EVALUATION OF DETRASHING COMPONENTS FOR A GREENCANE HARVESTER

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Abstract

New concepts and components for green cane harvesting were evaluated in field trials. A sticker chain assembly and tined detrashing rotors were fitted to a modified tractor. Cane was topped and base-cut and, while being conveyed to the bin by the sticker chain, the trash was removed from the canes by the rotors. The clean canes were deposited into a collecting bin which stored about 200 kg cane. The bundles were then deposited on the ground ready to be loaded with a grab loader onto box trailers.

Introduction

In August 1989 it was suggested that the principle of mechanical detrashing used on the SASEX mechanical pretrasher (Carnegie, 1989) could be adapted for use on a greencane harvester.

It was decided that, before constructing a specially designed harvester suitable for commercial production, the main components should be tested on a modified tractor. It should then be possible to evaluate the principles and design of the components, so that any faults could be corrected before constructing a purpose-built machine.

Modification of the tractor and manufacture of parts started in September 1991. Some of the completed components were tested during January 1992 and a number of faults were immediately identified. Short, droughted cane caused severe problems because the machine had been designed to harvest cane 1,2 to 2,2 m tall. Before a further trial was undertaken in August 1992, many modifications were made. After modification and further tests, construction on a bin was begun in November 1992. In May 1993 the machine was ready to harvest trials.

Method

A Ford 6600 tractor was fitted with an 80 kW turbocharged engine. The front axle was replaced by an arch to which heavy duty stub axles and wheels with 12,0-18 tyres were fitted. The legs of the arch contained the steering shafts, which were controlled by an hydraulic steering motor and actuators connected to the steering shaft crank arms, which were linked with a tie-rod. The rear wheels were extended to a track width of 3,0 m and a frame was built to connect the front arch carrier to the rear of the tractor, making a strong carrier for mounting the harvesting components. The large hollow 'backbone' of the frame was used as a reservoir and was filled with 500 l hydraulic oil. Although the total length of the machine, including the bin and crop gatherers, was 9,1 m, the centre to centre front to back wheels was 4,97 m. The modified tractor is illustrated in Figure 1.

Harvester components

Basecutter

A SASEX basecutter assembly (Boevey, 1992) equipped with auto-height control (Boast, 1986) was fitted to the right of the tractor front sub-assembly in line with the front wheel axles.

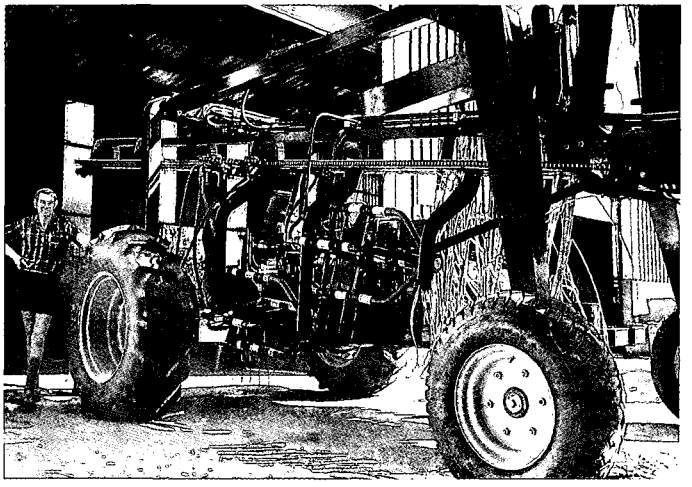

FIGURE 1 Modified tractor.

Sticker chain carrier

The cane carrier was made of a heavy duty frame which contained a chain with teeth affixed to each link, moving between 12 mm × 75 mm flat vescolene sections attached to flanges of 50 mm × 75 mm folded channel. The channel was made up of sprung segments each 500 mm in length. A stainless steel knife-edge protruding 2 mm was attached to each lower edge of the channelled segments.

Topper

A SASEX topper was fixed to the carrier frame to remove the tops and was located 100 mm behind and 300 mm above the leading edge of the sticker chain assembly.

Crop gatherers

Two assemblies, containing hydraulically driven chains with fingers, protruded ahead of the sticker chain and gathered the cane into an upright position before feeding it into the sticker chain (Figure 1).

Bin

To enable bundles of cane to be dumped clear of each successive row, a pusher table was fitted in runners to shift the bundle to the left side of the machine, where the bundle was partially compressed against the bin door before being dumped. To maintain a clear drop area for the incoming cane, a packer was fitted to runners built into the pusher table (Figure 2).

The rake

Inadvertent loading of trash and tops with the bundle was avoided by attaching a hydraulically operated rake ahead and below the bin.

Detrashing rotors

Two rotors with eight double-fingered spring tines were attached to pedestals, which suspended them from the sticker

FIGURE 2 Bin and extractor fan.

chain frame. The leading rotor hung just below the carrier chain and detrashed the upper 600 mm of cane. The other rotor trailed the first and was set to detrash the lower 600 mm (Figure 3).

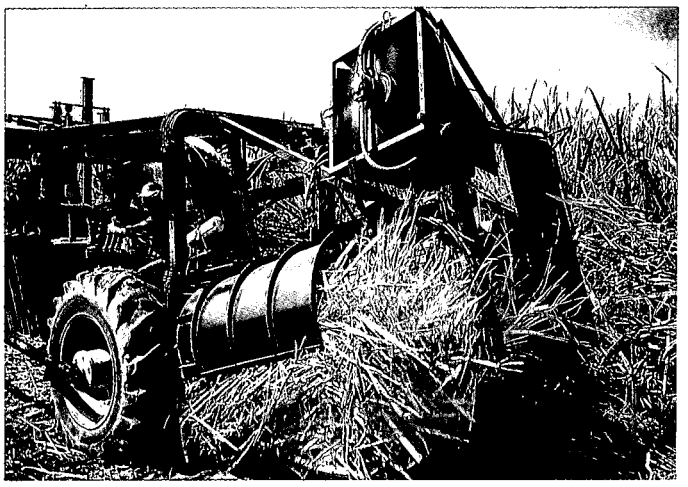

FIGURE 3 Detrashing rotors.

Saw

To prevent trash wrap and subsequent jamming of the base cutter, a hydraulically powered circular saw was attached to the base cutter carrier assembly. The saw, fitted close to the base cutter disc, cut through accumulating trash (Figure 1).

Extractor Fan

A ducted extractor fan was fitted, with the inlet facing the end of the sticker chain, to extract loose trash that was caught in the chain and not removed by the detrashers (Figure 2).

Hydraulics

Steering

The hydraulic steering motor received oil from an auxiliary pump which was part of the new engine.

Base cutter

A gearbox and 40 cc gear pump were fitted to the pto shaft of the tractor to supply oil to the base cutter motor.

Pumps

Double 63 cc gear pumps were mounted on the tractor front sub-assembly and driven by a shaft attached to the engine crankshaft pulley. These pumps supplied the oil required by the hydraulic motors of the sticker chain, detrashers, gathering chains, etc. Each 63 cc pump was flow-divided, and supply to individual motors was achieved by activating a small selector spool.

Raking/Dumping

To permit a rapid raking and bundle dumping sequence, it was decided that this process should be automated. The press of a button activated a timer, relays and micro-switches to energise electric solenoid-operated spool valves, which supplied oil to the raking and dumping actuators.

Field trials

It was decided that the machine should be operating efficiently before any measurements were made or results recorded. The following modifications were therefore made:

- Initially the machine had not been fitted with a saw, rake and extractor fan. These were fitted to correct problems

Table 1

Samples of standing sugarcane

Sample number	Variety	Trash		Tops		Cane (kg)	Total	
		kg	%	kg	%		Bundle weight (kg)	Extraneous matter (%)
1	N14	4,0	11,4	8,1	23,0	23,0	35,1	34,4
2	N14	2,8	10,8	3,2	12,3	20,0	26,0	23,1
3	N14	6,0	16,9	7,6	21,3	22,0	35,6	38,2
4	N14	1,8	8,6	4,6	22,7	13,9	20,3	32,1
5	N14	2,0	8,7	5,4	23,5	15,6	23,0	30,5
6	N14	2,2	8,0	6,0	21,8	19,3	27,5	29,8
7	N16	1,8	10,8	3,3	19,9	11,5	16,6	30,7
8	N16	2,1	12,6	2,5	14,9	12,1	16,7	27,5
9	N16	1,6	11,4	2,6	18,6	9,8	14,0	30,0
10	NCo376	1,4	7,43	5,0	27,3	11,9	18,2	34,7
11	NCo376	1,5	5,1	8,4	28,4	19,7	29,6	33,5
12	NCo376	2,6	10,9	5,7	23,9	15,2	23,8	34,9
Average		2,5	10,2	5,2	21,5	16,2	23,9	31,6

Table 2

Samples of harvested bundled cane

Sample number	Variety	Trash		Tops		Cane (kg)	Total	
		kg	%	kg	%		Bundle weight (kg)	Extraneous matter (%)
1	N14	14,5	4,9	22,1	7,5	258,0	294,6	12,4
2	N14	8,9	4,3	10,4	5,0	188,0	207,3	9,3
3	N14	40,9	8,6	24,8	5,2	411,7	477,4	13,8
4	N14	36,6	9,6	28,2	7,4	318,0	382,8	17,0
5	N14	6,5	5,9	14,6	13,2	89,8	110,9	19,1
6	N14	13,8	8,5	15,6	9,5	133,9	163,3	18,1
7	N14	7,8	6,0	13,2	10,2	108,0	129,0	16,2
8	N14	15,6	8,2	19,4	10,2	155,5	190,5	17,1
9	N14	15,7	6,7	20,8	8,9	197,3	233,8	15,6
10	N16	9,7	3,9	10,5	4,2	229,6	249,8	8,1
11	N16	10,7	4,7	9,0	3,9	206,3	226,0	8,7
12	NCo376	29,5	4,1	42,0	5,9	640,3	711,8	10,0
Average		17,5	6,2	19,2	7,6	244,7	281,4	13,8

encountered as harvesting trials progressed, and have been mentioned under the heading 'Harvester components'

- The standard SASEX base cutter assembly impeded the flow of cane past the base cutter disc. The base cutter assembly was redesigned and the cutting disc was off-set to the right of the main drive shaft housing. The profile was lowered to enhance the flow of cane. Although indications were that the flow was substantially improved, the premature replacement of collapsed bearings make the reliability of the new design questionable
- The additional hydraulic motors for the saw, rake and extractor fan necessitated several changes to the hydraulic circuit. The sticker chain conveyor needed more power than was originally anticipated; so a second hydraulic motor with an independent oil supply was connected to the sticker chain drive to double the available power. This reduced the frequency of the sticker chain jamming
- Fine trash and dust collecting against the radiator cores caused the engine to overheat, making it necessary to clean the radiator two to three times daily
- The extended side-shaft of the rear axle snapped and a new part was fitted
- Excessive wear to the vescolene wearing surfaces caused substantial cane losses because they were no longer able to grip the stalks. Ten millimetre diameter round bar welded to the centre of the channels gave only a slight improvement.

Controlled field tests

Tests were conducted to establish the efficiency and output of the machine. Before harvesting, random samples of standing cane were taken to establish the mass of extraneous matter in the crop (Table 1). Each sample consisted of 1,2 m of cane row.

After harvesting, bundles were sampled to establish the percentage extraneous matter remaining (Table 2).

All visible cane that had fallen from the sticker chain during harvesting was collected, weighed and classed as recoverable cane. Thereafter all the recovered cane, including the bundles, was removed from the plot and the trash blanket was burnt to expose any remaining cane. This was collected, weighed and classed as irrecoverable cane (Table 3).

Discussion

The droughted cane used for the field test had a significantly depressing effect on the performance of the machine. Large differences in stalk length accounted for the unacceptably high losses from the conveyor, and increased tops in the bundle. Figure 4 shows a number of stalks with the tops cut off at the average meristem height and the canes gripped by the sticker chain 300 mm below. The following might occur:

- Some or all of the seven shorter canes with a portion of top attached would be lost or included in the bundle

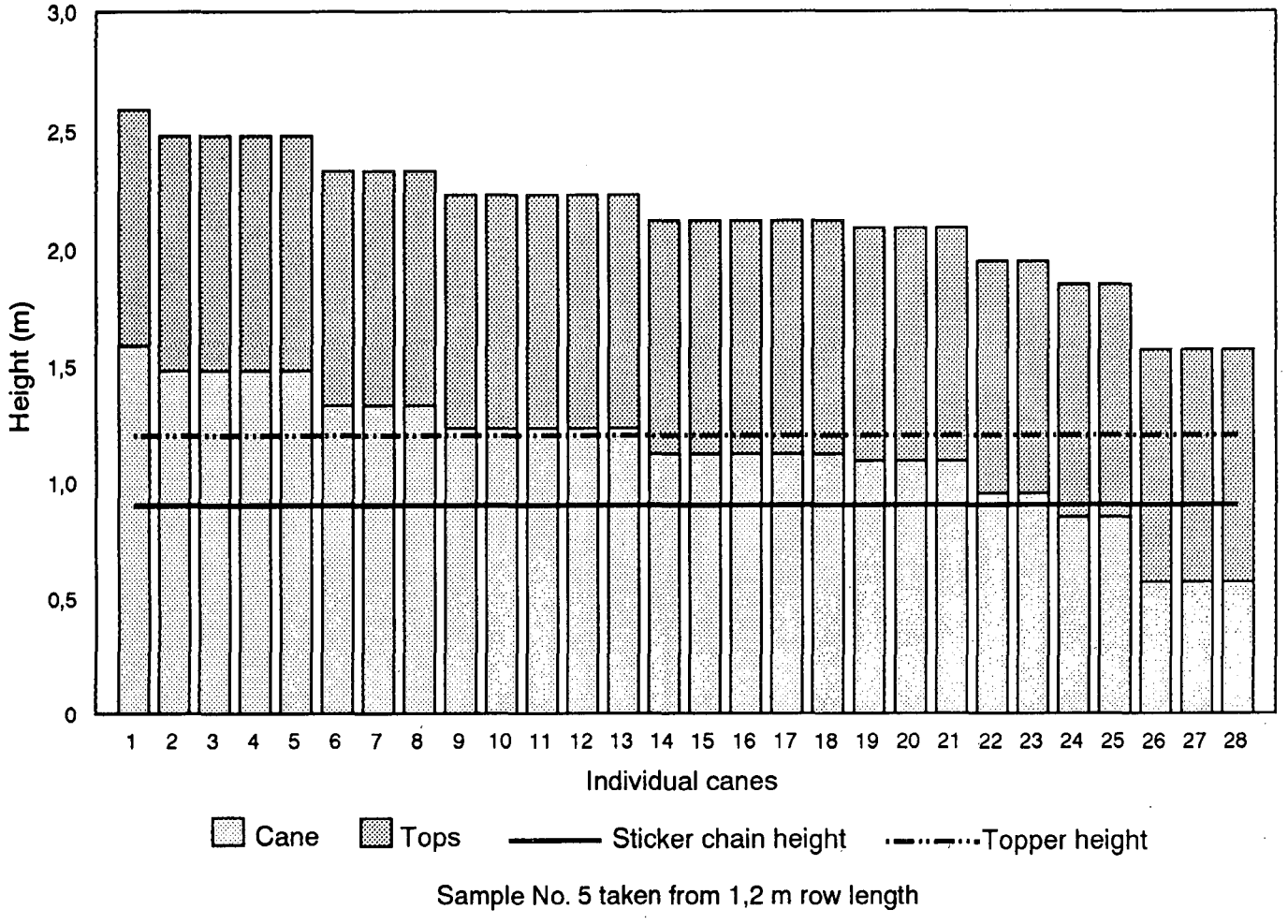

FIGURE 4 Level of sticker chain and topping height in a sample of canes of differing height.

Table 3

Losses and productivity

Plot number	Variety	Yield (t/ha)	Cane bundled (kg)	Dropped cane (recovered)		Dropped cane (irrecoverable)		Total crop (kg)	Time taken (min)	Harvest rate (tons/h)
				kg	%	kg	%			
1	N14	67,0	1 432,7	426,0	22,4	44,6	2,3	1 903,3	4,7	24,6
2	N14	67,0	6 096,3	1 630,0	19,2	749,0	8,8	8 475,5	19,2	26,4
3	N16	21,0	724,0	151,0	16,6	34,0	3,7	909,0	6,6	8,3
4	NCo376	59,0	15 903,5	425,0	2,5	671,5	4,0	17 000,0	41,8	24,4
Average		53,5	6 039,1	658,0	15,2	374,8	4,7	7 071,9	18,1	20,9

- Thirteen of the taller canes would have tops cut off below the meristem, and the portion of cane still attached to the tops would be lost.

The results of eight other samples supported this theory.

Although the rotational speed of the detrashing rotors had been reduced to minimise the number of canes being pulled from the sticker chain, the extraneous matter content in the bundles was considered to be acceptable (compare Tables 1 and 2).

Conclusion

This method of harvesting sugarcane requires upright standing cane, with no more than a 10° lean. Fields need to be well laid out and row spacing must not be less than 1,5 metres. The principle of detrashing cane while carried in a conveyor was demonstrated. Further research is necessary to establish the best design of conveyor and the best relationship between the detrashing rotors and the conveyor to eliminate cane losses and reduce power requirements. The results indicate that a commercial machine to harvest bundles of detrashed green cane at a rate of 25 tons/h could be successful.

Acknowledgements

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