SUGARCANE SPACING I.
HISTORICAL AND THEORETICAL ASPECTS

J. E. Irvine and G. T. A. Benda

U.S. Sugarcane Field Laboratory, AR, SEA, USDA; Houma, Louisiana, U.S.A.

C. A. Richard

American Sygar Cane League of the USA, New Orleans, Louisiana, U.S.A.

ABSTRACT

Row spacing has apparently evolved from close to wide spacings as an accommodation to mechanization. A review of experiments in over 80 years showed that decreased spacings resulted in increased yields of cane. More pronounced responses have been reported in temperate and sub-tropical sugarcane areas, but significant yield increases with closer spacings have been reported from the tropics. For a given area, as interplant distance decreases arithmetically, the plant population increases exponentially. Even though plant weight and the number of stalks per plant decrease with decreased spacing, the effect of population is such that the theoretical yield also increases exponentially with closer spacing.

DISCUSSION

In established natural stands of wild canes (*Saccharum spontaneum*), culms of small clones may grow as close as 2 cm and culms of larger clones may be only 5 cm apart. Cultivated sugarcane varies in interrow spacing; rows of *S. barberi* may be 30 cm apart and rows of the inter-specific hybrids in commercial production vary in distance from 60 to 240 cm (Table 1). In the past, interrow distances probably were less than those used at present. Spacings of 60 cm in 1819, 79 cm in 1833 and 91 cm in 1848 were described for Louisiana (Fleishmann, Silliman, and Spalding), and 91 cm for Spain (Spalding).

In an extensive review of interrow spacing studies before 1930, Webster reported that rows in India were as close as 46 cm, while in Argentina and Hawaii, rows were as wide as 244 cm with varieties of *S. officinarum*. After reviewing 214 comparisons in 6 countries, Webster concluded that, in the majority of cases, greater yields were obtained when cane was planted on close rows, and he cited the conclusion of Cross in 1919 which stated that the distance between rows of sugarcane should be the smallest which permits cultivation with modern equipment. Row spacings from 60 to 90 cm can still be found where sugarcane is produced by man and animal power. Wider spacings...
Among the earliest documented experiments on row spacing were those of W. C. Stubbs, who found that decreasing interrow spacing increased yields of *S. officinarum*. Even though he obtained as much as 23% more cane from 91 cm than from those with 150 cm rows, Stubbs preferred the latter because of the economy of seed cane. Spacing experiments have been repeated with different varieties and in different parts of the world. Of the 17 row-spacing experiments in 12 cane-growing regions (Table 1), decreased interrow spacing increased yield from 5 to 89% in all but one test, with an overall average increase of 31%. Seven tests have spacings of 61 cm or less, and these included some of the larger increases as well as the only decrease. That none of the comparisons reviewed by Webster, and less than half of the experiments in Table 1 included treatments with row spacings of less than 61 cm is probably due to pragmatic reasons relating to planting and cultivation.

**Table 1. Increased sugarcane yields through decreased row spacing.**

<table>
<thead>
<tr>
<th>Location</th>
<th>Harvests</th>
<th>Intercrop</th>
<th>Average yield</th>
<th>Average change</th>
<th>Age at harvest</th>
<th>Reference</th>
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<tr>
<td></td>
<td>no.</td>
<td>spacing (cm)</td>
<td>wider spacing</td>
<td>closer spacing</td>
<td>t/ha</td>
<td>%</td>
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<tr>
<td>Mississippi, USA</td>
<td>32ON</td>
<td>6</td>
<td>182 91 52</td>
<td>+35</td>
<td>8</td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>31ON</td>
<td>6</td>
<td>182 91 54</td>
<td>+70</td>
<td>8</td>
<td>(3)</td>
</tr>
<tr>
<td>Georgia, USA</td>
<td>31ON</td>
<td>3</td>
<td>168 107 60</td>
<td>+25</td>
<td>8</td>
<td>(8)</td>
</tr>
<tr>
<td>Louisiana, USA</td>
<td>29ON</td>
<td>7</td>
<td>182 91 85</td>
<td>+89</td>
<td>9</td>
<td>(12, 13, &amp; unpubl. data)</td>
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<tr>
<td></td>
<td>27ON</td>
<td>7</td>
<td>150 50 98</td>
<td>+41</td>
<td>12</td>
<td>(Gascho, unpubl. data)</td>
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<tr>
<td></td>
<td>23ON</td>
<td>2</td>
<td>120 60 70</td>
<td>+11</td>
<td>8-9</td>
<td>(9)</td>
</tr>
<tr>
<td></td>
<td>20ON</td>
<td>1</td>
<td>240 180 222</td>
<td>+36</td>
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<tr>
<td></td>
<td>18ON</td>
<td>3</td>
<td>152 91 142</td>
<td>+17</td>
<td>12-18</td>
<td>(Samuels unpubl. data)</td>
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<td></td>
<td>22ON</td>
<td>2</td>
<td>175 106 90</td>
<td>+48</td>
<td>12-18</td>
<td>(15)</td>
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<tr>
<td></td>
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<td>125 50 148</td>
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<tr>
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<td>200 50 134</td>
<td>+8</td>
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<td>(1)</td>
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<td>140 50 80</td>
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Sugarcane grown on closely spaced rows is believed to succeed in high latitudes because of the maximum utilization of both land area and incident light during a growing season shortened by frost. This view is supported by results from frost-prone areas (Georgia, Mississippi, Louisiana, Table 1). Results
from tropical areas with cane grown on a 12-month regime generally showed moderate increases, but limited results from crops of longer duration have shown negative effects. Colson cited Maxwell's data which showed that cane grown in Hawaii for 18 to 20 months on 150 cm rows had yields 36% higher than from 240 cm rows. Cane grown on 120 cm rows yielded 20% less than that on 150 cm rows. Similar decreases with long-cycle cane on close rows were observed in South Africa (Table 1).

Aside from the South African results with long-cycle cane, the six remaining cases with row spacings of 61 cm or less (Table 1) showed an increase in yield 43% above that of the wider spacing with which each was compared. Even larger increases have been reported for individual comparisons, with an increase of 83% with variety H 51-8029 spaced at 50 cm in Australia (Bull), and increase of 140% with CP 65-357 at 30 cm in Louisiana (Matherne). The results could be dismissed as vagaries caused by random chance, inadequate buffer in small plots, or unusual seasonal variations. However, as these exceptionally high yields were produced on exceptionally close spacings, these results should be considered in terms of the relationship between interplant spacing and yield.

The two primary components of yield of cane are stalk population and weight. Stalk population per unit area is directly affected by inter and intrarow spacing, and changes rapidly with close spacing (Fig. 1). Given, for simplicity, equidistant spacing between plant, one stalk per plant, and increments of 25 cm, there is relatively little change in area per plant (−24%) and population per hectare (+31%) when the interplant distance is decreased from 2.0 m to 1.75 m. A large decrease in area per plant and increase in population per hectare occur at closer intervals. Reducing the interplant spacing from 1.00 to 0.75 m increases the theoretical population of 79% and a reduction from 0.50 to 0.25 m is accompanied by an increase of 400%. Curve of Fig. 1 indicates that as the interplant spacing decreases arithmetically, the population increases exponentially.

![Figure 1](image)

**FIGURE 1.** Theoretical and observed population of sugarcane with different interplant and interrow spacings.
A similar theoretical relationship exists with changes in row spacings. If again, for simplicity, it is assumed that there is one stalk per plant, and the interval between plants in a row is fixed (0.2 m), the population curve (curve B) for row spacings is similar to that for equidistant spacings (Fig. 1).

Spacing affects the number of stalks per plant (Irvine and Benda¹⁰), wide spacing produces plants with many tillers and crowded plants may have but one stalk. Since the decrease in stalk number per plant might affect the shape of the population curve, the available data on populations were averaged for different spacings (Anonymous¹, Boyce², Bull⁴, Chen⁵, Matherne¹² and

**FIGURE 2.** Calculated yield from interplant spacings based on theoretical population (Fig. 1) and observed decrease in plant weight with close spacing.
another unpublished data). The observed population curve (curve C) is higher than the theoretical curve at wide spacings where tillering increases stalk population, but approaches the theoretical curve (curve B) at close spacings (Fig. 1).

Spacing affects plant weight (Irvine and Benda\textsuperscript{10} and Irvine \textit{et al.}\textsuperscript{11}) through tillering and stalk weight. A 93\% decrease in plant weight was observed over a 1.5 m reduction in interplant spacing. The decrease in plant weight with closer spacing is essentially linear. Using the values for plant weight and spacing, a yield curve was calculated (Fig. 2) which predicts much higher yields at spacings less than 0.6 m despite the decrease in weight per plant.

**CONCLUSION**

The results indicated that while wider spacing between rows or plants produces individual plants with higher yield, the greatest yield per unit of land area, for short cropping, will be obtained from the closest interplant spacings. The high yields at close spacing result from the exponential increase in stalk population.

**REFERENCES**


ESPACIAMIENTO DE CAÑA DE AZUCAR I.
ASPECTOS HISTORICOS Y TEORICOS

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RESUMEN

Aparentemente el espaciamiento de las hileras evolucionó de espaciamientos estrechos a anchos para acomodar la mecanización. Una reseña de los experimentos llevados a cabo por más de 80 años demostró que los espaciamientos más pequeños producen aumentos en rendimientos de caña; reportándose respuestas más pronunciadas en áreas cañeras templadas y sub-tropicales, pero en los trópicos se han reportado aumentos significativos en rendimientos con espaciamientos más juntos. Para determinada área a medida que la distancia entre plantas disminuye aritméticamente, la población de plantas aumenta exponencialmente. Aunque con espaciamientos más juntos merma el peso de la planta y el número de tallos por planta, el efecto de la población es tal que el rendimiento teórico también aumenta exponencialmente con espaciamiento más junto.