THE EFFECTS ON RATOON CANE OF SUB-SOILING IN A NUMBER OF SOILS IN THE SUGARBELT

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Abstract

Results are presented of the effects of subsoiling in ratoon cane on eleven different soil series. Of the eleven experiments reported, three showed that subsoiling produced a statistically significant depression in yield, seven gave no significant response and one indicated that subsoiling had induced a statistically significant increase in yield.

The effects of subsoiling ratoon cane in such different circumstances as the presence or absence of a trash blanket, the provision or lack of supplementary irrigation, good or poor rainfall, the use of different varieties, and the effect of different depths of subsoiling, are briefly discussed.

Introduction

Subsoiling of the inter-row in ratoon cane is quite a common practice in the South African sugar industry. The reasons for this operation are based, it seems, on growers observations that it is beneficial to crop growth. It is considered by some that the subsoiling operation is beneficial because it (i) shatters compacted soil layers, (ii) prunes the old root system and encourages the speedy development of new roots, (iii) results in improved rates of water infiltration, (iv) improves soil aeration, (v) increases the effective rooting depth of the crop, and (vi) facilitates root penetration. Although some of these effects are real, there is no recorded evidence of the combined effects producing an increase in the yield of cane at harvest. It was decided, therefore, to measure the response to subsoiling in ratoon crops on a number of different soils in the sugarbelt.

Experimental method

Experiment sites were selected for individual uniformity and so that they represent a wide range of soil series. They were located on three of the Experiment Station's farms and on six private farms. The equipment used depended on what was available and this ranged from fairly heavy equipment drawn by a D4 caterpillar tractor, to light subsoilers drawn by standard ± 50 h.p. wheel tractors. Depth of effective subsoiling varied accordingly, from approximately 24 to only 12 inches. Subsoiling depth was determined by measuring the mean depth from the bottom of the tine furrow to the undisturbed soil surface. A straight tip subsoiler tine was used in all instances. Subsoiling was always done with the tine in the centre of the inter-row and at a tractor speed which induced effective soil disturbance.

Gravimetric soil moisture determinations were carried out at two soil depths on all sites at the time of subsoiling. In all cases the soils were relatively dry and, on average, the equivalent soil moisture tensions were approximately 7.0 bars. The physical properties of the soils were also determined.

The experiments were laid out in the winter and early spring of 1967 and subsoiling was usually carried out within one or two weeks of harvesting the previous crop. In most of the experiments no signs of ratoon regrowth were evident at the time of subsoiling. Subsequent inter-row cultivation for weed control was carried out as and when required. During the growth of the crop, stalk height measurements were recorded at approximately monthly intervals, and in some experiments shoot counts were also made.

Layout and design

The experiments were of simple design. They consisted usually of a straightforward comparison between subsoiling and no subsoiling and, because of their simplicity, contained an unusually large number of replications. In most cases twelve replications were employed, usually in the form of repeated latin square or randomised block designs. Plot size varied according to the subsoiling equipment used, but generally consisted of six rows of cane fifty feet long. End effects of at least ten feet per row, together with single guard rows, were removed before harvest, leaving a net plot of approximately 0.013 acre.

Results

In experiment 1, on Glenrosa soil, two depths of subsoiling were compared. It can be seen from the results in Table I that yield was significantly $P = 0.05$) decreased where deep subsoiling had been carried out, but yield was not affected by shallower subsoiling.

In the plots which had been deep subsoiled there was a slight depression in stalk height, which persisted through the life of the crop. This effect, together with a slightly reduced stalk population, contributed to the depressed yield.

One month after subsoiling and following saturating rains, undisturbed soil core samples were taken for physical analysis from six replicates in Experiment I. Samples were taken at a point midway between the row and the centre of the inter-row, and at two depths, 4 to 8, and 16 to 20 inches. In Table II the first column indicates the number of hammer blows required to obtain each undisturbed core sampler; in a sense the core sampler was used as a soil penetrometer. Penetrability was easier where the soil had been subsoiled, particularly at the shallower depth. Only at the 4 to 8 inch sampling depth was there a measurable effect on soil pore space as a result of subsoiling. The effect on bulk

TABLE I
The response to the effects of subsoiling on different soils

Experiment number	Soil series	Mean subsoiling depth (inch)	Ground cover	Response (t.c.a.)	Variety	Ratoon	Age of crop (months)
1	Glenrosa	15	bare	−0.6 ±0.76	N:Co.376	4th	14
,,	,,	23	bare	−2.2* ±0.76	,,	,,	,,
2	Williamson	17	bare	−1.5 ±1.29	N:Co.376	3rd	14
3	Waldene (Dwyka)	14	bare	−0.4 ±1.00	N:Co.376	1st	17
4	Milkwood	13	trash blanket	−4.1** ±0.81	N:Co.376	1st	17
5	Avoca	18	bare	+1.9* ±0.43	N50/211	1st	12
6	Waldene (M.Ecca)	16	bare	+0.6 ±2.15	N54/113	1st	13
7	Rydalvale	14	bare	−2.1 ±1.66	N51/539	1st	14
,,	,,	14	bare	−3.6* ±1.19	N51/168	1st	14
8	Shortlands	20	trash blanket	−3.1 ±2.12	N:Co.310	3rd	17
,,	,,	20	bare	−0.3 ±2.12	,,	,,	,,
9	Cartref	22	trash blanket	+3.3 ±1.91×	N:Co.376	4th	18
,,	Cartref	22	bare	+0.9 ±1.91×	N:Co.376	4th	18
10	Inanda	13	bare	−0.3 ±1.40	N:Co.376	2nd	17
11	Clansthal	19	bare	−0.9 ±2.49	N:Co.376	2nd	17

×Estimated yields obtained from sample harvesting.
*P=0.05
**P=0.01

density was slight and occurred only at the shallower depth of subsoiling.

In half the number of plots in Experiments 4, 8 and 9, the trash blanket was removed prior to subsoiling and then replaced immediately afterwards. There is no evidence from the results of these experiments that the presence of a trash blanket influences the effects of subsoiling.

At most of the experiment sites, dry conditions prevailed for some weeks after subsoiling. However, the results obtained from the experiments which were either irrigated or which received good rainfall soon after subsoiling, indicate that the soil moisture status after subsoiling had no apparent effect on the response to subsoiling. Experiment 2 was irrigated, whilst Experiment 3 was a rainfed crop which received very little rain for the first month after subsoiling. These two experiments, established in August 1967, were both on similar Dwyka-derived soils, and in neither case is there any evidence of a response to the effect of subsoiling. Experiment 1 was subsoiled when the soil was relatively dry and 3.02 inches of rain were recorded within four days of subsoiling. Despite these theoretically favourable conditions, a negative response to subsoiling was obtained.

In experiment 7 on a Rydalvale clay, the effects of subsoiling significantly (P=0.05) depressed the yield of the variety N51/168 whilst the yield of N51/539 was also depressed but to a lesser extent. It is perhaps noteworthy that the variety N50/211 occurred in only one experiment, and it was in this, that the one and only statistically significant positive response to the effects of subsoiling was obtained (P=0.05).

Discussion

There is no indication from the results so far obtained that the subsoiling of ratoon cane with conventional equipment is a worthwhile operation under the conditions generally prevailing in the sugarbelt. In only one out of eleven experiments, the one sited on an Avoca soil, was there a statistically significant positive response to the effects of subsoiling. The response obtained, 1.9 ± 0.43 t.c.a., could hardly be considered worthwhile. This is the only experiment which was subsoiled as late in the year as October, the other experiments having been subsoiled in June, July and August. Because varieties differ in their pattern of root development (Glover[1], Evans[3]), there is some likelihood that differential variety responses to subsoiling may occur. This is borne out to some small degree by the results of Experiment 7 in which the yield depression was greater in N51/168 than it was in N51/539.

The late rains in the spring of 1967 may have adversely influenced the response to subsoiling, but this is considered unlikely in view of results from the irrigated experiment on the Williamson series, and in the experiments on Glenrosa and Cartref

TABLE II
Results of the physical analysis of a Glenrosa soil one month after subsoiling (mean of 6 replications)

Treatments	No. of hammer blows	Initial Moisture capacity % w/w	Total pore space % v/v	Macro pore space % v/v	Field capacity % w/w	Bulk density gm/cm3
		Sampling Depth 4–8 inches				
No subsoiling	209	18.8	43.4	10.9	21.1	1.52
Subsoiling to ±16 inches depth	124	20.6	45.6	14.2	21.3	1.45
Subsoiling to ±23 inches depth	88	20.6	49.9	18.2	21.9	1.41
		Sampling Depth 16-20 inches				
No subsoiling	421	28.2	49.3	11.0	28.7	1.34
Subsoiling to ±16 inches depth	296	29.1	50.6	10.6	29.0	1.35
Subsoiling to ±23 inches depth	211	31.3	51.5	9.4	30.8	1.35

soils, where good rains fell very soon after subsoiling.

The reasons for the lack of a positive response, and the depression in yield obtained from subsoiling, need consideration. The effects of subsoiling on the soil physical characteristics as indicated in Table II can be considered, in general, to be beneficial. Where substantial ridge and furrow effects result from subsoiling, this must also be of benefit on sloping, contoured land as it helps to prevent water run-off. What then are the factors that negate these benefits? It is considered that the action of the subsoiler tine in cutting roots, and the disturbance of the root/soil interface are the main causes of yield depression. It has been suggested (Glover[2]), with considerable supporting evidence, that the old root system may help support the new crop for a period of some eight weeks. This may apply particularly under dry conditions when, without the development of new shoots and their attendant roots, moisture for the new crop is translocated from depth by the old root system.

The possibility that the effects of subsoiling may benefit the succeeding crop cannot be ignored. A second crop, with no further deep tillage treatments being applied, is therefore to be harvested from most of the experiments.

Conditions exist which may influence the conclusions drawn from these experiments. Soil compaction is one such condition, but in these experiments very little soil compaction was observed on the experiment sites. Where the use of heavy in-field transport in wet conditions results in obvious soil compaction then the effect of subsoiling may result in yield improvement. This question is currently being investigated at the Pongola experiment farm. (Von der Meden[4].) Another condition which may influence the value of subsoiling is the situation created where the surface drying of irrigated, heavy soils, makes it necessary for a heavy tine machine such as a subsoiler to be used before a light tine cultivator can function effectively. These conditions have been observed in some parts of the Eastern Transvaal.

Conclusions

Under most soil conditions found in the South African sugarbelt the practice of subsoiling the inter-row in ratoon crops is not worthwhile. Any benefits which may accrue from this practice, such as soil aeration, the increase in effective rooting depth, and the prevention of run-off are seemingly nullified by the effects of root damage caused by the subsoiler tines. It is possible, though improbable, that the effects of ratoon subsoiling might be long-term and yield responses may be obtained with subsequent crops.

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Discussion

Mr. Browne: Did it require a lot of time and labour to carry out the sample harvesting technique?

Mr. Moberly: It was devised by Mr. Murdoch, our statistician. It is not very difficult but does depend on the condition of the cane and on unbiased sampling.

A test was carried out on lodged cane giving 70 tons per acre and the method was slow and tedious but on upright cane it is simple and fairly accurate.

Mr. King: If the subsoiling had been carried out at a later time of the year the results might have been otherwise owing to a difference in soil moisture.

Mr. Moberly: Gravimetric soil moisture determinations were carried out at two depths throughout the trials on the day of sub-soiling and on average the soil moisture tensions worked out at ± 7 bars, which is fairly dry.

Possibly it was because conditions were dry at the time that we got these adverse effects, but relatively little soil disturbance will be obtained by subsoiling in moist soil conditions.

Dr. Thompson: If subsoiling also affects the subsequent ratoon it might be possible to observe an effect in the crops due to be harvested soon, i.e. whether there has been any root damage.

I would not advise Mr. Browne to use the sample harvesting technique to measure increments in growth during a crop cycle. The error would be rather large unless measured over several months.

Dr. Gosnell: If in any of the experiments a hard pan or rock formation had been present, then subsoiling could have been expected to improve conditions.

Mr. Moberly: On the Waldene and Williamson soils there were iron concretion layers below which the subsoil tines penetrated.

On the Glenrosa the tine showed signs of getting right into the decomposing granite rock.

Mr. Rostron: Benefit from subsoiling is derived if there is a hard layer. If the benefit of breaking this is off-set by damage to roots then the results could prove negative.

Could not an experiment be carried out on a site where there is a deep plough pan and subsoiling be done between crops as a part of land preparation?

Mr. Moberly: This is being investigated on five different soils, including a Shortlands dolerite and a Rydalvale. We have ploughed with a Nardi plough to depths of 50″ and subsoiling to beyond 30″ is also being tested as a form of land preparation.

So far, except on the sandy soils, growth response is negative but we are waiting to measure the long term effect on subsequent ratoons.

Mr. Main: I suggest Mr. Moberly combines this subsoiling work with fertilizer application, in particular phosphate.

Surely a light subsoiler, not a Caterpillar, would create less disturbance in ratoon cane?

Dr. Macvicar: Both the short and long term effect should be studied. A shallow soil, in the short term, must be damaged by deep soil disturbance in respect of crop growth but in the long term it must improve.

Dr. Gosnell raised the question of impervious layers at depth and the bringing up of heavy pot clays but it would be difficult to predict the effect of this without carrying out tests.

Mr. Boyce: In our plant population studies we have shown that large differences in crop developments in the early stage have proved small in the final analysis.

In these experiments, were there any big differences in the early stages and what would have been the effect of later subsoiling?

Mr. Moberly: There were not large differences in development early on. The effect was a slight depression of both population and height right from the start.

It is difficult to assess the effect of root pruning by later subsoiling. It has been done elsewhere, notably Australia, but as a way of improving irrigation techniques. However, there is likely to be a depression in yield if roots are disturbed at a later stage.

Dr. Hill: My mind is now clear about the value of subsoiling ratoons. I do not know how such depths were reached in these subsoiling experiments but they were more than we have achieved, maybe due to better setting of the implement.

Last season one of the fields we cut had compacted badly in wet weather so we cleared the trash from three inter-rows onto one inter-row and subsoiled the bare ones. We noticed a tremendous response where we had not subsoiled, due perhaps to the trash blanket. Where a bare row was not subsoiled, e.g. near a drain, it was slightly better than a subsoiled row. We therefore seemed to get a response to trash and a negative response to root pruning which agreed with the results in this paper.

Mr. Odendaal: At the Kokstad Research Station subsoiling and ploughing have been compared with ploughing only. On a shallow soil, using maize which is an annual crop, a significant growth and yield response was obtained.

Mr. Moberly: There is not much chance with sugarcane of getting a plough pan, as ploughing is only carried out every eight years, on average.

With annual crops, ploughing with a disc plough to perhaps a depth of eight inches, you will likely get a plough pan.

Mr. Gilfillan: Although in one case the yields are only estimated, I note that two of the responses are on the Cartref series, which is highly subject to compaction.

Will levels of compaction be tried out on a Cartref series, following up with subsoiling treatment?

Mr. Moberly: This is not planned at present.

Mr. Hulley: I am new to the sugar industry, but older farmers have told me that subsoiling is used to counteract compaction.

However, if subsoiling is no good for this purpose can you suggest something else?

Mr. Moberly: We have not proved yet that it is

no good for this purpose. We are testing subsoiling under compacted soil conditions at Pongola.

Mr. Ardington: This paper seems to prove conclusively that it does not pay to subsoil ratoons.

Subsoiling is still beneficial before planting cane.

Mr. Stewart: Even if subsoiling is not carried out it seems that if there is a degree of compaction it will be beneficial to disturb the surface with a heavy tine cultivator to ensure better moisture penetration.

Mr. Souchon: We had compaction due to tractors operating and although subsoiling was carried out cane growth was not affected.

Mr. Wardle: Did the responses reported in this paper vary with row width? In a narrow row width subsoiling would probably cause more root damage.

Mr. Moberly: We normally used $4\frac{1}{2}$ feet as a row width. I think the roots would still grow across the inter-row and as much damage would be caused even if a wider row spacing was used.

In the Eastern Transvaal I have seen farmers subsoiling down the side of each row and this must cause still greater damage.