of tractor plus two trailers

Travel to zone (%)	Unload (%)	Load chains (%)	Tractor to field (%)	Uncouple (%)	Tractor to next trailer (%)	Couple (%)	Down time (%)	Total tons	Hauling rate-tons/h	payload tons	Ave. One way distance km	Average cycle time min
30,4	9,6	5,3	20,5	4,7	6,5	4,3	18,7	592	23,8	5,7	1,04	14,3

TABLE 4
Operational details of tractor plus one trailer

Travel to zone	Unload	Load chains	Travel to field	Chains loading	Loading	Chains after loading	Down time	Average payload	Total time min	Total tons	Hauling rate tons/hour	One way distance km	Average cycle time minute
20,7	7,0	3,3	13,9	4,6	33,2	9,9	7,4	5,3			16,3	1,02	20,23

R0,42/l, lubrication R0,84/l and repair R10,00/h. These costs reflect the total operating cost of the two machines from new to date. During its lifetime the Bell loader has performed a number of different loading operations, some of which have been mentioned previously by Meyer and Worlock¹.

Conclusion

The work rate established for various machines may be used to predict their performance when operating at full potential, as shown in Table 7. The Midway should cut 223 tons per eight hour day, the Bell should load 180 tons per day from windrows and one tractor with two box trailers should transport 162 tons per day. If breakdowns

TABLE 5
Labour output

Job allocation	Tons per man day
Burning	185,2
Harvester (Conductor included)	75,8
Loading	114,9
Windrowing	15,2
Hauling (Conductor & gleaners included)	32,1
Crane operator and helpers	18,2

TABLE 6
Machine operating costs

Machine	Vehicle hours	Total fuel ℓ	Total lubricants ℓ	Repair hours	Spares cost (R)	Total tons	Average operating cost/ton (R)
Midway cutter	670	3 801	521	135,2	2 737	11 225	0,55
Bell	3 118	13 726	1 011	190,9	3 203	35 151	0,33

TABLE 7
Expected output per eight hour day

Machine	At 100% availability		At 60% availability	
	Tons/hour	Tons/day	Tons/hour	Tons/day
Midway cutter	27,9	223	16,7	134
Bell loader	22,5	180	13,5	108
Hauling unit	20,3	162	12,2	97

TABLE 8
Labourers required for 100 t/day*

Operation	Labourers/day
Cutting	2
Loading	1
Hauling & gleaning	4
Windrowing	8
Trans-shipping	3

* Labour required for burning supplied by loading/hauling and gleaning/trans-shipping teams

and other factors reduce the daily performance to only 60% of this, these three machines would still be able to handle 134, 108 and 97 tons per day respectively. It can thus be concluded that a daily allocation of 100 tons is within the capability of these machines. To complete the system, a transloading device and fire fighting equipment are required.

Similarly, the number of field personnel, including operators, required for a 100 ton per day delivery rate can be estimated from Table 8 to be 18. Over a 200 day harvesting season, 20 000 tons of cane would be harvested by 18 people with this equipment. This works out at 0,9 men per 1 000 tons of cane harvested and transported.

Performance standards are needed to plan for mechanized operations and while standards can be established for individual machines, integrated man-machine systems need to be evaluated to obtain a true picture of their potential. The La Mercy farm affords the Experiment Station the opportunity of evaluating complete cane production systems.

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REFERENCES

1. Meyer, E. and Worlock, B. (1979). Experiences with mechanized cane production systems at La Mercy. *SASTA Proc* 53: 143-146.