COMPARATIVE TESTING OF A FLOATING AND A CONVENTIONAL FIXED BASE CUTTER

By

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Abstract

A novel system for controlling base cutter cutting height was designed and manufactured in an attempt to improve the performance of commercial sugarcane chopper harvesters. The system differed from previous attempts to control base cutter height by suspending the base cutter gearbox and associated components as a discrete module incorporating a passive height control system. The advantages offered by this system include the potential for rapid response to cutting height requirements, the elimination of the secondary effects of base cutter height adjustments on topper height setting and, being fully automatic, the system does not require additional hydraulic or mechanical control. This paper reviews the results of a testing program undertaken on the floating base cutter system during the 2000–2001 harvesting season (April to September 2000) with machines working in commercial cane fields. The results of the trial program indicated that the mineral trash levels (soil in cane) in loads transported from field to mill were consistently lower from machines fitted with the floating base cutter system relative to standard machines. The amounts of roots and stools removed from the field were also lower with the floating base cutter. However, under the conditions of the tests, statistical significance was not achieved.

Introduction

Interest in chopper harvesting of sugarcane has increased in Brazil, mainly for areas with suitable topography, and where there are labour shortages. The advantage of chopper harvesting over other mechanised harvesting options is the ability of these machines to cut, billet, clean and transport sugarcane as an integrated operation. Chopper harvesting does, however, have disadvantages. Fernandes et al. (1997) assert that, with this method of harvesting, more impurities (extraneous matter and soil) will be present in the cane being delivered to the mill and there will be greater losses of cane in the field.

Increased amounts of extraneous matter and soil in the cane to be processed increases the cost of transport and milling equipment maintenance, and reduces milling efficiency and the extraction of sucrose (Anon., 1988; Dick, 1986; de Beer, 1980; de Beer et al., 1983). Anon. (1988) observed that, by delivering poorer quality cane and leaving more cane in the field, losses could exceed whatever cost reductions might be effected through mechanisation. He estimated that each increment of 1% in extraneous matter caused a reduction of 1.3% to 1.4% in the theoretically recoverable sugar (TRS) content of the cane.

In an analysis of the sources of loss in the harvesting process, as well as determining the machine functions that significantly impact on loss and extraneous matter being sent to the mill, the base cutter, and in particular base cutter height, has a significant impact on both losses and extraneous matter.

On many harvesters, the base cutters are fixed to the machine chassis, and base cutter height control is effected by varying the height of the harvester through hydraulic cylinders acting on the chassis. While various attempts have been made to automate the control of base cutter height to enhance machine performance, none have apparently advanced to commercially viable systems. Other problems which could apply to base cutter height control systems that lift and lower the entire front section of the machine frame, include the effect on topping height and the dynamic stability of the machine when in pitch mode.

Methods and materials

To improve machine performance, the floating base cutter was developed. A simple mechanism consisting of articulated arms joins the base cutter components (motor, gear box, discs and blades) to the machine structure. As a result, variations in the level of the soil surface can be accommodated smoothly and quickly. The articulated arms allow the base cutter to move back-and-up or forward-and-down simultaneously. Two springs balance some of the weight of the equipment, thus reducing the pressure between the height control ‘hubcap’ and the soil (Figure 1).

This device (Figure 2) was designed and patented by the Mechanical Equipment Design Section of Copersucar Technology Center. During the 2000–2001 season, the design was improved and two prototypes were installed in Austoft A7700 chopper harvesters belonging to São Martinho mill. Tests and assessments were carried out in the field.

KEYWORDS: Floating Base Cutter, Unburnt Cane, Chopped Cane Harvester, Mineral Trash, Extraneous Materials.
Initial field observations

Advantages of the floating base cutter observed in the field included:

(a) The device works automatically when undulations are less than 100 mm. The operator is thus relieved of some responsibility and the work becomes less stressful.
(b) Less soil in the cane to be transported to the mill.
(c) Reduced amount of stubble pulled out of the soil.
(d) Reduced number of butts remaining in the field and reduced stool damage.
(e) Reduced maintenance costs because base cutter blades need to be changed less often.
(f) Reduced fuel consumption by the harvester.

Advantages observed at the mill included:

(a) Less maintenance required and less wear on mill equipment (crusher rollers, cane carriers, bagasse conveyors, rotary filters, steam boilers).
(b) Increased efficiency at the mill imbibition, clarification and juice decanting stations.
(c) Improved juice quality, with better alcohol and sugar quality as a result.

<table>
<thead>
<tr>
<th>Material</th>
<th>Base cutter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Floating</td>
</tr>
<tr>
<td>Trash (%)</td>
<td>0.07</td>
</tr>
<tr>
<td>Stubble (kg)</td>
<td>0.18</td>
</tr>
<tr>
<td>Butts in field (t/ha)</td>
<td>1.23</td>
</tr>
</tbody>
</table>

Table 1—Results of field trial in unburnt cane, conducted in dry soil between April and September 2000, on the floating and fixed base cutters.

Field testing program
The trial was carried out in a commercial production area of the Sâo Martinho Mill. The test harvester (Austoft A7700) equipped with the floating base cutter was used for all trials, with the floating mechanism either enabled or disabled for the test program.

The following test protocol was used:
- The visible cane losses in the field were assessed by identifying whole cane stalks, billets, pieces of cane, butts and tops.
- After harvest, these components were quantified as follows:
  - random 5 m lengths of single rows were identified;
  - all millable material left in these five rows was collected;
  - to separate whole stalks from tops, the tops were broken off at the natural breaking point;
  - a billet was defined as that part of the stalk with typical chopper cuts at both ends;
  - stubble was defined as the base of the cane stool with roots fixed in the soil;
  - butts were defined as the bases of stalks left intact in the field, i.e. not part of stools pulled out of the ground. If butts were longer than 20 cm, they were classified as pieces of cane stalk.
- One random sample per truck was taken in the field to determine the extraneous matter content. The samples were placed on a plastic sheet and cleaned manually, separating clean cane, stubble and trash (leaves and soil) before weighing.

The amount of stubble pulled out of the soil and left in the field was assessed:
- The root systems that would have been attached to cane stalks were included in stubble.
- The amount of stubble was determined by weighing the unearthed stubble and counting the number per sample.
- To build the database for the base cutter blades, the trial was conducted with two harvesters equipped with floating base cutters in comparison with six other machines equipped with conventional fixed base cutters. All were from the same fleet.

Results and discussion
Two harvesters, machine numbers 27 and 29, were assembled with the floating base cutter system for trials in the field, carried out from April to September 2000, using only machine 29. Five trials, which provided 69 sets of data, were conducted from 01/06/00 to 24/08/00.

Amounts of trash, stubble, and visible losses in the field
Table 2 and Figure 3 show the amounts of trash in cane to be sent to the mill, the amount of stubble and the amount of butts left in the field.

A variance analysis of the data shown in Table 2 and Figure 3 leads to the following possible conclusions:
- When the cane was harvested conventionally (fixed base cutter), the amount of extraneous matter was approximately twice (243%) as much as when the floating base cutter was used. The average difference was statistically significant.
- The numbers and weights of stubble that were pulled out of the soil by the conventional base cutter were approximately twice as high (190%) as those observed when the floating base cutter was used, although the average difference was not statistically significant.
- The visible losses (butts remaining in the field) were approximately 10% higher when the fixed base cutter was used than when the floating device was used, but the averages were not statistically different.

Table 2—Results of field trials showing the amounts of trash in cane, unearthed stubble and butts left in the field in four varieties.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Age</th>
<th>Soil (%)</th>
<th>Leaves (%)</th>
<th>Stubble (kg)</th>
<th>Butts (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Floating</td>
<td>Fixed</td>
<td>Floating</td>
<td>Fixed</td>
</tr>
<tr>
<td>SP80-1842</td>
<td>3R</td>
<td>0.11</td>
<td>0.42</td>
<td>6.9</td>
<td>7.7</td>
</tr>
<tr>
<td>RB835336</td>
<td>5R</td>
<td>0.06</td>
<td>0.18</td>
<td>10.6</td>
<td>11.5</td>
</tr>
<tr>
<td>SP79-2233</td>
<td>2R</td>
<td>0.06</td>
<td>0.05</td>
<td>8.5</td>
<td>6.8</td>
</tr>
<tr>
<td>RB835486</td>
<td>4R</td>
<td>0.06</td>
<td>0.14</td>
<td>5.0</td>
<td>7.0</td>
</tr>
<tr>
<td>RB835486</td>
<td>5R</td>
<td>0.04</td>
<td>0.05</td>
<td>5.4</td>
<td>5.1</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(data number)</td>
<td>(99)</td>
<td>(69)</td>
<td>(69)</td>
<td>(99)</td>
<td>(69)</td>
</tr>
<tr>
<td>Std deviation</td>
<td>0.03</td>
<td>0.16</td>
<td>2.33</td>
<td>0.34</td>
<td>0.01</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>39.51</td>
<td>90.41</td>
<td>32.00</td>
<td>30.66</td>
<td>52.62</td>
</tr>
</tbody>
</table>
Base cutter blade wear

All blades were made of SAE 5160 spring steel with 49 HRC hardness, a product generally found on the market. When the blade wear on the blades reached 4.4% by weight they were replaced (Figure 4). This was the point at which the blades were considered to be too blunt for further use. On the fixed base cutter, wear on the blades reached 4.4% after working for 25.1 hours. On the floating system, this point was reached only after 62.7 hours. Calculations showed that the blades on the floating device had to be changed 2.5 times less than those on the fixed base cutter (Figure 5). Thus, the floating base cutter saved 1200 blades and 120 blade changes, as shown below:

- Days per season = 200
- Number of days per blade change
  - Floating = 2.5 days
  - Fixed = 1.0 day
- One base cutter set (2 discs) = 10 blades;
  - each disc = 5 blades
- Quantity of blades per season:
  - Fixed = 200 × 1 day/1 change × 10 = 2000 blades
  - Floating = 200 × 1 day/2.5 changes × 10 = 800 blades
- Difference = 1200 blades
- Average time taken to change a base cutter set = 20 minutes
- Price per blade = US$1.75
- Harvester cost (hour/machine) = US$58.00
- Number of changes saved = 1 200 blades/10 blades per set = 120 changes.

Cost reduction per machine

- Blades: 1 200 × US$1.75 = US$2 100.00
- Time: 120 changes × 20 min/60 min/h × US$58.00/h/machine = US$2 320.00
- Total = US$4 420.00

Not taken into consideration in the above calculations were the beneficial effects for the mill from a 60% reduction in extraneous matter, and a 50% reduction in the amount of stools being pulled out of the soil (thus safeguarding subsequent ratoon yields). A mill that opts to install floating base cutters on its harvesters can expect a reduction in cane processing costs of US$4400.00 per machine per season.

Conclusions

The results of field trials to date showed that the floating base cutter performs better than the fixed base cutter. There are favourable implications for mills that introduce the floating base cutter on their chopper harvesters, as data showed that the floating base cutter caused the amount of extraneous matter in the cane delivered to the mill to be less, the amount of stubble pulled out of the soil to be less, and the visible infield losses to be lower.

However, it will be necessary in the future to conduct further trials because reductions in visible infield losses and the amounts of stubble pulled out of the soil were not statistically significant. Also, it should be kept in mind that the extraneous matter levels were in general very low because of the little rain that fell during the period of the trials. Proportionally, nevertheless, the differences between the two sets of data should be similar under both wet and dry conditions.
Fig. 4—Comparison between floating and fixed base cutters of time taken for blades to reach 4.4% wear.

Fig. 5—Condition of blades on the fixed base cutter (left) after 25.7 hours, and blades on the floating base cutter after 27.8 and 32.3 hours.

REFERENCES


ETUDE COMPARATIVE D’UN DISQUE DE COUPE FLOTTANT ET D’UN DISQUE FIXE CONVENTIONNEL

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Résumé
Un nouveau système pour contrôler la hauteur de coupe a été conçu et fabriqué en vue d’améliorer la performance des coupeuses en cannes tronçonnées. Le système diffère de ceux précédemment essayés par la liaison de la transmission des disques de coupe et de ses annexes avec un palpeur qui suit les variations de la surface du sol.

Une réponse rapide aux variations de la surface du sol et l’élimination des effets secondaires d’ajustement de la hauteur des disques de coupe sur le réglage de l’écumeur constituent les principaux avantages de ce système. De plus, étant totalement automatique, le système ne requiert pas de contrôles hydrauliques et mécaniques supplémentaires.

Cette communication passe en revue les résultats d’un programme d’évaluation du disque de coupe flottant pendant la saison 2000/2001 (avril à septembre 2000) avec des machines opérant dans des conditions industrielles.

Les résultats ont montré que la canne récoltée par des machines équipées de disques flottants contenait moins de matières étrangères minérales (terre) que celle récoltée par des machines conventionnelles. Le volume de racines et de souches était aussi inférieur avec les disques de coupe flottants. Toutefois, dans les conditions de, les différences entre les deux systèmes n’étaient pas significatives.

Mots clés: disque de coupe flottant, canne non brûlée, coupeuse en cannes tronçonnées, matière étrangère minérale.

ENSAYO COMPARATIVO ENTRE CUCHILLAS DE BASE FLOTANTE Y CUCHILLAS DE BASE FIJO CONVENCIONAL

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Resumen
Se diseñó y fabricó un novedoso sistema para controlar la altura de corte de las cuchillas de base, con el fin de mejorar el desempeño de las máquinas combinadas comerciales. El sistema differía de los diseños anteriores de control de altura de las cuchillas de base, en que la caja de engranajes de las cuchillas y sus componentes asociados estaban suspendidos como un módulo discreto, incorporando un sistema pasivo de control de altura.

Las ventajas ofrecidas por este sistema incluyen la potencia necesaria para una rápida respuesta a los distintos requerimientos de altura de corte, y la eliminación de los efectos secundarios del ajuste de altura de la cuchilla de base sobre el ajuste de la altura de la cuchilla de corte superior del tallo. Siendo el sistema totalmente automático, el mismo no requiere controles mecánicos o hidráulicos adicionales.

El presente trabajo analiza los resultados de experiencias conducidas con el sistema de cuchilla de base flotante durante la zafra 2000–2001 (Abril a Setiembre 2000), con máquinas operando en plantaciones comerciales.

Los resultados de las evaluaciones indicaron que los niveles de trash mineral (suelo en caña) encontrados en cargas transportadas del campo al ingenio, eran consistentemente menores que los encontrados en las máquinas equipadas con el sistema de cuchilla de base flotante en relación a las máquinas convencionales. Las cantidades de raíces y cepas extraídas del terreno con el sistema de cuchillas de base flotante eran también inferiores. Sin embargo, bajo las condiciones de los ensayos, no pudieron obtenerse diferencias significativas.

Palabras claves: cuchilla de base flotante, caña verde, cosechadora de trozos de caña, impurezas minerales, materias extrañas.