ISSUES TO CONSIDER WHEN IMPLEMENTING
A MECHANICAL HARVESTING SYSTEM

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ABSTRACT

Across the globe, sugarcane is cultivated under a wide range of topographical and climatic conditions and the harvesting methods employed are extremely diverse. This is not surprising, as the situation and requirements of most sugar industries are unique. Although it is estimated that 80% of the world's sugarcane is harvested manually many industries are contemplating a move away from manually based harvesting systems. This paper describes some of the numerous field and agronomic factors which influence not only machine performance and quality of cane delivered to the factory but also operating costs of mechanised harvesting systems.

Keywords: Mechanical, sugarcane, harvesting

INTRODUCTION

Sugarcane is a major crop of many countries around the globe. Many of these are developing countries that are facing a rapidly expanding rural population, often coupled with an increasing unemployment situation. Theoretically this should guarantee an adequate supply of manual labour. However, with rising aspirations and improved standards of living manual harvesting of sugarcane is likely to become a less popular way of earning a living in the future.

Some countries have embarked on research projects to develop harvesting machines or have imported both whole stalk and combine chopper harvesters. Often the most important lessons learned from these projects was that the imported machines were unable to operate on steep slopes, in recumbent cane and in fields not specifically prepared for mechanisation.

ISSUES TO CONSIDER WHEN MECHANISING A HARVESTING SYSTEM

There are a host of factors to consider when contemplating a change in harvesting system. These factors range from social and political issues to availability of labour, capital outlay, local tax implications, change in transport and mill receiving facilities. However in this paper only some of the more important field, agronomic and economic factors are discussed.

FIELD PREPARATION

Generally, the more sophisticated the mechanised harvesting system, the higher the standards of field preparation required.
SLOPE

Ideally, to obtain maximum performance from any mechanised harvester, sugarcane should be grown on flat to undulating terrain. This is so because many of the existing harvesting machines are relatively heavy and narrow and often have a high centre of gravity.

LAND PREPARATION

Thorough land clearing, although often extremely costly, pays dividends in all subsequent mechanised field operations (Robinson, 1977). It permits efficient and effective use of land preparation, planting, ratoon cultivation and mechanical harvesting machinery and transport equipment. When considering implementing a mechanised harvesting system some form of land leveling or smoothing is generally necessary. This operation will:

- improve drainage and reduce drainage costs
- allow for efficient use of irrigation water
- prevent formation of waterlogged areas
- provide conditions which will allow the highest possible economic speed of both harvesting and infield transport machinery.

Experience has shown that a successful mechanical harvesting operation depends primarily on proper soil preparation not only to achieve the fine tilth necessary for optimum cane germination, but also to create the desired row and interrow profile. Rocks and stones should be removed from fields as these can and do cause considerable damage to the base cutting, conveying, cleaning and chopping mechanisms of harvesters resulting in high maintenance costs and loss of operational time.

FIELD LAYOUT

The primary objective is to present the harvester, loader and infield transport vehicles with straight, evenly spaced rows. Fields should preferably be laid out in block form with a minimum number of irrigation and drainage ditches and acceptable row lengths to reduce time lost in turning. Rows must not terminate in a bank or ditch, or in another row. Adequately wide headlands for the safe and speedy turning of the harvester and haulout equipment must be provided. Road surfaces should be hardened and well maintained to allow fast transportation of sugarcane.

ROW SPACING

For any mechanised harvesting system to be successful, rows must be planted parallel to one another. Wider row spacings are preferred for mechanisation and should be compatible with the wheel tracks of infield haulout transport vehicles to avoid cane stool damage. Any possible increase in cane yield due to narrower row spacing may be negated by stool damage and soil compaction caused by the wheels or tracks of harvesting and haulout equipment running on or close to the cane rows.

CANE ROW PROFILE

Many of the linear, transverse windrowing and bundling harvesting machines operate best on a flat row culture, i.e. row and interrow are on the same level. Without exception, no mechanical harvester can base cut cane at ground level efficiently and cost effectively where cane is grown in a furrow.

When cane is grown on a ridge the ridge height (difference in height between the row and the interrow) should
be constant to avoid poor base cutting and to reduce excessive soil being included in the cane. Matching these two factors will result in improved harvester output, better ratooning, reduced cane losses and less extraneous matter in the cane.

CANE ROW LENGTH

Row length should suit both the harvester and transport equipment. Normally, row lengths of between 200 and 600 m will result in acceptable machine performance for most types of mechanised harvesting and loading systems. Ideally, rows from adjacent blocks must be aligned so that the harvester can travel from one block to another without stopping.

RATOON CROP MANAGEMENT

Mechanical cultivation is usually carried out after harvesting burnt cane to maintain a raised row profile, to smooth the interrow space or to ameliorate soil compaction. Stool pruning must be done in old ratoons where stool widths exceed base cutter dimensions, or harvester throat widths.

AGRONOMIC FACTORS

Although it is not possible to discuss all the agronomic factors associated with mechanical harvesting, it is prudent to expand on the following issues:

CANE VARIETIES

Sugarcane variety traits for mechanical harvesting that were considered most important by delegates attending the recent ISSCT joint mechanisation/factory processing workshop held in Mexico (de Beer and Purchase, 1998) were:

- Erectness
- Uniform stalk height
- Low residue/cane ratio
- Non-brittle
- Non-flowering
- Minimal tops and trash
- Self-trashing or loose leaved habit
- Tolerant to trash blankets
- Resistance or low incidence of suckering.

It is generally accepted that thin stalked, trashy varieties, which are prone to lodging, will result in high cane losses and extraneous matter levels when harvested.

SOIL COMPACTION

It is essential that row spacing and stool widths are compatible with harvester and infield haulout machinery track widths. The effect on cane yield of travelling in the interrow or on the cane row, is illustrated in Table 1 (Swinford and Boevey, 1984) for a Longlands soil form.
Table 1. A summary of cane and sucrose yields for 1st and 2nd ratoon crops

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1st ratoon 18/12/80-4/5/82</th>
<th>2nd ratoon 4/5/82-29/8/83</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nil</td>
<td>80</td>
<td>34</td>
</tr>
<tr>
<td>Moderate Interrow compaction</td>
<td>69</td>
<td>25</td>
</tr>
<tr>
<td>Moderate Row &amp; interrow compaction</td>
<td>58</td>
<td>20</td>
</tr>
<tr>
<td>Severe Interrow compaction</td>
<td>63</td>
<td>22</td>
</tr>
<tr>
<td>Severe Row &amp; interrow compaction</td>
<td>61</td>
<td>18</td>
</tr>
</tbody>
</table>


Soil compaction studies conducted in Colombia have reported similar results (Torres et al., 1989).

To avoid or reduce soil compaction harvesting machinery should be fitted with large diameter high flotation tyres, walking beam axles and weight transfer hitches (Poole, 1989). Total vehicle and trailer mass should be kept to a minimum to minimise potential soil compaction (de Beer et al., 1993).

Other factors, which reduce the risk of soil compaction, include:

- green cane harvesting
- harvesting susceptible fields during the dry period
- incorporation of organic matter
- avoiding over-irrigation
- allowing a proper drying off period in irrigated fields.

CANE QUALITY

Soil in cane:

A number of factors play important roles in levels of soil in cane including soil type, soil moisture, cane variety, age of crop, farming practices, inappropriate or poorly adjusted cultivation equipment, poorly maintained row profile, type of harvester, harvester component design, maintenance and adjustment of harvester components and operator proficiency (Benson, 1995).

Research conducted by the BSES in Australia has shown that soil in cane can be reduced by changing the base cutter disc angle from 11° to 17° (Ridge, 1995). Tests conducted on chopper harvesters have shown that soil levels increased by between 30 and 50% for every 2 km/h increase in harvester forward speed (Benson, 1995). Furthermore, soil levels increased by 60% as a result of changing base cutting from 20 to 60 mm depth below ground level under Australian conditions.

Extraneous matter:

Little information is available on extraneous matter levels for whole stalk bundling machines. Tests conducted in South Africa on a prototype green cane harvester showed that total extraneous matter content for the season was below 8% compared with the mill average of 12.6% (Pilcher and Boast, 1980).

The level of extraneous matter in cane harvested with chopper harvesters varies widely, and depends on a
number of factors including cane variety, yield, condition of the crop and weather conditions. Extraneous matter delivered by chopper combine harvesters ranges between 5 and 20% (de Beer et al., 1996).

CANE LOSSES

Cane losses following mechanical harvesting vary enormously, and depend on a host of factors including the following:

- cane variety
- crop conditions
- green or burnt cane
- harvester type
- operator proficiency
- field conditions
- weather conditions.

Cane losses when using the traditional Louisiana 'Soldier' whole stalk harvesting and chopper harvesting system have been assessed (Richard et al, 1996). Significant cane losses can occur through the cleaning systems of chopper combine harvesters. Cane loss through the primary and secondary extractor fans is highly dependent on variety (Ridge and Dick, 1989).

Machine adjustment:

With chopper harvesters there is a strong relationship between extractor fan speed, cane loss and extraneous matter (de Beer et al, 1996). Results of such research are given in Table 2.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Extractor Speed (rpm)</th>
<th>Cane loss (t/ha)</th>
<th>Extraneous Matter (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>1 000</td>
<td>1.2</td>
<td>10.6</td>
</tr>
<tr>
<td></td>
<td>1 250</td>
<td>3.7</td>
<td>8.5</td>
</tr>
<tr>
<td></td>
<td>1 450</td>
<td>9.7</td>
<td>7.4</td>
</tr>
<tr>
<td>Burnt</td>
<td>1 000</td>
<td>0.6</td>
<td>6.6</td>
</tr>
<tr>
<td></td>
<td>1 250</td>
<td>0.9</td>
<td>5.2</td>
</tr>
<tr>
<td></td>
<td>1 450</td>
<td>3.1</td>
<td>3.7</td>
</tr>
</tbody>
</table>

BSES engineers have successfully developed a cane loss monitor and fan speed controller which reduce losses to a minimum (Dick and Hilton, 1996).

Machine maintenance:

Machine maintenance and adjustment play important roles in machine availability and daily operating time, quality of cane harvested and cane losses. Tests conducted in Swaziland clearly illustrated the importance of maintaining machines in a good state of repair (de Beer and Boevey, 1979).
CANE DETERIORATION

Several researchers (Egan, 1967; Irvine and Legendre, 1973) have reported on the increased rate of cane deterioration in chopped cane compared with whole stalk cane, particularly in hot, humid conditions. Green cane deterioration for both whole stalk and chopped cane is slower than that of burnt cane (Wood, 1976).

ECONOMICS

There are numerous factors which influence the operating costs of harvesting machines, including field and crop conditions, operator proficiency, machine maintenance, number of loaders and number of transport units. The economic viability of any harvesting system is highly dependent on machine hourly output and total annual tonnage handled.

Several user-friendly computer-based models have been developed to estimate the performance and cost of sugarcane combine harvesters and associated infield transport (Ferguson and Wise, 1987; Sálassi and Champagne, 1996; Meyer, 1998). These models have been used successfully to assess the effect that various field parameters, infield cultural practices, number and capacity of infield transport vehicles and the haulout distances have on harvester output. One of the most important factors determining the viability of introducing a fully mechanised chopper harvesting system is cane throughput per machine (Meyer, 1997). With the aid of a model it is relatively easy to predict combine chopper harvesting costs and daily operating times for a range of annual tonnages, as illustrated in Figure 1.

Figure 1. Harvesting cost and daily operating hours vs annual cane throughput for a 200 day harvesting season (R6.2 = 1 US $)

CONCLUSIONS

There are numerous factors to consider when contemplating a move away from a manual based harvesting system to a mechanised harvesting system. This paper has highlighted some of the more important issues to consider when comparing alternative harvesting systems.

To achieve competitive harvesting rates for any mechanised harvesting system it is essential that the machines perform efficiently and attain a high throughput and usage. If sugarcane producers are serious about mechanising their harvesting operations special attention will have to be paid to field and crop conditions to ensure higher machinery throughput and efficiency.
REFERENCES


ASUNTOS PARA CONSIDERARSE MIENTRAS PONIENDO EN MARCHA UN SISTEMA COSECHADOR MECÁNICO

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RESUMEN

En todas partes del mundo se cultiva la caña de azúcar bajo un amplio rango de condiciones topográficas y climáticas, y son diversos los modos de cosechar. Esto no causa sorpresa porque son únicos la situación y requerimientos de la mayoría de las industrias azucareras. Aunque se estima que un 80% de la caña de azúcar del mundo es cosechada a mano muchas industrias están contemplando cambiar de los sistemas cosechadores manuales. Este papel describe unos de los numerosos factores de campo y agronómicos que influyen no sólo el desempeño de la máquina y la calidad de la caña suministrada a la fábrica sino también los costos operativos de los sistemas cosechadores mecanizados.

Palabras claves: mecánico, caña de azúcar, cosechar.

CONSIDERATIONS SUR LE CHOIX D’UN SYSTÈME DE RÉCOLTE MECANIQUE

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RÉSUMÉ

La canne à sucre est de par le monde cultivée sous un large panel de conditions topographiques et climatiques et, les méthodes de récolte sont extrêmement diverses. Ceci n’est pas surprenant puisque les situations et les besoins de la plupart des industries sucrières sont uniques. Même si au niveau mondial environ 80% de la canne à sucre est récoltée manuellement, beaucoup de pays producteurs pensent à une évolution de leur système de récolte. Ce document décrit quelques uns des nombreux facteurs agronomiques et culturaux qui influencent non seulement les performances des machines et la qualité de la canne livrée à l’usine, mais aussi les coûts d’intervention des systèmes de récolte mécanique.

MC: mécanique, canne à sucre, récolte