DEVELOPMENT OF A TROPICAL PRODUCTION SYSTEM FOR GREEN CANE

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ABSTRACT

The Colombian sugar industry is rapidly shifting to green cane harvesting as a result of environmental concerns and community pressure. The heavy cane crop under the tropical conditions complicates the management of green cane. The sugar industry realized from the beginning that it would have to take a holistic approach to developing new production systems. Even before legislation was enacted to control burning, the sugar sector began to develop the components of a green cane production system within an overall strategy that has evolved as the program has developed. This strategy has many facets including minimizing community pressure, continuous ongoing improvements to the production system, a flexible opportunistic approach to resolving problems, development of various alternatives and the integration of many components into commercially viable technology packages. Although the initial reaction to the green production systems was to see green cane as a threat and a problem to be resolved, a conscious effort was made to look for potential advantages or opportunities inherent in green cane systems and to incorporate them. This paper describes the strategy and results obtained to the present.

Keywords: Sugarcane, green cane, environment, varieties, harvest, residues.

INTRODUCTION

The Colombian sugar industry is concentrated in the flat valley bottom of the upper reaches of the Cauca River in a region with a total population of more than 4 million people, the majority of whom live in the valley bottom. This paper describes how the sugar sector, which is concentrated in this area is moving towards harvesting green cane.

THE COMMUNITY

Over the last two decades the sugar industry has expanded rapidly to occupy more than 180,000 ha in cane, but, in spite of dominating the agricultural sector, the overall importance of the sugar sector in the region has diminished. The modernization of the country and the region has brought environmental concerns to the population at large. The burning of cane is highly visible and, as cane is harvested all year round, people are constantly reminded that the practice exists. In the decade of the nineties politicians and community leaders complained vociferously about the cane ash (pavesa). Although the pavesa did not cause health problems, the nuisance value was sufficient that the Ministry of the Environment decreed no agricultural burning after the year 2005. Furthermore, the community, local regulating agencies and the sugar sector were instructed to present a concerted plan for “clean production systems”. Within this framework Cenicaiia spearheads the Colombian sugar industry’s efforts to develop green cane production systems. The strategy is to resolve the immediate problems of managing green cane, whilst never losing sight of its potential advantages over the longer term.

PRODUCTION PROBLEMS

Green cane harvesting involves more than changing the harvesting operation. Management of the cane fields
after the harvest and the factory operations may have to be modified. Furthermore the ecology of green cane production systems differs from that of burnt cane and the relations between the crop, and its pests and diseases may be altered.

The Colombian mills processed green cane until the decade of the seventies. However the cane was carefully cleaned by the cutters and hand loaded into wagons. Later with the introduction of mechanical loading, burning became common practice and cane cutters are now loath to harvest green cane. Their cutting rates decrease considerably and they demand higher pay rates to compensate. Mechanical harvesting has been tried in various mills however until very recently there was no experience with mechanical harvesting of green cane. The first modern factory experiences, with high levels of trash in green cane, caused consternation in the industry.

The industry’s first major concern was the harvesting operation, however, it became evident that post harvest problems in field management were potentially severe with the large quantity of residues left in the field after harvest (Torres and Villegas 1996, Cock et al 1996). Germination of the ratoon crops was reduced in wet periods, and normal field operations such as cultivation, fertilization and renovation of old plantations were difficult or impossible.

OPPORTUNITIES

The first reaction of the sugar sector to the change cane to green cane was that of a threat to future profitability. However, with time it became evident that green cane may present new opportunities.

Burning cane inevitably leads to a longer period between burning and milling than between cutting and milling with green cane. This opens the opportunity for milling fresher cane with a multitude of advantages (Foster 1979). Early experiences with hand cut, clean green cane indicated that sugar recovery could be as much as one percentage point greater than with burnt cane.

In Colombia the weather patterns are highly variable, and with cane harvested throughout the year, it is common to burn fields and then harvest them after heavy rainfall. The net result is high trash and severe damage to the succeeding ratoon crop (Torres and Villegas 1990). In extreme cases ploughing out and replanting is necessary. The move to green harvesting offers more flexibility in the harvesting operations: if it rains harvesting can stop and then be continued when conditions improve.

The residue left after the harvest is a major problem. If effectively handled it may contribute to improved soil fertility and structure, and act as mulch to reduce evaporation and weed populations (Gosnell 1970, MacMahon 1990, Wood 1986). This residue has traditionally been considered as a waste product. The term, trash, gives the impression of a useless product. Nevertheless the residue may be useful with its potential as an energy source being particularly exciting. Based on the energy estimates of Ripoli et al (1991) the residue in the field in Colombia after harvest has an energy equivalent of about 60 barrels of oil per ha.

PROGRAM STRATEGY

The overall strategy evolved as the program developed. The strategy has many facets including minimizing community pressure on the sugar sector, continuous on-going improvements to the production system, a flexible opportunistic approach to resolving problems, development of various alternatives and the integration of many components into commercially viable technology packages.

MINIMIZE COMMUNITY PRESSURE

The community pressure on the sector, at first, was related to the nuisance value of ash falling on residential areas and a strategy was devised to minimize the inconvenience. The sector was, however, concerned about possible air pollution, and wished to demonstrate that cane burning was either not a health hazard or if it were...
to confront the situation. At the same time the sector began to develop technology that would reduce pollution caused by cane burning.

Continuous improvement of production system

The move to green cane was destined to be a gradual process: we never conceived that a radical new technology for green cane would become available at a certain point and then be rapidly adopted. The shift would be a process of continuous improvement that would eventually result in a radically different production system. The first stages of development would resolve immediate production problems, whilst over the longer term the systems would take advantage of the new opportunities offered by green cane.

It was evident from the beginning that the evolution of these new production systems could be based on various approaches. In the shorter term a highly pragmatic approach of trying the best guess could lead to rapid progress. This pragmatic approach is attractive; nevertheless, the technology based on quick fixes may be uncoordinated and incapable of realizing the potential benefits of green cane. Hence over the longer term individual production factors should be carefully analyzed and, based on the knowledge gained, integrated technological packages developed that exploit the full potential of green cane.

Alternatives

Cenicaña has used a multiple alternative strategy in which various alternative solutions to problems are identified so as not to depend on only one possibility. Furthermore the agro climatic and social conditions are heterogeneous and different technologies are required for the different circumstances. For example, mechanical harvesting in the South, with over 2000 mm of annual rainfall and local villages dependent on the cane cutters' income, is less acceptable than in the more developed, drier central region.

Integrated technology

The production technology to be adopted is made up of multiple components, which may have been developed in relative isolation on small-scale plots. There may be unsuspected interactions between the different components and problems of scale; hence the need to evaluate the whole package at the commercial level.

PROGRAM DEVELOPMENT AND RESULTS

Since the end of the decade of the eighties Cenicaña and the sugar sector have implemented a program directed towards green cane that is based on the strategies described above.

Minimize community pressure

The first objective was to reduce the pavesa falling on the residential areas. State agencies had established norms that were not effective in reducing the nuisance caused by the pavesa. The automatic weather network established by the sugar sector in 1992 now consists of 28 automatic stations connected to a central database by radio telemetry. The information from this network has provided the basis for major changes in management of cane burning.

The wind patterns were considered to be the most important parameter controlling the distribution of pavesa. Our work showed that diurnal patterns predominate in our conditions. Thus, we rapidly determined probabilities of wind vectors at different times of the day for different areas. In 1996 a pilot area was established in which burning was strictly controlled according to the wind probability patterns and real time data. The number of complaints was drastically reduced and this scheme has been adopted by the sugar industry. More recently information on the different trajectories of pavesa under different weather conditions and with different burn techniques have been used by local regulatory agencies to modify regulations for the benefit of both the sugar sector and the community.

The main concern about burning was related to its nuisance value, nevertheless the sugar sector wished to evaluate long term effects on public health. The sector participated in a study at the University of California,
Davis, commissioned by various sugar industries to determine the main products of cane burning and also financed an independent study on cane burning in Colombia. More recently the industry financed a study by the Pneumology Institute in Bogotá to evaluate the incidence of chronic respiratory problems in cane growing regions.

The newly formed Colombian Ministry of the Environment used the sugar sector as a test case for its policy of setting environmental standards by negotiated agreements between the sector, local authorities and representatives of the community. In this manner the sector signed an historic agreement in November 1996 to gradually reduce burning and move to cleaner production systems.

Rapid progress has not been without problems. Government agencies were keen to eliminate burning standing cane rapidly without necessarily minimizing pollution or nuisance value. Today large areas are harvested green, however, some field residues are still being burnt: pollution is probably greater with the slow poor burn of the residues than with standing cane. In addition, efforts to convince the community that the cane crop is relatively friendly to the environment have not been successful: a campaign showing that the cane crop fixed more carbon dioxide than tropical forests backfired and had to be withdrawn.

Components of Production System
The production system has to eventually be integrated into an overall package, nevertheless to simplify the development process it is divided into components, which can be studied individually.

The move to green cane will almost certainly over the long term accelerate mechanical harvesting; nevertheless manual harvesting is likely to continue to be important over the next decade. Hence we have had to address both mechanical and manual harvesting of green cane.

The characteristics of the varieties planted and the way they are managed is critical to the efficiency of the harvesting operations. Cenicaña is developing erect, uniform stalk height, thick stalked, self-trashing varieties with short tops. Furthermore high sucrose content is being stressed as this may partially offset the higher levels of trash in green cane (Torres et al 1997). The newly developed varieties are showing promise both for mechanical and manual harvesting of green cane.

The present generation of mechanical harvesters cut and load between 20 and 25 t cane per h under commercial conditions, however with new varieties like CC 85-68 rates of 30-38 t/h are obtained. With manual harvesting several of the newer selections not only allow cutters to achieve higher working rates but also reduce the trash levels in cane (table 1).

### Table 1. Manual harvesting of varieties selected for green cutting (Cauca mill).

<table>
<thead>
<tr>
<th>Variety</th>
<th>Harvest system</th>
<th>Cutting efficiency (t/man-day)</th>
<th>Sucrose % cane</th>
<th>Cane production (t/ha)</th>
<th>Sucrose production in can (t/ha)</th>
<th>Trash (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCSP 89-1997</td>
<td>Clean green</td>
<td>3.7</td>
<td>13.8</td>
<td>109</td>
<td>14.5</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>Normal green</td>
<td>5.7</td>
<td>12.1</td>
<td>130</td>
<td>15.2</td>
<td>5.1</td>
</tr>
<tr>
<td>CC 85-68</td>
<td>Clean green</td>
<td>2.9</td>
<td>14.1</td>
<td>97</td>
<td>14.0</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Normal green</td>
<td>6.4</td>
<td>12.8</td>
<td>115</td>
<td>15.7</td>
<td>7.3</td>
</tr>
<tr>
<td>MZC 74-275 (check variety)</td>
<td>Clean green</td>
<td>2.0</td>
<td>14.7</td>
<td>80</td>
<td>11.7</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Normal green</td>
<td>4.6</td>
<td>13.0</td>
<td>94</td>
<td>12.2</td>
<td>6.3</td>
</tr>
</tbody>
</table>
Mechanical harvesters have been modified for our conditions but working rates of approximately 20t cane/h with trash levels commonly above 10% do not compare well with those obtained by other industries.

Cenicañí felt that a radical new approach was required for our heavy cane crops but the major manufacturers showed little interest in working with us at the time. Nevertheless we entered into an agreement with a small manufacturer, LA CANE, to develop a two-row harvester that would have a greater working rate and produce cleaner cane. The first prototype, tested in Colombia towards the end of 1996 had several minor mechanical problems, but potential cutting rates of around 70t per hour with less than 8% trash were indicated. These results lead us to commission a commercial prototype. Furthermore, LA CANE has successfully tested a commercial harvester of the same basic design in Louisiana, where lighter crops are the norm.

The mills manually harvest “clean green cane” and standard “green cane”. In clean green cane the cutters remove all the dry leaves and sheaves adhered to the stem. Although they are paid higher rates, the lower trash levels and subsequent improvements in sugar recovery make it an attractive option with higher percentage recoverable sugar and total sugar recovered similar to that in burnt cane (table 2).

Table 2. Different manual cane harvesting systems in commercial plots in the pilot farm of San Carlos Mill.

<table>
<thead>
<tr>
<th>Harvest system</th>
<th>Lot</th>
<th>Tons cane/ha</th>
<th>Tons sugar/ha</th>
<th>Recoverable sugar %</th>
<th>Trash %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Green</td>
<td>MJ20</td>
<td>144</td>
<td>19.6</td>
<td>13.6</td>
<td>&gt;1</td>
</tr>
<tr>
<td></td>
<td>MJ21</td>
<td>134</td>
<td>19.3</td>
<td>14.4</td>
<td>&gt;1</td>
</tr>
<tr>
<td></td>
<td>SE25</td>
<td>138</td>
<td>15.9</td>
<td>11.6</td>
<td>4</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>139</td>
<td>18.3</td>
<td>13.2</td>
<td>2</td>
</tr>
<tr>
<td>Burnt cane</td>
<td>MJ20</td>
<td>156</td>
<td>20.1</td>
<td>12.9</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>MJ21</td>
<td>139</td>
<td>17.8</td>
<td>12.8</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>SE25</td>
<td>177</td>
<td>18.1</td>
<td>10.2</td>
<td>6</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>157</td>
<td>18.7</td>
<td>12.0</td>
<td>3</td>
</tr>
</tbody>
</table>

In standard manual harvesting, in spite of increased trash levels, the levels of recovered sugar have not dropped noticeably. Cenicañí has shown that burning itself reduces sucrose in cane by between 0 to 6% and furthermore the loss of sucrose under tropical conditions after burning is 0.1% per hour during the period from 48 to 72 hours after burning and cutting (Cenicañí 1996). With green cane there are no losses due to burning and the time between beginning the harvesting operation and milling can be reduced. The mills have exploited these advantages and over the last few years the average recovered sugar has increased from 11.0% to more than 11.6% in 1996-1997 in spite of an increase in the area harvested green.

In the short term windrowing was successfully tested to manage cane residues (Torres and Villegas 1996). This practice has been widely adopted by the sugar industry, however the windrowed residues obstruct machinery and do not allow the fields to be ploughed for renewal of plantations. Furthermore the operation is expensive and the residues themselves are a fire hazard.

Experimental fields in which the residues were chopped after harvest produced cane yields equal to or greater than those obtained with other systems, allowed traditional cultivation practices and eliminated the fire hazard (Cock et al 1996). The residues were chopped using a standard forage harvester, however this machine had
a throughput of less than 0.5 ha/h. Cenicaña has worked closely with various manufacturers to develop a residue chopper with a capacity of 2 ha/h and a cost of approximately US$50/ha. A CLAAS Jaguar forage harvester with a head developed specifically for cane residues is now entering into commercial trials.

The areas harvested green are being monitored to provide an early warning of any drastic changes in disease and pest incidence so that appropriate action can be taken. Monitoring of Perkinsiella shows that pest populations are influenced by the change to green harvesting (figure 1).

![Dynamics of Perkinsiella oviposition under burnt and green cane conditions.](image)

**Figure 1.** Dynamics of Perkinsiella oviposition under burnt and green cane conditions.

**New Opportunities**

The residues left in the field after harvest are considered to be a problem. They are, however, a potential source of renewable energy in the form of biomass. Colombia is potentially in a particularly advantageous position due to the very high levels of residues and the continuous supply throughout the year. There are various obstacles to the utilization of residues and no one system will be optimal for all circumstances. We see three different major possibilities: burning directly in boilers to produce steam, pyrolytic gasification to power gas turbines; and fermentation of residues to produce biogas. In order to produce steam or pyrolyse residues relatively low moisture levels are necessary, whilst for fermentation higher moisture levels would be acceptable. Hence fermentation may be preferable where natural drying of residues in the field is difficult. The sector is carrying out a pre feasibility study to see if there is any possibility of developing economically viable systems of producing electrical energy from the biomass in the residues.

**The Overall System**

The various components of new practices and technologies become available as individual advances that need to be incorporated into the overall production system. This is being done by mills and individual farmers. Cenicaña assists in this process through a series of Pilot Farms.

The mills and Cenicaña dedicate areas of 50-300 ha to Pilot farms. A committee, comprising staff from the mills and Cenicaña, mutually agree on the optimal technology package which is applied on a commercial basis, with precise record keeping so as to determine the economic viability of the overall package. The first of the Pilot farms has demonstrated that, in the drier areas, cane can be successfully grown and harvested green.

The approach taken by the Colombian sugar sector is allowing it to change to green cane without disastrous consequences. A key factor has been the incorporation of new components of technology continuously into the overall production process as they become available.

At the same time we have maintained a clear idea of where the industry is headed, ensuring that not only do we resolve the immediate problems, but that we also develop a viable technology for the sector over the longer
term. Wherever possible the sugar industry has attempted to keep ahead of political pressure, implementing environmentally sound practices voluntarily.

Technology on its own is not sufficient to ensure a smooth change to green cane. The sugar sector has responded to the legitimate concerns of the public, whilst at the same time improving the knowledge base from which concerns about the environment can be rationally discussed.

ACKNOWLEDGEMENTS

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REFERENCES


RESUMEN

La industria Colombiana se está moviendo rápidamente a la cosecha de caña verde como resultado de la preocupación ambiental y por la presión social. Las cañas de altas producción obtenidas en el trópico complican el manejo de la caña en verde. La industria azucarera visualizó desde un comienzo la necesidad de seguir una aproximación integral para el desarrollo de los nuevos sistemas de producción. Con anticipación a la expedición de las leyes que prohíben las quemadas agrícolas, el sector azucarero inició el desarrollo de los componentes de un sistema de producción en verde con una estrategia global que ha evolucionado en la medida en que el programa de cosecha en verde se ha establecido. Esta estrategia cubre muchos aspectos incluyendo la necesidad de minimizar la presión social, realizar mejoras constantes al sistema de producción, desarrollar un mecanismo de respuesta oportuno y rápido a los problemas, y desarrollar varias alternativas e integrar los diferentes componentes en paquetes tecnológicos comercialmente viables. Aunque la reacción inicial al sistema de producción en verde fue la de ver la caña verde como una amenaza y la de un problema por resolver, se ha hecho un esfuerzo consciente para identificar las ventajas potenciales e incorporar las oportunidades que ofrece el sistema de producción en verde. Este artículo describe la estrategia y los resultados obtenidos hasta el momento.

DEVELOPPEMENT D'UN SYSTÈME DE PRODUCTION EN CANNE VERTE

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RÉSUMÉ

L'industrie sucrière colombienne, à cause de problèmes environnementaux et des pressions de la population se convertit rapidement dans la récolte de cannes vertes. La masse végétale que représente la canne en conditions de culture tropicale compliquent la gestion de la récolte en canne verte. Dès le départ, l'industrie sucrière a compris qu'elle devait avoir une approche globale pour développer de nouveaux systèmes de production. Bien avant l'entrée en vigueur de la législation portant sur le contrôle du brûlage, le secteur sucrier a développé différentes techniques qui permettent la gestion de la production en canne verte. Cette approche a évolué en fonction du développement du programme.

Parmi les nombreuses facettes de cette stratégie, se retrouvent la minimisation des pressions de la population, l'amélioration continuelle du système de production, une approche pragmatique pour résoudre les problèmes, le développement d'alternatives variées et l'intégration de plusieurs techniques dans des ensembles fonctionnels. Bien que les premières réactions vis à vis de ce nouveau système de production furent de considérer la canne verte comme une menace et un problème à résoudre, un effort fut consenti pour en déterminer les avantages et les opportunités potentiels et de les exploiter.

Ce document décrit la stratégie et les résultats actuels.

MC: canne à sucre, canne verte, environnement, variétés, récolte, résidus