MANUAL SUGARCANE CUTTER PERFORMANCES IN THE SOUTHERN AFRICAN REGION

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Abstract

The South African sugar industry harvests in excess of 20 million tons of sugarcane annually. More than 90% of this tonnage is currently being harvested manually. During 2002, the South African Sugar Association Experiment Station's Agricultural Engineering Department conducted a comprehensive cane cutter survey throughout the South African and Swaziland sugar industries. The primary objective was to identify the productivity ranges for manual cane cutters across various harvesting systems, in both green and burnt cane. Factors impacting on cane cutter performance were also investigated. A small number of time and motion studies were also conducted to identify the time utilisation of the various cane cutter tasks.

Results indicate that cane cutter performances vary widely between cutters, farms and regions, and average output is greatly dependent on harvesting systems. Factors influencing cutter performance appear to follow Herzberg's 'Motivation-Hygiene' response theory, where general working conditions and wages do not affect productivity if they are adequate, but aspects such as conferring responsibility motivate for higher output. Future research requirements are also proposed.

Keywords: sugarcane, harvesting, manual harvesting, performance, productivity

Introduction

The South African sugar industry harvests in excess of 20 million tons of sugarcane annually. More than 90% of this tonnage is currently being harvested manually. A large proportion of the area under sugarcane production in South Africa is on undulating to steep topography, which does not lend itself to mechanised harvesting. It is therefore highly unlikely that mechanised harvesting will become the norm in the near future in these regions. Thus, it becomes essential that the manual cane harvesting operation be well managed to ensure that good quality cane is delivered to the mill, with infield cane losses reduced to a minimum. There is nevertheless the risk of labour becoming scarce, either due to the impact of debilitating diseases or unwillingness to perform these arduous tasks. Rising costs also dictate that improved productivity is essential to the economic viability of farms.

Traditionally, cane cutters begin work early in the morning (about 05h00) and usually finish work in the early afternoon (around 14h00). The harvesting season is normally from April to December.

Two basic systems are used in South Africa to harvest the crop manually:
- Cut and stack green or burnt cane.
- Cut and windrow green or burnt cane for subsequent mechanical loading.

It is estimated that at present more than 80% of the crop is burnt before harvesting. A large proportion of the burnt sugarcane is manually cut, topped and windrowed, and then mechanically loaded onto infield or road transport vehicles. In most instances worker remuneration is based on the amount of cane cut and windrowed, or cut and stacked each day, at a fixed rate per ton. However, many growers use a sliding scale system, whereby the rate paid to the cutter per ton increases above a certain tonnage.

Previous studies indicated areas where improvements in productivity could be made. Studies in the Philippines showed that, by improving the method of cutting, trashing, topping and piling, and by introducing a time incentive scheme, cutter performance improved by 15,44 and 20,67% respectively (Alba and Escober, 1974). Spalding (1992) indicated benefits in splitting cut and stack activities into cut only and stack only. This split harvesting operation resulted in a 54% improvement in labour productivity and a 62% increase in the self-loading infield haulage productivity due to consistently larger stack weights.

Other studies have researched the effect of different cane knives on performance. A study by de L Smit *et al.* (2001) compared short handled and long handled curved knives, and found the only difference in output to be the cutters' perception of exertion – indicating that the choice of knife and its usefulness depends on the preferences of the cane cutter. Nonetheless, other studies (Brooks, 1983) found some productivity enhancement with modified knife types. A third area of investigation is in the nutrition and fluid intake of cane cutters (Lambert *et al*., 1994), which was found to affect productivity positively. Time and motion studies, such as described by Brooks (1983) also indicated the impact of the amount of time spent on various tasks in a cutter's day.

In many regions growers are using the services of contractors who not only harvest the cane, but in many instances also transport the cane to the transloading site or directly to the mill. One of the reasons for using contractors is to avoid managing labour-related legislation. With greater administrative burdens, there is a growing move to investigate using contractors, and therefore information on productivity effects would be informative.

Method

The Agricultural Engineering Department at the South African Sugar Association Experiment Station (SASEX) conducted a comprehensive cane cutter survey throughout the South African and Swaziland sugar industries. The primary objective was to identify productivity ranges for manual cane cutters across harvesting systems, in both green and burnt cane, in the various regions. The questionnaire aimed at establishing the factors that could be linked directly to cutter performance.

A detailed questionnaire covering issues ranging from cutter gender, age and nationality, daily cutter output, remuneration, remunerative structure, cane yield, cane variety and burning practices to accommodation and meals, was drawn up on a computer using a Microsoft Excel spreadsheet. The survey was conducted between May and July 2002. The SASEX Extension Officers in the various regions were asked to select companies and growers who kept records of cane cutter performances for the 2001/02 season. To familiarise participants with the type of questions they would be required to answer, they were supplied with copies of the questionnaire well in advance of the visit to the estate or farm.

A total of 58 company estates, harvesting contractors and private growers were visited, accompanied by the local Extension Officer. The information gathered during each farm visit was logged onto a hard copy of the questionnaire, as well as directly onto the computer spreadsheet. The data was first analysed using Microsoft function tools such as sort and pivot tables.

The South African Cane Growers' Association then used SPSS statistical software to investigate factors affecting cane cutter performance.

Additional information was gathered at the end of the 2002/03 season when motion studies were conducted on 12 individual cane cutters operating in different cane harvesting systems. The aim of these studies was to determine the time spent by cutters on their various tasks during a normal working day.

Results

Descriptive statistics

The survey included 3373 male and 296 female cane cutters. As can be expected, Zulus and Xhosas make up the majority of cutters in KwaZulu-Natal regions, while Mozambicans and Swazis make up the bulk of cutters in the northern irrigated regions. All regions showed the average age of cane cutters to be between 30 and 42. It is interesting to note that the average age of male and female cutters in all regions is very similar. Furthermore, the results indicated that the average age of cutters was lower than expected, bearing in mind the speculation around the negative effects of the HIV Aids pandemic.

The type of cane knife preferred by cane cutters is given in Table 1. The long handled curved cane knife was preferred by cane cutters in all harvesting methods, except in the case of cut and stacking in green cane, where a variety of knives are used. The lack of overall variation in the data unfortunately precludes any further investigation into the productivity impacts of different cane knives.

Table 1. Type of cane knife used for various harvesting methods (% farms).

Cane knife used	Cut and stack		Cut and windrow		Cut and bundle	
	Burnt (%)	Green (%)	Burnt (%)	Green (%)	Burnt (%)	Green (%)
Long handled curved	64	22	89	0	84	67
Short handled curved	18	33	11	0	13	33
Mixed	18	45	0	0	3	0

A summary of average cutter output for various harvesting systems is given in Table 2. It is interesting to note that cutter output is affected more by the harvesting system than by whether cane is harvested burnt or green. Both burnt and green cut and stack systems illustrate the lowest cutter output. By contrast, the cut and windrow system had significantly the highest output.

Table 2. Average cane cutter performance for various harvesting systems.

Harvesting system	No. of samples	Average cane yield (t/ha)	Cutter output (tons/day)	Cutters per 1000 tons
Cut and stack (green)	10	72,50	3,45	1,79
Cut and stack (burnt)	18	69,60	4,20	1,44
Cut and bundle (green)	6	73,94	5,58	1,07
Cut and bundle (burnt)	22	69,93	6,56	1,08
Cut and windrow (burnt)	30	92,87	8,01	0,99

Time and motion studies

The time and motion studies were conducted in both burnt and green cane, and in both cut and stack and cut and windrow harvesting systems. The method used was the direct time study suitable for repetitive work (Currie, 1963; Murray and Meyer, 1982). The studies were conducted on six different farms, with two cutters being monitored simultaneously on each farm. A summary of the data collected during these studies is given in Table 3.

Table 3. Summary of time and motion studies.

Study No.	Cutter No.	Harvesting system*	Total time (h)	Cane yield (t)	Output (t/man/day)
1	1	C&W (B)	10,96	65	5,27
	2	C&W (B)	11,01	65	7,84
2	3	C&S (G)	8,37	100	4,89
	4	C&S (G)	8,42	100	4,04
3	5	C&S (G)	8,17	66	3,00
	6	C&S (G)	8,73	66	4,20
4	7	C&S (B)	6,12	86	4,00
	8	C&S (B)	4,95	86	3,30
5	9	C&W (B)	6,54	115	9,00
	10	C&W (B)	6,81	115	14,00
6	11	C&S (B)	7,66	109	8,50
	12	C&S (B)	6,51	109	6,20

* C&S = Cut and stack, C&W = Cut and windrow, (B) = Burnt, (G) = Green

Although the study sample is relatively small, it does show a wide range in cutter output within individual farms and also between farms. The percentage time cutters spend on various tasks also varied widely between cutters and harvesting systems. An example of the time spent by cutters on various tasks when cutting and stacking green cane is shown in Figure 1. As found by Brooks (1983), higher performing cutters spend a larger proportion of their shift time on cutting.

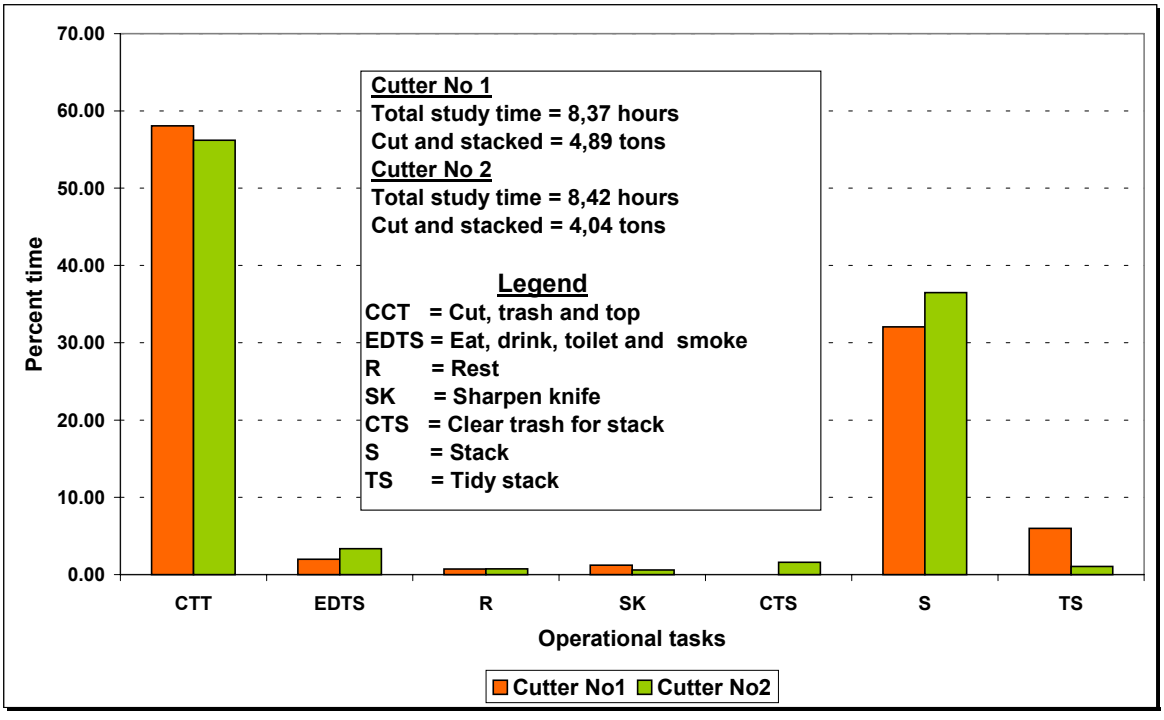

Figure 1. Typical percentage time spent by cutters on various tasks (cut and stack in green cane).

There were also significant differences in cutter productivity between the two main harvesting systems, i.e. cut and stack and cut and windrow, as shown in Figure 2. In burnt cane, cutters using the cut and windrow method of harvesting spent 77% of their time cutting cane, compared with 56% when using the cut and stack harvesting system. This resulted in 61% more cane being harvested.

Figure 2 also illustrates green versus burnt harvesting. The graph appears to indicate that cutters spent 15% more time cutting green cane than burnt cane when using the cut and stack harvesting system. However, the 'Cut and Top' bar for green cane includes an additional function (trashing) and therefore does not indicate that more time is spent on the cutting function alone. In fact, more time is spent on 'Other' processes. This resulted in a 28% reduction in cutter output, which corresponds with the 18% reduction in the cane cutter survey descriptive results.

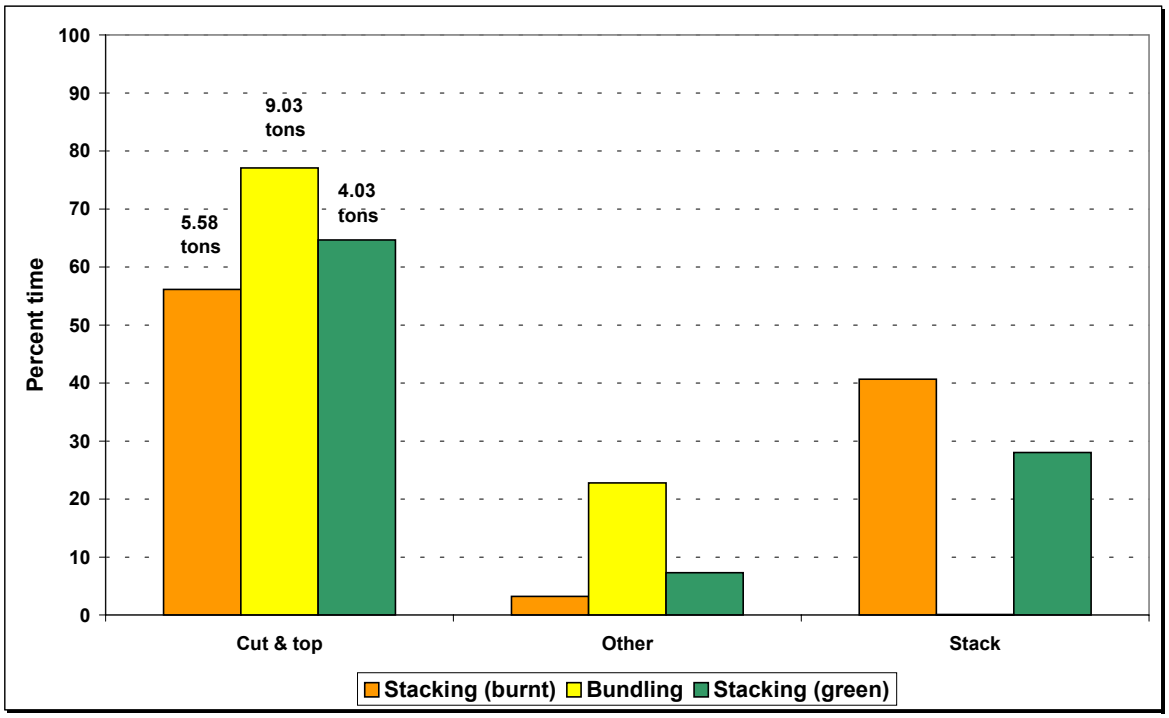

Figure 2. Average time (%) spent by cutters on various tasks for three harvesting systems.

Statistical analysis

The primary aim of the statistical analysis was to identify the factors responsible for some farms having higher average cane cutter productivity than others. Growers could apply the elements to their own enterprises to improve productivity and thereby lower costs.

Methodology

As illustrated in Table 2, the output norm for cutters is dependent on the type of cutting system. As a result, each system was analysed individually. With the predominantly male cutting force, results from male cutters only were used. In addition, due to the small sample size of Cut and Bundle (Green), this system could not be analysed. However, trends were noted.

All aspects covered in the survey form could potentially impact on cutter output. Each variable was therefore investigated using SPSS statistical software. For each cane cutting system, each variable was initially plotted against cane cutter output per day and the spread visually inspected. If differences in output were apparent in the data, means tests, correlation checks and regression analyses were performed to test the significance of the difference.

During this analysis, respondents were also grouped regionally, and the regional identification was superimposed on the data. Thus, regional differences were simultaneously checked to ensure that the difference captured in the variable was not due to high regional correlation. Regional differences are to be expected due to differences in terrain and varieties used.

Results and implications

The variables studied can be categorised in three broad groups: (i) 'people characteristics', (ii) field and cutting conditions, and (iii) remuneration and living conditions. A large number of the variables either did not display significant differences, or analyses could not be performed, as there was no variation in the data.

People characteristics' included nationality, age and length of service. Cane cutter performance did not indicate significant differences as a result of any of these characteristics. One would have expected experience to have an effect on cane cutter output. However, the length of service indicated only the time employed with the current employer and therefore did not capture this characteristic adequately.

Work and field conditions included terrain, crop varieties and cutting procedures. This group did illustrate some significant differences. Stony ground had a significantly negative impact on cutter performance, with the steepness of the terrain also having some impact. Variety and cane tonnage also affected productivity, with higher tonnages linked to higher productivity. The provision of water in the field had a significant impact (significant at 15% significance level and higher in some systems). When water was provided, productivity increased. This result agrees with the findings by Lambert *et al.* (1994) that weight loss from cutting, primarily due to fluid loss, could lead to chronic fatigue and consequent productivity declines. They indicated that at least six litres of water should be consumed while cutting, to minimise fluid loss.

There were two other interesting findings in this second category. Firstly, the person responsible for deciding performance bonuses had significant impacts (significant at the 20% level in some instances). Higher productivity was achieved when indunas supervised, than when managers, foremen or a combination of these supervised. The indunas have possibly more incentive to supervise better and ensure productive cutting gangs when they are given greater responsibility. The second interesting finding involved the use of helpers. Every cutting system indicated a negative effect on cutter performance when helpers were used. This was significant up to the 1% level. It is possible that the distraction element impacts on cutting time and concentration, and offsets any productivity improvements that occur with the splitting of tasks.

The third broad category of variables investigated the impacts of remuneration and living conditions. These did not feature as predominately as some might expect. Wage levels and structure did not appear to impact on productivity. The differences in basic task wages across farms did not indicate significant productivity differences. In the Cut and Bundle (Burnt) system, end of season bonuses did have positive productivity impacts (at the 1% significance level), as did permanent employment contracts (as opposed to seasonal or casual).

With the introduction of various laws and higher administrative burdens, many farmers have moved away from providing rations with wages and are paying only 'clean' wages. With studies indicating the importance of good nutrition (Lambert *et al.*, 1994) there is some concern that productivity will decline when balanced meals are not ensured. However, in this analysis, payment of clean wages did not appear to affect cane cutter productivity. Further investigation would be required on this aspect, as it was not clear from the data for what length of time clean wages had been paid.

The higher administrative burdens and labour relation issues have also caused a greater use of contractors. In this data, the use of contractors was extremely regional, with some sample regions using only contractors and others using none. However, where the sample indicated both types, such as in the Midlands, the use of contractors versus own labour did not appear to elicit productivity changes. The small sample size precludes statistical analysis, but visually both methods recorded both high and low average productivities, indicating no clear difference.

In general, the type and quality of staff housing does not appear to impact significantly on cutter performance. There were some individual cases: Cut and Stack (Green) illustrated a negative relationship with multiple beds (significant at the 10% level). Cut and Bundle (Burnt) had a significantly positive relationship, individually, with the provision of cooking facilities (5% significance) and television (15% significance), as well as illustrating significant differences at the 5% level in the total accommodation score (which total facilities supplied). Security aspects generally had little impact, as did the provision of soccer grounds, teams and soccer clothing.

Discussion and Conclusions

The survey showed that cane cutter productivity varied widely between harvesting systems and cutters, and between estates and farms. The time and motion studies have suggested that if the trash and topping tasks were removed, cutter productivity could be increased significantly. Studies have shown that the task of stacking cane expended three times as much energy while stacking, compared to the cutting task in the cut and stack harvesting system (Morrison and Blake, 1974). It is therefore not surprising that the cutter productivity in a cut and windrow system is generally substantially greater than the cut and stack harvesting system. The development and testing of mechanical cutting tools, and pre-trashing and topping devices should therefore be actively encouraged.

The results from the statistical analysis can give management some insight into the reasons why cane cutter output levels differ. The nature of these results appears to follow a Herzberg (1968) 'Motivation-Hygiene' response theory. In short, this proposes that the factors leading to worker satisfaction ('motivator' needs) are quite different from those causing dissatisfaction ('hygiene' needs). Job satisfaction and dissatisfaction are thus not opposites, as motivator needs are independent of hygiene needs. Hygiene needs would include working conditions, salary and job security. Motivator needs include recognition, responsibility and achievement. Thus, if salary and accommodation are sufficient to cause satisfaction, they will not necessarily influence work output positively. However, if dissatisfaction occurs, productivity will be adversely affected. Motivating aspects such as conferring responsibility to indunas and recognising good work will often elicit positive productivity responses.

It is proposed that employers approach productivity improvement methods with multiple strategies. Firstly, they need to ensure that there is no dissatisfaction with 'hygiene' needs, e.g. provision of water in the field (which also has important physiological impacts), and payment of market related salaries. Secondly, 'motivator' factors, such as conferring responsibility to and recognition of staff, should be incorporated into the style of management. Finally, field and crop conditions must be acknowledged and improved where possible, e.g. investigating varieties with higher tonnages. Factors such as stony ground and steep terrain may not be easily overcome, but must be factored into the costs and benefits of planting land to cane.

This study did not indicate significant differences between employing contractors and using own staff, and a larger sample is needed if further research is required. Similarly, no significant productivity difference was identified with 'clean' wages, and more research is required to fully investigate this impact.

However, for many growers the decision to employ contractors or pay clean wages is not for the purpose of seeking improved productivity, but rather to minimise staffing commitments and administrative burdens. This, then, becomes an individual cost-benefit decision.

It is likely that manual harvesting will remain popular in the South African sugar industry for the foreseeable future, despite legislative and health issues. It will therefore be to the benefit of the industry to conduct further research into quantifying and improving productivity. In addition, the industry should encourage and recognise both innovative harvesting methods and successful management systems.

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