ASSESSING THE LINKS BETWEEN CANE SUPPLY SCHEDULING AND CANE PAYMENT SYSTEM IN THE SEZELA MILL SUPPLY AREA

Report to South African Sugarcane Research Institute Association

Mount Edgecombe

South Africa

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ASSESSING THE LINKS BETWEEN CANE SUPPLY SCHEDULING AND CANE PAYMENT SYSTEM IN THE SEZELA MILL SUPPLY AREA

Executive Summary

In the South African sugar industry, sugarcane is traditionally delivered to the various mills uniformly over the milling season and across all supply areas. This type of delivery schedule does not always exploit the different cane quality patterns that exist in certain mill supply areas. These regional differences in 'recoverable value' of sugar patterns (RV) are primarily due to soil and climate differences and differences in agronomic practices.

It would be expected that by re-scheduling cane deliveries in accordance with peak RV periods in each mill supply sub-area, overall recovery of sugar could be maximized. Such a change of cane deliveries would however, need to take cognisance of capacity constraints in the supply chain, including on farm harvest and cane handling operations, cane transport and mill processing.

A first study, conducted in 2002 in the Sezela mill area, investigated the potential for improving mill area profitability by modifying cane supply and harvest scheduling to account for sub-region cane quality trends. Production and delivery data from mill weighbridge and cane quality databases were analysed for 2000 and 2001 to determine cane quality trends as well as the capacity and variability of cane deliveries through the season. This was carried out to investigate how sugar production could be maximised by changing the structure of cane deliveries from the fields to the mill, bearing in mind the existing harvest and transport systems as well as mill capacities (Guilleman *et al.*, 2002; Guilleman *et al.*, 2003). This first study showed that potential gains ranging from 1 to 5% of the current annual sugar production might be achieved by re-arranging cane supply scheduling according to homogeneous quality-based sub-areas. This represents for Sezela millers and growers an increase of between 3 000 tons RV and 11 000 tons RV annually with a value of between R4.05 million and R14.85 million (based on R1 350/ton RV in 2002).

As a result of the interest shown by both the miller and grower representatives in the results of the first study a second study was undertaken in 2003 to investigate more precisely the practicalities of implementing changes in the cane supply delivery patterns. This second study analysed (i) the supply curve characteristics from 2000 to 2002, (ii) the relevance of the quality-based zoning according to climatic variability (1998-2002) and (iii) the available capacities along the supply chain (growers, hauliers and mill). A total of five new scenarios were then simulated and discussed with the growers and the miller.

The methodology used for the second study was similar to the first study. Cane quality data for the 1998 to 2002 seasons was accessed directly from the mill database, while the 1998 and 1999 data were supplied by SASA. An analysis of grower, haulier and mill capacities was carried out using data captured by the weighbridge and mill records. Interviews were conducted using a sample of the stakeholders (growers, hauliers and miller) in order to assess both existing and spare cane harvesting, transport and crushing capacities. Once all this new information was assimilated, new cane delivery scenarios were designed and simulated using the spreadsheet programme developed during the first study.

The results showed that, at the mill area level, cane quality (measured in %RV) varied according to a bell-shaped curve during the season. However, each year had its own particular

profile. However, the 2000 and 2001 seasons were low quality years characterized by low %RV and high variability. Inter-annual variability of Coastal cane quality was higher when compared with the Inland zone. The instability of the Coastal quality may have been due to the effects of *Eldana saccharina* infestation. Furthermore, the Inland cane quality was higher than the Coastal zone throughout the season.

In refining alternative cane delivery scenarios, cognisance was taken of variability of total cane production, length of milling season, as well as weekly cane deliveries from one season to another. Furthermore, harvesting, infield transport, transloading and road haulage capacities and other issues such as labour availability and cash flow should be taken into account. Considering the total crop, crush capacity and the quality dependent crush capacity, the mill capacity was pegged at 70 000 tons per week in a 38-week milling season when the new scenarios were evaluated.

The results showed that the highest RV gains were obtained when the Coastal zone deliveries were delayed by four weeks at the beginning of the season and the Inland zone cane deliveries stopped nine weeks before the end of the season. However, this scenario is somewhat risky as it uses the total crush capacity and is more sensitive to the cane quality variations. The next best RV gains were obtained where the Inland production area was increased together with a shorter Inland harvest window. Potential gains ranged from 1 to 3%.

The results of the interviews indicated that commercial growers could easily sustain a 50% increase in cane deliveries if harvest windows were shortened. Grower/hauliers had sufficient capacity to increase their average deliveries by as much as 30%.

A third study, conducted in 2004, assessed various cane payment systems in relation to the re-scheduling of the cane supply in the Sezela area. The study combined three stages in order to answer these issues. Firstly, three supply scenarios were selected from the studies carried out in 2002 and 2003, while adding the 2003 season data to the analysis. Secondly, the current relative payment system was analysed as an incentive to deliver rateably. Thirdly, two alternatives payment system scenarios were defined and their impacts on the growers' revenues were simulated. This study was completed with a grower survey regarding the quality management processes at farm level.

Alternative cane supply scenarios
After extensive discussions and because of their potential feasibility and value, the stakeholders selected four scenarios from the former studies conducted in 2002 and 2003. These were:

- Reference scenario: every zone delivered from the beginning to the end of the season;
- S1: Coastal deliveries were delayed (two weeks) and Inland stopped delivering four weeks before the end of the season. S1 aimed at (i) decreasing the impact on the RV tonnage of the lower and more variable quality of Coastal cane at the beginning of the season and (ii) focusing Inland deliveries around the %RV peak and stop inland deliveries before rain disrupted their deliveries;
- S1bis: Coastal deliveries were delayed by four weeks and Inland stopped delivering nine weeks before the end of the season. This scenario was based on the same objective as S1, but extended the supply system to its capacity limitations;
- S2: Coastal delivered throughout the season, while Inland started delivering two weeks after the season started and stopped six weeks before its end. S2 took into account the

necessity to harvest older Coastal cane at the beginning of the season to minimize the risk of yield loss due to *Eldana saccharina*. Inland deliveries were focused around the %RV peak.

The difference between the RV tonnage produced by Inland and Coastal zones in the reference scenario and RV tonnages produced in alternative scenarios were computed for each year between 2000 and 2003. Expected gains for Coastal + Inland zones varied from 360 tons RV to 6 000 tons RV per season, which accounted for 0.45 to 7.44 million Rand. S1bis systematically showed the best results, while the S1-S2 ranking varied according to the season. But the largest differences were mainly linked around the season and the corresponding %RV curve profiles, the flatter the profile the smaller the gain. For example 2002 shows less gain than 2001 while its total production was more.

Sharing the gains of alternative supply scenarios

The relative payment system aims at encouraging large-scale growers to deliver rateably throughout the season while small-scale growers can deliver any time without consequences to their revenue. The study showed that this hypothesis is generally applied, as individual differences between paid and delivered RV decrease when the number of delivery weeks throughout the season increase.

A change of harvest scheduling per sub-area without changing the payment system impacts greatly on the gains shared between the sub-areas. Inland systematically transfers some of its gains to Coastal and SSG growers. The transferred amount varies according to the supply scenario. It reaches its maximum with S1bis in 2003, as Inland revenues decrease compared with the reference scenario while Coastal benefits greatly. The trend occurs with S2 as well although Coastal supplies remain identical. This phenomenon is also sensitive to the year. In 2000 the transfer linked to S2 is greater than in 2003, as Inland loses relative RV tonnage compared to the reference.

These results confirm the hypothesis that alternative supply scenarios based on local re-arrangements of harvest scheduling affect the way gains are shared between growers. Alternative payment systems were designed in order to correct the distortions created by the supply scenarios in the current situation

Alternative payment systems

Two alternative payment systems were simulated. The first alternative, called Sys1, replaced the mill weekly %RV average by the sub-area weekly %RV average. The season average remained the same, i.e. calculated at the mill area level. The Sys1 formula is defined as follows:

$$\%RV_{i,j\ \text{relative}} = \%RV_{i,j\ \text{measured}} - \%RV_{j\ \textbf{sub-area}\ \text{average}} + \%RV_{\text{mill area average for the season}}$$

where i = grower i j = week j

The second alternative, called Sys2, consisted of splitting the mill area into the three sub-areas, Inland, Coastal and SSG, and compared growers within each zone separately. Sys2 formula is then:

$$\%RV_{i,j\ \text{relative}} = \%RV_{i,j\ \text{measured}} - \%RV_{j\ \textbf{sub-area}\ \text{average}} + \%RV_{\textbf{sub-area}\ \text{average for the season}}$$

The simulations carried out without changing the mill supply schedule showed that Sys1 lead to a general and consequent transfer of RV from Inland to Coastal and SSG. This transfer amounted for 2 000 to 6 000 RV tons depending on year, i.e. from 3 to 8% of the total annual Inland revenue. This loss resulted because the Inland deliveries were compared to a higher average %RV, while Coastal deliveries were compared to a lower value. The stakeholders rejected this alternative because of these strong distortions and no other simulation was conducted using this method.

Comparatively Sys2 lead to a very small transfer from Coastal and Inland to SSG. This figure did not exceed 312 tons. It rectified the reverse transfer from SSG to Inland and Coastal in the current payment system, which occurred because of its lower cane quality. This process fairly distributed the gain between Coastal and Inland growers, as 89% and 73% of them earned or lost less than 1% of their current revenue over the four years respectively, and very few exceed 2%. The impact was more diverse on SSG revenues because of their small number of deliveries during the season.

The Sys2 alternative rectified the distortion noticed with the current payment system when applied to the alternative supply scenarios. In that case, each sub-area was nearly paid according to its RV production, as the same basis was used both to organize rateable deliveries and to calculate relative RV. Indeed Sys2 was based on the basic principle that profits go to the stakeholders making the effort to improve their cane quality.

The general trend was that a majority of Inland growers gained extra-revenue, as the RV transfer between Inland and Coastal was almost cancelled. 86% of them would gain more over the last four years. However, both positive and negative variations remain in a narrow range for most of the growers (± 2%), SSG around (± 5%).

Nevertheless the RV balance between the sub-areas may change from one week to another according to the year. By allowing RV transfer between sub-areas, Sys0 reduces the loss risks arising from particular poor local potential. Moreover, a subsidy process from Inland to Coastal and SSG can be seen as a mill area strategy: growers located in a better area for production allow disadvantaged growers to remain active and so the mill to operate at full capacity.

Grower's cane quality management

The interviews conducted with the sample of growers indicated that there was no difference in practices arising between large and medium-scale growers.

Coastal "good quality" growers tended to adopt specific practices to improve their quality, such as using ripeners, managing *Eldana* infestation, better planning of their harvest, fertilizing their soils according to their nutrient balance and topping correctly in order to reduce fibre content. By comparison, Inland growers invested less in quality management as they took advantage of the better climatic conditions. Inland "good quality" growers gave more attention on harvest-to-crush delays, topping and ripeners compared with "poor quality" growers from the same sub-area.

Curiously the choice of new varieties did not seem a factor for improving quality anywhere.

The supply scenarios consisting of delaying Coastal deliveries at the beginning of the season and ending Inland deliveries earlier in the season should have a positive impact on cane yields

because of (i) the better adjustment between the growth period and rainy conditions and (ii) more time available to conduct fertilization and weeding. Avoiding humid periods will also reduce the risk of harvesting under poor conditions which impact on harvest delays and cane quality. These scheduling changes could also impact on the variety selection but this issue would need further investigation.

The research results have given the Sezela stakeholders a good basis to make their decisions regarding a change in supply organisation and payment system. The research program can now address new topics emerging from the challenges facing the South African sugar industry for the future. It will mainly consist of investigating the impact of innovative technologies and industrial outputs on both supply organisation and the three components of the payment system. As in the past these issues will be addressed as part of a collaborative research project between CIRAD and SASRI.

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1. BACKGROUND

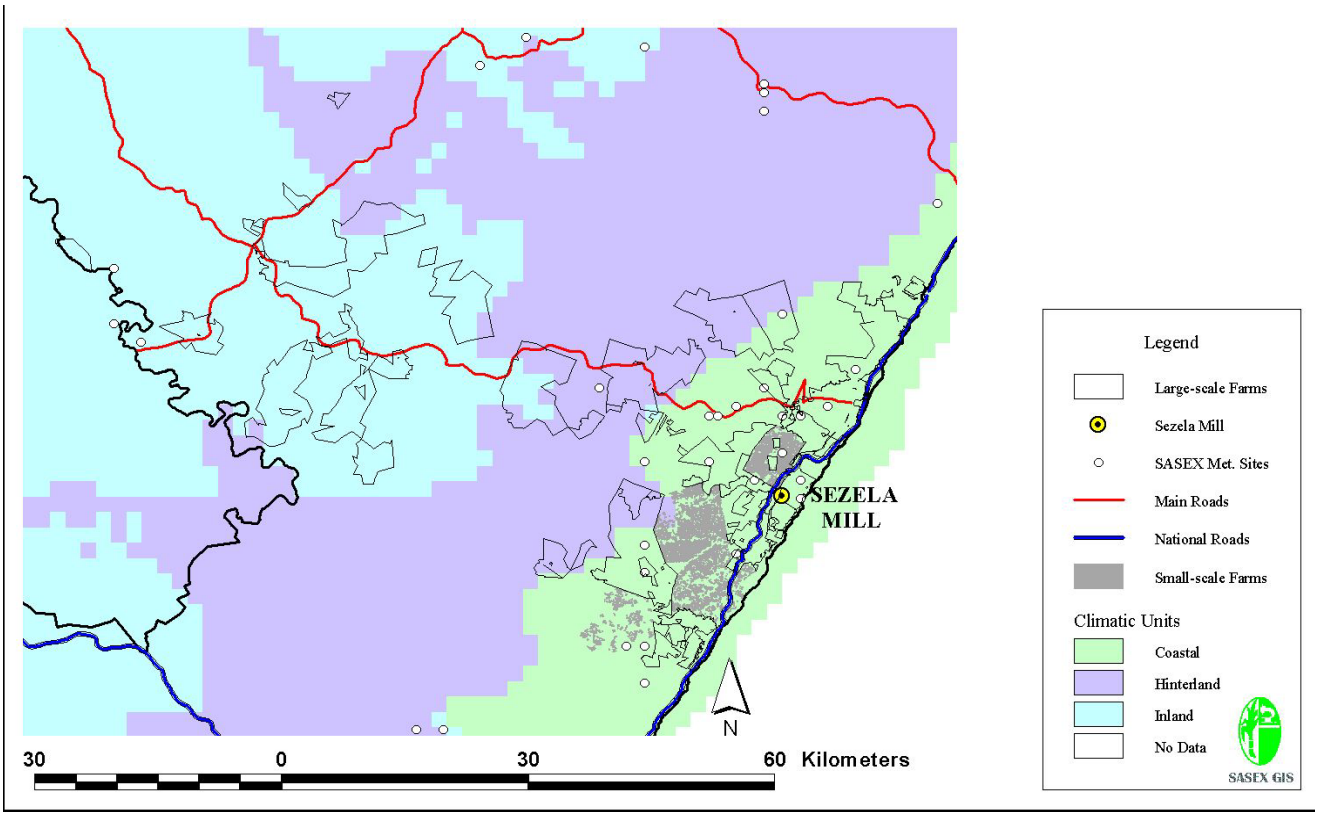
The South African sugar industry consists of 15 mills operated by five companies located in KwaZulu-Natal and Mpumalanga. On average 22 millions tonnes of sugarcane are produced annually, mainly by 1 700 large-scale growers accounting for 72% of the production, as well as 12 miller-cum-planter estates (13%) and 50 000 registered small-scale growers (15%). The South African Sugar Association (SASA) embodies the partnership between millers and growers. SASA provides specialist services to the sugar industry and is responsible for distribution of the proceeds from sugar and molasses sales to cane growers and millers. Negotiations between millers and growers regarding the general organization of the industry, such as the cane payment system, are conducted under the SASA umbrella.

Since its liberalization in 1998, the South African sugar industry is facing new challenges. The national market remains protected by means of import tariffs and minimum prices, but over a half of SA total sugar production is exported at a price that fluctuates according to the global market. The industry needs to improve its efficiency in order to remain competitive internationally, especially since the Rand has appreciated against the Dollar for the last two years.

Profitability gains can be sought for at different levels of the industry (cane production, sugar extraction and products marketing), which is the aim of most research programs conducted in sugarcane production (varieties, fertilisation, irrigation, harvest techniques), milling and refining technology (sugar extraction methods) and economy (market awareness). But there is also potential to improve profitability at the mill area level by looking at cane supply management. This process involves interactions between numerous stakeholders: farmers and harvesting contractors who both manage harvesting, hauliers who transport cane to the mill, and millers who organize supplies in order to regulate the mill operation. Therefore improving cane supply management requires a system analysis and specific methodology in order to provide useful information to both growers and millers (Muchow *et al*., 2000).

Various ways of improvement can be considered, ranging from changes in harvest and transport techniques to new rules of delivery allocation (Gaucher *et al*., 1997). CIRAD, SASRI and the Sezela mill have been conducting a collaborative research project since 2002 into the potential benefits that could be expected from re-arranging cane supply scheduling based on the variation of quality patterns within the mill supply area (Guilleman *et al*., 2003; Le Gal *et al.*, 2004a and 2004b).

During the two first years of the project various supply scenarios were compared in terms of their sugar production, assessed by the RV (Recoverable Value) indicator. They aimed at maximizing RV production by crushing better quality cane during the season. The supply area was split into three quality-based sub-areas - Coastal, Inland and Small-Scale Growers (Map1) - and various harvest windows were allocated to each sub area according to its specific quality curve. The objective was to benefit from the better %RV of Inland at the beginning of the season (Figure 1).



Map 1: Zoning of the Sezela mill area

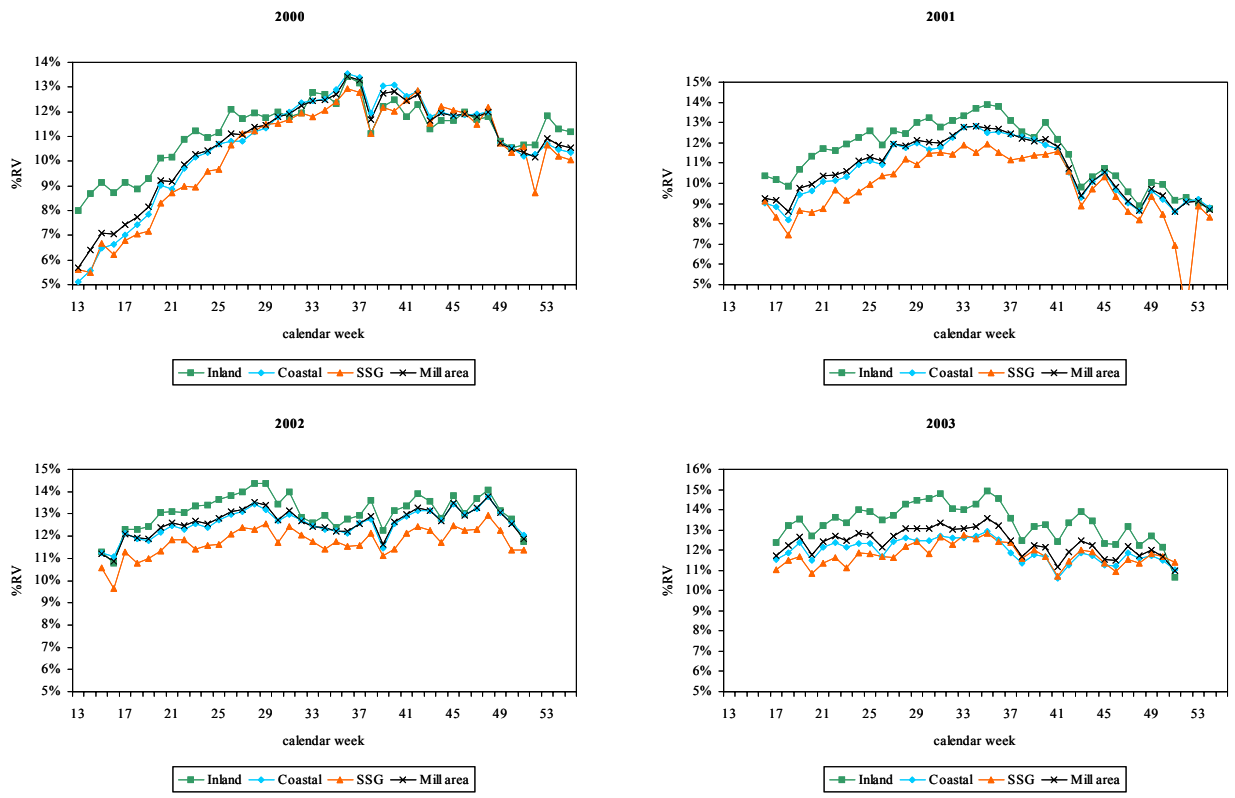


Figure 1: Weighted weekly %RV for Coastal, Inland and mill area (2000-2003)

Both the mill supply and the RV production were simulated for the overall season using a dedicated calculation tool. These simulations showed RV gains ranging from 0.5 to 2.5% of the current RV production. Results depend on the climatic years as they impact on the RV curve shape. The scenarios feasibility was assessed mainly by investigating the available capacities along the supply chain. Both extra-harvest and transport capacities were found while the mill could crush around 70 000 tons of cane per week. Consequently every scenario could be implemented without any extra-investment.

Considering these results, both miller and growers were keen on investigating the links between these supply scenarios and the cane payment system. Would the current relative payment system fairly share the RV gains amongst the stakeholders? What changes would be necessary to maintain equity? A third study was then conducted from April to August 2004. It aims at defining alternative cane payment system and simulating their impact on the stakeholders' revenues according to various supply scenarios (Papaïconomou, 2004).

2. PROBLEM STATEMENT

2.1. The Sezela mill supply area

The Sezela mill is supplied with sugarcane by a large variety of growers including its mill-cum-planter estate (13%), 180 large-scale farmers (72%) and 5 000 small-scale farmers (10%). The remaining 5%, called diversion cane, is supplied by two other Illovo mill areas (Eston and Umzimkulu), which operate at full capacity. Since the establishment of the RV payment system in 2000, 2.23 millions tonnes of cane were crushed per year on average, with quite large variations from one year to another (Table 1).

	2000	**2001**	**2002**	**2003**	**Average**
Starting week	13	16	15	17	
Closing week	55	54	51	51	
LOMS*	43	39	36	35	38
Annual tonnage	2 426 405	2 187 319	2 321 365	2 006 104	2 235 298
t/week	56 428	59 117	62 740	57 317	58 925

* *Length Of the Milling Season*

Table 1: Annual LOMS and cane production in the Sezela mill area

Depending on the year, the crushing season starts from mid-March to mid-April and ends before Christmas (2002 and 2003) or in January the following year. The mean weekly crushed tonnage ranges from 56 428 t to 62 470 t. These performances show the flexibility of the mill capacity but are lower than the theoretical capacity (66 000 t/week corresponding to 2 500 000 t during 38 weeks). Indeed the mill capacity is adjusted according to specific circumstances (e.g. high production level in 2000 and 2002), while the LOMS remains around 37 weeks. This value is considered as economically optimal (Moor and Wynne, 2001) and is contractually agreed by both miller and growers. It enables the mill to operate for a minimum period during seasons with low yields in order to secure the bagasse supply of its downstream plant where co-products such as furfural are produced.

The mill supply management involves up to four operators[1]: growers who grow their cane, often cutting and sometimes transporting it as well, harvest-contractors who cut and load the cane on behalf of the growers (usual arrangement for the small scale growers), hauliers dedicated to cane transport and the mill

The Mill Group Board (MGB) is responsible for the season planning and the cane supply coordination between these operators. Before the season starts growers estimate their production and they receive in return a DRD (Daily Rateable Delivery) from the MGB. The calculation takes into account the total cane production for the mill area, the mill capacity and the planned LOMS. DRDs are uniform throughout the season and throughout the mill area. Monthly and daily adjustments are made during the season in case of unforeseen events or better estimation of the remaining production. The mill manages its supply directly with the hauliers rather than the growers. Each haulier gets a DRD, which aggregates his growers' DRDs, and has to co-ordinate his daily supply in order to fulfil it.

2.2. The current cane payment system

The current cane payment system is based on three main components in order to achieve six objectives simultaneously: (i) covering both growers and millers' production costs, (ii) sharing the total sugar value between millers and growers, (iii) sharing the growers' part between them, (iv) encouraging growers to deliver good quality cane, (v) encouraging large-scale growers to deliver rateably and (vi) not penalizing small-scale growers who deliver non-rateably during the season.

- *Component 1: sharing the value between millers and growers and covering production costs*

The total annual sugar and molasses production is sold by SASA. The net revenue is then shared between growers and millers using a fixed ratio. This ratio is calculated according to their respective production costs. It is negotiated every 10 years in order to take into account technological and economic changes in the industry. The last negotiation was in 2004. It gave 37% of the net value to the millers and 63% to the growers.

As millers share their part according to their respective mill productions, they are encouraged to improve the sugar process efficiency. On the other hand the impact of a fixed ratio on the growers' efficiency is less obvious, as they can ask for an increase in their production costs to be reflected in their share ratio.

- C*omponent 2: encouraging growers to deliver good quality cane*

Cane quality is a crucial parameter for the cane supply chain as it impacts on sugar production and stakeholders' profitability. From the miller's point of view, cane quality refers to sucrose content and the possibility to extract this sucrose. The higher the fibre and non-sucrose contents, the more difficult sucrose extraction becomes. High fibre will retain sucrose during the diffusion process, while high non-sucrose will prevent an efficient crystallisation.

The sugar industry has defined an indicator in order to assess the potential amount of sugar extracted from cane and to link the farmers' payment to the quality of cane they deliver. The Recoverable Value rate (%RV) is derived from the Estimated Recoverable Crystal (ERC)

[1] See Guilleman *et al*., 2002 for details regarding the way cane supply is managed from the growers to the mill.

formula (Murray, 2002; Moor, 2002). It includes the sucrose (S), non-sucrose (NS) and fibre (F) contents of the cane as follows:

$$\%RV = \%S - d \,.\, \%NS - c \,.\, \%F$$

The "c" factor reflects the sucrose trapped by fibre and lost during the process. The "d" factor reflects both the sucrose trapped by non-sucrose and the molasses revenue earned from non-sucrose.

The %RV measured in cane consignments by the Cane Testing Service (CTS) is dependent on many factors, including climate (Singels and Bezuidenhout, 2002), variety selection (Salassi *et al*., 2002), production techniques (Lionnet, 1996; Meyer, 2001) and harvest/transport conditions (Mann, 1980; Steward and Fischer, 1983). RV curves for the Sezela mill area show various profiles according to the climatic year (Figure 1). 2000 and 2001 show a bell-shape curve with a peak in the middle of the season while 2002 and 2003 curves are much flatter. The differences between Inland and Coastal %RV curves also vary according to the year.

- C*omponent 3: encouraging large-scale growers to deliver rateably without penalizing small-scale growers*

A relative payment system has been implemented since 1975 in order to discourage growers from over-delivering when their cane quality is at his best (Buchanan, 1975). The principle is to pay the grower by comparing his deliveries to the average of the overall mill area. The comparison is made weekly as follows:

$$\%RV_{i,j\ relative} = \%RV_{i,j\ measured} - \%RV_{j\ mill\ area\ average} + \%RV_{mill\ area\ average\ for\ the\ season}$$

where:
i = grower i
j = week j

This formula allows growers to be paid according to their actual RV production assuming they deliver throughout the season. The small-scale growers with few deliveries during the season are paid uniformly whenever the week they deliver, as their relative RV is higher than their actual one at the beginning and the end of the season.

Components 2 and 3 jointly govern how the growers' total revenue is shared between them. Each grower is paid according to his cane tonnage multiplied by his relative %RV, which is calculated from his actual %RV measured on two-third of his deliveries. One RV ton is valued at the whole industry level by dividing its total net revenue with the total RV production. The RV price was R1 240 per ton in 2004.

This system is contracted between millers and growers within the Sugar Agreement Act. Both components 1 and 2 cannot be changed without the agreement of the whole industry, while the reference used in the relative %RV calculation may be decided within any local mill area. As the supply scenarios simulated in 2002 and 2003 changed the delivery pattern of sub-areas, stakeholders assumed that they could have an impact on growers' revenues. They asked the two following issues to be addressed:

- How the gains obtained from a re-organization of harvest scheduling would be shared using the current payment system?

- Would modifications of the relative payment formula provide a fairer share of these gains?

The study combined three stages in order to answer these issues. Firstly, three supply scenarios were selected from the studies carried out in 2002 and 2003, while adding the 2003 season data to the analysis. Secondly, the current relative payment system was analysed as an incentive to deliver rateably. Thirdly, two alternatives payment system scenarios were defined and their impact on the growers' revenues was simulated. This study was completed with a grower survey regarding the quality management processes at farm level.

3. METHODS

3.1. Simulation tools

This third study uses the same methodology as the two former ones[2]. It aims at providing information to both miller and growers, regarding (i) the impact of new modes of cane supply management on the profitability of the mill area and (ii) the share of gains between stakeholders. This objective is achieved by using simulation models, which provide a simplified representation of the supply chain and enable one to quickly compare a large range of scenarios by changing some of the parameters included in the model. Manipulating these components and results enhance stakeholders' common knowledge and capacity to find agreed solutions (Hatchuel and Molet, 1986).

The mill supply is modelled using a simulation tool which enables the assessment of alternative supply scenarios based on a simplified representation of the various operators in the supply chain, with their constraints and relationships (Figure 2). Changes of structure and capacities are simulated and their consequences in terms of sugar production quantified at the mill area level. Balance between delivery performances and mill crushing capacity can be investigated and discussed according to various hypotheses of supply chain structure and planning/operation rules (Gaucher *et al*., 2003). This modelling technique was preferred to optimisation tools developed in Australia (Higgins, 1999; Higgins *et al*., 1998; Higgins and Muchow, 2003) because of the lower stakeholders' integration within the South African supply chain.

A similar simulation technique was followed to compare scenarios of relative cane payment system. A calculation tool was developed using spreadsheet software. It enables one to calculate the growers' economic gains according to (i) a mill supply scenario and (ii) a cane payment system. Input variables are as follows:

- the weekly deliveries per grower as available in the mill database;

- the weekly %RV per grower, calculated from the mill database. The calculation took only into account the measured deliveries while in the mill database a %RV value is assigned to the non sampled deliveries by calculating the weighed %RV average of the three last measured deliveries;

[2] See Guilleman *et al*., 2002 for more details.

- the selected supply scenarios, which define the harvest windows per sub-area and per grower.

As deliveries are not rateable throughout the season because of low production (medium- and small-scale growers) or various hazards (rainfall, breakdown of equipment, shortage of labour and fires) the simulated weekly delivered tonnages per grower were calculated as follows:

- calculation of a weekly DRD by dividing the total cane production with the number of delivery weeks. The simulated deliveries follow the same weekly pattern as the actual ones, except for the weeks out of the harvest windows assigned to the grower's sub-area.
- Growers deliver respectively 20%, 50% and 75% of their DRD during the three first weeks, and 50% then 20% during the two last weeks because of structural constraints at the beginning and the end of the season.

A work sheet was then built-up for each combination of one season, one supply scenario and one payment system scenario. It included per grower and per week during the season: actual delivered tonnage, modelled delivered tonnage, weeks with deliveries, measured %RV, RV tonnage, calculated relative %RV and relative RV tonnage. The gains were then calculated by comparing total relative RV tonnages with the reference scenario at three levels: overall supply area, sub-area and grower.

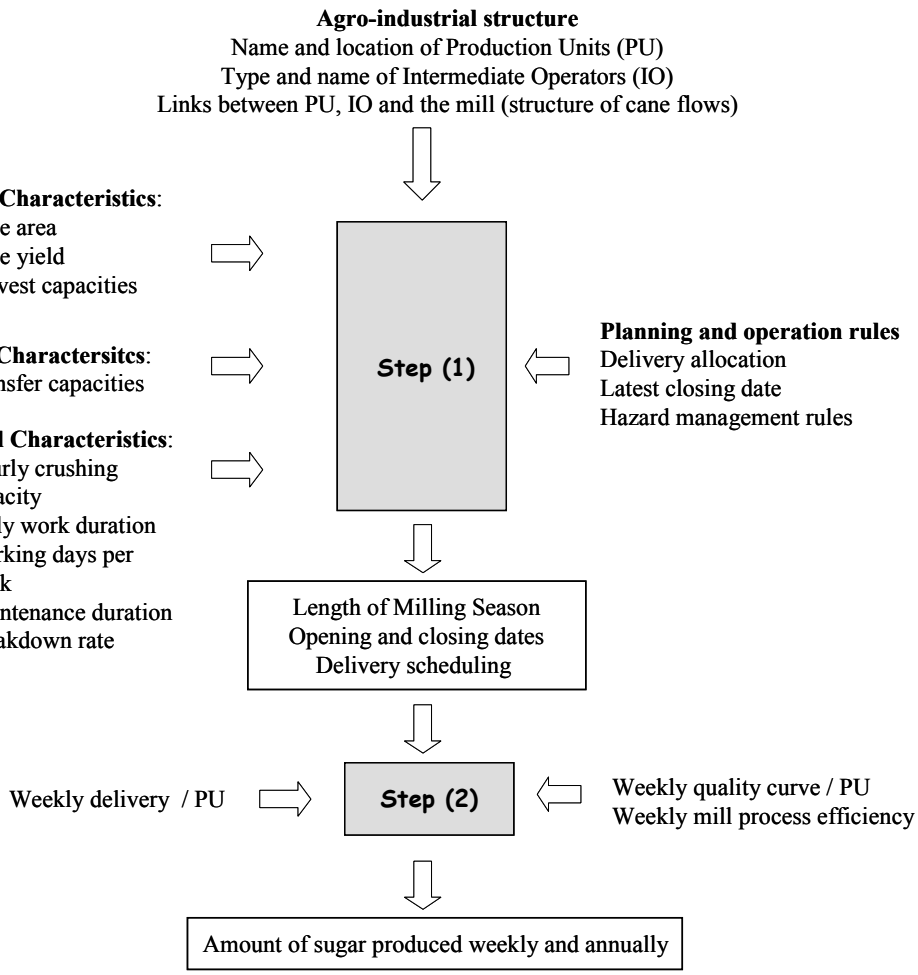


Figure 2: Conceptual framework of mill supply modelling

3.2. Quality survey

A farm survey was conducted during this study to better understand what the growers' practices were regarding cane quality management. Some questions were added about the growers' perceptions of the cane payment system. Our objective was mainly to get some basic knowledge and some trends about these issues, which could justify or not further in-depth investigation. Consequently this survey was carried out by interviewing a limited sample of growers without monitoring their practices during the season.

3.2.1. Sampling

The small-scale growers (RV production < 225 tons) were not included in the sample for three reasons. Firstly, they were not directly concerned by the re-arrangements of harvest scheduling because of their harvest constraints (contractors' availability). Secondly, former investigations indicated that their cutting decisions were based on criteria other than only quality. For example cash need is a strong harvesting determinant. Thirdly their lack of funds reduce their investment capacity into improving quality. So the sample excluded the whole SSG zone plus 25% of the Inland and Coastal growers' population.

The sampling was conducted separately in these two zones, in order to take into account the climatic factor that should influence quality management practices. It was based on two criteria:

- *Annual RV production per farm*, with two categories: large-scale and medium-scale growers, with a limit of respectively 700 RVtons and 1 000 RVtons in Coastal and Inland. It was assumed that medium-scale growers had less negotiation power with their harvesting contractors and their hauliers, which could impact on their harvest-to-crush delays.

- *Annual and weekly %RV per farm*, with two categories: "good quality" and "poor quality" growers. It was assumed that differences of quality management should arise more easily by selecting the extreme cases. The selection was based on (i) the annual %RV average over the last four years and (ii) a comparison between the individual %RV curves and the 2003 average curve per sub-area. The growers with a consistently high or low %RV were sampled.

Table 2 shows the sample interviewed. There was some imbalance between quality categories both in Inland and Coastal. The "good quality" category is over-sampled in Inland and the "poor quality one in Coastal.

Sub-area	Farm size	Good quality	Poor quality	Total
Coastal	Large-scale	5	7	12
	Medium-scale	1	2	3
	Total	6	9	15
Inland	Large-scale	6	1	7
	Medium-scale	2	2	4
	Total	8	3	11
Total		14	12	26

Table 2: Distribution of interviewed growers per sampling criteria

3.2.2. Questionnaire

The questionnaire was based on the recommendations made by the Sugar Industry to get a clean, topped, mature and fresh cane. The following topics were addressed per grower:

. quality objectives and quality monitoring processes;

.quality-orientated practices: choice of variety, fertilizers, ripener, pest management, irrigation, harvest organisation;

. perception on the current payment system;

.extra-costs linked to alternative supply scenarios: cash-flow management, labour and equipment costs.

Frequency analysis was applied to collected data, as the sample was too small to use statistic tests and data were qualitative. The following variables were finally kept to conduct the analysis:

. Good fertilisation practices (according to the recommendations);

. Use of ripener agent;

. Efficient use of ripener agent, in terms of spraying date, rainfall, choice of product, choice of cane plot;

. Choice of new varieties (N38, N41);

. Efficient harvest planning, using software or manual monitoring. It took into account the various varieties, plot circumstances, cutting dates from the former year;

. risk of *Eldana saccharina* infestation;

. Harvest-to crush delay < 48h.

4. RESULTS

4.1. Selection of supply scenarios

The stakeholders selected 4 scenarios from the former studies conducted in 2002 and 2003, because of their potential feasibility and value (Figure 3):

- Reference scenario: every zone delivers from the beginning to the end of the season;

- S1: Coastal deliveries are delayed (two weeks) and Inland stops delivering four weeks before the end of the season. S1 aims at (i) decreasing the impact on the RV tonnage of the lower and more variable quality of Coastal cane at the beginning of the season and (ii) focusing Inland deliveries around the %RV peak and stop inland deliveries before rain disrupted their deliveries;

- S1bis: Coastal deliveries are delayed by four weeks and Inland stops delivering nine weeks before the end of the season. This scenario is based on the same objective as S1, but push the supply system to its capacity limitations;

- S2: Coastal delivers throughout the season, while Inland starts delivering two weeks after the season start and stops six weeks before its end. S2 takes into account the necessity to

harvest older Coastal cane at the beginning of the season to minimize the risk of yield loss due to *Eldana saccharina*. Inland deliveries are focused around the %RV peak.

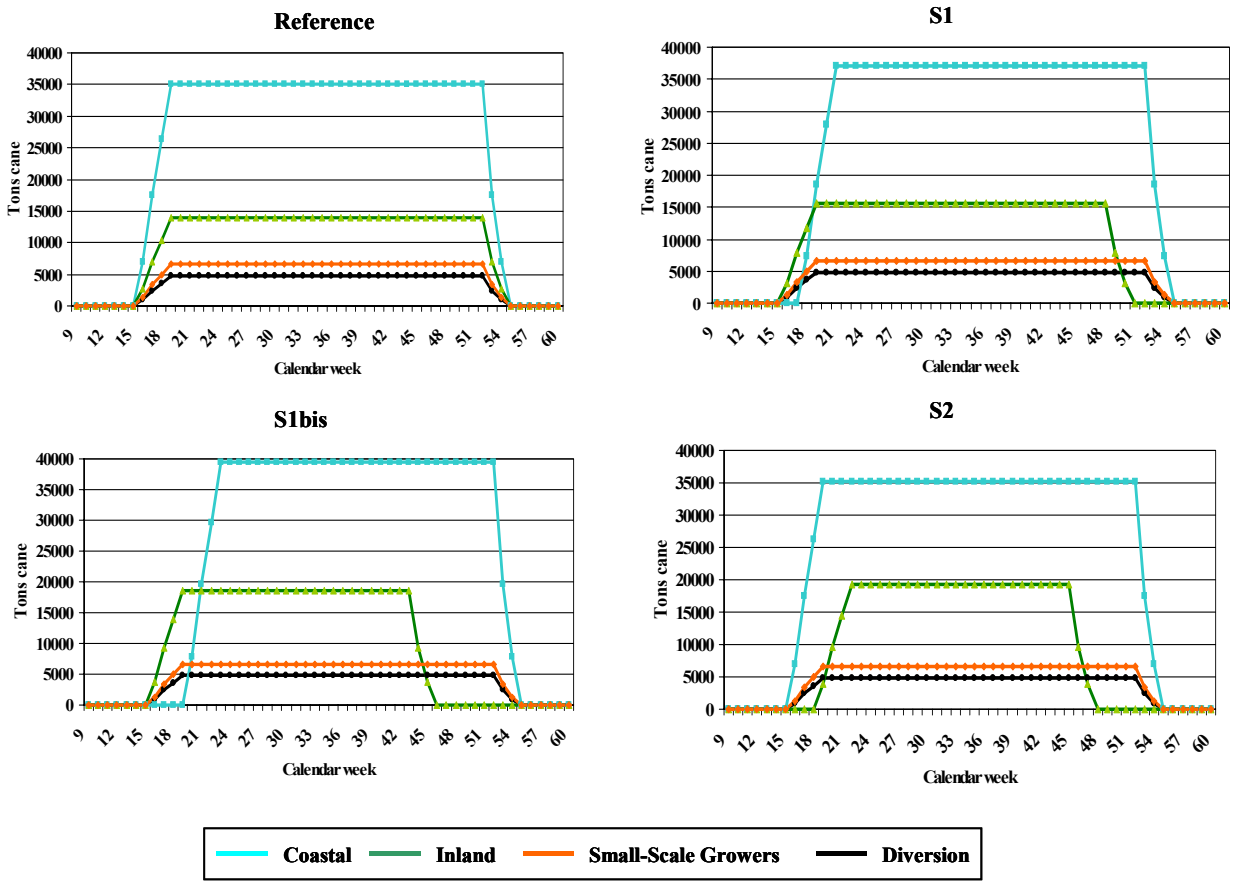


Figure 3: Simulated supply scenarios

The difference between the RV tonnage produced by Inland and Coastal zones in the reference scenario and RV tonnages produced in alternative scenarios were computed for each year between 2000 and 2003. Expected gains for Coastal+Inland zones vary from 360 tons to 6 000 RV tons per season, which accounts for 0.45 to 7.44 million Rand (Figure 4). S1bis shows systematically the best results, while the S1-S2 ranking varies according to the year.

But the largest differences are mainly linked to the year and the corresponding %RV curve profiles. The flatter the profile the smaller the gain is. For example 2002 shows less gain than 2001 while its total production was bigger. This result applies for the sub-areas gains as well (Figure 5), as their specific RV curves do not systematically adjust to every scenario. For example Inland production decreases in 2002 with both S1 and S1bis scenarios because of higher %RV values at the end of the season.

These results highlight the impact of climatic year on both the total and local gains expected from a given scenario. As only four years of RV data are available it is quite difficult to assess the long-term risk stakeholders would take by reducing sub-regional harvest windows. Using agro-physiological models could provide some guidance, assuming they are able to simulate RV curves for the main varieties cultivated in the supply area.

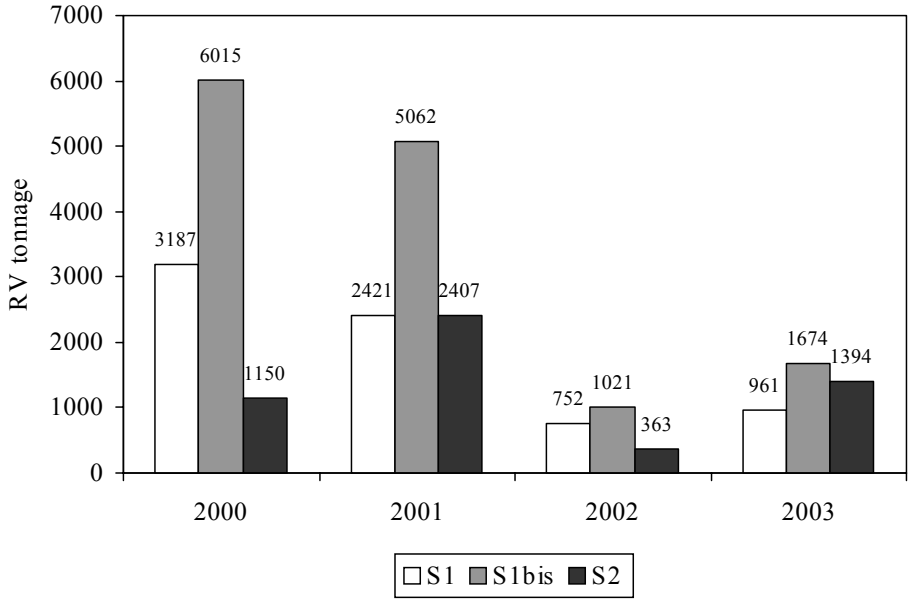
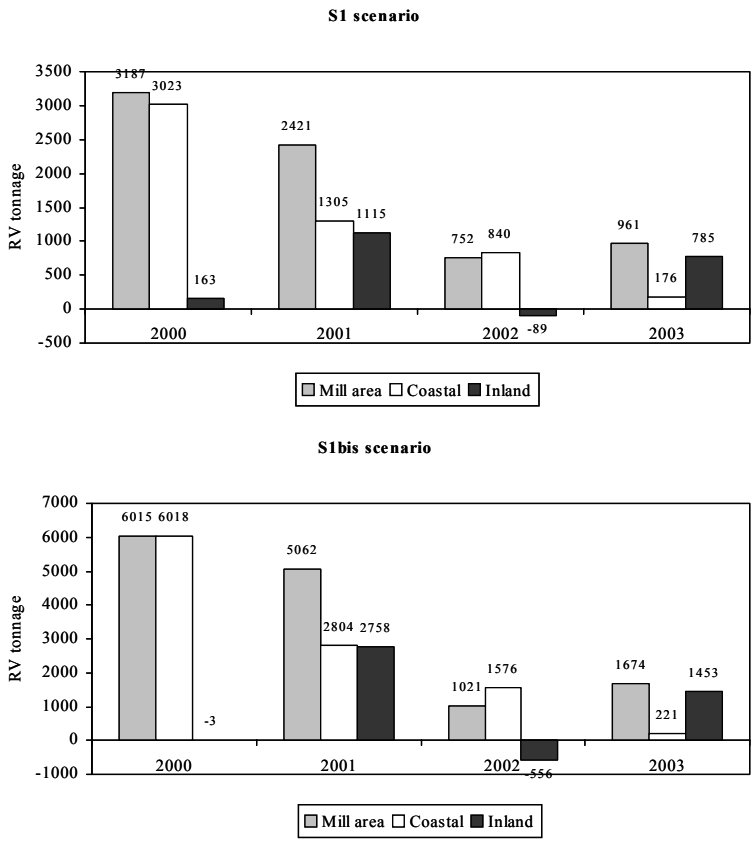


Figure 4: Simulated gains (RV tons) for each scenario from 2000 to 2003



Nota-bene: Gains obtained with S2 come only from Inland

Figure 5: Simulated gains (RV tons) per sub-area for each scenario from 2000 to 2003

4.2. Sharing the gains with the current payment system

The current payment system implies that any RV gain obtained at the mill supply area level is firstly shared between the miller and the growers according to the fixed 36-64% rate. We did not address this component of the system in the study as it is negotiated at the industry level. Instead we focused our investigation on the relative component, which is manageable at the mill area level.

4.2.1. Analysing the current relative payment system

The relative payment system aims at encouraging large-scale growers delivering rateably throughout the season while small-scale growers can deliver any time without consequences on their revenue. If the system works properly large-scale growers will be paid for the total RV tonnage they delivered during the season while small scale growers will get a higher paid RV when they deliver during a low quality period.

Figure 6 shows that these hypothesis are generally confirmed, as individual differences between paid and delivered RV decrease when the number of delivery weeks throughout the season increase. But the gap scarcely exceeds ± 10% for the small-scale growers.

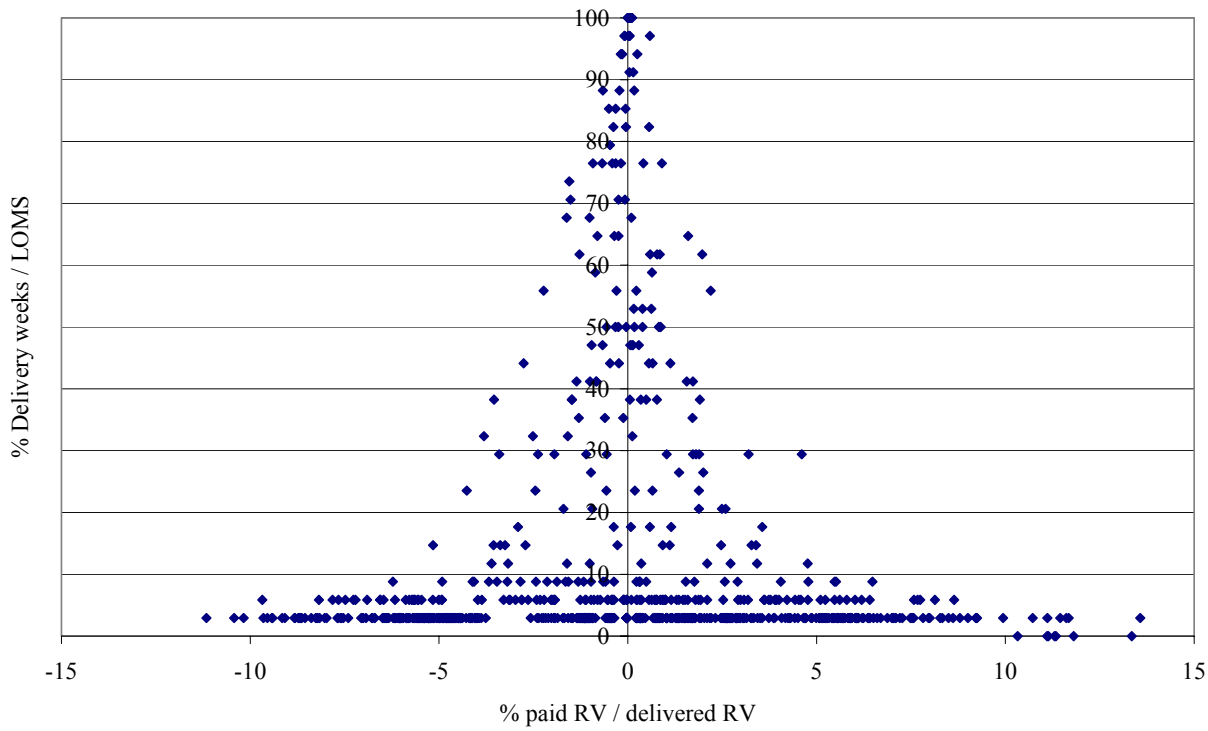


Figure 6: Distribution of differences between paid and delivered RV according to the number of delivery weeks during the 2003 season

The impact on the regularity of large-scale growers' delivery is less obvious (Figure 7). The two farms taken as example show no gap of RV payment while their actual delivery curves are quite variable compared with their DRD. These results suggest that (i) a compensation process occurs during the season and (ii) deliveries need to remain flexible in order to cope with various hazards faced by the growers.

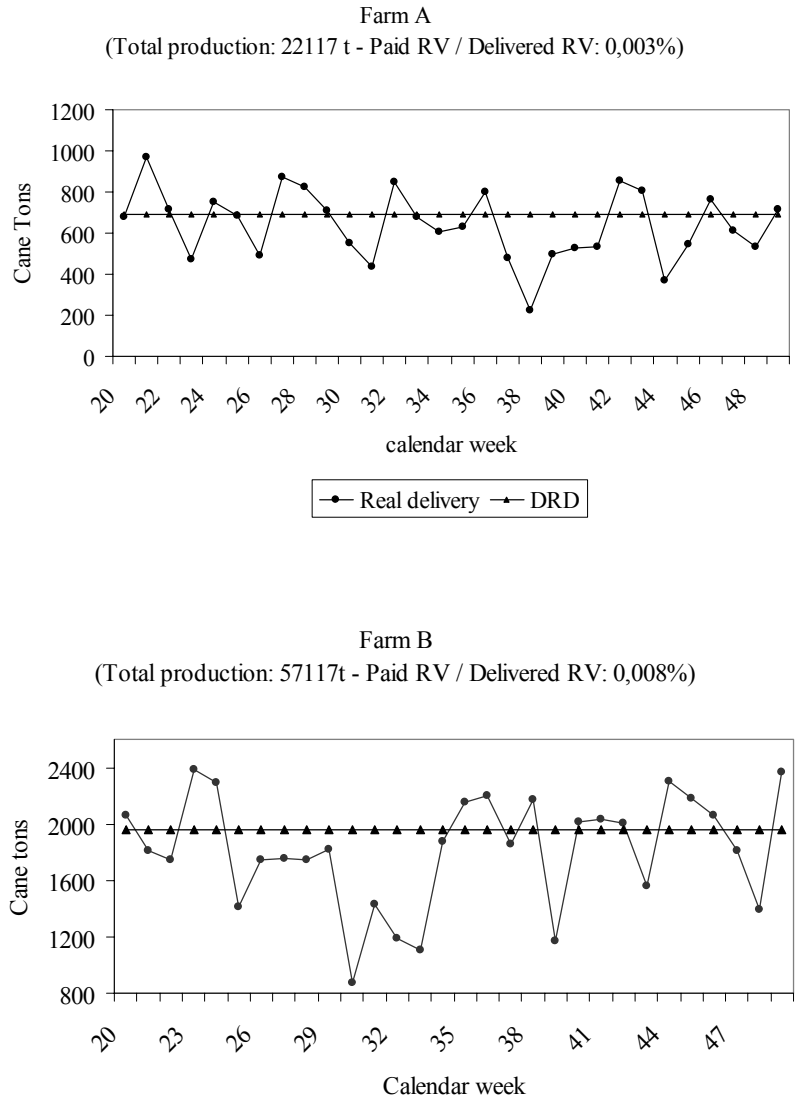


Figure 7: 2003 actual deliveries and DRD for two large-scale growers

4.2.2. Sharing the gains of alternative supply scenarios

Changing harvest scheduling per sub-area without changing the payment system impact greatly on the gains share between sub-areas (Figure 8). Inland systematically transfers some of its gains to Coastal and SSG. The transferred amount varies according to the supply scenario. It is maximal with S1bis in 2003, as Inland revenues decrease compared with the reference scenario while Coastal greatly benefits. The trend occurs with S2 as well although Coastal supplies remain identical. This phenomenon is sensitive to the year as well (Figure 9). In 2000 the transfer linked to S2 is greater than in 2003, as Inland losses relative RV tonnage compared to the reference.

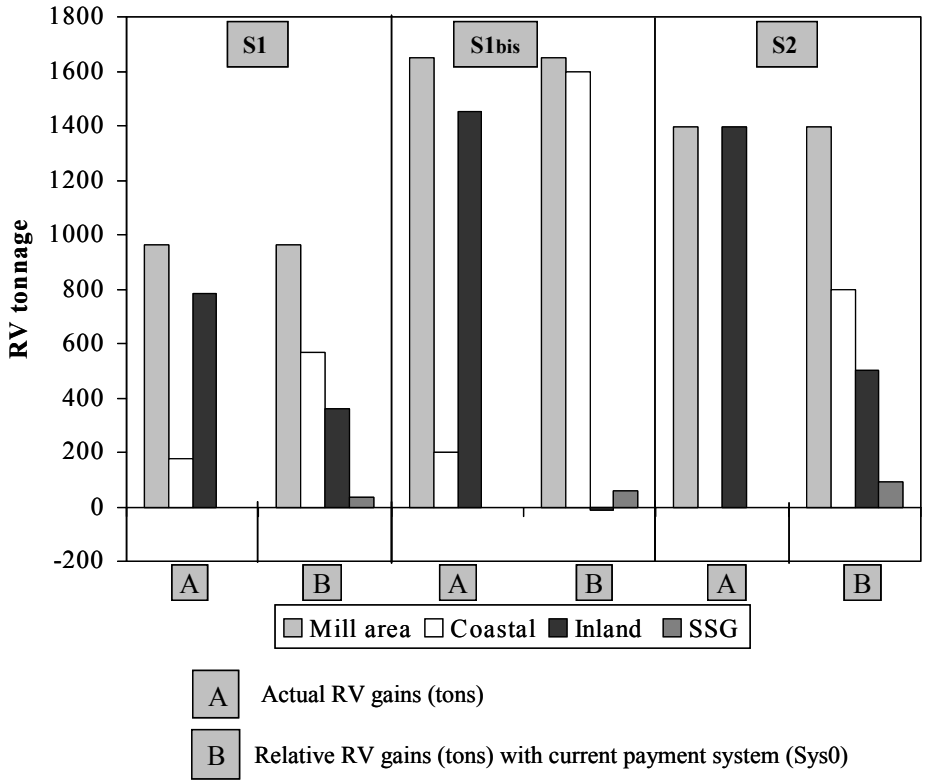


Figure 8: Sharing of RV gains between sub-areas according to the supply scenario

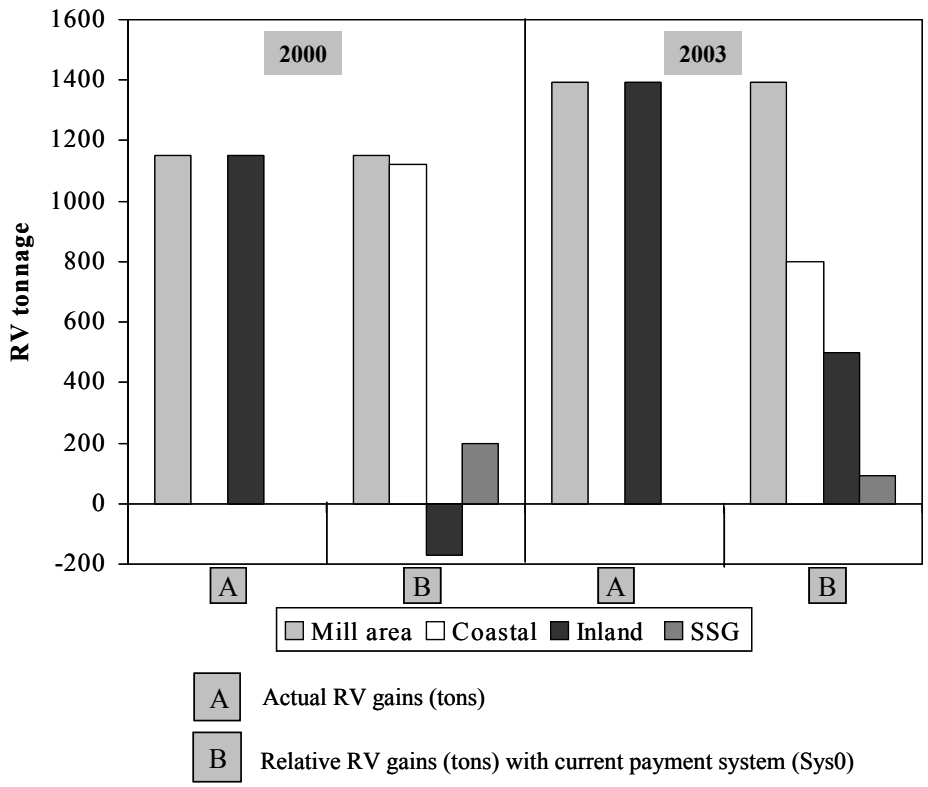


Figure 9: Sharing of RV gains between sub-areas according to the year (scenario S2)

These results occur because the three alternative scenarios challenge the rateability of delivering between sub-areas. So the reference used to compare deliveries a particular week changes according to the sub-areas delivering at that time. For example for S2 scenario (Figure 10-a,b):

- Inland does not deliver at the beginning and at the end of the season (Figure 10-b). Then the mill %RV average decreases as it is determined by the Coastal average. Deliveries supplied by Coastal and SSG are then better paid than in the current context, as they are compared to a lower value.

- In the middle of the season Inland delivers proportionally more cane than in the current context. Then the Inland/Coastal delivery ratio increases and the mill average are closer to the Inland average. Every delivery is then disadvantaged as they are compared to a higher value.

This general trend depends on the profiles of RV curves obtained a specific year. For example in 2000 there is a large difference of %RV between Coastal and Inland at the beginning and the end of the season but a small – sometime reverse – one in the middle. These differences affect the S2 scenario as follows:

- at the beginning and the end of the season the weekly mill %RV average decreases considerably and both Coastal and SSG relative RV increase consequently;

- in the middle of the season the weekly mill average decrease slightly as the weight of Inland cane increases, which is positive for all the growers.

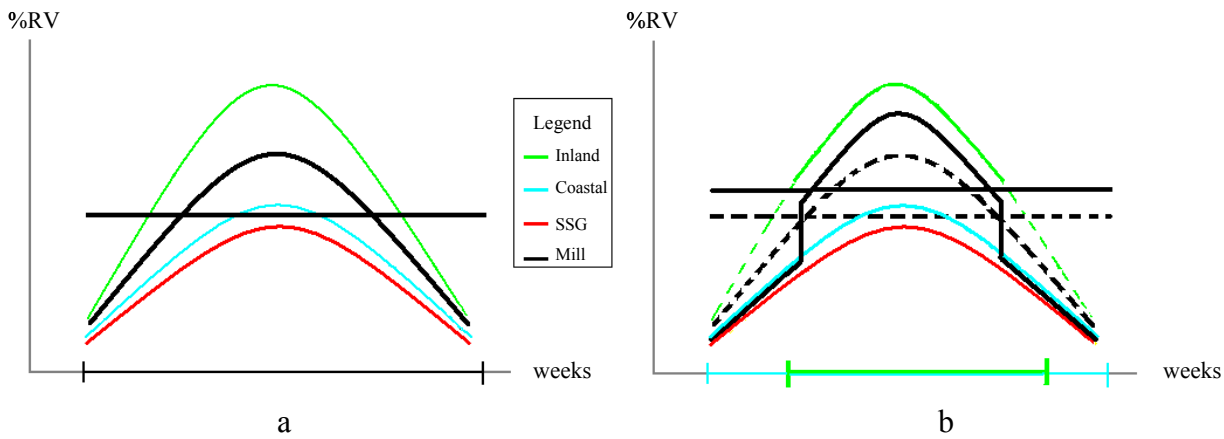


Figure 10: Changes in the average %RV curve with the scenario S2

These results confirm the hypothesis that alternative supply scenarios based on local re-arrangements of harvest scheduling affect the way gains are shared between growers. The definition of the relative payment system explains this conclusion, as it links the reference used to compare growers to the rateability of their deliveries. Alternative payment systems have been designed in order to correct the distortions created by the supply scenarios in the current context.

4.3. Simulating alternative payment system scenarios

4.3.1. Scenario definition

Two alternative payment systems were simulated using the calculation tool presented in part 2. They differ from the current context, called Sys0, only by the reference used to compare growers. The Mill Group Board can decide these changes, as they do not need an agreement from the whole industry.

The first alternative, called Sys1, replaces the mill weekly %RV average by the sub-area weekly %RV average. The season average remains the same, i.e. calculated at the mill area level. So Sys1 formula is defined as follows:

$$\%RV_{i,j\ \text{relative}} = \%RV_{i,j\ \text{measured}} - \%RV_{j\ \textbf{sub-area}\ \text{average}} + \%RV_{\text{mill area average for the season}}$$

where:
i = grower i
j = week j

The second alternative, called Sys2, consists of splitting the mill area into the three sub-areas, Inland, Coastal and SSG, and comparing growers within each zone separately. Sys2 formula is then:

$$\%RV_{i,j\ \text{relative}} = \%RV_{i,j\ \text{measured}} - \%RV_{j\ \textbf{sub-area}\ \text{average}} + \%RV_{\textbf{sub-area}\ \text{average for the season}}$$

where:
i = grower i
j = week j

Originally the objective was to compare growers to groups closer to their own climatic circumstances of production. It was consistent with the growers' perspective, which considers the relative payment system as an incentive to deliver not only rateably but also better cane quality than the others.

4.3.2. Impact of alternative payment systems with the current supply schedule

The simulations carried out without changing the mill supply schedule show that Sys1 leads to a general and consequent transfer of RV from Inland to Coastal and SSG (Figure 11). This transfer amounts for 2 000 to 6 000 RV tons depending on year, i.e. from 3 to 8% of the total annual Inland revenue. This loss comes as the Inland deliveries are compared to a higher average %RV, while Coastal deliveries are compared to a lower one. Stakeholders rejected this alternative because of these strong distortions and no other simulation was conducted using this method.

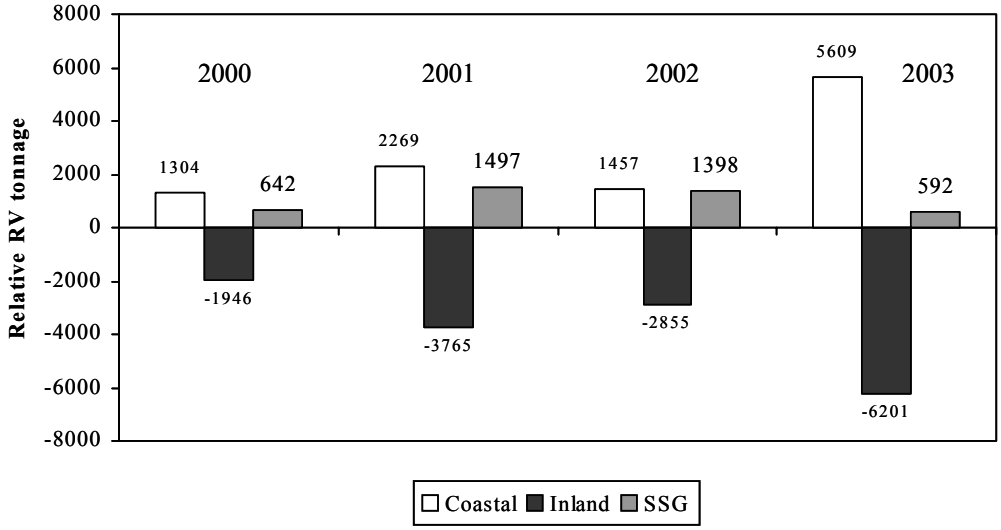


Figure 11: Variations of revenue per sub-area and per year with the Sys1 payment system compared with the existing situation

Comparatively Sys2 leads to a very small transfer from Coastal and Inland to SSG (Figure 12). This figure does not exceed 312 tons. It rectifies a reverse transfer from SSG to Inland and Coastal in the current payment system, which occurs because of its lower cane quality. This process is fairly distributed between Coastal and Inland growers (Figure 13). Respectively 89% and 73% of them earns or looses less than 1% of their current revenue over 4 years, and very few exceed 2%.

The impact is more diverse on SSG revenues because of their small number of deliveries during the season. Their individual results depend on the gap between the mill average curve and the SSG curve when they deliver. A larger gap means that they will gain from their initial revenue, which was compared to a higher average. The process is quite unpredictable and no grower won or loses systematically from one year to another, as we checked for the -5% category during the four studied years.

4.3.3. Combined impact of Sys2 and supply scenarios on growers' revenues

Figure 14 shows that the Sys2 alternative rectifies the distortion noticed with the current payment system. In that case each sub-area is nearly paid according to its RV production, as the same basis is used (i) to organize rateable deliveries and (ii) to calculate relative RV. Some small differences arise, consisting of Coastal and Inland subsidizing SSG as already mentioned. So the Sys2 – S2 combination leads to a small deficit for Coastal, which does not change its delivery schedule. Indeed Sys2 is based on the basic principle that profits go to the stakeholders making efforts.

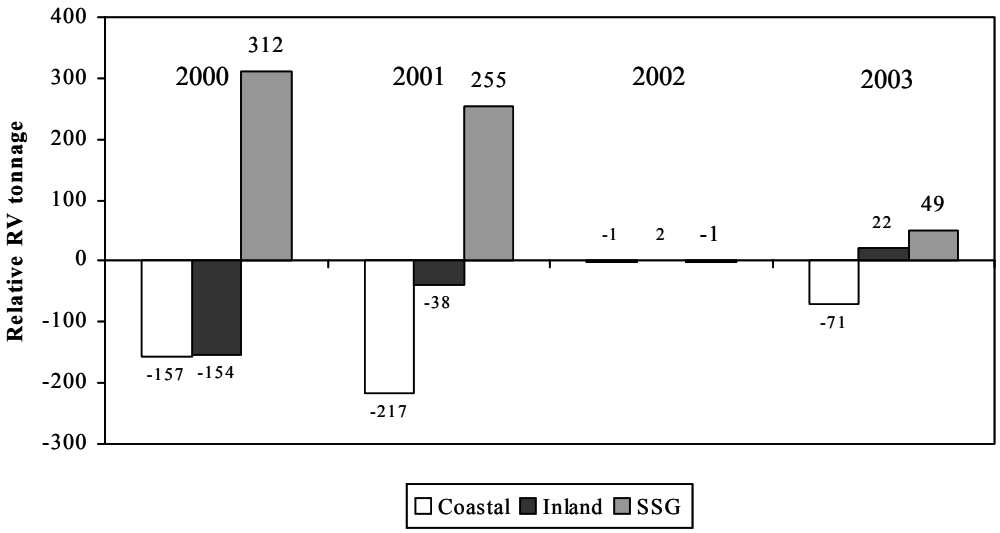


Figure 12: Variations of relative RV per sub-area and per year with the Sys2 payment system compared with the existing situation

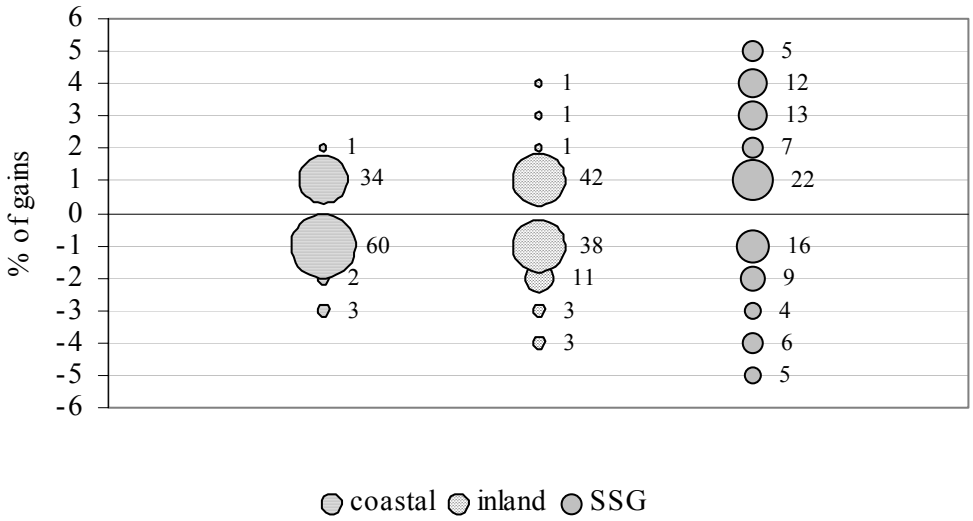


Figure 13: Impact of the Sys2 payment system on growers' gains compared with the existing situation

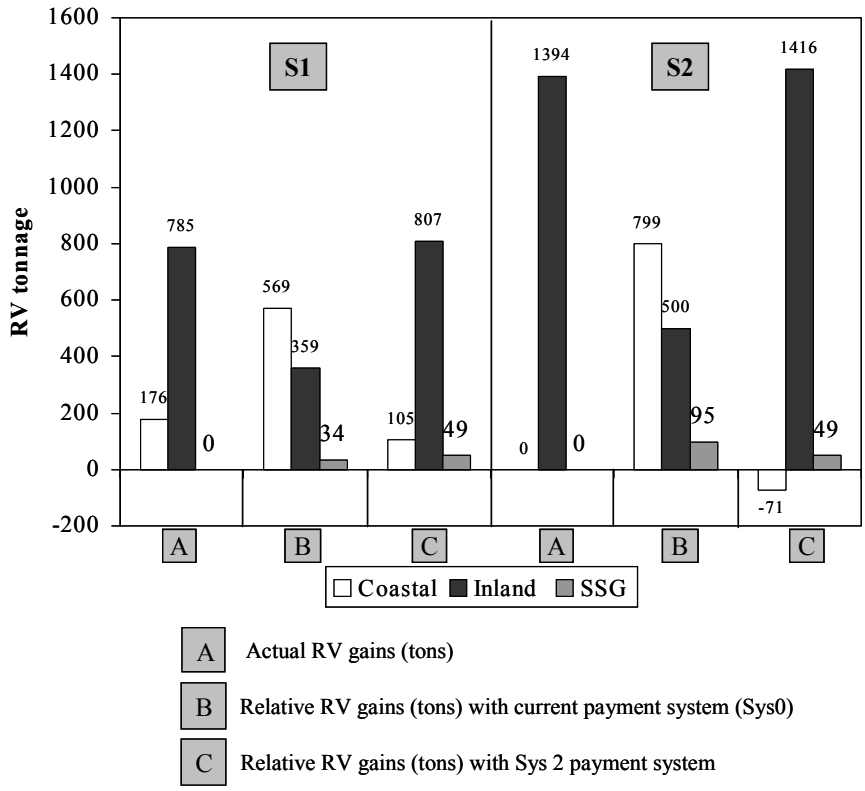


Figure 14: Combined impact of Sys2 payment system and supply scenarios on sub-areas' relative RV gains

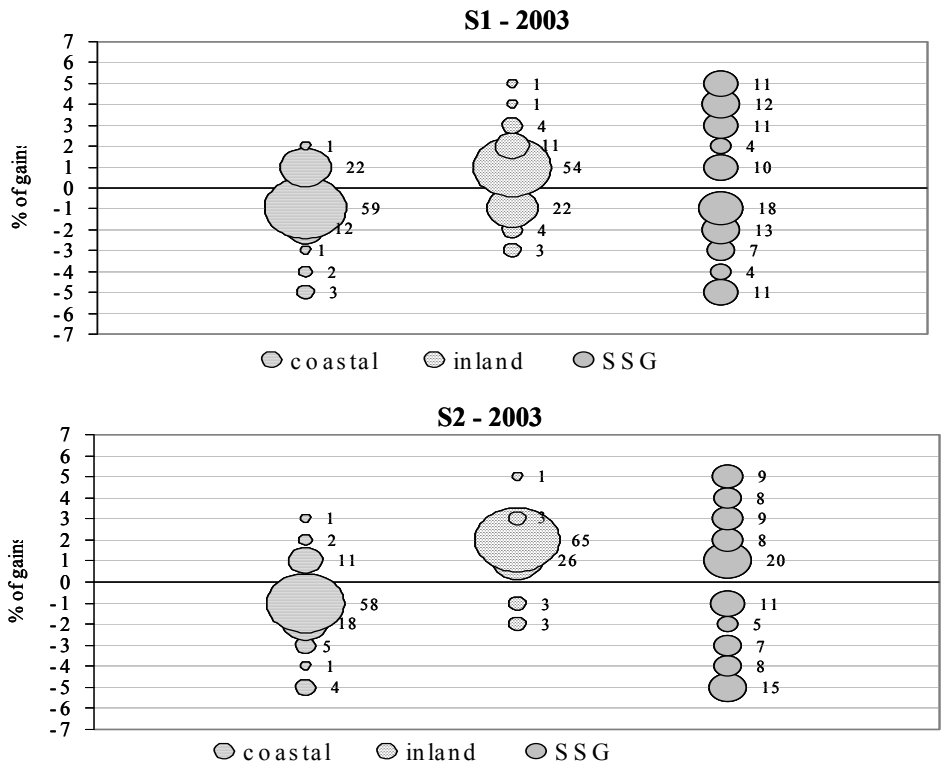


Figure 15: Comparison of Sys0 and Sys2 impacts on growers' revenue according to the supply scenario

Gains obtained within a sub-area are then distributed between its growers using the same relative principle. Figure 15 compares individual revenues received from Sys0 and Sys2 payment systems under both S1 and S2 supply scenarios respectively. The general trend consists of a majority of Inland growers gaining extra-revenues, as the RV transfer between Inland and Coastal is almost cancelled. 86% of them would win more over the last four years. However, both positive and negative variations remain in a narrow range for most of the growers, SSG excepted.

4.3.4. Synthesis

The two most feasible supply scenarios, i.e. S1 and S2, give similar RV gains, except in 2000 when S1 is more efficient. The main difference lies in the distribution of effort between sub-areas: S1 involves both Coastal and Inland while S2 concerns only Inland. Consequently the sub-areas' commitment in the total gain at the mill area level varies according to the scenario. S1bis remains the most profitable option and should be also considered in spite of the fact that it would test the crushing rate of the mill.

On the payment system side, Sys1 is not suitable as it leads to a significant RV transfer from Inland to Coastal even in the current context. This transfer occurs as well with the current payment system combined with the alternative supply scenario. This process is greatly altered by using Sys2, as the spatial link between the rateability of deliveries and the reference used to compare deliveries' RV is then restored. These results show that changing supply scenarios requires at least a discussion about its impact on the growers' revenues *via* the relative payment system.

Indeed the selection of a few "supply scenarios" – "payment system scenarios" is not obvious and depends on the objectives of the mill area stakeholders. For example Sys2 seems a fairer system than Sys0 assuming different harvest windows are allocated to each sub-area. Nevertheless the RV balance between the sub-areas may change from one week to another according to the year. By allowing RV transfer between sub-areas Sys0 reduces the loss risks arising from particular poor local conditions. Moreover a subsidy process from Inland to Coastal and SSG can be seen as a mill area strategy: growers located in a better context of production allow disadvantaged growers to remain active and so the mill to operate at full capacity.

The S2 – Sys2 combination may be challenged as well. There is apparently no interest for the Coastal growers to select this combination as their revenue will remain similar. But S2 has been designed to take into account the risk of *Eldana saccharina* infestation on Coastal carry-over cane. S2 – Sys2 could encourage Coastal growers to solve this problem in order to swap to a S1-type scenario and to get some gains from new harvest windows. In that case Sys0 would not be suitable, as it would transfer RV tonnage to growers who do not make any specific effort.

4.4. From system payment to growers' quality management

4.4.1. Growers' perspective on the current payment system

Since its establishment in 2000 the RV formula has been largely debated. Some growers consider that it penalizes Coastal production which naturally shows a higher non-sucrose level. Most of the sampled Coastal growers have changed their cultural practices, e.g. by

carefully managing the cutting height, to improve quality and revenue. Inland growers acknowledge that their revenue has increased with the RV formula without making any particular effort.

The concept of the relative payment was introduced in 1975 but it is still perceived very differently by the various growers. They understand its incentive for delivering rateably but most of them consider that the pressure applied by the Mill Group Board on the large-scale growers is more compelling. For half of them the relative system is also an incentive to deliver better quality cane by exceeding the weekly %RV average. This process impacts differently on the growers' revenues. For 60% to 70% of them the weekly comparison part of their revenues does not exceed 10% (Figure 16). But for the remaining 30 to 40% this part exceeds 10%, if not 25%. In that case losses are greater than gains. Sys2 reduces this impact as growers are compared on a more homogeneous basis.

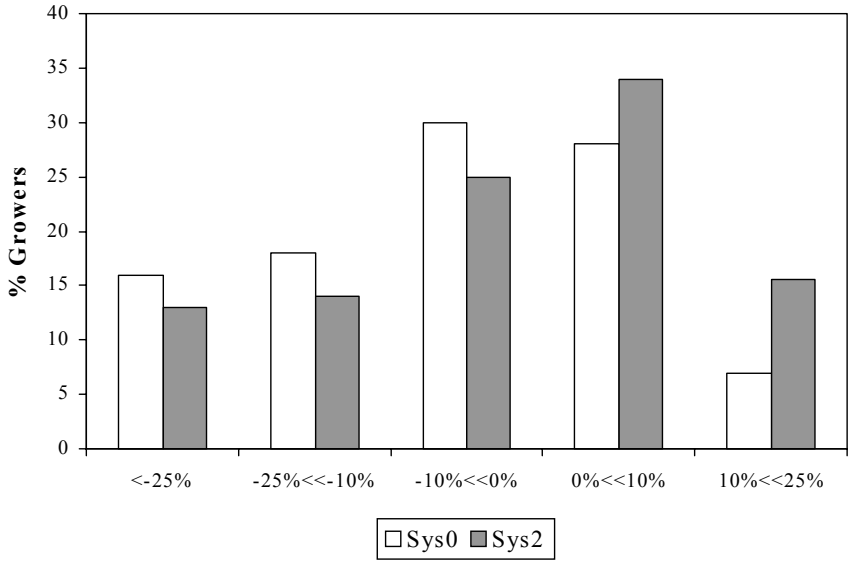


Figure 16: Proportion of growers' revenues coming from the weekly RV comparisons

4.4.2. Growers' quality management

The interviews conducted with the sample of growers from Coastal and Inland show the following results:

- No difference of practices arises between large- and medium-scale growers.

- Coastal "good quality" growers tend to adopt specific practices to improve their quality (Figure 17 and Figure 18), such as using a ripening agent; fighting against *Eldana* infestation; better planning their harvest; fertilizing their soils according to their nutrient balance; and cutting in stalk in order to reduce fiber content. By comparison Inland growers invest less in quality management as they take advantage of better climatic conditions.

- Inland "good quality" growers give more attention on harvest-to-crush delays, stalk cutting and a ripening agent compared with "poor quality" growers from the same sub-area (Figure 18).

Curiously the choice of new varieties does not seem a factor for improving quality anywhere.

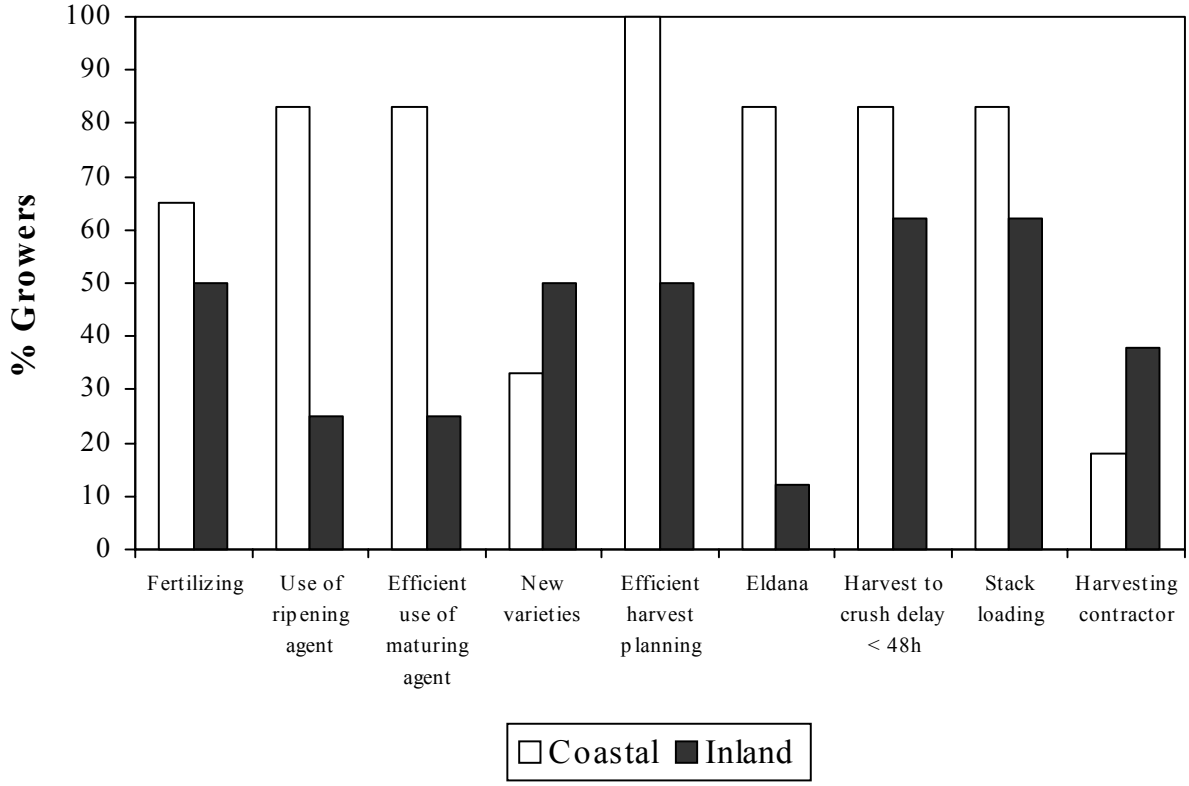


Figure 17: Comparison of cultural practices between "good quality" growers from Coastal and Inland

4.4.3. Potential impact of scenarios on quality and delivery management

The supply scenarios consisting of delaying Coastal deliveries at the beginning of the season and ending Inland deliveries earlier in the season should have a positive impact on cane yields because of (i) the better adjustment between the growth period and rainy conditions and (ii) more time available to conduct fertilization and weeding. Avoiding wet periods will also reduce the risk of harvesting in bad condition, which impacts on harvest delays and cane quality. These scheduling changes could also impact on the variety selection but this issue would need further investigation.

This potential gain regarding cane yield would complement the expected RV gains. But they would like these changes to be planned early in the season by the Mill Group Board, in order to organize both their chemical treatments and their labour recruitment for cutting.

On the payment system side, some growers expressed the risk of opportunistic strategies from individuals trying to over-deliver when average %RV is expected to be lower. Such behaviour is theoretically possible, as growers may increase their production estimation or declare false accidents such as fires. Actually the Mill Group Board is able to control and penalize this behaviour, which would have a detrimental impact on the growers' revenues. Indeed %RV curves are quite difficult to predict a specific year, and delivering more cane during poor quality periods would have a negative effect on the total %RV average.

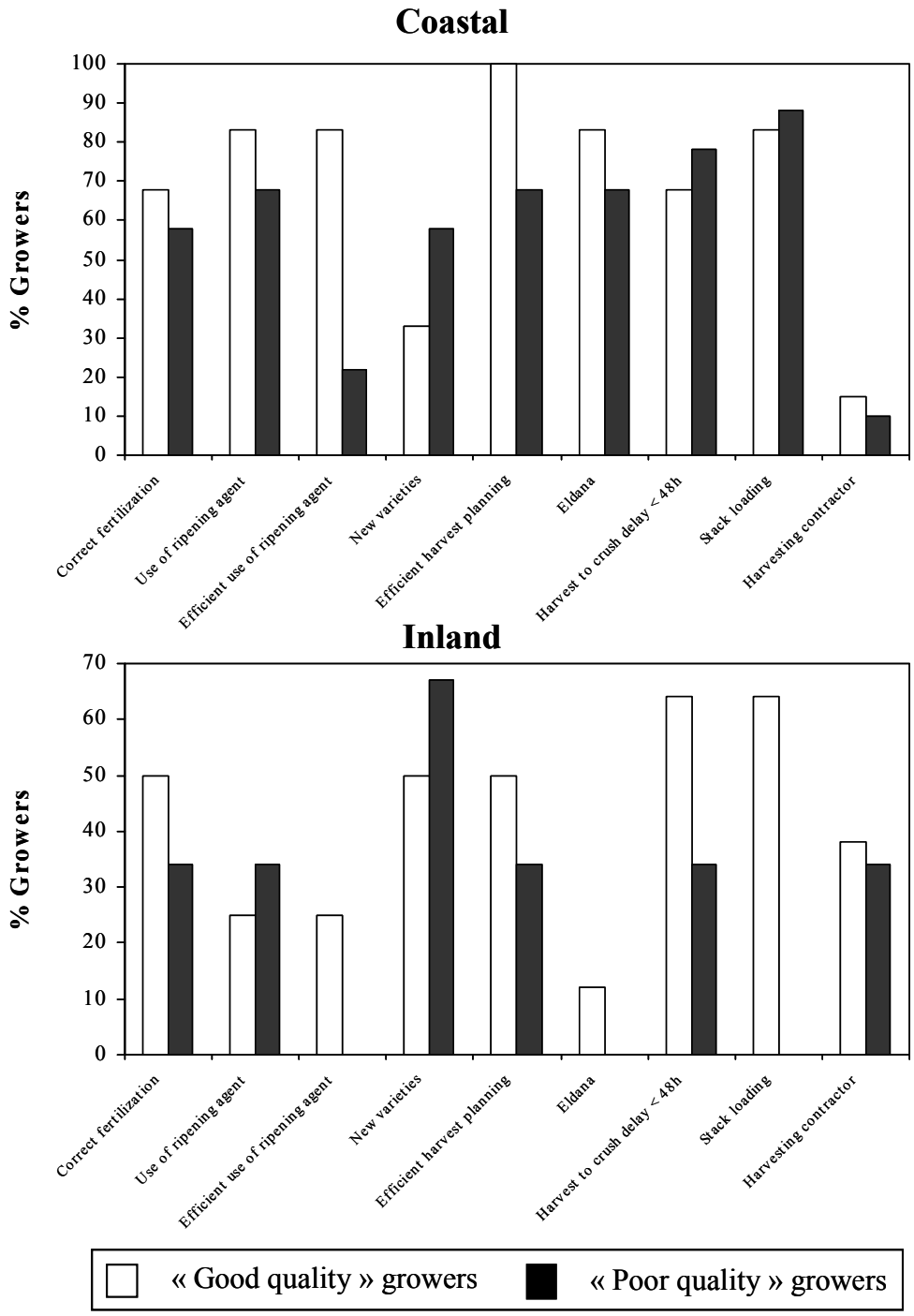


Figure 18: Comparison of cultural practices between "good quality" and "poor quality" growers within Coastal and Inland

5. DISCUSSION

The study conducted in 2004 showed that modifying harvest scheduling within the mill supply area would impact differently on growers' revenues according to the selected relative payment system. The choice of a reference used to compare deliveries is mainly linked to the stakeholders' objectives: would they accept some RV transfer between sub-areas or would

they prefer to adopt a strict adjustment between RV production and revenues? Implementing such scenarios still raises a range of issues that guide the way this research program could go forward.

5.1. Field level

At the field level two main agronomic issues need to be addressed in order to assess the impact of alternative supply scheduling on the total RV production:

- *What could be the impact of reduced harvest windows on cane yield and %RV?*

Simulations are based on historical cane yield and %RV data. But new harvest windows could impact on cane yield and %RV at the field level and then at the mill area level. The relationship between harvest date, cane yield and %RV could be addressed by both (i) analysing historical data collected at the field level[3] and (ii) using an agro-physiological model such as CANEGRO (Singels and Bezuidenhout, 2002) in order to simulate this relationship over a large range of locations and climatic conditions.

- *What could be the risk of Eldana saccharina infestation and its impact on cane yield and cane quality?*

Eldana saccharina affects cane yield and cane quality by boring into cane stalks and giving way to infection by secondary organisms (Way and Goebel, 2003). These attacks impact on cane stalk mass, %fibre and % non-sucrose. This process justifies the S2 supply scenario but it hampers Coastal to gain RV tonnage by reducing its harvest windows. A better knowledge of *Eldana* infestation process and its relationship with cane yield and cane quality would improve the risk assessment of delaying Coastal harvest windows.

5.2. Farm level

The study conducted in 2003 showed the existence of extra harvest capacity at farm level. This statement concerns mainly loading and transport equipment while labour availability raises some critical issues mentioned by growers during the current study. On one hand cutters are more difficult to find because of Aids and low youngsters' attraction for this activity. On the other hand their cost increases with the new labour legislation. This has been addressed in the "industry strategic initiative" which has proposed plans.

The current study showed that the relative payment system impacts differently than expected on the growers' behaviour: (i) they do not systematically deliver rateably and (ii) some of them consider it as an incentive to deliver better quality cane. The quality management survey gave only some general indications about these processes. It could be interesting to specifically investigate how growers practically manage their harvest organization and their cane crop in order to understand how such practices impact on delivery scheduling and %RV at the farm level.

5.3. Mill area and industry levels

This 3-year study provides to Sezela stakeholders a good basis to undertake any change regarding supply organisation and payment system. The zoning relevancy could be addressed

[3] Some data set should be available at the Sezela Estate farm.

more carefully before implementation, for example by taking the 15-month cycle as a limit between Coastal and Inland. Such a study could be conducted on a simulation basis, by using a model such as CANEGRO.

The 2003 study showed that hauliers owned extra capacities in order to transport cane from loading zones to the mill. These extra capacities would be useful in case of harvest windows reduction. Nevertheless they are costly and should be optimised, based on a fleet reduction and a better efficiency of transport organization. This type of system has been successfully implemented in the timber industry and has shown significant savings through increased vehicle utilization. This would be in addition to the potential gain of sucrose for the area. A prospective study was conducted in 2004 to address this issue. Preliminary results indicate that if the scheduling of vehicles were introduced there could be a significant reduction in the number of vehicles delivering cane to the mill.

At the industry level stakeholders are facing new challenges in order to remain internationally competitive. Structural constraints such as labour issue and environmental regulation, as well as temporary constraints such as the strong currency and climatic hazards, require specific attention and adapted solutions. On another hand new opportunities arise, particularly regarding the sugarcane outputs. Sugar will remain central for the immediate future but a range of co-products could progressively increase their share in the industry revenues such as ethanol, furfural or electricity production.

Both these constraints and opportunities will impact on the supply organisation and the payment system used in the industry. Innovative changes need to be investigated rather than small modifications of the current context. For example the following issues could be addressed using simulation:

- What would be the impact on RV production of optimising variety utilisation at the mill area level?
- What would be the impact of harvesting groups and mechanization on supply organisation and growers' RV comparison?
- What would be the impact of new outputs on cane payment system and supply organisation?

5.4. The way forward

Sezela stakeholders have now a good view on the alternative possibilities linked to their initial question. So the work plan designed for 2005 onwards is orientated on (i) solving some agronomic issues, (ii) duplicating the methodology in other mill areas and (iii) tackling the new issues listed above.

- *Simulation of the relationship between harvest date and cane yield*

This issue has been raised since the first study in 2002. It needs to use the CANEGRO software to model the impact of harvest date on cane yield in various climatic conditions. These results will then be implemented in the supply simulations carried out with the simulation tool MAGI© developed by CIRAD (Le Gal *et al*., 2003).

- *Duplication of the methodology to other mill areas*

Several South African mill areas show quality-homogenous sub-areas like Sezela. They have been contacted by SASRI to duplicate the methodology experimented in Sezela on their own supply areas. Supply simulations will be facilitated by using MAGI©. These new locations will supplement our knowledge basis, which will help to validate the methodology and to test the software.

- *Modelling supply scenario with MAGI©*

MAGI© will also be used to investigate the impact of alternative technologies (varieties, harvest mechanization, green cane cutting) or production of new outputs (e.g. ethanol) on supply organisation at the mill area level. We suggest keeping Sezela as a trial site, as many data are available and a trusting relationship has been established with the local stakeholders. This topic will also involve specialists able to provide relevant data and knowledge regarding the innovations to be simulated.

- *Investigating the cane payment system*

The study conducted in 2004 investigated the only component of the payment system, which could vary at the mill area level. The strategic changes that the industry should face in the future and its need to encourage both millers and growers to be more efficient justify enlarging this investigation to the three components of the system, i.e. the share process between millers and growers, the formula linking revenue to cane quality and the relative payment system. This component will be undertaken as part of a PhD research conducted both in La Réunion and South Africa.

CONCLUSION

This third study conducted with the Sezela mill supply area complements the two former studies by analysing the combined impacts of alternative supply organisation and payment system on stakeholders' revenues. It shows that positive RV gains may be expected from reducing harvesting windows on three quality-based sub-areas over the last four years. The amount gained depends on the annual RV curve profiles; the flatter the curves the smaller gains are.

Part of the RV gains is transferred from Inland to Coastal sub-area with the current relative payment system. Growers may accept it as a means to maintain enough production in the Coastal area. But changing the RV comparison reference is necessary if they refuse this transfer. This objective may be achieved by comparing growers within their supply sub-area, as this alternative restores the link between delivery rateability and RV comparison.

These results give to the Sezela stakeholders a good basis to make their decision regarding a change in supply organisation and payment system. The research program can now address new topics emerging from the challenges facing the South African sugar industry for the future. It will mainly consist of investigating the impact of innovative technologies and industrial outputs on both supply organisation and the three components of the payment system. As before these issues will be addressed as part of a collaborative research project between CIRAD and SASRI.

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