Two high-fibre sugarcane varieties adapted for energy use in Guadeloupe

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Abstract In Guadeloupe (French West Indies), studies (REBECCA project) were conducted to investigate the benefit of producing sugarcane as a dedicated energy feedstock using the entire dry shoot biomass (DSB). After a first selection from among 36 Poaceae, 10 sugarcane varieties were tested and compared to R579, the best local commercial sugarcane (CSC), (three replications, 40-m² plots, volcanic soil) over 3 years in wet tropical conditions. Wet and dry biomasses as well as energy yield (EY, MJ/m²) were measured on stalks, tops, green and dead leaves. Two varieties (WI81456, WI79460) from WICSBS (Barbados) were very efficient and well-adapted. The DSB was 81 t/ha/year and the low heating value of this DSB was 133 MJ/m² after a 12-month cropping cycle. Dry/wet DSB was 0.36 (0.43 without tops). These varieties were cropped using the same practices as local CSC, but yields were higher: +33% for stalks and +71% for DSB). These two varieties could be considered as good feedstock for a biomass power plant but they need to be dried before being used. Growers, purchasers and agronomists are now informed of local potential yield and quality of the tested varieties.

Key words Multipurpose sugarcane varieties, biomass, biofuel, energy cane, energy yield

INTRODUCTION

Sugarcane bagasse is increasingly used to produce energy, but studies involving high-fibre sugarcane for dedicated energy production are not well progressed despite reports of initial research (Alexander 1985, Matsuoka et al. 2014). Studies conducted in Guadeloupe (French West Indies) were designed to investigate the benefits of producing sugarcane biomass as a dedicated energy feedstock in order to reduce dependency on fossil fuel (REBECCA project). If results are positive, the cultivation of high-fibre sugarcane could be proposed to farmers in marginal or wet zones where the sugar content of sugarcane is normally low. Previous experiments sought to find high-performance varieties for this purpose from sugar-producing and multipurpose varieties. A first analysis focused on plant cane (Chopart and Bachelier 2012), and in a related study low heating value predictions were carried out using near-infrared reflectance spectroscopy (Chopart et al. 2013). An excellent relationship was found between the dry shoot biomass (DSB) and its energy yield (EY), regardless of cultivar, age or plant part.

The objective of this study, which took place over 3 years (plant cane and two ratoons), was to improve our knowledge about the energy yields of these varieties. A further aim was to propose two or three varieties to be cultivated in large plots in order to demonstrate their validity to farmers and prepare proposals for an agro-industrial project.

MATERIALS AND METHODS

The 10 best sugarcane varieties from an initial selection of Poaceae species (Chopart and Bachelier 2012) were compared to sugarcane variety R579 which was considered the best local commercial sugarcane (CSC). The experiment was conducted over 3 years on a farm (altitude: 100 m; longitude: 61°34; latitude: 16°03) in wet conditions (rainfall: 2500-3000 mm/year) within 40 m² replicated plots (three replicates). Dry shoot biomass (DSB) was determined within sub-plots (4.5 m²) and included stalks, tops, and green and dead leaves. Three important characteristics for dedicated bioenergy use were evaluated: DSB, EY and the moisture content of the biomass.
RESULTS AND DISCUSSION

There was no decrease in yield (DSB) between the first and third year, at least for the two best varieties (Fig. 1). We therefore presented the average results obtained over three years. Significant differences in DSB existed amongst the eight best varieties (Fig. 2).

**Fig. 1.** Evolution of the total shoot dry biomass yield (t/ha) of the local commercial sugar cane (control) and the two best varieties of high-fibre sugarcane between the first and third year of continuous cultivation (three 12-month cropping cycles). Numbers in brackets are standard deviation for three replications.

**Fig. 2.** Average yields of total shoot dry biomass yield (t/ha) obtained over three continuous 12-month cropping cycles (plant cane and two ratoons, of the best height high-fibre varieties and the control (variety R579, local commercial sugarcane). Columns with same letter do not differ significantly at the 5% level probability (Newman-Keuls test).
Four varieties, WI81456, WI79460, WI80542 and BBZ92076, from WICSBS (Barbados) appeared to be efficient biomass accumulators and possibly well-adapted for energy use. The mean DSB of the two best varieties, WI81456 and WI79460, after a 12-month cropping cycle was 81.5 t/ha/year (Fig. 3 Table 1) with an EY of 133 MJ/m². Their dry/wet biomass ratio (Table 1) was 0.36 for the entire DSB (0.43 without tops). These high-fibre cane varieties were cultivated using the same conventional practices as those used for local CSC, but yields were higher: +33% for stalks and +71% for DSB. Despite their great height and biomass, the two best varieties were not more sensitive to lodging than the commercial varieties.

**Table 1.** Dry shoot biomass and dry/wet stalk biomass ratio of the two best varieties harvested after 8 or 12 month cropping cycles during three cropping cycles. Numbers in brackets are standard deviation for three replications.

<table>
<thead>
<tr>
<th>Cropping cycle</th>
<th>Dry shoot biomass (t/ha)</th>
<th>Dry/wet ratio in stalks</th>
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<tbody>
<tr>
<td></td>
<td>WI81456</td>
<td>WI79460</td>
</tr>
<tr>
<td>8 months</td>
<td>56.1 (4.1)</td>
<td>48.6 (5.6)</td>
</tr>
<tr>
<td>12 months</td>
<td>84.9 (5.0)</td>
<td>78.1 (3.9)</td>
</tr>
</tbody>
</table>

In Guadeloupe, it is better to harvest these varieties after a 12-month cropping cycle, but it is also possible to harvest them after only 8 months, with lower yields and a stalk biomass with a higher water content (Table 1).

Part of the biomass should be left in the field in order to maintain the soil organic content. This retained biomass will depend on soil and climate. Priority should be given to the use of the tops, the greenest and wettest part of the plant. The dry biomass of the tops was 8.2 (Standard deviation, SD: 0.33) and 9.1 (SD: 0.36) t/ha, respectively, for the two best varieties, WI79456 and WI79460, whereas the tops of the commercial variety R579 produced 5.5 t/ha (SD: 0.2).

**CONCLUSIONS**

For 3e years, yields (DSB, EY) of the two best high-fibre varieties were very high after a 12-month cropping cycle and well above the best local CSC (R579). These two varieties could therefore be considered as good feedstock for a biomass power plant but they need to be dried before being used as fuel. This should be taken into account in the energy and economic balances. These varieties were cultivated in the same way as the local sugarcane variety. They could therefore...
be more easily integrated into cropping systems where sugarcane already exists, using the same equipment and the same cultivation techniques, or with very small differences.

On the basis of this study, information is now available on the potential yield of locally tested high-energy varieties (although they were obtained in small plots). It will be necessary in the future to assess yields in large plots and their consistency of the feedstocks over more than 3 years.

ACKNOWLEDGMENTS

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REFERENCES


Deux variétés de canne à sucre à haute teneur en fibre sont adaptées à un usage énergétique en Guadeloupe

Résumé. En Guadeloupe (Antilles Françaises), des études (projet REBECCA) ont été conduites pour estimer l’intérêt d’une culture de canne à sucre dédiée à la production d’énergie en utilisant la totalité de la biomasse aérienne (DSB). Après une première sélection parmi 36 Poacées, 10 variétés de canne à sucre ont été testées et comparées à la R579, la meilleure variété locale de canne à sucre commerciale (CSC), (trois répétitions, parcelles de 40m², sol d’origine volcanique) pendant 3 ans en climat tropical humide. Les biomasses fraîches et sèches et le rendement énergétique (EY, MJ/m²) ont été mesurés sur les tiges, les parties sommitales, les feuilles vertes et mortes. Deux variétés (WI81456 et WI79460) du WICSBS (Barbados) ont été très performantes et bien adaptées. Le DSB a été de 81 t/ha/an et le pouvoir calorifique inférieur de cette DSB a été de 133MJ/m² après 12 mois de culture. Le rapport des biomasses sèches et mortes. Deux variétés (WI81456 et WI79460) du WICSBS (Barbados) furent très performantes et bien adaptées. Le DSB a été de 81 t/ha/an et le pouvoir calorifique inférieur de cette DSB a été de 133MJ/m² après 12 mois de culture.

Mots-clés: Variétés de canne à sucre multiusage, biomasse, biocombustibles, canne énergie, rendement énergétique

Dos variedades de caña de azúcar con alto contenido de fibra adaptadas para uso energético en Guadalupe

Resumen. En Guadalupe (Antillas Francesas), se llevaron a cabo estudios (Proyecto REBECCA) para investigar el beneficio de producir caña de azúcar como materia prima destinada a la producción de energía utilizando biomasa seca total (BST). Después de una primera selección entre 36 Poaceas, 10 variedades de caña de azúcar fueron evaluadas por tres años en suelos volcánicos en condiciones tropicales húmedas y comparadas con R7579, la variedad comercial (VC) más sembrada. Las parcelas fueron de 40 m² con tres repeticiones. Peso de biomasa seca y húmeda, así como el rendimiento energético (RE, en MJ/m²) se midieron en los tallos, puntas, hojas verdes y muertas. Dos variedades (WI81456 y WI79460) de WICSBS (Barbados) fueron muy eficientes y bien adaptadas. La BST fue de 81 t/ha/año y el poder calorifico de esta biomasa fue de 133 MJ/m² después de un ciclo de cultivo de 12 meses. La relación biomasa seca/biomasa húmeda fue de 0.36 (0.43 sin puntas). Estas variedades fueron cultivadas utilizando las mismas prácticas que la VC local, pero los rendimientos fueron superiores: + 33% para los tallos y + 71% para BST. Estas dos variedades podrían ser consideradas como buenas materias primas para una planta de energía de biomasa, pero tienen que ser secadas antes de ser utilizadas.

Los productores, compradores y agrónomos están informados del rendimiento potencial local y la calidad de las variedades ensayadas.

Palabras clave: Variedades de caña de usos múltiples, biomasa, biocombustibles, caña energética, rendimiento energético