

MODIFIED DUAL ROW PLANTING SYSTEM FOR GREEN CANE MANAGEMENT IN THE TROPICS

By

J.S. TORRES, F. VILLEGAS and A. DURÁN

Colombian Sugarcane Research Center, Cenicaña
jtordes@cenicana.org

KEYWORDS: Row Spacing, Sugar and Cane Yields, Control Traffic.

Abstract

AFTER GREEN cane harvesting in high yielding fields, a large amount of residues are left on the soil surface which interfere with the standard cropping practices, normally in burnt fields. A new planting system arrangement has been tested to reduce cane stool damage, soil compaction, cost of residue handling, allelopathic effects, herbicide use, and to improve irrigation efficiency. The so-called modified dual row planting (MDRP) allows for controlled traffic paths of 3.9 m wide followed by a set of three dual rows of cane at 0.8 m between rows and 2.1 m in between two adjacent pairs of dual rows. Total furrow length per hectare is equivalent to a single-row planting at 1.75 m spacing (5714 m of cane row/ha). The 3.9 m strip opens enough space to place the residues during manual cutting and leave the cane rows free of residues. The traffic of wagons loaded with cane is conducted on top of the green trash which later decomposes to enrich these areas with organic matter. During development of the plant cane, other crops can be planted to benefit from these open spaces. The MDRP, tested under different soil and climatic conditions, was found to produce a lower cane yield (10 to 20 t/ha) in plant cane as compared to the single-row planting spacing at 1.75 m spacing. After the harvest of the plant and several ratoons, the benefits of the MDRP, due to controlled traffic and less compaction, resulted in a more stable cane production; the cumulative cane production after four cropping cycles showed a higher cane production than the single-row planting. The MDRP also allows for a good separation of the cane windrows from the trash swaths which results in at least 1% higher sugar recovery.

Introduction

The use of large farm machinery for sugarcane cultivation and harvesting has resulted in higher efficiencies at the expense of sound agronomic practices and crop sustainability (Torres and Rodríguez, 1996; Bull *et al.*, 2001). Direct cane stool damage by cane loader and infield transport equipment was more important than compaction itself in determining cane yield of the following ratoon crop (Torres and Villegas, 1993). Later on, Torres and Pantoja (2005) reported that, under wet conditions, controlled traffic of the mechanical harvesting system resulted in similar cane yields as the plots without infield traffic. Therefore, they advised that traffic of infield machinery should be controlled to sustain production in any harvesting system under the conditions of the Cauca Valley in Colombia.

In Australia, Bull and Bull (1996 and 2000) presented a new planting system with dual, triple and quad rows. Row spacing was reduced from 1.5 m to 0.5 m resulting in a linear increase in cane yield of up to 60 t/ha. This system has management limitations due to lack of machinery to fit the narrow spacing. All three farming systems have in common the adoption of strip traffic lanes between the set of cane rows where the soil remains compacted, and no ripping is executed within this area to accommodate machinery traffic. The area between the set of cane rows corresponds to

minimum tillage zones where the soil remains uncompacted promoting soil health. Therefore, new planting systems with dual, triple and quad rows were proposed to improve soil structure. The three high density farming systems outlined by Bull *et al.* (2001) involved the use of controlled traffic zones, minimum tillage and precision planting.

Harvesting of sugarcane during rainy periods is a common practice that creates problems in the succeeding crop. The use of large capacity wagons with high flotation tyres has not been sufficient to reduce the field problems of compaction and direct crop damage. Matching infield machinery tracks to fit inter-row spacing is required to reduce direct cane stool damage and to limit compaction to the inter-row.

The Colombian sugar industry has been shifting from 1.5 m row spacing to new plantings at 1.65 m and 1.75 m. These spacings open more room to accommodate the large amount of green cane residues in the inter-row after trash lining and, at the same time, look for a better fit to the track widths of the existing infield machinery.

Torres and Rodríguez (1996) presented a review paper describing the forces acting on the soil during the compaction process and compiled a list of the most desirable management practices to minimise, offset or eliminate soil compaction. In general, infield machinery should be lighter, be mounted on high flotation tyres, track widths should match row spacing, and controlled traffic paths should be implemented to reduce stool damage.

In order to adopt most of the well known recommendations to reduce soil degradation, eliminate stool damage, improve fertiliser use efficiency, decrease the need for herbicides, increase irrigation efficiency and minimise the extra cost for green cane residue handling, a new farming system, so-called modified dual row planting system (MDRP) is under experimentation in the Cauca Valley of Colombia.

Materials and methods

Within the Colombian sugar industry, infield machinery varies in size, weight and track widths, so it is almost impossible to select a single-row spacing that can eliminate compaction or cane stool damage while opening enough inter-row space to accommodate cane residues to reduce allelopathic effects on ratoon regrowth. The new planting system corresponds to a modification of the conventional dual-row planting where a set of two rows of cane is planted at a distance that varies between 0.3 m to 1.0 m apart and a fixed distance (1.3 to 1.8 m) is kept to separate the centres of dual rows.

Using computer graphic aids, different row-spacing arrangements and infield machinery track widths were plotted to select the best row spacing that could help to achieve the objectives of the system. No single-row spacing was identified to suit the traffic of infield equipment.

Therefore, it was necessary to favour the establishment of a dedicated traffic strip where any infield machinery track width could be accommodated without running over the nearest cane row (Figure 1). The so-called Modified Dual Row Planting has a traffic strip width of 3.9 m and three dual rows of cane at 0.8 m apart and 2.1 m in between two adjacent pairs of dual rows.

Planting of the cane using the new configuration required modification of the furrow opener and the use of surveying equipment to mark the row direction and the spacing between dual rows. The new system was initially planted in a small area at Cenicaña's experiment station and later on was presented at a cane grower meeting.

The new idea seemed so interesting that a few months later (in 2003), the planted area amounted to 424 ha. Growers at Cenicaña were worried that a new idea that had not been fully proven experimentally was at a high risk.

Fertilisation of the cane row was executed at 50 days after planting as it was necessary to adjust the position of the chisels and hose outlets of the fertiliser box to apply half of the fertiliser dosage on each side of the cane rows.

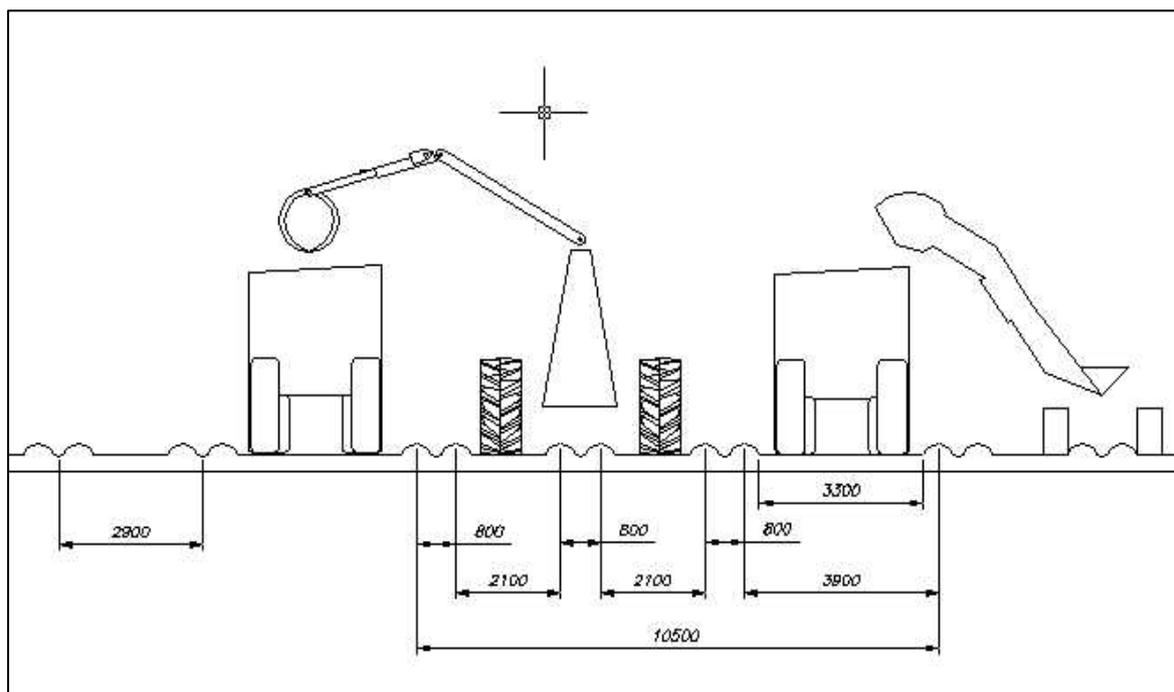


Fig. 1—Schematic view of the modified dual row planting system (units in mm).

In order to avoid the convergence of the dual rows into a single row of cane due to intensive cane tillering at such a close spacing (0.8 m), a small duck foot cultivator blade was run over the centre of the dual rows during a hilling up operation. At the same time, the inter row between the dual rows was ready for furrow irrigation. The surface area that comes in contact with the irrigation water is reduced to 25% of the planted area, leaving room for more storage of rainfall water. When a newly planted field under conventional single row spacing is surface-irrigated, the applied volume of water normally amounts to 2500 m³/ha while the irrigation of the MDRP consumed only 500 m³/ha of water increasing the water use efficiency.

The new MDRP planting system has been evaluated and compared to planting at either 1.65 m or 1.75 m spacing at commercial scale under different soil types and climatic conditions using cane varieties CC 85-92, CC 84-75, CC 93-744, CC 92-2198, CC 93-7510 and MZC 84-04.

Results and discussions

Furrow irrigation

The inter-row between the pair of cane rows was shaped to obtain a parabolic furrow able to carry up to 8 litres per second (L/s) of water. The furrow irrigation system was evaluated at the Mayaguez sugar mill using furrow discharge rates of 4, 5 and 6 L/s applied to the single-row planting at 1.75 m and to the MDRP. As the discharge rate increased, the amount of water applied to MDRP decreased from 1160 m³/ha with 4 L/s to 600 m³/ha with a flow rate of 6 L/s due to a shorter advance time of the water while the volume of water applied to the 1.75 m spacing varied between 1540 m³/ha (4 L/s) and 1250 m³/ha (6 L/s). In terms of depth of water applied to the soil, using a discharge rate of 6 L/s in MDRP resulted in 90 mm of water while, at 1.75 m spacing using the same discharge rate, the applied water depth was equivalent to 125 mm. It is necessary to consider that rainfall events in the tropics can occur at any time; therefore, it would be advantageous to leave some storage capacity in the soil for those rainfalls.

Cane and sugar yields

The cane yield and sugar recovery of the plant cane crops were used to calculate the sugar yields which are presented in Figure 2 as isoproductivity curves. At a first glance, three cane

productivity groups could be identified as a function of the row spacing. The highest cane yield group consisted of plantings made at 1.65 m spacing with cane yields above 170 t/ha and sucrose content (IRSC) of 11.5%. A second group consisted of plantings at 1.75 m with cane yields between 140 and 170 t/ha and sucrose content below 11.5%.

A third productivity group included the MDRP which showed a great dispersion in cane yields varying from 80 to 150 t/ha due to the lack of sufficient plant population per unit area and because of the effects of soil, climate and cane varieties planted.

In general, a cane yield difference of 20 to 25 t/ha in favour of the single-row plantings at either 1.65 m or 1.75 m was registered. At the same time, the MDRP showed a tendency to form a cluster with high sucrose content above 11.5% as a result of the cleaner cane sent to the factory

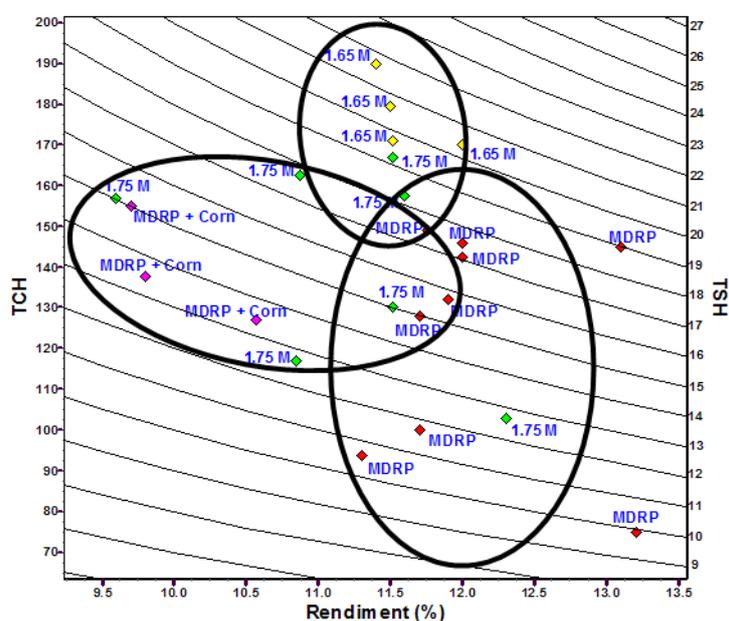


Fig. 2—Isoproductivity curve from the plant cane of the MDRP and single-row spacing at 1.65 and 1.75 m in the Cauca river valley of Colombia.

The big differences in cane yield between the plant cane of the new planting system and the single-row plantings caused dissatisfaction and aversion of the cane growers to continue evaluating the new system. A remedial action was taken by Cenicaña and new plantings were conducted at CIAT's experiment station and the Pichichí sugar estate to test new options to improve the cane yield of the MDRP.

The wide open strips of 3.90 m by 120 m long, intended to accommodate the residues and be a dedicated area for the traffic of the cane wagons, occupy an area of 0.37 ha (37%) which is quite large and has a definite impact on cane yield. A hypothesis emerged to upgrade the cane yield of the new system (Figure 3).

If the reduced population density was the cause of the lower cane yield of this system, it would be necessary to increase the density by planting one or two extra rows of cane in the centre of the 3.9 m strip that may result in a cane yield of the MDRP as high as the ones from the single-row spacing.

After the harvest of the plant cane, the extra rows of cane could be discarded to merge into the MDRP system. It is expected that after harvesting the plant cane all the benefits of the system, such as controlled traffic zones, reduced compaction and stool damage would accrue to sustain a higher cane yield during the following ratoon crops with the possibility that the crop would last longer.

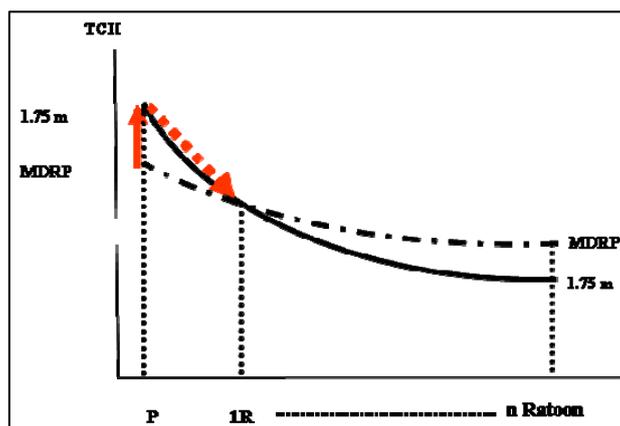


Fig. 3—Hypothesis to upgrade cane production of the MDRP system.

The proposed hypothesis was tested at CIAT’s experiment station by planting one extra row in the MDRP (Figure 4). After three consecutive crops, the cumulative cane production of the MDRP system amounted to 468 t/ha while the cane production at 1.75 m was 459 t/ha, which agrees quite well with the hypothesis. It was clear that, after harvest of the plant cane, the benefits of the system allow for a more stable cane yield, and the crop is expected to last for more ratoons. In addition to the benefits of a more sustainable cane production, an economic analysis including the cost of water, labour savings, reduced use of herbicides and soil improvement due to build-up of organic matter in the wide strips would be necessary.

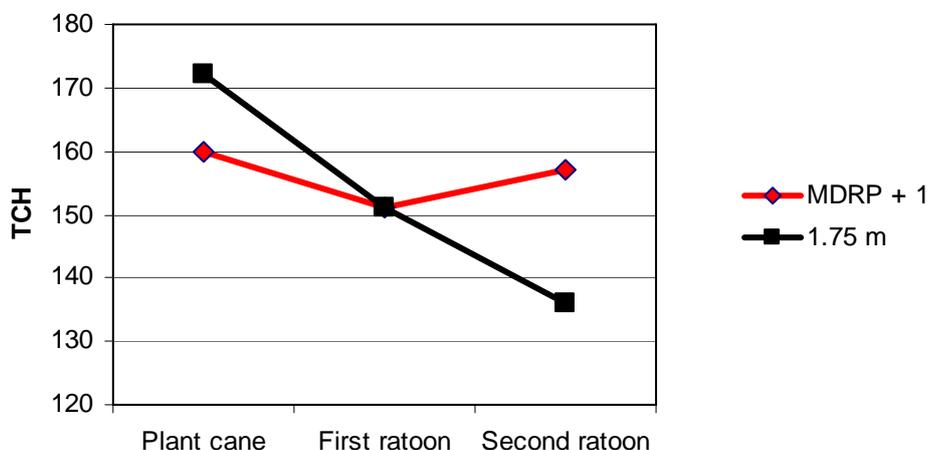


Fig. 4—Cane yield of CC 85-92 variety planted with one extra row (MDRP+1) and 1.75 m spacing at CIATs Experiment Station.

When the cane is manually green harvested, 50 to 100 t/ha of fresh residues are left on the soil surface which needs to be trash lined to avoid germination problems due to stool covering and allelopathic effects. Trash lining can be executed mechanically using two or three passes of a finger wheel and trash re-accommodation along the cane rows needs to be done manually for a total cost of US\$50 to \$75/ha. The manual harvest of the cane from MDRP results in a combined system of cane cutting and trash lining. A gang of two cane cutters can handle the cane from the three pairs of double rows of cane and make a hip centred on the central dual row; the cane is based cut and the tops are placed directly on the 3.9 m traffic strip. After harvest, there is no need to trash line the residues, thus eliminating the extra cost of residue handling and having a faster sprouting of the ratoon cane. The trash placed on the traffic strip will act as a cushion to alleviate the traffic of the

wagons loaded with cane. The grab loader runs in the 2.1 m space that separates two pairs of adjacent dual rows, without causing serious compaction or stool damage.

The continual addition of residues after three crops of cane to the traffic strips on a clay soil (Vertisol) that was previously used as grazing land has resulted in a build up of soil organic matter. The organic matter content on the 2.1 m spacing that separates the dual row was 3.9% from 0 to 20 cm and 3.35% from 20 to 40 cm depth in the soil profile while, in the traffic strip where there is accumulation of residues, the organic matter content increased to 5.4% from 0 to 20 cm and to 3.4% from 20 to 40 cm depth.

Conclusions

We strongly believe that the MDRP system is a good option to manage cane in a sustainable way, to reduce compaction and stool damage problems, reduce the use of water for irrigation and opens the possibility to intercrop leguminous and other crops such as potatoes, beans or tomatoes. Once the benefits of the system are properly quantified and the temporal differences in cane yield in relation to the single-row planting spacing are accepted or compensated with the planting of one or two extra rows of cane, the adoption of this system may become a reality.

REFERENCES

- Bull, T.A. and Bull, J.K.** (1996). Increasing sugarcane yields through higher planting density—preliminary results. In: Wilson, J.R., Hogarth, D.M., Campbell, J.A. and Garside, A.L. (ed.). *Sugarcane: Research Towards Efficient and Sustainable Production*, 166–168. CIRO Div. of Tropical Crops and Pastures, Brisbane, Australia.
- Bull, T.A. and Bull, J.K.** (2000). High density planting as an economic production strategy (a) Overview and potential benefits. *Proc. Aust. Soc. Sugar Cane Technol.*, 22: 9–15.
- Bull, T.A, Norris, C.P., Robotham, B.G. and Braunack, M.V.** (2001). New farming systems for sugarcane production. *Proc. Int. Soc. Sugar Cane Technol.*, 24: 52–57.
- Torres, J.S. and Pantoja, J.E.** (2005). Soil compaction due to mechanical harvesting in wet soil. *Proc. Int. Soc. Sugar Cane Technol.*, 25 (2): 332–339.
- Torres, J.S. and Rodríguez, L.A.** (1996). Soil compaction management for sugarcane. Review paper. *Proc. Int. Soc. Sugar Cane Technol.*, 22 (2): 222–230.
- Torres, J.S. and Villegas, F.** (1993). Differentiation of soil compaction and cane stool damage. *Proc. Int. Soc. Sugar Cane Technol.*, 21 (2): 294–305.

SYSTEME MODIFIE DE PLANTATION EN RANGS JUMELES POUR LA GESTION EN CANNE VERTE SOUS LES TROPIQUES

Por

J. S. TORRES, F. VILLEGAS and A. DURÁN

Centre de Recherche de la Canne de Sucre de la Colombie, Cenicana

jtortes@cenicana.org

**MOTS-CLÉS: Écartement, Rendements,
Teneur En Sucre, Passages Maitrisés.**

Résumé

APRÈS la récolte en vert sur des parcelles à haut rendement, une quantité importante de résidus en surface interfère avec les pratiques culturales standard que l'on emploie normalement en canne brûlée. Une nouvelle adaptation du système de plantation a été testée afin de réduire l'endommagement des souches, la compaction du sol, les coûts de manipulation des résidus, les effets d'allelopathie, l'utilisation des herbicides, et d'améliorer l'efficacité de l'irrigation. La

plantación en doble-rang modificada (MDRP) tient compte des chemins de roulement de 3.9m de large comprenant entre eux 3 lignes jumelées de 0.8m entre rangs et 2.1m entre paires de rangs.. La longueur totale de sillons par hectare est équivalente à une plantation en rang simple de 1.75 m d'écartement (5714 m/ha). Les allées de 3.9 m de large laissent assez d'espace pour les résidus provenant de la coupe manuelle et laisse les lignes de cannes sans résidus. Le passage des remorques chargées de canne s'effectue sur les résidus verts qui se décomposent ensuite pour enrichir le sol en matière organique. Durant le développement de la canne plantée, d'autres cultures peuvent être plantées sur ces allées ouvertes. Le MDRP, testé sous différentes conditions de sol et de climat, a produit un rendement plus faible (10 à 20 t/ha) en canne plantée que le système en rang simple avec un écartement de 1.75 m. Après la récolte de la canne plantée et de plusieurs repousses, le système MDRP, dû à des passages contrôlés et moins de compaction, entraîna une production plus stable; et après 5 cycles, une production cumulée supérieure à celle du système en rangs simples. Le système MDRP a permis aussi une bonne séparation des andains de résidus de canne et a produit ainsi une qualité de sucre extractible supérieure de plus de 1%.

SISTEMA DE PLANTACIÓN EN DOBLE SURCO MODIFICADO PARA MANEJO DE CAÑA VERDE EN LOS TROPICOS

Por

J. S. TORRES, F. VILLEGAS and A. DURÁN

Centro de Investigación de la Caña de Azúcar de Colombia, Cenicaña

jtorres@cenicana.org

PALABRA CLAVE: Distanciamiento Entre Surcos, Producción de Azúcar y Caña, Tráfico Controlado.

Resumen

DESPUÉS de la cosecha en verde en cañaverales de alta producción, queda sobre la superficie del suelo una gran cantidad de residuos que interfieren con las prácticas normales de cultivo en campos quemados. Se evaluó un nuevo sistema de diseño de plantación para reducir el daño a la cepa, la compactación del suelo, el costo del manejo de los residuos, los efectos alelopáticos, el uso de herbicidas y mejorar la eficiencia del riego. El llamado surco doble modificado (MDRP) permite un tránsito controlado por la trocha de 3,9 m de ancho seguida por un conjunto de tres surcos dobles de caña a 0,8 m entre surcos y 2,1 m entre dos pares de surcos dobles adyacentes. La longitud total de surcos de caña que se dispone en una superficie de una hectárea en el nuevo diseño, es equivalente a lo plantado en un diseño de surco simple espaciados a 1,75 m (5714 m de surco/ha). Los 3,9 m de trocha abierta dan suficiente espacio para colocar los residuos que se producen durante la cosecha manual y deja a los surcos de caña libres de residuos. El tránsito de carros cargados con caña se realiza sobre los residuos verdes cuya posterior descomposición enriquece esas áreas con materia orgánica. Durante el desarrollo de la caña planta se pueden plantar otros cultivos, para obtener beneficios en ese espacio. El MDRP, evaluado bajo diferentes suelos y condiciones climáticas, produjo en caña planta una disminución en la producción de caña (10 a 20 t/ha), comparado con la plantación en surco simple espaciados a 1,75 m. Después de la cosecha de la planta y varias socas, los beneficios del MDRP, debidos al tránsito controlado y a la menor compactación, resultaron en una producción de caña más estable y la producción acumulada después de cuatro ciclos mostró mayor producción de caña que en la plantación en surco simple. El MDRP también permite una buena operación de limpieza de la caña que deriva en menores niveles de trash en la materia prima, lo cual resulta en por lo menos 1% más de recuperación de azúcar.