MAXIMISATION OF SUGARCANE YIELDS AND REDUCTION OF PRODUCTION COSTS—A PARTICIPATORY RURAL APPRAISAL

By

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KEYWORDS: Row Spacing, Variety, Vertisols, Dual Rows.

Abstract
DECLINING cane yields coupled with increased costs of production pose great concern in today's Indian sugar industry. Hence, there is reason to look at some of the agronomic manipulations to reduce production costs and maximise yields. An experiment was conducted in vertisols of tropical India to evaluate the influence of row spacings of 90 (conventional), 120, and 150 cm and a dual row configuration spacing on cane and sugar yields using the varieties CoC671 and Co86032. The wider row spacing of 150 cm gave significantly higher cane yields (156.6 t/ha) than the conventional row spacing (95.3 t/ha). The 120 cm row spacing and the dual row spacing also produced higher cane yields (123.4 t/ha and 114.8 t/ha, respectively) than the conventional row spacing. The higher yields at the wider row spacings were mainly due to a better survival of tillers, which resulted in taller stalks and improved stalk weight at harvest. The interactive effects between row spacings and varieties were significant for variety Co86032 by virtue of its higher tillering habit at row spacings of 120 cm and 150 cm, while CoC671 was more responsive at a row spacing of 120 cm. Due to higher cane yields and reduced cane seed costs, the 150 cm row spacing produced the highest cost:benefit ratio (1:2.3). A participatory rural appraisal conducted over an area of 418 ha confirmed the benefits of wider row spacings, as the altered row spacings produced cane yields that were 21.2 t/ha to 33.2 t/ha higher than the conventional 90 cm row spacing.

Introduction
Declining sugarcane yields and escalating costs of production are major concerns in the sugarcane-growing areas in India. Cane yields need to be increased and cost of production reduced. With higher cane and sugar yields, the utilisation of sugarcane for the generation of energy and the production of enriched bio-composts and other by-products could also be considered. The row spacing generally used in India is 90 cm or less. This is considerably narrower than the row spacings used in other cane growing countries (Richard et al., 1991).

There are reports from around the world indicating higher cane and sugar yields with wider row spacings (Richard et al., 1991). Irvine et al. (1980) considered that wider rows or wider distances between plants produced higher stalk numbers and higher cane yields in sub-tropical areas. Similarly, wider row plantings in tropical areas have been found to produce higher cane yields, facilitate mechanisation of field operations, and reduce production costs (Sundara, 2003).

Coleti et al. (1987) indicated greater yields with a wider spacing of 110 cm when compared to narrower spacings. Under Vapi (South Gujarat) conditions, it has been reported that yields of 341 t/ha were achieved by adopting wide row spacing (MangalRai, 2002). In addition to potentially producing higher yields, there is also the potential to produce intercrops that would bring in additional profits at wider spacings (Mahadevaswamy, 2001). The present investigations were aimed at assessing the performance of two varieties at various row spacings and to validate the results on farmer fields by utilising a participatory rural appraisal (PRA).

Materials and methods
A field study was conducted on vertisols in tropical India during the 2000–2001 growing season. Treatments were arranged in a split plot design with three replications. Main plots were row spacings of
90 cm (conventional planting), 120 cm and 150 cm, and a 75–150–75 cm dual row spacing (distance between rows and between outside rows was 75 cm and 225 cm, respectively). Sub-plots consisted of two varieties, CoC671 and Co86032. The land, after twice ploughing with a tractor, was opened with furrows as per the row spacings. Manures and fertilisers were uniformly added into the furrows and mixed with soil. The cane sets were put in the furrows manually and covered with a small layer of soil, which was immediately followed by irrigation and herbicide application with manual weeding at later stages. The other cultivation practices recommended for sugarcane were scrupulously followed as described in Table 3.

The crop was harvested 12 months after planting. Data collected at harvest included: number of millable stalks per subplot (stalks/ha), stalk weight (kg/stalk) and cane yield (t/ha). A sample consisting of 10 randomly collected stalks from each subplot was used to determine stalk weight. The sample was then crushed and the expressed juice analysed to determine sugar recovery levels (Meade and Chen, 1977).

Sugar yield (t/ha) was calculated as stated by Mathur (1981). The data were subjected to statistical analysis using standard analysis of variance techniques and means separated using LSD tests at P ≤ 0.05. The costs per hectare for the various cultural practices under different spacings and varieties were used to estimate the costs of production.

The results were validated in a PRA (Participatory Rural Appraisal) study during the 2001–2002 growing season. This study was carried out over an area of 418 ha covering 425 small farmers. The row spacings adopted in the PRA were the conventional 90 cm row spacing, and spacings of 120, 150, and 180 cm and a dual row (75–150–75 cm) arrangement. The number of farmers using these row spacings on at least portions of their farms was 418, 145, 207, 3 and 43, respectively. The varieties, CoC671 and Co86032, were planted on many of these farms. The test was carried out in four different locations of the Godavari Sugar Mills Ltd., viz., Sameervadi, Mudalagi, Mudhol and Jamakhandi.

Results and discussion

Experimental results from the plant-cane crop on the effect of row spacings and varieties on stalk weight and population are presented in Table 1 and cane and sugar yield in Table 2. Cane yields from the widest row spacings of 150 cm were significantly higher (156.6 t/ha) than the conventional row spacing (95.3 t/ha). Further, other row spacings i.e. 120 cm and dual row spacings, resulted in relatively higher cane yields (123.4 t/ha and 114.8 t/ha, respectively) compared to the conventional row spacing (Table 2). Higher yield using the altered crop geometries over the narrow row spacing was attributed to better tiller survivability that ultimately resulted in taller and heavier stalks at harvest. Scandaliaris et al. (1989) observed that growing cane up to a 160 cm interrow spacing increased shoot and stalk population and raised the efficiency of solar energy utilisation as a consequence of greater leaf area index resulting from the greater number of shoots, and the same benefits were maintained until the third crop.

### Table 1—Effect of row spacings and varieties on yield parameters of sugarcane.

<table>
<thead>
<tr>
<th>Row configuration</th>
<th>Stalk weight (kg)</th>
<th>Stalk population ('000/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CoC671</td>
<td>Co86032</td>
</tr>
<tr>
<td>90 cm</td>
<td>1.3</td>
<td>1.1</td>
</tr>
<tr>
<td>120 cm</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>150 cm</td>
<td>1.3</td>
<td>1.5</td>
</tr>
<tr>
<td>Dual row 75–150–75 cm</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Mean</td>
<td>1.3</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Source of variation

<table>
<thead>
<tr>
<th>Spacings</th>
<th>LSD (0.05)</th>
<th>Spacings</th>
<th>LSD (0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varieties</td>
<td>NS*</td>
<td>Varieties</td>
<td>6.78</td>
</tr>
<tr>
<td>Interaction</td>
<td>0.31</td>
<td>Interaction</td>
<td>18.72</td>
</tr>
</tbody>
</table>

*NS = Non-significant

The alteration of row geometry from the conventional 90 cm row spacing enhanced the plant-cane crop’s cane and sugar yields by 29.6 t/ha and 4.6 t/ha, respectively. This increase in cane yield is attributed to higher stalk weight (8.3%) and stalk population (18.2%) (Table 1). Sugarcane productivity was higher by 41.3, 27.9 and 19.5 t/ha in response to row spacings of 150, 120 cm and dual rows (75–150–75 cm), respectively.
The highest sugar yield (22.1 t/ha) in the plant-cane crop was obtained with the variety Co86032 at the row spacing of 150 cm. Other row spacings have also produced higher plant-cane sugar yields compared to the conventional method due to higher cane yield (Salunkhe et al., 2001).

Singh (1993) felt that, under wide row spacings, stalk height and stalk weight were better due to optimum population and/or availability of ample sunlight. However, wider row spacings require complete establishment in terms of plant population in the intra row for full realisation of cane yields, as plant population per unit area is critical in these altered row geometries.

<table>
<thead>
<tr>
<th>Row configuration</th>
<th>Cane yield (t/ha) mean</th>
<th>Sugar yield (t/ha) mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CoC671</td>
<td>Co86032</td>
</tr>
<tr>
<td>90 cm</td>
<td>96.2</td>
<td>94.4</td>
</tr>
<tr>
<td>120 cm</td>
<td>126.5</td>
<td>120.3</td>
</tr>
<tr>
<td>150 cm</td>
<td>121.8</td>
<td>151.4</td>
</tr>
<tr>
<td>Dual row 75-150-75 cm</td>
<td>118.1</td>
<td>111.5</td>
</tr>
<tr>
<td>Mean</td>
<td>96.2</td>
<td>94.4</td>
</tr>
<tr>
<td>Source of variation</td>
<td>LSD (0.05)</td>
<td>LSD (0.05)</td>
</tr>
<tr>
<td>Spacings</td>
<td>35.48</td>
<td></td>
</tr>
<tr>
<td>Varieties</td>
<td>NS*</td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td>42.38</td>
<td></td>
</tr>
</tbody>
</table>

*NS = Non-significant.

There was no significant difference between the two varieties with respect to cane and sugar yields in the plant-cane crop. The interaction effects between varieties and row widths for stalk weight, stalk population, and cane and sugar yields were significant. The highest stalk weight was observed in Co86032 at the 150 cm row width and was significant over the 90 cm row spacing. Stalk weight for the variety CoC671 did not differ across row widths.

The variety Co86032 behaved similarly with regards to stalk population and cane and sugar yields. The highest cane yield (151.4 t/ha) in this plant-cane crop was obtained with Co86032 at 150 cm, which was significantly higher than the 90 cm (94.4 t/ha) spacing.

Sugar yield for Co86032 was highest at 150 cm (22.1 t/ha) particularly when compared to the conventional row width (90 cm). Numerical differences in cane yield existed for CoC671 due to row width but the widest row (150 cm) and the dual rows (75-150-75 cm) did not yield more than the 120 cm row spacing in this study.

The variety CoC671 characteristically produces low tiller numbers and this might be one of the reasons for the lower yield with row spacings beyond 120 cm. Alteration of crop geometry helped to increase stalk weight from 1.2 to 1.5 kg and stalk population from 89 400 to 102 500/ha and thereby contributed to higher productivity in the plant-cane crop. Therefore, varieties with a high tillering trait should be more responsive to wider rows.

Similarly Hunsigi et al. (2003) were of the opinion that the profuse tillering varieties such as Co86032 when grown on vertisols yield higher at wider row spacings. Coleti et al. (1987) opined that yields of the plant crop and four succeeding ratoon crops with single rows gave better yields than the double rows and the best was with 110 cm single row spacing.

The total cost of cultivation was higher in the conventional 90 cm spacing (US$859.2) and dual rows of 75-150-75 cm (US$763.6) compared to wider row spacings of 120 cm (US$741.8 and 150 cm (US$730.9) (Table 3). The extra cost under conventional planting and dual row spacings was attributed to the more intensive usage of labour/ha (opening furrows, earthing up, weeding, preparing seedcane sets, and irrigation and manure application) and also to higher expenditures for seedcane.

The cost of cane seed and planting was US$21.7 and 32.6 per ha lower for the 120 cm and 150 cm row spacings, respectively, compared to the conventional planting method. Similarly, total production costs incurred were lower in the dual row planting and wider row planting systems as reported by Salunkhe et al. (2001). The cost:benefit ratio was the highest (1:2.25) for the 150 cm row spacing due to increased cane productivity and reduced planting and cultivation costs compared to the other row spacing geometries.
Among the various row spacings tested on farmer fields, the wider row spacings of 120 and 150 cm were extensively followed (45.1% and 25.7%, respectively). The data revealed that the wider row spacings produced cane yields that were 21.2 t/ha to 33.2 t/ha higher than the conventional 90 cm spacing (Table 4). The wider row spacings of 120 and 150 cm that were practised on large scales on farms produced cane yields of 121.7 t/ha and 112.5 t/ha. The 180 cm row spacing used by only a few growers (0.7% of all growers) produced cane yields of 114 t/ha.

Table 4—Plant cane yield as influenced by row configuration.

<table>
<thead>
<tr>
<th>Row configuration</th>
<th>Area covered (ha)</th>
<th>Number of participating farmers</th>
<th>Area %</th>
<th>Sugarcane yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 cm</td>
<td>107.5</td>
<td>145</td>
<td>25.7</td>
<td>121.7</td>
</tr>
<tr>
<td>150 cm</td>
<td>188.6</td>
<td>207</td>
<td>45.1</td>
<td>112.5</td>
</tr>
<tr>
<td>180 cm</td>
<td>2.9</td>
<td>3</td>
<td>0.7</td>
<td>114.0</td>
</tr>
<tr>
<td>Dual row 75–150–75 cm</td>
<td>32.8</td>
<td>43</td>
<td>7.8</td>
<td>109.7</td>
</tr>
<tr>
<td>90 cm</td>
<td>86.2</td>
<td>418</td>
<td>20.6</td>
<td>88.5</td>
</tr>
</tbody>
</table>

Fig. 1—Effect on plant cane yield following the adoption of the PRA technique in different locations of the Godavari Sugar Mill area.
The problems related to the implementation of new technology such as altered row geometries are: poor cultural operations, poor irrigation layouts and methods, and establishment of early stands.

Due to higher cane productivity and reduced costs associated with seedcane usage (from 10 to 15 at the 90 cm spacing to 3.7 to 5.0 t/ha at the 120 cm and 150 cm spacings) and labour to plant and culture the crop, farmers were able to increase profits.

Across the various altered row spacings, the cane yields were higher at Jamakhandi (36%) followed by Mudalagi (31%) and Sameerwadi (29%) area (Figure 1).

This is attributed to favourable agro-climatic parameters coupled with the progressive nature of farmers in following improved technologies.

Overall, the adoption of wider row spacings, along with other recommended practices by growers, enhanced sugarcane yields 28% to 36% over the yields where the conventional 90 cm row spacing was used.

Conclusion

Sugarcane production costs are steadily increasing. There is a need to reduce these costs while increasing productivity for the benefit of farmers and the sugar industry.

This study demonstrated on an experimental and large scale that wider row spacings of 120 cm and 150 cm under tropical vertisols could increase cane yield per ha by 28% and 36%, respectively, in the plant-cane crop.

This reduced production costs by US$21.7 to US$32.6/ha when only the decreased cost for seed cane is considered. The row spacing change also improved the ease of other cultural operations, while providing small farmers with an opportunity to use intercropping as a source of additional income.

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REFERENCES


MAXIMISER LES RENDEMENTS ET REDUIRE LES COUTS DE PRODUCTION –UNE EVALUATION RURALE PARTICIPATIVE

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MOTS CLES: Espacement des Lignes, Variété, Vertisols, Rangs Jumelés.

Résumé
LES CHUTES de rendements en canne et les augmentations des coûts de production représentent aujourd’hui une source de grande inquiétude pour l’industrie sucrière de l’Inde. Il y a donc lieu de revoir certaines pratiques agronomiques afin de réduire les coûts de production et de maximiser les rendements. Un essai a été mis en place dans les vertisols de la région tropicale de l’Inde afin d’évaluer l’influence des espacements de 90 cm (conventionnel), 120 cm et 150 cm et les rangs jumelés sur les rendements en canne et en sucre des variétés CoC671 et Co86032. Les rendements réalisés avec l’espacement le plus large – 150 cm – étaient significativement supérieurs à ceux obtenus avec l’espacement conventionnel (156,6 t/ha contre 95,3 t/ha). Dans les deux autres traitements, l’espacement à 120 cm et les rangs jumelés, les rendements étaient aussi plus élevés – 123,4 t/ha et 114,8 t/ha respectivement. Les rendements plus forts obtenus avec les espacements plus larges étaient attribués à une meilleure survie des tiges produisant des tiges plus longues, avec un poids plus élevé à la récolte. L’interaction espacement X variétés était significative pour la Co86032 en raison d’un plus fort tallage à 120 cm et 150 cm. Par contre, la CoC671 répondait mieux à l’espacement de 120 cm. En raison d’un rendement en canne plus élevé et du coût réduit du matériel de plantation, l’espacement de 150 cm produit un rapport coût/bénéfice plus élevé (1:2,3). Une évaluation rurale participative sur une superficie de 418 ha a confirmé les bénéfices obtenus avec les espacements plus larges, ces derniers produisant des rendements en canne supérieurs de 21,2 à 33,2 t/ha à ceux obtenus avec un espacement conventionnel.

MAXIMIZACIÓN DE RENDIMIENTOS DE CAÑA DE AZÚCAR Y REDUCCIÓN DE PRECIOS DE PRODUCCIÓN – UNA VALORACIÓN RURAL PARTICIPATIVA

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PALABRAS CLAVES: Espaciamiento de Fila, Variedad, Vertisols, Filas Dobles.

Resumen
RENDIMIENTOS de caña menores sumados a mayores costos productivos generan grandes preocupaciones en la industria azucarera de India, hoy en día. De ahí que haya razón para examinarse algunas de las gestiones agronómicas para reducir los precios de producción y maximizar los rendimientos. Un experimento se hizo en vertisols de la India tropical, para evaluar la influencia del espaciamiento de las hileras de 90 (convencional), 120, y 150 centímetros y un espaciamiento de configuración de hilera doble en producción de caña y azúcar, usando las variedades CoC671 y Co86032. El espaciamiento de hilera más ancho de 150 centímetros dio una producción de caña significativamente más alto (156,6 t/ha) que la del espaciamiento convencional (95,3 t/ha). El espaciamiento de hilera de 120 centímetros y el espaciamiento de hilera doble, también tuvieron una mayor producción de caña (123,4 y 114,8 t/ha, respectivamente) que el espaciamiento de hilera convencional. Los rendimientos superiores con los espaciamientos de hilera más anchos fueron principalmente debido a una supervivencia mejor de los brotes que producían cañas más altas y mejoraron el peso de la caña en la cosecha. Los efectos interactivos entre los espaciamientos de hilera y variedades fueron significantes para la variedad Co86032 en virtud de su hábito de producir brotes más altos con los espaciamientos de hilera de 120 y 150 centímetros, mientras que la CoC671 fue más sensible en un espaciamiento de hilera de 120 cm. Debido a los superiores rendimientos de caña y a los reducidos costos de caña semilla, el espaciamiento de hilera de 150 centímetros produjo la mejor proporción de costo: beneficio (1:2,3). Una valoración rural participativa hecha sobre un área de 418 ha, confirmó los beneficios de espaciamientos de hilera más anchos, ya que los espaciamientos de hilera alterados produjeron rendimientos de caña que fueron de 21,2 a 33,2 t/ha mayores que los de espacio de hilera convencional de 90 centímetros.