Effect of traffic-control strategies for harvesting sugarcane

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Abstract This study aimed to evaluate the effect of traffic control strategies for harvesting sugarcane. A randomized complete-block design was used with four treatments that resulted from the interaction of two factors of variation (cane harvester and tractor coupling), with and without auto-guidance systems. The experiment was conducted on a 6.6-ha commercial sugarcane field, located on the Cascajal Farm of the Manuelita S.A. sugar mill near Palmira, Valle del Cauca, Colombia. Results indicate that fewer changes occurred in soil properties, such as soil bulk density, resistance to penetration, and inter-row profile change, in treatments with controlled traffic as compared with treatments without traffic control. Traffic control, therefore, has a positive effect on the evaluated soil properties, but no significant effect on labor performance or quality of mechanical cutting of cane.

Key words Precision agriculture, traffic control, sugarcane

INTRODUCTION

The harvesting of sugarcane involves several controllable factors, such as logistics, workers, and machinery, as well as uncontrollable factors, such as climate, amount of biomass in the field, and soil properties. By installing auto-guidance systems in cane harvesters to control their track in the field, referred to as controlled traffic, cane farmers hope to reduce operational problems such as accidents, increase labor efficiency, reduce harvester operator fatigue, reduce traffic damage, and maintain soil bulk density within rows (Braunack and Peatey 1999; Braunack and McGarry 2006; Tullberg et al. 2007).

Here, we evaluated interaction of two factors of variation (cane harvester and tractor coupling), with and without auto-guidance systems.

MATERIALS AND METHODS

The experiment was conducted in a 6.6-ha commercial sugarcane field on the Cascajal Farm of Manuelita S.A. near Palmira, department of Valle del Cauca, Colombia. We used a randomized complete-block experimental design with four treatments that resulted from the interaction of two factors of variation: cane harvester and tractor coupling, each at two levels: and with auto-guidance system (Auto) and without auto-guidance, in other words manual steering (Manual). Treatments were as follows: Auto (harvester)–Auto (tractor), Auto (harvester)–Manual (tractor), Manual (harvester)–Auto (tractor), and Manual (harvester)–Manual (tractor), for a total of 16 experimental units (Fig. 1).

Fig. 1. Experimental design.
Response variables were classified into soil physical properties (soil deformation, bulk density, resistance to penetration) (Fig. 2) and performance efficiency (cut time, operational field efficiency). We used a Case A8800 harvester on which a Case Autopilot® auto-guidance system was installed with RTK GNSS correction, and a Case Magnum 290 HP tractor on which an AccuGuide system with RTX Center Point GNSS correction was installed.

RESULTS AND DISCUSSION

Soil deformation occurred in all cane rows evaluated (Fig. 3). However, there were no significant differences between treatments. Inter-rows in the Auto-Auto treatment recorded the lowest deformed area (169.7 cm²), compared with the Manual-Manual treatment (286.4 cm²). For soil compaction, the Auto-Auto treatment recorded a change of -0.01 g/cm³ in soil bulk density, whereas the Manual-Manual treatment recorded a change of +0.13 g/cm³, indicating a temporary increase in soil compaction when both harvester and tractor are steered manually.

For soil penetration resistance, significance differences between the Auto-Auto and the Manual-Manual treatments only occurred for the first 3 cm of the soil profile. The average value of change in soil penetration resistance in the Auto-Auto treatment was -0.22 MPa, compared with +0.29 MPa in the Manual-Manual treatment.

Contrasting results were obtained in terms of labor performance because both cut and harvester turn times were less in the Manual-Manual treatment as compared with the Auto-Auto treatment (Table 1). Harvester speed and harvester cut productivity also recorded higher and significantly different average values in the Manual-Manual treatment as compared with the Auto-Auto treatment - we attribute this to the higher amount of cane biomass in the latter treatment as compared with the former.
CONCLUSIONS

- There were fewer changes in soil properties when the sugarcane harvester was controlled by an auto-guidance system than with manual steering.
- Use of auto-guidance systems in sugarcane harvesters had no positive effect on improving labor performance parameters because these parameters depend on cane biomass.

ACKNOWLEDGEMENTS

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REFERENCES


Table 1. Harvest performance parameters.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cut time (min)</th>
<th>Turn time (min)</th>
<th>Stop time (min)</th>
<th>Speed (km/h)</th>
<th>Cut productivity (ha/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto-Auto</td>
<td>2.48 a</td>
<td>1.23 a</td>
<td>0.098 a</td>
<td>3.47 a</td>
<td>0.63 a</td>
</tr>
<tr>
<td>Auto-Manual</td>
<td>2.35 a</td>
<td>1.18 a</td>
<td>0.010 a</td>
<td>3.65 a</td>
<td>0.66 a</td>
</tr>
<tr>
<td>Manual-Auto</td>
<td>2.85 a</td>
<td>1.12 a</td>
<td>0.083 a</td>
<td>3.32 a</td>
<td>0.60 a</td>
</tr>
<tr>
<td>Manual-Manual</td>
<td>2.07 a</td>
<td>1.10 a</td>
<td>0.004 a</td>
<td>4.15 a</td>
<td>0.75 b</td>
</tr>
</tbody>
</table>

*Treatments in the same column with the same letters are not significantly different (P < 0.05).

Effet des stratégies du ‘traffic control’ dans la récolte de canne à sucre

Résumé. Cette étude visait à évaluer l’effet des stratégies de traffic control dans la récolte de la canne à sucre. Un essai avec blocs randomisés a été mis en place avec quatre traitements découlant de l’interaction de deux facteurs de variation (récolteuse de canne et attelage du tracteur), avec et sans le système d’autoguidage. L’expérience a été réalisée sur une exploitation commerciale de 6.6 ha, situé sur l’exploitation de Cascajal appartenant à l’établissement sucrier de Manuelita S.A. près de Palmira, Valle del Cauca en Colombie. Les résultats démontrent que les propriétés du sol, tels que la densité apparente du sol, la résistance à la pénétration et le profil de l’entre-ligne, subissent moins de changement avec les traitements ‘traffic-control’. Par conséquent, le ‘traffic control’ a un effet positif sur les propriétés du sol qui ont été évaluées, mais aucun d’effet significatif sur la performance de la main d’œuvre ou la qualité de la récolte mécanique de la canne.

Mots-clés: Agriculture de précision, traffic control, canne à sucre

Efecto de estrategias de tráfico controlado para cosecha de caña de azúcar

Resumen. El estudio tuvo como objetivo evaluar el efecto de estrategias de tráfico controlado para cosecha de caña de azúcar. Un diseño experimental en bloques completos al azar fue usado con cuatro tratamientos que resultaron de la interacción de dos factores de variación: cosechadora de caña y tractor de cadeno, con y sin sistema autoguía. El experimento fue llevado a cabo sobre 6.6 ha de un campo comercial de caña de azúcar localizado en la Hacienda Cascajal del Ingenio Manuelita S.A. cerca de Palmira (Valle del Cauca – Colombia). Los resultados indican que se generaron pequeños cambios en las propiedades físicas del suelo evaluadas, tales como densidad aparente, resistencia a la penetración y cambio de perfil en el entre surco en los tratamientos con tráfico controlado, comparado con los tratamientos sin tráfico controlado. El control de tráfico, sin embargo, tiene un efecto positivo sobre las propiedades físicas evaluadas, pero no tiene efectos positivos sobre la eficiencia ni sobre la calidad del corte mecánico de la labor de cosecha.

Palabras clave: Cosecha, tráfico controlado, sistema autoguía, agricultura de precisión, caña de azúcar