THE PERFORMANCE OF MACHINERY FOR MECHANICAL HARVESTING AND LOADING OF SUGARCANE

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Abstract

The South African Sugar Association Experiment Station, Agricultural Engineering Department, conducted time and motion studies on various loading and harvesting machinery in two separate harvesting trials on a large commercial estate in Swaziland in the 1998/1999 and 2000/2001 seasons. During these trials machinery performance and associated infield cane losses were assessed.

The results of these studies showed that mechanical loader and combine harvester performance varied considerably depending on the type of machine, cane yield, and crop and field conditions. Instantaneous loading rates and mechanical harvesting pour rates varied between 60 and 100 tons per hour. Infield cane losses were significantly lower where the cane was manually cut and mechanically loaded using high-capacity push-pile loaders compared with cane harvested by combine harvester.

Keywords: mechanical loader, harvester, performance, losses

Introduction

An ever increasing quantity of sugarcane is being mechanically loaded and harvested throughout the various cane producing regions within the South African sugar industry. An illustration of this is that in excess of 10 chopper harvesters currently operate in various parts of the industry.

The Agricultural Engineering Department at the South African Sugar Association Experiment Station (SASEX) last conducted trials to assess mechanical loading, combine harvesting performance and cane losses some 20 years ago (de Beer and Boevey 1977a; de Beer and Boevey, 1977b; de Beer and Boevey, 1979; de Beer, 1980). It was therefore decided to undertake similar trials to ensure that up-to-date machinery performance information is available to the industry.

Method and materials

Two separate harvesting trials were conducted at Royal Swaziland Sugar Corporation (RSSC), Simunye to assess machinery performance and to determine infield cane losses associated with various types of mechanical loaders and a combine harvester during the 1998/1999 and 2000/2001 seasons.

Trial No 1

This trial was conducted in Field 502 at RSSC from 30 August to 4 September 1998. There were three treatments:

Treatment 1: Hand cut, Tamhe push-pile loader (mounted on a Bell 1754 two wheel drive tractor) loading into bins

Treatment 2: Hand cut, J&L continuous loader loading into bins

Treatment 3: Case Austoft harvester harvesting burnt cane and delivering the billeted cane into bins.

In all cases the cane was burnt prior to harvesting and for Treatments 1 and 2, four rows of cane were placed into a windrow.

There were seven replications in each treatment where the plot area was ± 0,4 ha and the tons cane loaded or harvested was ± 45 tons. Treatments were randomly assigned to plots. The field was irrigated by the overhead dragline method and the cane variety was third ratoon NCo376, which was 10,3 months old and yielded 94 t/ha. The cane rows were ridged up and the row spacing was 1,5 m.

Machinery performance was measured using the time and motion study method (Curry, 1963; Murray and Meyer, 1982). After mechanical loading or harvesting was completed and each plot was gleaned by the RSSC harvesting crew, cane loss sampling was carried out by the Swaziland Sugar Association Extension Services Agronomy staff. The method of measuring cane left in the field after mechanical loading or harvesting was to randomly select sample areas within the treatment plot and peg out a 6 m^2 sampling area using four pegs joined together by a length of rope. Cane left behind including whole or damaged stalks and stalk pieces, whole or damaged billets, millable cane tops (topscane) and stubble were carefully gleaned and weighed using a 5 kg spring balance.

Trial No 2

This trial was conducted in Field 1010 at RSSC from 9-13 October 2000. There were five treatments:

Treatment A: Hand cut, Cameco push-pile loader loading into bins

Treatment B: Hand cut, Cameco SP 2254 push-pile loader loading into Landtrains

Treatment C: Case Austoft harvester harvesting burnt cane and delivering the billeted cane into high-lift trailers

Treatment D: Case Austoft harvester harvesting green cane and delivering the billeted cane into bins

Treatment E: Case Austoft harvester harvesting in burnt cane and delivering the billeted cane into bins.

All treatments were randomly assigned to plots. A total of eight replications per treatment were completed in the time available. The average treatment plot areas and tons cane loaded or harvested were ± 0,48 ha and 38,7 tons respectively. The field was surface drip irrigated and the cane variety was fourth ratoon

NCo376 which yielded 80 t/ha. The cane was planted at 1,5 m spacing.

Machinery performance and infield cane losses were determined in a manner similar to that described for Trial No 1.

Results and discussion

Trial No 1

Machinery performance

The results of the time and motion studies showed that the Tamhe loader's forward speed and loading rate varied little between plots, being 0,8 to1,0 km/h and 51 to 70 t/h respectively. The J&L continuous loader's forward speed and loading rates varied considerably, ranging from 2,2 to 4,4 km/h and 151 to 270 t/h respectively. This variation can be ascribed to stony ground in some of the plots as well as operator proficiency. The combine harvester's pour rate also varied considerably between plots despite the relatively uniform plot yields. The pour rates were between 64 and 110 t/h, mainly due to outcrops of shale and stones in certain plots. A summary of machinery performance is given in Table 1.

Infield losses

A total of 42 cane sample areas, two per plot, was analysed. Although the total area per plot sampled was relatively small, the results nevertheless gave a reasonable indication of the field losses that can be expected for the various harvesting methods. The average per cent losses in treatments 1 to 3 for various categories of cane stalk are given in Table 2.

Table 2 shows that there were no significant differences in total cane losses between the various treatments. The amount of stubble and topscane gleaned in Treatments 1 and 2 was no reflection on mechanical loading but rather a function of the manual harvesting operation. More cane was left in the field as whole stalks in Treatment 1 than with the other treatments. On average more stubble cane was left behind by the chopper harvester. This was due mainly to the operator lifting the base cutters to avoid excessive base cutter blade wear in some of the plots containing rocky outcrops.

Table 1. Summary of machinery performance.

Treatment	Average cane yield (t/ha)	Average forward speed (km/h)	Range in instantaneous load/harvesting rate (t/h)
1 - Tamhe loader	107,6	0,9	51 – 70
2 - J & L loader	105,2	3,0	151 – 271
3 -Austoft harvester	99,2	5,1	65 – 110

Trial No 2

Machinery performance

The average machinery forward speed and instantaneous loading or harvesting rates per treatment are shown in Table 3. The Cameco loader operated at an average forward speed of 1,9 km/h. The machine's loading rate varied significantly between plots, from 67 to 107 t/h. This variation was ascribed to varying cane tonnages, field condition and operator proficiency.

The combine harvester's average forward speed and instantaneous pour rate in burnt cane were 5,7 km/h and 71,1 t/h respectively. As expected, the harvester's forward speed and pour rate was lower in green cane than in burnt cane.

Infield losses

The total field losses for individual treatments, expressed as a percentage of total tons, for each category of cane stalk are given in Table 4. As previously, the amount of stubble and topscane gleaned for Treatments 1A and 1B were no reflection on mechanical loading but rather a function of the manual harvesting operation. Table 4 shows that for the hand harvested treatments the greatest percentage losses could be attributed to whole and damaged stalk pieces, stubble and topscane.

For the combine harvested treatments the largest amount of cane left in the field consisted of whole and damaged billets. The results clearly showed that cane losses in the hand cut, mechanically loaded treatments were significantly lower compared with combine harvested treatments.

There are numerous factors affecting mechanical loader and combine harvester performances, infield losses and quality of cane delivered to the factory (de Beer and Purchase, 1999; Meyer, 1998; Meyer, 1999).

Factors affecting mechanical loader and combine harvester performance include, amongst others, the following:

- Cane yield
- Erect or lodged cane
- Burnt or green cane
- Neatness of the windrows
- Number of rows of cane piled onto each windrow
- Placement of windrow in relation to rows
- Uniformity of row spacing
- Length of rows/windrows
- Field layout and conditions (short rows, stumps, rocks etc.)
- Matching of row spacing and machine

Table 2. Average per cent cane loss per treatment.

Treatment	Whole stalk	Damaged stalks	Stubble cane	Tops-cane	Whole billets	Damaged billets	Total loss
1	0,83	0,73	0,57	1,06	-	-	3,18
2	0,05	0,04	0,78	1,07	0,88	0,80	3,62
3	0,01	0,01	1,01	0,36	0,74	1,03	3,15

Table 3. Summary of machinery performance.

Treatment	Average cane yield (t/ha)	Average forward speed (km/h)	Range in instantaneous load/harvesting rate (t/h)
A - Cameco loader (bin)	76,6	1,9	72 – 107
B - Cameco loader (Landtrain)	79,3	1,8	72 – 103
C - Austoft harvester (burnt, high-lift)	79,7	5,6	47 – 88
D - Austoft harvester (green, bin)	81,8	4,9	57 – 75
E - Austoft harvester (burnt, bin)	86,3	5,7	51 – 92

Table 4. Average per cent cane loss per treatment.

Treatment	Whole stalk	Damaged stalks	Whole stalk pieces	Damaged stalk pieces	Stubble cane	Tops-cane	Whole billets	Damaged billets	Total loss
A	0,07	0,04	1,06	0,45	0,55	0,46	0,00	0,00	2,63
B	0.05	0,07	1,32	0,74	0,63	0,57	0,00	0,00	3,37
C	0,03	0,00	0,20	0,29	0,41	0,11	1,58	1,76	4,38
D	0,07	0,36	0,20	0,48	0,42	0,32	1,29	1,89	5,03
E	0,00	0,03	0,05	0,24	0,22	0,06	2,08	2,38	5,06

- Push-piling and grab capacity and design
- Number and efficiency of transport units
- Machine condition and maintenance
- Operator proficiency.

Conclusions and recommendations

The trial results showed that there were significant differences in performance between the various mechanical loaders. Instantaneous loading rates varied from 62 to 212 tons per hour. The performance of the combine harvester in burnt cane in both trials was comparable with that in previous trials (de Beer and Boevey, 1979 and de Beer, 1980). Combine harvester output was lower in green cane than in burnt cane.

The results in both trials clearly showed that, where cane was manually cut and mechanically loaded, infield losses were lower compared with cane that was chopper harvested. However, when using a chopper harvester, field losses were similar in both green and burnt cane.

Further research is needed to determine the effect that different types of harvesting systems have on cane quality as well as factory performance. This is of particular importance to both growers and millers where the cane payment system is based on the relative value system. Also, in view of mounting environmental pressure not to burn cane prior to harvesting, any future research should include trials where the cane is harvested green.

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