# THE AGRICULTURAL CONSEQUENCES OF HARVESTING SUGARCANE CONTAINING VARIOUS AMOUNTS OF TOPS AND TRASH

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## Abstract

Should the exploitation of all above ground components of the sugarcane crop become commercially attractive and be implemented, it could have significant consequences for sugarcane growers. A number of trials were therefore conducted to establish performance standards for labour and equipment for different harvesting systems, when cane which contains various quantities of trash and tops is handled. There was little effect on the output of manual cutters. As extraneous matter content increased mechanical cutter and loader performance declined. The most serious consequence was a loss in payload of up to 44%. Harvesting and loading all the tops and trash with the cane and delivering it to the factory will increase the cost by one third compared with the cost of handling burnt and topped cane.

## Introduction

There is considerable interest in the use of sugarcane for the manufacture of products other than sugar. If commercial use is found for the leafy top parts and green and dead leaves (trash) clinging to the stalks of sugarcane, the effects and costs of harvesting and removing all or some parts of the crop from the field need to be known. A number of trials were therefore conducted at the La Mercy farm of the South African Sugar Association (SASA) to establish performance standards for various harvesting and handling systems. Some of these trials (part of a collaborative project between the Sugar Milling Research Institute (SMRI) and the Experiment Station (SASEX)), were also concerned with the effect of whole cane harvesting on factory performance. This paper is a report on the agricultural consequences of harvesting sugarcane containing various amounts of trash and tops.

## Methods

For the SMRI/SASEX project, sugarcane from fields 505, 603, and 604 at La Mercy were harvested in 4 sections at two-weekly intervals from June 9 to July 21, 1988. Cane was harvested as follows:

Trial 1: unburnt, topped, not trashed
Trial 2: burnt, topped
Trial 3: unburnt, not topped, not trashed
Trial 4: burnt, not topped.

Harvesting occurred over 2 days (Thursdays and Fridays), loading and transporting to a loading zone occasionally requiring an extra day (Saturday). Cane was manually cut and piled into small bundles and loaded by Bell loader into 5 ton basket trailers. The experienced loader/operator used his judgment to load the trailers for maximum practical payload. For each trial sufficient cane was cut to make 8 hilo loads (5 basket trailer loads per hilo). The trucks were loaded from 06h00 on Mondays and the cane was delivered to the Maidstone mill where processing commenced at about 10h00 when all 8 trucks had arrived. A report on factory performance can be found in a 1989 South African Sugar Technologists' Association paper by Reid and Lionnet (in press).

The variety was NCo376 and the average yield was 120 t/ha. Cane was 19 to 20 months old at harvest and some lodging had taken place. Cane from badly lodged patches was excluded. The cane had flowered profusely. Fields were checked for eldana borer on June 11 but infestation was low, averaging 3,3 e/100 stalks in fields 603 and 604 and 11 e/100 stalks in field 505. There was very little evidence of stalk damage.

Representative samples were taken from the bundles of harvested cane in the field before they were loaded, 5 stalks per bundle, each sample consisting of 20 stalks, ie representing cane from 4 bundles. Care was taken not to disturb clinging trash but inevitably some trash would have been lost in the handling of the stalks. Trash contents could thus have been underestimated. The number of 20 stalk samples varied from 16 (trial No. 3) to 26 (trial No. 2). Approximately 10% of all bundles were sampled.

Stalks from each sample were carefully stripped of all trash and if not topped, or if topped too high by the cutters, tops were broken off at the natural breaking point. Trash, tops and cleaned stalks were weighed separately. The 20 stalk samples were analysed at the Experiment Station for dry matter, sucrose, fibre and brix contents. Dry matter contents of sub-samples of the trash and tops were also determined. Tops and trash from trial 3 and the tops from trial 4 were additionally analysed for sucrose, brix and fibre contents.

Tons of cane cut and bundled per man-hour, in-field loading rates and payloads of trailers and hilo trucks were recorded.

To complete the exercise, additional time studies were done over the ensuing three months of the season to establish harvester (manual and mechanical) and loader outputs for different harvesting systems.

## Results and Discussion

### *SMRI/SASEX project*

The results of the SMRI/SASEX project are given in Tables 1, 2 and 3. The fields were selected for even cane growth, but the average fresh stalk mass varied from 854 gm (trial 2) to 999 gm (trial 4) a variation of 15% (Table 1). Output of cutters and the Bell loader could have been adversely affected during trial 2 compared with the results from the other trials where better cane was handled. The exercise was conducted during the dry and cool winter when the pol % stalk increased from 13,4 to 14,5 over the 6 week period. The cane in trial 2 was probably stressed compared with that from the other trials, resulting in a relatively high pol % stalk of 13,9. Mass of pol per stalk increased from 124,5 gm (trial 1) to 144,9 gm (trial 4) with trial 2 again being the exception at only 118,7 gm per stalk.

**Table 1**

**Millroom analyses, SMRI/SASEX project**

| | 13-6-88 (unburnt topped) | | | | 27-6-88 (burnt topped) | | | | 11-7-88 (unburnt not topped) | | | | 25-7-88 (burnt not topped) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Clean cane | Trash | Tops | Total | Clean cane | Trash | Tops | Total | Clean cane | Trash | Tops | Total | Clean cane | Trash | Tops | Total |
| No samples | 18 | | | | 26 | | | | 16 | | | | 24 | | | |
| DM% | 28,6 | 82,1 | 20,9 | 32,1 | 29,0 | 84,9 | 26,2 | 29,2 | 28,3 | 87,9 | 30,2 | 33,3 | 29,3 | 85,6 | 35,5 | 30,6 |
| Fibre | 14,0 | | | | 14,0 | | | | 13,3 | 85,5 | 26,4 | 20,9 | 13,5 | | 27,4 | |
| Brix | 14,6 | | | | 15,0 | | | | 15,0 | 2,2 | 3,8 | 12,4 | 15,8 | | 8,1 | |
| Brix % DM | 51,0 | | | | 51,7 | | | | 52,9 | 2,6 | 12,7 | 37,2 | 54,0 | | 22,8 | |
| Purity | 91,5 | | | | 92,7 | | | | 90,9 | 6,6 | 54,1 | 88,0 | 91,8 | | 47,7 | |
| Pol % | 13,4 | | | | 13,9 | | | | 13,6 | 0,15 | 2,1 | 10,9 | 14,5 | | 3,8 | |
| g "fresh"/stalk | 929 | 71,1 | 28,6 | 1028,7 | 854 | 4,0 | 23,7 | 881,7 | 987 | 100,3 | 180,8 | 1268,1 | 999 | 6,0 | 90,5 | 1095,5 |
| % | 90,3 | 6,9 | 2,8 | 100,0 | 96,8 | 0,5 | 2,7 | 100,0 | 77,8 | 7,9 | 14,3 | 100,0 | 91,2 | 0,5 | 8,3 | 100,0 |
| Per 100 of cane | 100 | 7,6 | 3,1 | 110,7 | 100 | 0,5 | 2,8 | 103,3 | 100 | 10,2 | 18,3 | 128,5 | 100 | 0,6 | 9,1 | 109,7 |
| g DM/stalk | 265,7 | 58,4 | 6,0 | 330,1 | 247,7 | 3,4 | 6,2 | 257,3 | 279,3 | 88,0 | 54,6 | 421,9 | 292,7 | 5,1 | 37,3 | 335,1 |
| g Brix/stalk | 135,6 | | | | 128,9 | | | | 148,0 | 2,2 | 6,9 | 157,1 | 157,8 | | 7,3 | |
| g Pol/stalk | 124,5 | | | | 118,7 | | | | 134,2 | 0,2 | 3,8 | 138,2 | 144,9 | | 3,4 | |

**Table 2**

**Sugar Industry Central Board whole cane analysis**

| Trial No. | Pol | Brix | Purity | Moisture | Fibre | Ash |
|---|---|---|---|---|---|---|
| 1 | 11,53 | 13,61 | 84,63 | 65,16 | 21,22 | 2,48 |
| 2 | 13,57 | 15,35 | 88,40 | 70,25 | 14,40 | 1,13 |
| 3 | 10,63 | 13,23 | 80,36 | 65,48 | 21,58 | 2,76 |
| 4 | 13,39 | 15,50 | 86,37 | 69,82 | 14,68 | 2,11 |

**Table 3**

**Field results, SMRI/SASEX project**

| | Unburnt topped | Burnt topped | Unburnt untopped | Burnt untopped |
|---|---|---|---|---|
| **Total mass** | | | | |
| Tons/man hour, cut and bundle | 1,03 | 1,06 | 1,51 | 1,33 |
| Tons/trailer | 4,16 | 5,17 | 3,60 | 4,99 |
| Tons/hilo | 20,79 | 26,04 | 18,16 | 24,95 |
| Loading rate | 28,50 | 34,16 | 21,7 | 31,9 |
| Instantaneous loading rate | 35,77 | 43,17 | 33,6 | 45,7 |
| **% mass sent to mill** | | | | |
| Cane | 90,3 | 96;8 | 77,8 | 91,2 |
| Tops | 2,8 | 2,7 | 14,3 | 8,3 |
| Trash | 6,9 | 0,5 | 7,9 | 0,5 |
| **On clean cane basis** | | | | |
| Tons/man hour, cut and bundle | 0,93 | 1,03 | 1,17 | 1,21 |
| Tons/trailer | 3,76 | 5,00 | 2,80 | 4,55 |
| Tons/hilo | 18,77 | 25,21 | 14,13 | 22,75 |
| Loading rate | 25,73 | 33,07 | 16,88 | 29,07 |
| Instantaneous loading rate | 32,30 | 41,79 | 26,14 | 41,68 |
| **Clean cane as % of burnt and topped cane** | | | | |
| Tons/man hour, cut and bundle | 90,3 | 100,0 | 113,6 | 117,5 |
| Tons/trailer | 75,2 | 100,0 | 56,0 | 91,0 |
| Tons/hilo | 74,4 | 100,0 | 56,0 | 90,2 |
| Loading rate | 77,8 | 100,0 | 51,0 | 88,0 |
| Instantaneous loading rate | 77,3 | 100,0 | 62,6 | 99,7 |
| **DM% sent to mill** | | | | |
| Cane | 28,6 | 29,0 | 28,3 | 29,3 |
| Tops | 20,9 | 26,2 | 30,2 | 35,5 |
| Trash | 82,1 | 84,9 | 87,9 | 85,6 |
| Total | 32,1 | 29,2 | 33,3 | 30,6 |

These data can be compared with the results of the direct cane analysis tests performed by the Sugar Industry Central Board (SICB) on whole-cane samples (see Table 2). The significant effect of trash and tops on all quality criteria is obvious. For untrashed cane which was not topped the pol % cane dropped from 13,6 for the cleaned sample to 10,63 for the material entering the factory. The effect of tops on juice purity is illustrated by comparing the results of the clean cane analyses for trials 3 and 4 (Table 1) with the SICB results for the same trials in Table 2.

Excluding the contribution of trash and tops to the mass of the crop, the highest cutter/bundler output was attained when harvesting burnt cane without topping (118%), followed by harvesting unburnt cane without topping (114%), and harvesting burnt and topped cane (100%, control). When cutting unburnt cane and topping the stalks, cutter output was only 90% of that when cutting and topping burnt cane (Table 3). If manual topping during the harvesting operation is excluded, cutter output should increase by 18% in burnt and 26% in unburnt cane. Output of cutters when harvesting unburnt cane without topping was 3% lower than for burnt cane. Note that in all these trials no manual trashing was done.

Loader output was affected seriously when loading unburnt cane compared with burnt cane. Considering only the actual loading operation (instantaneous loading rate), output decreased by 23% in cane that was unburnt but topped, and by 37% in cane that was unburnt but not topped. Loading burnt cane which was not topped did not affect loader output.

The most obvious effect of harvesting whole cane was evidenced in payload. Compared with burnt and topped cane (100%) payloads for trailers and hilo trucks averaged:

burnt and not topped : 91%
unburnt and topped : 75%
unburnt and not topped : 56%

Unburnt cane with tops thus resulted in a 44% loss in payload. When the tops were left in the field payload decreased by 25% compared with burnt and topped cane. Payload decreased by 9% when burnt cane was not topped.

Based on the performance figures shown in Table 3 the costs to harvest, handle and deliver to the Maidstone mill all the cane (14 000 tons per year) from La Mercy, were calculated for each of the systems (Appendix 1). Total costs for each of the four systems are summarised in Table 4.

**Table 4**

**Summary of harvesting costs (R/tons on a clean cane basis)**

| Operation | System | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Manual cutting and bundling | 1,75 | 1,58 | 1,39 | 1,34 |
| Mechanical loading | 1,67 | 1,58 | 1,95 | 1,62 |
| Infield haulage | 2,18 | 1,90 | 2,56 | 1,99 |
| Transloading | 1,69 | 1,60 | 1,85 | 1,63 |
| Road haulage | 3,34 | 2,49 | 4,45 | 2,76 |
| Total | 10,63 | 9,15 | 12,20 | 9,34 |

Burnt topped cane was least expensive to handle (R9,15/t) followed by burnt cane not topped (R9,34/t), unburnt topped cane (R10,63/t) while unburnt cane not topped was the most expensive (R12,20/t). Expressed in percentages with burnt topped cane as standard (100%), the costs were:

burnt and not topped : 102%
unburnt, not trashed, topped : 116%
unburnt, not trashed, not topped : 133%

These results refer strictly to the conditions at La Mercy in 1988 but could be regarded as a reasonable estimate for other local situations.

Other factors which could affect the relative agricultural costs of the four systems are:

*Nutrition*

There is no evidence that any of these harvesting systems should result in nutritional requirements differing from standard FAS recommendations.

*Weed control*

The same chemical weed control programme would be used for all systems subsequent to the harvesting operation. With unburnt tops left behind in the field (system 1) there could be a saving of as much as R80/ha on labour during follow-up hand weeding operations.

*Yield advantage*

For systems 1 and 2 (unburnt and burnt tops scattered) on better soils and harvesting in summer, the advantage over systems 3 and 4 could be 6 t/ha. However, for the fields at La Mercy with Middle Ecca soils of low yield potential and harvesting in winter no significant differences in yield from the four systems would be expected.

*Soil conservation*

It is not possible to quantify the economic loss due to the soil erosion which might occur when following any one of the four harvesting systems. It is recommended that erodible soils should be protected during periods when high intensity rainstorms are expected. Whole cane harvesting during the summer rainfall period should therefore be confined to fields in which the soil is resistant to erosion, and where the slope is relatively flat.

*Additional measurements*

The results of a number of studies conducted to establish performance standards for different harvesting systems are given in Tables 5, 6, 7 and 8. These studies were done over a three month period and not necessarily under similar field conditions. Some deduction was necessary to complete the list of performance standards for systems which could not be evaluated in the time available. For this part of the project both mechanical and manual cutting were practised. From the data in these tables the labour and equipment requirements for various harvesting systems can be established.

**Table 5**

**Manual output**

| Activity | Trash and tops % | Output | | |
|---|---|---|---|---|
| | | Total mass t/man hour | Excl. trash and tops | |
| | | | t/man hour | t/m day* |
| 1. *In unburnt cane* | | | | |
| 1.1 *Manual cutting* | | | | |
| cut, top, trash, bundle | 5,3 | 0,983 | 0,931 | 7,5 |
| cut, top, trash, stack | 5,3 | 0,435 | 0,412 | 3,3 |
| cut, top, not trashed, stack | 9,7 | 0,447 | 0,404 | 3,2 |
| cut, not topped, not trashed, stack | 22,2 | 0,594 | 0,462 | 3,7 |
| cut, top, not trashed, bundle | 9,7 | 1,030 | 0,930 | 7,4 |
| cut, not topped, not trashed, bundle | 22,2 | 1,510 | 1,170 | 9,4 |
| 1.2 *With mechanical cutting* | | | | |
| not topped, not trashed, stack | 22,2 | 1,27 | 0,990 | 7,9 |
| not topped, not trashed, bundle | 22,2 | 2,12 | 1,650 | 13,2 |
| not topped, trashed, bundle | 18,7 | 1,92† | 1,617 | 12,9 |
| topped, trashed, bundle | 5,3 | 1,36† | 1,294 | 10,4 |
| mech. topped, not trashed, bundle | 9,7 | 2,09 | 1,890 | 15,1 |
| topped, trashed, stacked | 5,3 | 0,82† | 0,78 | 6,2 |
| 2. *In burnt cane* | | | | |
| 2.1 *With manual cutting* | | | | |
| cut, top, bundle | 3,2 | 1,06 | 1,030 | 8,2 |
| cut, not topped, bundle | 8,8 | 1,33 | 1,210 | 9,7 |
| cut, topped, stack | 3,2 | 0,71 | 0,687 | 5,5 |
| 2.2 *With mechanical cutting* | | | | |
| not topped, bundle | 8,8 | 3,13 | 2,85 | 22,8 |
| topped, bundle | 3,2 | 1,9 | 1,84 | 14,7 |
| topped, stacked | 3,2 | 1,25† | 1,21 | 9,7 |
| topping bundled cane | 3,2 | 6,32 | 6,12 | 49,0 |

* 1 man day=8 man hours
† by deduction

**Table 6**

**Bell loader output (excluding tops and trash)**

| Activity | Output tons/h | |
|---|---|---|
| | Instantaneous | Overall |
| 1. *Loading only* | | |
| 1.1 *In unburnt cane* | | |
| not topped, not trashed, from bundles | 26,14 | 16,88 |
| topped, not trashed, from bundles | 32,30 | 25,73 |
| topped, trashed, from bundles | 51,55* | 37,26* |
| not topped, not trashed, from linear windrow | 17,00 | 14,08 |
| 1.2 *In burnt cane* | | |
| topped, from bundles | 41,79 | 33,07 |
| not topped, from bundles | 41,68 | 29,07 |
| topped (cut and topped mechanically), from linear windrow | 17,94 | 15,24 |
| 2. *Loading and topping* | | |
| 2.1 *In unburnt trashed cane* | | |
| topping and loading from bundles | 22,14† | 18,45† |
| 2.2 *In burnt cane* | | |
| topping and loading from bundles | 30,01 | 23,71 |

* Exceptionally good field conditions
† By deduction

**Table 7**

**Payload (excluding tops and trash)**

| Material | Payload (tons) | |
|---|---|---|
| | 5 ton basket trailer | Standard hilo truck |
| 1. *Unburnt cane* | | |
| not topped, not trashed, Bell loaded from linear windrow | 2,57 | 12,62 |
| not topped, not trashed, Bell loaded from bundles | 2,80 | 14,13 |
| topped, not trashed, Bell loaded from bundles | 3,76 | 18,77 |
| topped, trashed, Bell loaded from bundles | 4,73 | 23,63 |
| not topped, not trashed, hand stacked, self-loading trailer | 3,27 | 16,38 |
| 2. *Burnt cane* | | |
| not topped, Bell loaded from bundles | 4,55 | 22,75 |
| topped, Bell loaded from bundles | 5,00 | 25,21 |
| topped, Bell loaded from linear windrow | 4,54 | 22,70 |

**Table 8**

**Output of front end cutter (excluding tops and trash)**

| | tons/field hour |
|---|---|
| unburnt cane | 19,8 |
| burnt cane | 26,5 |

For example, to harvest and deliver to a loading zone 60 tons of cane per day the manual labour requirement, including machine operators and two gleaners/chain men, for a selected number of harvesting systems would be:

| | Man days required | |
|---|---|---|
| | With mechanical cutting | Without mechanical cutting |
| topping, trashing and stacking (self-loading trailers) | 13 | 22 |
| topping and stacking burnt cane (self-loading trailers) | 10 | 14 |
| topping, trashing and bundling (mechanical loading, basket trailers) | 10 | 12 |
| topping and bundling burnt cane (mechanical loading, basket trailers) | 9 | 12 |
| bundling burnt cane (mechanical topping and loading, basket trailers) | 7 | 11 |

## Conclusions

Sufficient data have been accumulated to determine adequately the effects on labour and equipment performance when harvesting sugarcane containing various amounts of trash and tops.

No problems were encountered in the field during the gathering of this information. Labour cut and bundled or stacked all cane variations with equal ease and with little effect on productivity. Similarly, no problems were experienced when using mechanical cutters, loaders and cranes to handle the crop; but output decreased as the amount of trash and tops increased. Payload was most seriously affected by increased quantities of extraneous matter, with decreases as great as 44% being measured.

No serious agronomic problems are envisaged if all vegetative material is removed from the field. Nutritional and weed control requirements would be similar. Operations on highly erodible soils on steep slopes, however, would have to be timed to avoid unacceptable soil losses.

If it should be to the industry's advantage to accept at the sugar factories unburnt cane which has not been topped or trashed, the additional handling cost would be about one third of the cost for harvesting and delivering burnt topped cane.

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## APPENDIX 1

1. *Manual cost (cutting and bundling)*

| *System* | *1* | *2* | *3* | *4* |
|---|---|---|---|---|
| tons / man / day | 7,44 | 8,24 | 9,36 | 9,68 |
| total cost R/day | 13,00 | 13,00 | 13,00 | 13,00 |
| cost per ton | 1,75 | 1,58 | 1,39 | 1,34 |

2. *In-field loading (14 000 tons per year)*

price of standard Bell loader: R81 600

| *System* | *1* | *2* | *3* | *4* |
|---|---|---|---|---|
| loading rate t/h | 25,7 | 33,1 | 16,9 | 29,1 |
| operating hours per year | 545 | 423 | 828 | 481 |
| cost R/h | 42,83 | 52,41 | 32,94 | 47,25 |
| cost R/ton | 1,67 | 1,58 | 1,95 | 1,62 |

3. *In-field haulage (14 000 tons per year)*

Price of 2 WD, 45 kW tractor : R51 000
Price of 5 ton basket trailer : R14 000
Distance to loading zone : 1 km
Average speed : 12 km/h

| *System* | *1* | *2* | *3* | *4* |
|---|---|---|---|---|
| cycle time (min) | 26,2 | 26,5 | 27,4 | 26,8 |
| payload | 3,76 | 5,00 | 2,80 | 4,55 |
| trips required per day | 19 | 14 | 25 | 16 |
| hours per day | 8,1 | 6,2 | 11,4 | 6,9 |
| operating hours per year | 1059 | 802 | 1464 | 888 |
| cost R/h | 28,74 | 33,22 | 24,54 | 31,48 |
| cost R/ton | 2,18 | 1,90 | 2,56 | 1,99 |

4. *Transloading (14 000 tons per year)*

Price of trailed crane with used tractor: R42 000

| *System* | *1* | *2* | *3* | *4* |
|---|---|---|---|---|
| loading rate t/h | 26 | 35 | 20 | 32 |
| operating hours per year | 538 | 400 | 700 | 438 |
| cost R/h | 44,00 | 56,00 | 37,00 | 52,00 |
| cost R/ton | 1,69 | 1,60 | 1,85 | 1,63 |

5. *Road haulage (maximum use)*

Price of hauler (eg. MB 2828) : R242 000
Price of tridem trailer : R61 000
Distance to mill : 11 km
Operating hours per day : 20
Average speed : 35 km/h
Cycle time : 1 h 48 min
Number of trips possible per day (20h): 11
Distance travelled per year : 48 400 km
Cost R/km : R2,85

| *System* | *1* | *2* | *3* | *4* |
|---|---|---|---|---|
| payload | 18,8 | 25,2 | 14,1 | 22,8 |
| tons per year | 41 300 | 55 500 | 31 100 | 50 000 |
| cost R/ton | 3,34 | 2,49 | 4,45 | 2,76 |