A FIRST REPORT ON THE LA MERCY PROJECT

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Abstract

There had been a long-felt need for the sugar industry to acquire a large area of land on which the Experiment Station could conduct tests with mechanical harvesters and mechanical harvesting systems on field layouts suited to such operations. For this purpose the Experiment Station was able to lease 958 hectares of the area expropriated for the La Mercy airport in 1974. On this land four adjacent catchments of approximately equal area were placed under four field layouts already in use on sugarcane farms. Records were kept of all operations on the catchments, and these included the construction of conservation works and land preparation up to the time of planting, which required 61 % of total tractor hours up to and including planting.

A plant crop and at least one ratoon have been harvested from all four areas using various mechanical harvesters. A wealth of experience has been gained on the practical aspects of mechanized sugarcane production. It is particularly valuable because it has been gained on soils and topography typical of much of the land under sugarcane in the industry, and on a field scale. After the first four years it can confidently be claimed that the objectives are being achieved.

Introduction

At a meeting of the Mechanical Harvesting Subsidy Committee on the 20th August 1974, it was agreed that the sugar industry should:

(*a*) establish the direct and indirect costs of operating mechanical sugarcane harvesters under South African conditions; and

(*b*) accumulate knowledge on —

  (i) the establishment of field layouts suitable for mechanical harvesting, and

  (ii) the transport and transhipping facilities necessary for the efficient operation of mechanical harvesting systems.

At the same meeting it was emphasized that mechanical operations, and particularly mechanical harvesting, would only be efficient if fields were satisfactorily laid out for this purpose. Concern was expressed that the industry might be expected to change expensive conservation works when accommodating progressive developments in mechanization, before practical experience had been gained and before any field experiments had been carried out. This emphasized the need for facilities to be made available to the Experiment Station where the development of new harvesting systems, the testing of commercial harvesters, the accumulation of cost data and exercises in land preparation and field layout could be conducted.

At that time all existing Experiment Station land was already fully occupied and difficulties were anticipated in obtaining large areas from co-operators. By fortunate coincidence, the opportunity arose to acquire 958 hectares of the land expropriated, but not immediately required for the new La Mercy airport. This land, 16 kilometres north of the Experiment Station, has topography and soils typical of the coastal sugarcane areas. The S.A. Sugar Association was successful in securing a lease from the Government and on the 1st October 1974 the Experiment Station assumed responsibility for what is now called the La Mercy farm, illustrated in Fig. 1.

It was impractical for the Experiment Station to develop the whole area straight away, and those parts not required for immediately proposed projects were used for commercial cane production. A contractor has been employed to carry out the various field operations necessary on this land.

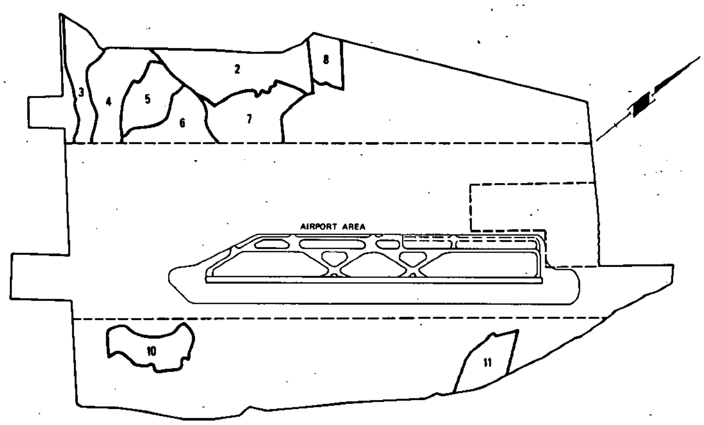

FIGURE 1 La Mercy Farm.

In the south-west corner of the leased area, four adjacent catchments with a total area of 112 hectares (Areas 3, 4, 5 and 6, Fig. 1) were identified as being suitable for the main La Mercy project, which is to investigate conservation layouts to which mechanized operations can be satisfactorily adapted and on which all operations can be accurately costed.

The old homestead, with its outbuildings, was converted into the farm headquarters, with a dwelling for the farm manager, office accommodation, a meeting room and the necessary staff facilities, a workshop and a tractor parking shed.

The area surrounding the homestead was prepared as a permanent site for Sugarmech (area 7, Fig. 1), fulfilling a long-felt need, strongly advocated by the trade for a number of years, for a permanent and central site near the main Natal machinery dealers. Convenient access was provided by good roads and overnight accommodation for visitors was available in and around Durban. A permanent site on Station property has also made the staging of Sugarmech a much easier task for the Experiment Station.

Twenty-four hectares (area 11, Fig. 1) on the north-eastern side were reserved, without replanting, for harvester testing. The existing layout and field preparation were of a standard suitable for this operation. After harvesting with the McConnel Stage II at the end of 1976 this area was also returned to commercial crop production.

On four catchments, totalling 19 hectares, in the south-east corner (area 10, Fig. 1), the Station's department of Land and Water Management has implemented a run-off and erosion trial.

The Field Services department has also developed land for the Agronomy and Plant Breeding divisions in area 2, and for the Agricultural Engineering division in areas 2 and 8 so that they have commercial cane available for machine development and testing. By September 1977 a total area of 202 hectares, comprising areas 2, 3, 4, 5, 6, 7 and 8 (Fig. 1) had been prepared, and most of it planted.

The field layouts

Four field layouts which have been recommended under various circumstances to sugarcane growers in various parts of the industry were implemented on the selected trial area comprising four adjacent, steep-sided valleys. These are illustrated diagrammatically as areas 3, 4, 5 and 6 in Fig. 2. Area 4 is 33 hectares in extent, and the other three each occupy 26 hectares.

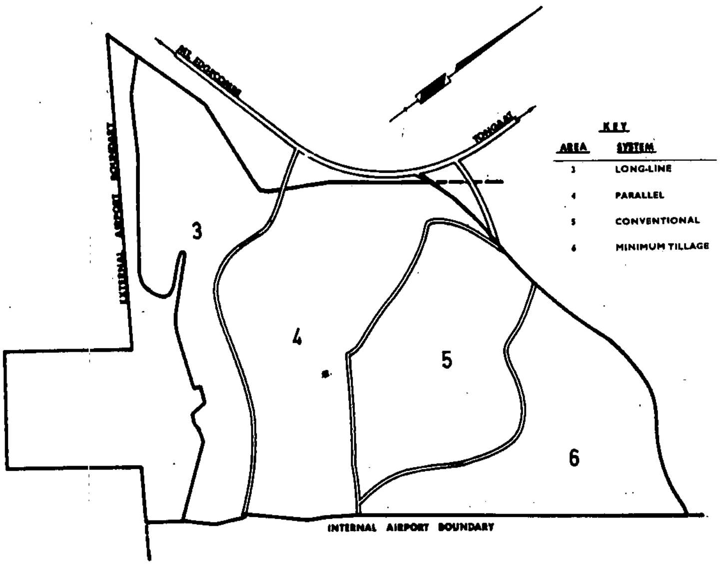

FIGURE 2 Field layout systems.

The layouts imposed on these areas are referred to as Long-line (3), Parallel (4), Conventional (5) and Minimum Tillage (6) respectively. The features that are common to these four layouts are:

- a design to ensure machine efficiency;
- a system of crest and terrace roads (except area 6);
- a conservation system of grassed waterways and water-carrying terraces (except area 6);
- all waterways and crest roads traversable by machines;
- a piped drainage system, mostly interceptor, to remove wetness where it occurs;
- all loose rock removed;
- land surface smoothed with a land plane to facilitate laying out.

Dykes of Middle Ecca sandstone run through areas 4, 5 and 6, the largest outcrop occurring in area 6. Dolerite outcrops also intrude into areas 3 and 4, resulting in shallow soil. Rock removal, therefore, constituted a major part of land preparation. All four areas were severely eroded and all major waterways were dongas, up to three metres deep. When work started the whole area was under established cane, recently harvested. Cane had to be slashed repeatedly to avoid hampering other operations. A bulldozer on tracks was hired to push large rocks into dongas, to fill in dongas as far as possible and to obliterate existing roads. The bulldozer was also used to construct the main network of new roads for the whole area before any ploughing was done. These roads are the northern boundary road, a crest road 1,1 kilometre long in area 3 and demarcation roads around two crest strips in area 4.

Soils in the area are derived from Middle Ecca and dolerite, as can be seen from the soil parent material map, Fig. 3. Numerous patches of loose shale and decomposed dolerite occur in the plough layer.

The Long-line layout — area 3

This type of layout was evolved by a sugar company to suit its particular mechanized harvesting system. The basic approach is to plan a whole land face of more or less constant slope as a single unit. In each of these land units cane rows have the same alignment, all being parallel to a master line. This is defined as the row direction which would result in the least number of short rows on that particular unit of land.

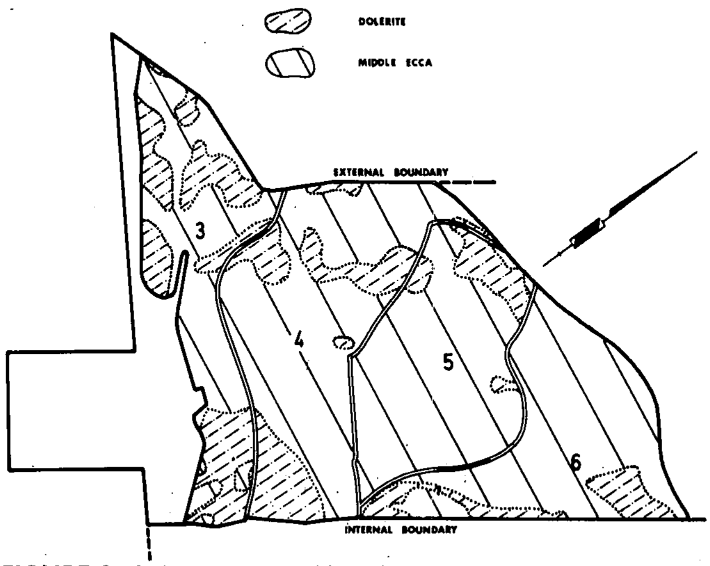

FIGURE 3 Soil parent material boundaries.

Row alignment is superimposed on, but independent of, a conservation network of roads, naturally located waterways, and infield terraces. Waterways are shaped and stabilized under grass. Slope variations within a single unit may produce appreciable variations in gradients along cane rows. Cane rows are expected to continue in the same direction after the gaps where terraces and waterways occur. The shape of these structures is such that machines can readily traverse them, thus increasing the distance over which a machine might operate in one direction continuously.

Land preparation started with the ploughing out of the existing cane, after which the enormous task of rock removal followed, requiring a total number of 585 man-days. Smoothing the land surface with a land plane was time-consuming but had to be done to obtain an even layout. This also caused secondary problems such as subsoil exposure in shallow areas, and the creation of wet spots where hollows were filled. Ripping and reploughing had to be done to restore soil tilth.

Waterways, terraces and crest roads were constructed with farm equipment; the work on terraces was frequently slowed down due to the occurrence of subsurface rock. All terraces are of the bench type and also serve as infield roads. Waterway shaping and grassing presented no problems but the plants needed periodic watering during dry spells.

Planting was done with a Waletz mechanical planter at a row spacing of 1,5 m. Considerable difficulty was experienced in crossing terraces and maintaining row alignment in some part of this layout where row gradients were as steep as 12%.

Interceptor drains were required around the two main waterways. The drainage scheme comprised 1 760 m of 50 mm diameter and 295 m of 75 mm diameter flexible PVC and 405 m of 110 mm diameter semi-rigid PVC drainage pipes. All pipes were laid in a sand envelope.

The Parallel layout — area 4

This layout is planned according to topographical units which are defined as contiguous areas of land having similar topographical features. The layout is especially suited to topography where much of the land comprises wide ridges and hill crest areas. The crest areas are grouped and planned together, whilst the hill slopes comprise another unit for planning.

Valley bottoms are incorporated with the hill slope areas wherever possible. The main aim again is to minimize the number of short lines.

Hill crest areas are laid out symmetrically about the crest centre line, their length and width being limited by the longitudinal and transverse slopes, soil erodibility and management practices, as indicated in Table 1. All cane rows run parallel to the crest line and are therefore parallel to one another. The area is bounded by a cambered, drained demarcation road which is wide enough for machines to turn on. Broad-based terraces and natural waterways cross the crest strips where necessary.

TABLE 1

Maximum slopes applicable to parallel crest areas

Soil type	Sands		Loams		Clays	
Management	Burnt	Trashed	Burnt	Trashed	Burnt	Trashed
Maximum longitudinal slope	5%	6%	6%	7%	7%	8%
Maximum transverse slope	7%	8%	8%	9%	9%	10%
Distance between broad-based terraces	40 m	50 m	60 m	70 m	70 m	80 m

Hill slopes are protected by parallel contour terraces which normally carry both run-off water and infield traffic. In making the terraces parallel their gradients are allowed to vary within acceptable limits, and the normal surface interval between terraces is reduced by 25 per cent to compensate for steepened gradients. Excessive slope changes requiring re-alignment of terraces necessitate wedge-shaped correction strips which then contain all of the short lines in the field unit.

Land preparation followed the procedure used for area 3, which is separated from area 4 by a crest road. The major problems were again a large amount of loose rock and a large donga in the main waterway.

The two crest strips comprise a substantial part of this area and the rest of the topography is slightly more even than in the other areas. The longer crest strip is only half of its possible width because of the boundary crest road next to area 3, while the shorter strip uses the full crest width and is of ideal length, 350 metres.

Here again waterways and terraces were constructed with farm equipment. Broad-based terraces cross crest strips where necessary and all other terraces are of the bench type and serve as infield roads. Waterways cross crest strips in all natural saddles.

Planting on the crest strips was done by a Massey-Ferguson planter and Massey-Ferguson 165 tractor at a row spacing of 1,8 metres. No problems were experienced, except that the strip which is 1,1 kilometers long required numerous infield seedcane stations and more labourers than was convenient. The hill slopes were planted with a Waletz planter-Country 754 tractor combination at a row spacing of 1,5 metres. Area 4 required less underground drainage than did the other three areas. Total lengths of drainage pipe used were 1 290 metres of 50 mm diameter flexible and 615 metres of 100 mm and 220 metres of 150 mm diameter semi-rigid PVC. All pipes, except for the 150 mm solid walled, were laid in a sand enveope.

The Conventional layout — area 5

This layout was done to the standard Experiment Station specifications which have been recommended to growers for about the past fifteen years. In this layout no attempt is made to keep infield structures parallel nor to plan topographical units separately. As a substantial portion of the industry has already been planned and laid out on these lines, area 5 will provide an opportunity to assess the adaptability of available harvesting machines to a conservation system that is common in the cane belt.

Terraces on standard grades carry run-off water from the panels above them to natural grassed waterways and also constitute infield access roads. The terraces run from crest roads to waterways. Cane rows are aligned according to a master line method which ensures that each row drains freely into either a waterway or a terrace structure. By hilling up the soil in the cane rows slightly the interrows become channels to carry water.

Terraces are constructed so that machines can enter the panels above them without difficulty, but not necessarily those below them.

This area was the last of the four to be developed and the cane on it required slashing for some time. This proved to be costly because the effects of soil erosion and exposed rock caused obstructions, and because slashing left a thick layer of plant material on the soil surface.

Land preparation procedures were the same as those used for other areas but the heavy layer of plant material on the soil surface made ploughing slower and three ploughings were necessary before land smoothing could be done. Fortunately, the relative evenness of the topography, compared to that in area 3, facilitated this operation but tractor-land plane side slip was considerable. The waterways, bench-type terraces and a crest road were constructed with farm equipment. All terraces serve as infield roads. The area was planted with the Waletz planter-County tractor combination with a row spacing of 1,5 metres.

This area required the most underground drainage of all. Interceptor drainage was necessary along the main waterway, and pattern drainage was required in a secondary depression. Altogether, 2 130 metres of 50 mm diameter and 385 metres of 75 mm diameter flexible PVC drainage pipe as well as 730 metres of 110 mm diameter and 195 metres of 150 mm diameter semi-rigid PVC piping, were laid. All the pipes, except the 150 mm diameter solid walled, were laid in a sand envelope.

The Minimum Tillage layout — area 6

This layout has no infield structures except grassed waterways in all natural depressions. Conservation is effected by minimum tillage and strip cropping. The minimum tillage principle ensures that the land is never left under a bare fallow which would make it particularly vulnerable to erosion. Strip cropping provides panels of cane of different ages, so that the cane on a hillside is never all harvested or replanted at one time.

Cane rows run approximately on a true contour across the slope and no hilling up of the soil is done, so that run-off can find its way naturally through the rows and eventually into waterways. Access roads are limited to crest roads and one road halfway down the slope, parallel to the cane rows. The whole area is divided into approximately equal-sized contour panels with grassed breaks between the strips to provide access and facilitate strip cropping.

The layout is considered to have distinct advantages on very uneven topography, as infield obstructions are reduced to a minimum and waterways and roads are readily traversable by machines.

Land preparation was the same as for the other areas, except that rock removal was more costly because the rocky areas were much larger and rock damage made the frequent replacement of plough discs necessary. An area of 1,5 hectares was so rocky that it was considered not worth planting. The second ploughing, after the rocks were removed, gave satisfactory results, but because the land was so uneven this area needed considerably more land smoothing than the others. This operation resulted in subsoil being exposed and consequent tilth problems, but after a fallow period lasting two months conditions improved.

The only structure built was a spill-over road on the contour, about halfway between crest and valley bottom. The road and waterway were shaped with farm equipment. Several tractor-Waletz planter combinations were used in planting area 6, the steeper portions with the County, and row spacing was again 1,5 metres. Breaks were left between the strips, parallel to cane rows, and were grassed to curb erosion.

After the old crop had been ploughed out and a row of gum trees removed, numerous springs developed in the fields around the main waterway and its two tributaries. This necessitated interceptor drainage to which some random drains were linked to drain isolated wet areas. A total of 1 685 metres of 50 mm diameter and 735 metres of 75 mm diameter flexible PVC drainage pipe were laid in sand envelopes.

The relative areas of crop land lost in the four layouts are compared in Table 2.

TABLE 2

Comparison of land lost in four different layouts

Structures	Area 3	Area 4	Area 5	Area 6
Roads				
No.	5	3	2	—
length (m) . . .	1 728	2 055	1 095	—
area (ha) . . .	0,9	1,0	0,5	—
Waterways				
No.	7	11	8	11
length (m) . . .	1 476	2 307	1 866	2 076
area (ha) . . .	1,1	4,7	2,0	1,5
Terraces				
No.	10	10	8	7 (breaks)
length (m) . . .	4 688	4 539	4 545	2 640
area (ha) . . .	2,3	2,3	2,3	1,3

Mechanization systems

Costing and timing was done on all cane-producing operations. Tractor hours, labour and all materials required for each task were recorded by farm personnel while S.A. Cane Growers staff computerized and analysed the data. The Experiment Station intends using the information to determine the cost of all operations per crop cycle for each field in the four layouts. By comparing these costs over a number of crop cycles, the effect of layout design on mechanization efficiency should eventually become apparent.

The tractor hours and labour requirements of the various operations for the plant crop are summarized in Table 3 for the four layouts. It is interesting to note that the tractor hours required for land clearance, land preparation and the construction of conservation works comprised 60% of the total. This gives an indication of the amount of work required to alter and prepare poorly laid out fields to the standards required for full mechanization. Shaping and stabilizing waterways, to Experiment Station specifications, required an average of 46 man-days per hectare. Harvesting was done mechanically, resulting in an average labour output of 8,4 tons per man-day. This is considered reasonable for the first crop to be harvested with untrained operators using unproved machines and systems. The effect of infield hauling distance is clearly illustrated when the tractor hours required for hauling from area 3, the furthest from the loading zone, and from area 6, the closest to the loading zone, are compared.

TABLE 3

Tractor hours and manpower requirements for the plant crop for the four layouts

Operation	Tractor hours per hectare				Man-days per hectare			
	3	4	5	6	3	4	5	6
Land clearance	18,8	10,5	12,0	14,9	41,6	25,6	6,5	18,4
Land preparation	52,1	66,0	57,1	48,5	8,7	12,5	9,5	8,0
Conservation	31,7	31,3	22,6	19,0	38,4	45,7	53,4	47,1
Drainage operations	9,1	6,1	9,4	8,0	14,1	21,7	16,4	16,3
Planting	6,5	12,1	18,2	8,9	23,2	30,3	36,6	33,7
Weed control	5,4	12,2	9,1	6,9	17,7	27,5	23,0	27,3
Fertilization	1,3	2,1	1,6	1,0	0,5	1,1	0,9	0,8
Harvesting	21,5	16,3	17,1	13,0	13,2	13,0	14,6	12,0
Transport/ haulage	21,4	19,0	14,8	13,2	12,9	15,5	12,1	12,2
TOTAL	167,7	175,6	161,4	133,5	140,6	192,8	173,1	175,9

Maintenance costs, breakdowns, fuel consumption and the type of operation are given for selected machines. This recording procedure will continue until the units are replaced and the results will be valuable to the Agricultural Engineering Division in giving advice on various machine systems for growers.

Detailed test reports (Meyer[2,3,4,5,6]) have been prepared on the performances of a wide range of agricultural implements. Accurate time and motion studies have also been conducted on specific implements and machine systems to establish mechanization standards and to improve machine efficiency (Meyer and Worlock[7]).

Field test officers in charge of various testing or developing programmes have written comprehensive reports, which include the effects of layout design on the performance of machines (Boast, van der Merwe and Pilcher[1]). These reports show that problems were experienced with all harvesters when negotiating conservation structures in area 3. It was recognized, however, that the layout used in area 3 made mechanical cutting possible on the steepest section where slopes exceeded 40%. In this section the Sasex cane cutter, for example, could operate by cutting "downhill".

The McConnel Stage II which is a rather long, cumbersome machine, caused problems on practically all conservation layouts. Headlands were too narrow for turning, resulting in excessive field time, conservation structures were difficult to negotiate and longer rows would have been preferable. Rocks also caused problems. The performance of this machine was unacceptable on slopes exceeding 21%.*

After the plant crop on all fields had been harvested the operators concluded that the parallel system (area 4) was the most suitable for mechanization. This conclusion needs to be confirmed by using a range of harvesting machines to cut fields in rotation for a number of crop cycles and by long-term cost data.

* Unpublished reports, S.A.S.A. Experiment Station.

Conclusions

The La Mercy project has been functioning for only four years but a wealth of experience has already been gained on many practical aspects of mechanized sugarcane production. This experience is particularly valuable because it has been gained on soils and topography typical of much of the land under sugarcane in the industry, and on a field scale. The facilities available at La Mercy have played a part in the development of the Sasex, Edgecombe and Midway harvesting machines, and in testing integrated systems for minimum tillage, crop spraying, cane loading and transportation. After the first four years it can be claimed with conviction that the objectives of the La Mercy exercise are being fulfilled. These objectives are:

To provide as much practical information as possible for the South African sugarcane grower concerning the adaptability of mechanized operations to different conservation methods; to observe the effects of four different conservation methods; to provide cost data on all methods and operations and to compare the performances of different cane harvesting machines and systems.

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