Sugarcane performance under different row configurations designed to accommodate in-field traffic

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Abstract Moving from manual to mechanized harvest increases infield traffic. In San Carlos (Ecuador) the sugarcane area under mechanical harvest increased from 26% in 2005 to 86% in 2015. The adoption of controlled traffic contributes to the reduction of soil compaction. Trials were conducted to measure the impact of different row configurations on sugarcane growth and yield. From 2009 to 2011 plant cane and first-ratoon crops were evaluated in five trials where four row configurations were compared: single-row spacings at 1.5 m, 1.65 m and 1.8 m, and dual-row spacing at 1.8 m (0.5 m between dual rows). From 2012 to 2015 the standard single row at 1.5 m was compared to dual row (DR) at 1.9 m spacing (0.5 m between dual rows), and cane yield response compared for 64 paired fields. Results suggest the higher planting density of the DR increased cane yield, and the single-row spacings wider than the standard resulted in reduced yields. DR produced 9%, 7% and 12% higher cane yields in the plant crop, and 5%, 27% and 47% in the first ratoon than single-row spacings of 1.5 m, 1.65 m, and 1.8 m, respectively. In the paired-fields comparison, cane yield from the dual row spacing was 7% and 3% higher in plant cane and the first ratoon, respectively. To adopt controlled traffic in San Carlos a dual row configuration is recommended to reduce yield losses from single-row spacings wider than the standard row spacing.

Key words Sugarcane, row-spacing, controlled traffic, dual row, planting density

INTRODUCTION

In San Carlos, Ecuador, the area under mechanized harvest increased from 26% in 2005 to 86% in 2015. Moving from manual to mechanized harvest increases infield traffic. The mismatch between the standard row spacing of 1.5 m and the wheels of harvesting equipment mostly at 1.8-2.0 m resulted not only in soil compaction in the inter-row area but also on the row. Traffic can reduce sugarcane yield by increasing soil bulk density and limiting the availability of soil water (Braunack and Peatey 1999; Garside et al. 2008).

The adoption of controlled traffic can help to reduce soil compaction in the crop production area. A row spacing wider than 1.5 m is needed to adopt controlled traffic. It has been reported that under certain environments single-row spacings wider than 1.5 m cause a reduction in cane yield (Ridge and Hurney 1994).

Our study evaluated sugarcane growth and yield under various row configurations that are suitable for controlled traffic. The objective of this paper was to determine whether wider single-row spacings are sufficient to reduce stool damage and to increase yields relative to dual rows (DR) with a potentially higher stalk population per hectare.

MATERIALS AND METHODS

Five commercial scale trials (11.9-18.4 ha) were planted between 28 September and 12 November 2009 in five fields of the San Carlos Mill. Four row configurations were evaluated: single row spacings at 1.5 m, 1.65 m and 1.8 m, and DR at 1.8 m spacing with duals at 0.5 m (1.3m + 0.5 m). Each trial consisted of one commercial field divided in four equal areas (3-6 ha), each area consisted out of one treatment. Each trial was planted with a different variety: CC-8592, ECU-01, CR74250, SP792233 and Ragnar.

In each trial, stalk population was determined from 60 10-m-row length subplots, and stalk diameter and stalk height were determined from 300 plants per treatment taken at 30-day intervals from 30 days after planting (DAP) until 330 DAP (harvest age). At the same time, leaf area index (LAI) was estimated by measuring the length and width at the widest point of green leaves of 150 plants per treatment 7-9 times during the crop cycle of the plant cane. Cane yield and sucrose recovery of plant cane and the first ratoon were measured at harvest as for commercial cane at the mill.
From 2012 to 2015 cane yield data of commercial fields (3-31 ha) were used to compare the yield of the standard single row at a spacing of 1.5 m with the 1.9 m DR configuration (1.4 m + 0.5m). Paired fields were selected so that factors such as variety, soil type, start date, and region were equal for each pair of fields. We compared 64 paired fields, of which 45 started with a plant crop and 19 with a first-ratoon crop.

RESULTS AND DISCUSSION

Commercial trials

Results of stalk population, stalk height and stalk diameter at 330 DAP, and leaf area index at 270 DAP measured in the five commercial scale trials are shown in Table 1.

Stalk population (stalks/m²) at harvest was higher under the DR configuration for all five varieties. On average, stalk population under the DR configuration was 40% higher than with the conventional 1.5 m row spacing (5.9 versus 4.2 stalks/m²); this difference was statistically significant. Results suggest that stalk population at 330 DAP was strongly affected by planting density, with higher planting densities having higher stalk populations. Under single-row spacings of 1.65 m and 1.8 m, stalk population at harvest was 7% and 13% lower than the standard row spacing of 1.5 m, respectively.

Stalk height at harvest was significantly lower in the DR configuration compared to the 1.5 m row spacing but similar to the 1.65 m and 1.8 m. Stalk diameter at 360 DAP was significantly lower in the DR configuration compared to the three single-spacings treatments. A higher plant density, with higher crowding, was the apparent cause of the thinner stalks in the DR treatment.

LAI at 270 DAP was on average 33% higher under the DR configuration compared to the 1.5 m row spacing for all five varieties. Under single-row spacings of 1.65 and 1.8 m LAI at 270 DAP compared to 1.5 m was 6% and 15% lower, respectively. The higher LAI in the DR configuration was a characteristic that was observed throughout the growing cycle and seems associated with a higher stalk population. Results indicate that LAI was strongly affected by row spacing.

<table>
<thead>
<tr>
<th>Row spacing (m)</th>
<th>Stalk number 330 DAP (stalks/m²)</th>
<th>Stalk height 330 DAP (cm)</th>
<th>Stalk diameter 330 DAP (cm)</th>
<th>Leaf area index 270 DAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR (1.3 x 0.5)</td>
<td>5.9 a</td>
<td>318 b</td>
<td>2.37 b</td>
<td>1.95 a</td>
</tr>
<tr>
<td>1.5</td>
<td>4.2 b</td>
<td>330 a</td>
<td>2.48 a</td>
<td>1.60 b</td>
</tr>
<tr>
<td>1.65</td>
<td>3.9 c</td>
<td>319 ab</td>
<td>2.48 a</td>
<td>1.39 c</td>
</tr>
<tr>
<td>1.8</td>
<td>3.6 d</td>
<td>316 b</td>
<td>2.50 a</td>
<td>1.28 d</td>
</tr>
<tr>
<td>p value</td>
<td>&lt;0.0001</td>
<td>0.066</td>
<td>0.012</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Means in the same column followed by different letters differ significantly. Test: Duncan P = 0.05.

Cane yield (t cane/ha, TCH) of the plant crop was 14% higher under the DR configuration compared to the standard 1.5 m row spacing. Cane yield was 2% higher in the 1.65 m, and 4% lower under the 1.8 m, respectively, compared to single-row 1.5 m. Cane yield of the first ratoon under the DR configuration was 10% higher than the standard 1.5 m row spacing. Cane planted with single-row spacings of 1.65 m, and 1.8 m had 15% and 24% lower cane yields than the 1.5 m row spacing, respectively. Whether the differences are statistically significant could not be determined since all replicates of each treatment were harvested together, giving only total cane yield per treatment.

The higher stalk population at 330 DAP in the DR configuration could explain the higher cane yield compared to single-row spacings. The cloudy conditions that prevail at San Carlos make solar radiation suboptimal for sugarcane growth and, hence, it is a limitation on shoot emission and stalk population. The higher planting density of the DR configuration contributes to overcome this limitation. The higher LAI observed in the DR configuration, especially during the initial growth phase, increased radiation interception, which is highly desired in a low solar radiation environment with an average of 10 MJ/m²/day such as San Carlos.
Paired fields

The plant cane data of 45 paired fields harvested from 2012 to 2015 showed that cane yield under DR was 7.3% higher than under single row spacing of 1.5 m. For 19 first-ratoon paired fields harvested from 2012 to 2015, cane yield under DR was 3% higher than the single row spacing of 1.5 m. Differences were not significant (Table 2). Cane yield was, however, higher in the DR compared with the single row at 1.5 m in 73% of plant cane and 58% of first-ratoon paired fields.

Table 2. Cane yield of 45 plant cane and 19 first-ratoon paired fields.

<table>
<thead>
<tr>
<th>Row spacing (m)</th>
<th>Plant cane yield (t/ha)</th>
<th>First-ratoon cane yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR (1.4 x 0.5)</td>
<td>118</td>
<td>107</td>
</tr>
<tr>
<td>1.5</td>
<td>107</td>
<td>104</td>
</tr>
<tr>
<td>p value</td>
<td>0.07</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Test = t-test (P = 0.05).

Our results from the paired fields confirm the trend observed in the commercial scale trials that in San Carlos the higher planting density of the DR configuration tends to not only compensate the yield loss that occurs at wider single-row spacings, but it increases cane yield compared to the standard 1.5 m single-row spacing.

CONCLUSIONS

To adopt controlled traffic in San Carlos a 1.9 m dual-row configuration (1.4 m + 0.5 m) needs to be implemented to avoid yield losses associated with single row spacings (1.5 m and wider). Cane planted in the dual-row configuration had a higher stalk density and cane yield compared to the standard 1.5 m (and wider) row spacing.

REFERENCES

Rendimiento de la caña de azúcar bajo diferentes distancias entre hileras diseñadas para dar cabida al tráfico dentro del campo

**Resumen.** El cambio de cosecha manual a cosecha mecanizada aumenta el tráfico dentro del campo. En San Carlos (Ecuador) el área de caña de azúcar bajo cosecha mecánica aumentó del 26% en 2005 al 86% en 2015. La adopción de tráfico controlado contribuye a la reducción de la compactación del suelo. Se llevaron a cabo ensayos para medir el impacto de diferentes distancias de siembra entre hileras en el crecimiento y la producción de la caña de azúcar. De 2009 a 2011 cultivos de caña plánta y de primera soca fueron evaluados en cinco ensayos en los que se comparó cuatro distancias entre hileras: una sola hilera a 1,5 m, 1,65 m y 1,8 m, y doble hilera a 1,8 m (0,5 m entre hileras dobles). Desde 2012 hasta 2015, la distancia estándar de 1,5 m se comparó con la doble hilera (DH) a 1,9 m de distancia (0,5 m entre hileras dobles), la respuesta de la producción de caña se comparó en 64 pares de lotes. Los resultados sugieren que la mayor densidad de siembra de la DH incrementó la productividad de caña y que las separaciones de una sola hilera más anchas que el estándar resultaron en una disminución en la productividad. DH produjo tonelajes de caña 9%, 7% y 12% más altos en caña plánta, y 5%, 27% y 47% en la primera soca que separaciones de una sola hilera a 1,5 m, 1,65 m, y 1,8 m, respectivamente. En la comparación de pares de lotes, la producción de caña de la DH fue 7% y 3% más alta en la caña de la planta y la primera soca, respectivamente. Para adoptar el tráfico controlado en San Carlos se recomienda una configuración de doble hilera para reducir las pérdidas de rendimiento de separaciones de una sola hilera más anchas que el estándar.

**Palabras clave:** Caña de azúcar, distancia entre hileras, tráfico controlado, doble hilera, densidad de siembra