

# THE CONCEPT OF MINIMUM TILLAGE IN SUGARCANE

By G. A. IGGO\* and P. K. MOBERLY

South African Sugar Association Experiment Station

## Abstract

A comparison is made of growth and sugarcane yield of plant cane established by minimum tillage and by conventional tillage systems. Yields from two experiments on different soil series indicated that satisfactory yields can be achieved with minimum tillage. In a third experiment on a heavier soil, which has not yet been harvested, crop growth measurements indicate a small advantage in favour of conventional tillage. The merits of a minimum tillage system for establishing plant cane are discussed.

## Introduction

For growers re-establishing sugarcane on the steeper slopes of the sugar belt there is a constant threat of heavy rains, falling during the fallow period, resulting in severe soil erosion. This applies particularly to fields ploughed out late in the season or to fields which are ploughed out early but which require a long fallow period in order to eliminate volunteer plants. The introduction of any cultural practice which would eliminate, or at least reduce, the erosion hazard would be of considerable value to the sugar industry.

The current conventional method of establishing plant cane is to plough out the final ratoon crop following harvest and, in the following few months, cultivate repeatedly before replanting. Although it results in a time lag, the main objective of the repeated cultivation is to eliminate volunteer plants of the old ratoon crop which may transmit diseases such as ratoon stunting (RSD) to the new plant crop. Many factors can contribute to the length of the fallow period between harvest and planting but, as a rule, it ranges from two to six months. As the fallow period is unproductive, any reduction in its length will be of economic importance.

A series of experiments conducted by the South African Sugar Association Experiment Station between 1972 and 1974 (Iggo<sup>1</sup>) illustrated that glyphosate could kill sugarcane. Previously Baird *et al*<sup>2</sup> had reported that glyphosate was inactivated when applied to the soil, leaving no residues harmful to subsequent plant growth.

The observation that sugarcane did not respond to deep tillage operations (Moberly<sup>3</sup>), and later the advent of glyphosate prompted an investigation into the concept of minimum tillage for establishing sugarcane. Minimum tillage has for many years been practised in a number of countries for establishing various crops. The advantages of minimum or no tillage systems, over conventional cultivation techniques, have been given as quicker turn-round time from one crop to the next, reduced soil erosion because the fields are protected by the old crop stubble, reduced manpower inputs and reduced machinery and fuel requirements.

This paper reports on three experiments established on different soil series to compare the germination, subsequent growth and sugarcane yields of cane planted using the conventional and minimum tillage systems.

## Materials and method

The locality, soil series and physical soil analyses of the three experiments are presented in Table 1. The procedures of operation for either the minimum tillage or the conventional

tillage treatments were similar for the three experiments. After burning and harvesting of the last ratoon crop the conventional tillage plots were ploughed to a depth of approximately 30 cm. At intervals in the subsequent weeks the plots were disced a number of times to remove volunteer plants and the length of the fallow period for each experiment was determined by the efficacy of the cultivation operations in achieving this objective. When acceptable control of volunteer plants had been achieved, the land was tilled with a rotary hoe, furrowed out and planted. The length of the fallow period from ploughing to planting for Experiment I was 14 weeks, for Experiment II: 9 weeks and for Experiment III: 7 weeks.

TABLE 1

Experiment localities and soil series

Experiment	Site	Soil Series	Clay %	Sand %	Silt %
Expt. I	Shakaskraal	Waldene	12	76	10
Expt. II	Mt. Edgecombe	Rydalvale	37	47	14
Expt. III	Mt. Edgecombe	Phoenix	40	44	17

With the minimum tillage treatments the ratooning cane was left to develop 5–6 unfurled leaves before being sprayed with 4.32 kg ai of glyphosate per hectare. The seed was planted in the inter-row of the old ratoon crop after one pass with a rotary hoe had been made and the furrows drawn. The planting date of the minimum and conventional tillage treatments was the same.

The dates of the various procedures of establishment are presented in Table II. The seedcane used for each experiment

TABLE 2

Dates of treatment operations for the three experiments

Experiment	Harvest date of ratoon crop	Ploughout of conventional treatment	Glyphosate application min. tillage treatment	Planting date of both treatments
Expt. I	26. 10. 1973	7. 11. 1973	12. 12. 1973	19. 2. 1974
Expt. II	18. 1. 1974	22. 1. 1974	8. 3. 1974	29. 3. 1974
Expt. III	23. 9. 1974	7. 10. 1974	23. 10. 1974	26. 11. 1974

was of variety NCo 376 first removed from hot water treated material. Fertilizer at planting and subsequent topdressings were applied according to both soil and third leaf analyses. The crops in Experiments II and III were grown under rain-fed conditions but Experiment I received supplementary overhead sprinkler irrigation. During the development period, 1 046 mm of rainfall were recorded and 380 mm of supplementary irrigation were applied.

Experiment I was harvested after 15 months and Experiment II after 19 months. At the time of writing, Experiment III has not been harvested but crop growth measurements have been recorded.

\* Present address: c/o E. I. du Pont de Nemours & Co., Nairobi, Kenya

TABLE 3  
Yield results of Experiments I and II

Treatment	EXPERIMENT I					EXPERIMENT II				
	tc/ha	ers %c	ters/ha	Stalk counts x10 <sup>-3</sup>	Stalk heights cm	tc/ha	ERS %c	ters/ha	Stalk counts x10 <sup>-3</sup>	Stalk heights cm
Minimum tillage . . . . .	152	9,8	14,9	146	217	110,0	11,7	12,9	123	220
Conventional tillage . . . . .	137	11,1	15,1	143	208	102,8	10,9	11,4	128	214
MEAN . . . . .	145	10,4	15,0	145	213	106,4	11,3	12,2	126	217
S.E. Treatment Mean . . . . .	3,62	0,14	0,42							

## Results

### Yield results

The yield results of Experiments I and II are presented in Table 3.

In tons cane per hectare, minimum tillage increased yields by 10,9% and 7,0% respectively in Experiments I and II, primarily as a result of greater stalk length. The ers% cane for the minimum tillage treatment in Experiment I was lower ( $P > 0,01$ ) than that in the conventionally tilled plots, which resulted in a marginally lower ters/ha (n.s.). The substantial depression in ers% cane from minimum tillage is considered to be primarily due to excessive nitrogen availability which is discussed in more detail under nutrition. Although the results of Experiment II were not amenable to statistical analysis, the yield in ters/ha was increased by 13,2% following minimum tillage.

### Crop growth

Throughout the growth of the crop in Experiment I, the shoot population was slightly higher after minimum tillage. Stalk heights were always greater after minimum tillage and this advantage was maintained until harvest. Growth measurements in Experiment II indicated a slightly higher shoot population after conventional tillage but stalk length was always greater after minimum tillage. Fifteen months after planting Experiment III, shoot populations were equal for the two treatments but the stalk length in the conventionally tilled plots was 10% greater than in the minimum tilled plots, which indicates that the ultimate cane yield will be slightly superior in the conventionally tilled plots.

### Nutrient status of soil and third leaf

#### Nitrogen

Analysis of soil samples (0–20 cm depth) taken at the time of planting the experiments indicated that the level of soil nitrogen in the minimum tillage plots was higher than in the conventionally tilled plots. In total soil N% the levels measured are given below:

	Experiment I	Experiment II
Minimum tillage . . . . .	0,096	0,173
Conventional tillage . . . . .	0,076	0,120

The higher soil N content in the minimum tilled plots was reflected in the appearance of the crop and also in the third leaf analysis, particularly in Experiment I on the Waldene series soil, which is known to mineralise only small quantities of nitrogen (Wood<sup>4</sup>). The mean nitrogen % dry matter in third leaf from the two treatments, sampled at three different times, is shown below:

	18/6/74	6/8/74	4/10/74
Minimum tillage . . . . .	2,01	1,74	1,87
Conventional tillage . . . . .	1,82	1,52	1,92

Because of the nitrogen deficiency in the conventionally tilled plots, additional fertilizer nitrogen was applied to all plots in August 1974. Thereafter the discrepancy in leaf N content between treatments tended to decline.

#### Phosphorus and potash

Analysis of soil samples taken at 0–20 cm depth indicated that the available soil P and K content in ppm was higher in the minimum tillage plots than in the conventionally tilled plots. The implications are that the inverting action of the mouldboard plough has moved appreciable quantities of these elements deeper down the soil profile. The values in ppm are shown below:

	P		K	
	Experi-ment I	Experi-ment III	Experi-ment I	Experi-ment III
Minimum tillage . . . . .	64	93	72	127
Conventional tillage . . . . .	50	79	46	96

In Experiment I on the Waldene series soil, third leaf analysis indicated that K uptake by the plant was slightly greater in the minimum tillage plots and this agrees with the soil K content. The third leaf K% dry matter for two dates of sampling are given below:

	18/6/74	6/8/74
Minimum tillage . . . . .	1,04	1,36
Conventional tillage . . . . .	0,94	1,21

Because of the K deficiency shown in the conventionally tilled plots all plots received additional K fertilizer in early spring and this corrected the deficiency, judging by the subsequent leaf analysis in August.

In Experiment III, on the poorly-drained, hydromorphic Phoenix series soil, the reverse situation was observed with regard to third leaf K content which was marginal in the cane grown in the minimum tilled plots, and adequate in the conventionally tilled plots. The values for two sampling dates are given below:

	21/1/75	27/3/75
Minimum tillage . . . . .	1,03	1,09
Conventional tillage . . . . .	1,13	1,16

In poorly-drained soils the uptake of K by the plant is reduced more severely than the uptake of other nutrients (Samuels<sup>5</sup>), and it seems likely that the soil aeration resulting from ploughing in the conventionally tilled plots has improved K absorption by the plant.

In all the experiments the third leaf P content was adequate and similar for both methods of land preparation.

### Soil moisture

In Experiments I and II soil samples were taken from the lower side of the planting furrow immediately after furrowing out. The mean soil moisture per cent was found to be considerably higher in the minimum tilled plots than in the conventionally tilled plots and these values are given below:

	Experiment I	Experiment II
Minimum tillage . . . . .	14,0	27,3
Conventional tillage . . . . .	9,4	16,6

The substantial soil moisture conservation resulting from minimum tillage is of considerable importance, particularly where moisture is the major growth limiting factor.

### Soil physical characteristics

In Experiment I, on the Waldene series soil, it became apparent that the surface of the soil in the conventionally tilled plots was more compacted than was the soil in the minimum tilled plots. Undisturbed soil core samples were taken at 0–10 cm depth and the mean results from 16 determinations for bulk density (BD) and total pore space (TPS) are given below:

	BD (g)/cm <sup>3</sup>	TPS (% v)
Minimum tillage . . . . .	1,46	44,9
Conventional tillage . . . . .	1,57	40,7

The change in soil physical characteristics is thought to be due primarily to the desiccating effect of ploughing and cultivating and the inverting action of the plough which brings some gleyed subsurface material to the surface.

### Discussion

The results obtained to date indicate that minimum tillage is likely to improve sugarcane yields on sandy loam soils, which are the most difficult to manage as they are the most erodible and compactable. On clay loams or loamy clays there is unlikely to be any great difference in yield between the two systems. However, on the heavy hydromorphic soils it seems likely that benefits might be obtained from a degree of soil disturbance. These represent a very small percentage of the sugar belt soils.

The degree of tillage required in the old inter-row before furrowing out and planting will depend on the soil texture and moisture content. In the Aeolian Recent Sands, for example, no tillage would be required before planting. In loams and clays tillage will be required into which to plant, but the depth of fine tillage need be only approximately 20–25 cm.

Assuming that equal yields can be obtained with minimum tillage and conventional tillage systems, advantages of minimum tillage would include: a shorter fallow period between crops (the only delay from harvesting to planting being the time required for the old ratoon crop to develop sufficient leaf area for glyphosate to be effective); substantially reduced risks of soil erosion as at no stage would the land be denuded of vegetation; reduced cultivation costs; and the control of problem perennial weeds by the application of glyphosate. A disadvantage of the system could be the possibility of a poor kill of the old ratoon crop on account of unfavourable climatic conditions at the time of glyphosate spraying or the misapplication of the chemical. When major alterations to a field layout are planned, then the technique of minimum tillage would not be feasible.

### Acknowledgements

The authors wish to thank Monsanto S.A. (Pty) Ltd. for supplying the glyphosate used in the experiments.

### REFERENCES

1. Iggo, G. A. (1974). A new chemical (glyphosate) for killing sugarcane. SASTA Proc. 48: 74-77.
2. Baird, D. D., Upchurch, R. P., Homesley and Franz, I. E. (1971). Introduction of a new broadspectrum post-emergence herbicide class with utility for herbaceous perennial weed control. Proc. 26th North Central Weed Sci. Soc. Conf.: 18-20.
3. Moberly, P. K. (1972). Deep tillage investigation on five soil types of the S.A. Sugarbelt. SASTA Proc. 46: 205-210.
4. Wood, R. A. W. (1968). Nitrogen fertilizer use for cane. The S.A. Sug. J. 52, No. 3,4: 9.
5. Samuels, G. (1969). Foliar diagnosis for sugarcane. Agriculture Research Publications Puerto Rico 240-241.