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**Improving sugarcane supply chain management
in the South-African sugar industry**

*Visit report to SASRI
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Summary

The purpose of visiting SASRI was aimed (i) at finalizing the 2004 study report about the cane payment system and (ii) at discussing extensions of the research activities conducted since 2002 in the Sezela mill area. Three main activities were investigated. Firstly, an extension of the methodology used in Sezela to the Amatikulu mill area will start in the following months. The report gives some indications about the steps to follow. Secondly, information was collected in order to simulate the impact of an optimal variety plan on the sugar production at Sezela. Thirdly, contacts were made to tackle new strategic issues linked with the diversification of sugarcane outputs (electricity, ethanol, bio-molecules). Meanwhile the English version of the software MAGI was completed. A workshop will be organized in July in order to carry on these three new initiatives. It will follow the SASTA Congress where a paper based on the 2004 study will be presented.

Key words: sugarcane, supply chain, simulation, variety, bioenergy

Acronyms

ATP	Action thématique programmée (CIRAD call for research proposals)
ADD	Agriculture et développement durable (Agriculture and Sustainable Development – Call for research proposals managed by INRA)
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
INRA	Institut national de recherche agronomique
RV	Recoverable Value (cane quality indicator used to pay the growers)
SASA	South African Sugar Association
SASRI	South African Sugarcane Research Institute
SASTA	South African Sugar Technologists' Association
SMRI	South African Milling Research Institute

Acknowledgements

I would like to thank Peter Lyne and Eddie Meyer, from the Agricultural Engineering Department at SASRI, for organizing this visit in Mount Edgecombe and for committing themselves to the various activities of the collaborative project between CIRAD and SASRI regarding mill supply management (mentioned as the SUCRERIE Project in the text).

1. Introduction

The SUCRERIE project started in 2002 with joint funding from CIRAD, INRA and SASRI¹. It aimed at investigating the ways to improve the sugar value chain by focusing on the relationship between growers and millers. Studies were conducted in 2002 and 2003 in the Sezela mill area in order to assess the RV gains expected from re-arranging the harvest scheduling based on cane quality variations within the mill area (Guilleman *et al.*, 2003; Le Gal *et al.*, 2004a,b). A third study was conducted in 2004 in order to assess the impact of the cane payment system on the growers' revenues assuming a new harvest scheduling would be implemented.

This visit to SASRI aimed at (i) finalizing the report presenting the 2004 results, (ii) working on new supply issues (impact of an optimal variety plan on the Sezela mill area sugar production), (iii) discussing the extension of the methodology used at Sezela to other mill areas, (iv) working on the English version of MAGI (software currently developed by CIRAD to simulate mill supply scenarios) and (v) discussing the future of the project according to new strategic issues raised in the South African sugar industry.

2. 2004 study report

A French student, Hugo Papaïconomou, did his Master internship in 2004 on the cane payment issue. He wrote his Master study report in French (Papaïconomou, 2004) and I extracted from this report an English synthesis that was discussed with our SASRI colleagues, P Lyne and E Meyer (Le Gal *et al.*, 2005a). This report was finalized during the visit. Copies have been sent to the Sezela stakeholders for comments before the final edition.

A paper has already been submitted and accepted for the 79th SASTA Congress, which takes in place in Durban from the 19th to the 22nd of July 2005 (Le Gal *et al.*, 2005b). This paper presents the main results obtained in the 2004 study. We also discussed the slide show that will be used for the oral presentation during the Congress.

3. Simulation of variety-based scenarios

During my former visit at SASRI we jointly considered that the Sezela studies conducted since 2002 was completed as far as the issues raised by both the miller and the growers' representatives were concerned. It was decided to investigate new issues that could be valuable for the mill area profitability, even if they are rather theoretical (Le Gal, 2004). One option consisted of simulating the impact of an optimal variety plan on the sugar production of a mill area. It was suggested that Sezela be kept as a well known case study.

Some contacts were made during the current visit in order to (i) get a better understanding of the variety diversity and its adaptation to the Sezela context, (ii) define a simulation methodology and (iii) collect the basic data needed to conduct the simulations. These three steps were discussed with the variety specialists at SASRI (K Redshaw, M Smith) and D McElligot at Sezela.

¹ See the list of acronyms p.1

The following information is now available:

- the actual variety distribution in the Sezela mill area;
- an optimal variety distribution taking into account the new varieties available in the industry². This optimal plan is defined according to climatic and soil sub-areas;
- some quality curves per variety extracted from the mill delivery database.

However, extra information is needed to carry out the simulations: average yield and quality curves for each variety planned in each sub-area. The mill database mainly includes quality information regarding the older varieties, such as NCo 376, but little regarding the new varieties and their yields. So we decided to base the information collection on expert knowledge. I will provide the RV curves calculated from the mill database for the main varieties currently cultivated. K Redshaw and D McElligot will (i) correct the dataset and (ii) add the figures of the new varieties according to their own experience (field observations, growers' perceptions, variety trials).

The simulations will be conducted using the software MAGI once the dataset is completed.

4. Extension to the Amatikulu mill supply area

The Department of Agricultural Engineering at SASRI has been contacted by the Amatikulu mill to apply the methodology used at Sezela in their supply area. This Mill area includes both Coastal and Inland sub-areas, with a good tonnage balance between them (40 and 60% respectively out of the total cane production). Small-scale growers are also better represented than in Sezela (around 36% out of the total cane production). Moreover, it should be easier to develop new supply scheduling as the only mill output is sugar and molasses³.

We agreed on the following methodology and time schedule to conduct the decision support process:

- step 1 (from now to July): definition of the quality-based sub-areas and calculation of the RV curves for each sub-area using the delivery data recorded at the mill level;
- step 2 (July workshop): demonstration and training on MAGI; discussion about the scenarios to be simulated (definition of harvest windows per sub-area);
- step 3 (from July to November): scenarios simulation and results discussion.

The methodology used to conduct step 1 is based on the following stages:

a- Definition of the quality-based sub-areas:

The process aims at defining the geographical limits between sub-areas showing contrasting quality patterns. Various sources of information may be combined: existing divisions, agro-climatic data, usual cutting cycles (in months), and expert knowledge.

² As sugarcane is a semi perennial crop (around 6-year cycle between two plantings) the variety replacement might take quite a long time within a specific area.

³ The furfural production plant in Sezela makes it difficult to simulate scenarios which would shorten the LOMS, because it relies on bagass coming from the sugar factory.

Specific sub-areas might be created for the small-scale growers, combined or not with their locations (Coastal or Inland for example). Indeed, their behaviour regarding cane quality management is rather specific (priority to cash-flow rather than optimum quality; constraints of harvesting contractors' availability; difficulties to get inputs).

b- Assignment of every grower to a sub-area

This stage is needed in order to calculate the RV curves per sub-area. Usually a table is created in the database, which gives the correspondence between the grower's quota number and his sub-area code.

c. Calculation of RV curves per sub-area

We assumed that the Amatikulu mill collects all the delivery records and includes them in a computerized database. Each delivery record should include at least:

- . the grower's quota number;
- . the delivery week;
- . the delivery Net Mass (tons);
- . the %RV.

One can calculate the weekly weighed %RV average after assigning a sub-area code for each delivery, by using the following formula:

$$\overline{\%RV_{ij}} = \left(\sum_{k=1}^n \%RV_{ijk} \times NetMass_{ijk} \right) \div \left(\sum_{k=1}^n NetMass_{ijk} \right)$$

where: i = sub-area "i" j = week "j" k = delivery "k"

These calculations should be carried out for each year since 2000 (first year with the RV system). The results could be reported in a spreadsheet table with the following format:

Weekly %RV average per sub-area

	Calendar week														
	7	8	...	...	...	...	...	...	...	...	...	...	...	50	51
Coastal	8,5	8,9												11,8	11,6
Inland	10,1	10,5												12,0	11,8
SSG	8,0	8,2												11,5	11,4

One can then draw graphs based on these figures and compare sub-areas' %RV curves between them. The harvest windows per sub-area will be partially defined according to these curves.

We still need to identify the task force that will be committed to this activity (mill and growers' representative, technical staff) and the task distribution between them (who will do what?).

5. MAGI

MAGI is a software package developed by CIRAD in order to simulate the sugar mill supply throughout a harvest season, taking into account the structure of the supply area, the stakeholders' capacities, the season characteristics, the cane quality curves and some delivery

allocation rules. An intense development and evaluation process has been conducted over the past few months in order to finalize this program.

The current version enables one to simulate a whole scenario and to calculate the resulting total sugar production. Nevertheless the Results module has still to be improved. So I presented this version to P Lyne and E Meyer but I did not leave them a copy of the program.

We worked together on the English translation of the French version. All the accessible labels were reviewed. Some parts still need to be translated (column labels in some tables; error messages). This has been included in the modifications list that needs to be done in the near future.

The Results module has to be finalized before July in order to simulate the variety-based scenarios and to give a copy of MAGI to our SASRI colleagues. Then they will be able to test it on the Amatikulu case.

6. New strategic issues

The worldwide sugar industry is facing new strategic issues as the international sugar price is quite low and the increase of oil price makes some cane co-products economically viable, such as electricity and ethanol⁴. Sugarcane is then progressively considered as a raw material source for a large range of products⁵. Improving the value chain should then be based on a combination of co-products, balanced according to their relative prices on the local and international markets.

This potential diversification of outputs raises new issues with direct links to the SUCRERIE project problematic:

- *What would be the impact of new process outputs on the way mills are supplied?* For example parameters such as Length of Milling Season (LOMS) or delivery allocation patterns might be modified according to the cane component which is sought for (whole biomass, sugar, fiber, etc.).

⁴ See for a recent example found in the 2004 Abstracts of Presentations, SPRI (www.spriinc.org/Abstracts%20SPRI%20Conf.html)

Ethanol Production by the ZeaChem Process: An Element of a Sugarcane Biorefinery. Les A. Edye, Sugar Research Institute, Mackay, Australia. In the near future the biorefinery concept of complete utilization of cane field biomass will become a pivotal element for a sustainable sugarcane industry. An industry that produces liquid fuels, electricity and commodity chemicals from a renewable source in regional communities will contribute to all elements of the triple bottom line and should be considered a compelling vision. In Australia, the Cooperative Research Centre for Sugar Industry Innovation through Biotechnology commenced in August 2003 and will embark on a significant program of research and development to underpin sugarcane biorefining. Fermentation to ethanol and other renewable commodities and biomass treatment processes such as pulping are technical elements of the biorefinery concept. The Sugar Research Institute has undertaken to assess the ZeaChem process – a novel fermentation route to bio-ethanol. This presentation covers the capacity of the sugar industry to produce ethanol and our preliminary assessment of the ZeaChem process.

⁵ See for example : *Handbook of sugarcane derivatives*. ICIDCA, 2000. 485 p., for a list of potential outputs of the cane process (Cuba Research Institute of Sugarcane By-Products).

- *How cane quality would be assessed in relation with various process outputs?* The current methodology is adapted to sugar production. What are the modifications needed for electricity, ethanol, bio-molecules that can be extracted from sugarcane, or a mix of them?
- *How growers would be paid for their sugarcane assuming its outputs vary from one season to another or even within a season?* We assume that growers would like to share the value gained from a diversified range of co-products with millers. In that case the current agreement between them has to be reviewed according to these new potentialities.
- *How these evolutions would impact on the cane crop management?* Variety selection, cycles, harvest organization could have to change according to both the new and variable requests from the mills.
- *How the supply chain would increase its whole flexibility in order to cope with more market variation?* While the industry is currently focused on sugar, it should have in the future to select its outputs according to their relative prices, and to adjust its supply chain management accordingly on rather short-term notice. Then the stakeholders' relationship would have to be organized in order to adjust quickly to market-driven decisions.

These strategic issues provide an exciting frame for a new collaborative project between SASA and CIRAD. But the partnership has to be enlarged compared with the current project, for two main reasons:

. At present SASRI is not mandated to research on any other output than sugar. So the links between cane management and co-products are not included in its programs. This strategic move will probably take place in the future but the final decision has to be made by its board.

. This problem involves both millers and growers as well as the whole supply chain, from cane production to marketing. So other Sugar Industry bodies such as the South African Cane Growers' Association and the South African Sugar Millers' Association, plus the SMRI⁶, have to be involved in the project. I got a positive contact with A Wynne (SA Cane Growers Association) for that purpose. Moreover, the University of Kwazulu-Natal should also be part of this project, as some supply chain research is conducted on the sugar industry in The College of Engineering, Science and Agriculture (C Bezuidenhout).

A new project will need new funding. Some opportunities have to be explored on the French side (ATP CIRAD, ADD INRA) and the European side (under the "bio-energy" umbrella). On a practical side it would be necessary to assign a PhD student or a Postdoc at SASA to conduct the day-to-day research work on such a complex subject.

My next visit to SASRI in July will give the opportunity to discuss this specific matter, during the SASTA Congress as well as the workshop that we have organized.

⁶ The Sugar Milling Research Institute is funded by the South African millers and located at the University of Kwazulu-Natal. It is specialized in the industrial process component of the supply chain.

7. Conclusions: the July workshop

The SUCRERIE project is almost complete in that the first phase focused on supply scenarios linked to quality-based delivery patterns is being finalised. Some extensions are still to be carried out (Amatikulu case, variety-based scenarios), and the software MAGI still needs to be finalized but the main components have been carried out.

New opportunities are emerging from the evolutions affecting the worldwide sugar industry. We may assume with good confidence that sugarcane will be more and more considered as a source of diversified outputs. Their combination in a specific mill area will result from a complex reasoning including relative prices, industrial integration, local potential, relationship between growers and millers. These changes will impact the whole supply chain, and particularly the way this relationship is managed. The methodology and the concepts designed and experimented in the SUCRERIE project would find a valuable field of application by tackling these issues.

A workshop is planned in July to both finalize the current phase and discuss the following one. The first objective will include:

- a meeting with the Sezela stakeholders in order to finalize the 3-year project conducted with them. This meeting will aim at understanding their position regarding a change in the mill supply organization ;
- a workshop with the Amatikulu stakeholders in order to discuss the quality-based zoning and to introduce MAGI and the simulations they could carry out with the software ;
- the finalization of the variety-based scenarios: dataset per variety, selection of variety distribution scenarios, simulation of the selected scenarios with MAGI.

The second objective will address the possibility to enlarge the project to by-products issues: how the outputs and diversification of the sugarcane value chain would impact on the mill supply organization and the cane payment system? Which partnership? Which resources? Which methodology? New contacts will be made in that respect (Millers' Association, SMRI)

Caroline Lejars will attend this workshop and we will also discuss the collaboration project between La Réunion and South Africa: involvement of C Lejars in the project (which part of her PhD study on cane payment system will be conducted in South Africa?), research exchanges between the two locations.

This workshop will be combined with my participation of the 79th SASTA Congress, where I will present the paper based on the 2004 study results (Le Gal *et al.*, 2005b).

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