

IMPACT OF ALTERNATIVE RELATIVE CANE PAYMENT SYSTEMS AND HARVEST SCHEDULING ON GROWERS' REVENUES

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Abstract

The Centre de coopération internationale en recherche agronomique pour le développement, the South African Sugarcane Research Institute and the Sezela mill have since 2002 been conducting a collaborative research project into the potential benefits that could be expected from re-arranging cane supply scheduling based on the variation of quality patterns within the Sezela mill supply area. The supply area was split into three quality-based sub-areas determined by climatic conditions, and various harvest windows were allocated to each sub-area according to its specific recoverable value (RV) curve. Simulations of the mill's cane supply and the associated RV % cane showed gains ranging from 0.5 to 2.5%. A study was conducted in 2004 with the objective of investigating the relevancy of the current and alternative relative payment systems when distinctive supply sub-areas are defined within the mill supply area. Two alternatives to the current relative payment formula were designed and their impacts on growers' revenues were simulated. Alternative 1 switches the weekly RV average of the overall supply area with the weekly RV average of each sub-area. Alternative 2 considers each sub-area as a completely separate supply area. Simulations have shown that re-organising mill supply by separating subarea deliveries impacts differently on the growers' revenue, depending on the selected payment system. The current system and Alternative 1 both lead to RV transfer from Inland to Coastal, while Alternative 2 keeps RV revenue close to actual RV.

Keywords: sugarcane, mill supply, delivery allocation, cane payment system, revenue, simulation

Background

The South African sugar industry exports over half of its total production at a price that fluctuates in response to the global market. It is facing new challenges to remain internationally competitive in an environment characterised by low sugar prices, a strong local currency against the US dollar and several dry seasons. Efficiency and profitability gains should be sought at every level of the supply chain, from cane production to process and marketing of both sugar and co-products. Each stage can be improved, as well as the interactions between them. In this respect there is potential to improve profitability at the mill area level by looking at cane supply management. As this process involves interactions between numerous stakeholders and tasks, a system analysis has to be implemented based on a supply chain management framework (Lambert *et al.*, 1998; Muchow *et al.*, 2000).

Various improvements can be considered, ranging from changes in harvest and transport techniques to new rules of delivery allocation (Gaucher *et al.*, 1997). The Centre de

coopération internationale en recherche agronomique pour le développement (CIRAD), the South African Sugarcane Research Institute (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 in quality patterns within the mill supply area (Guilleman *et al.*, 2003; Le Gal *et al.*, 2004a and 2004b). The objective has been to maximise the Recoverable Value (RV) of cane delivered from a given cane supply area.

The supply area was split into three quality-based sub-areas - Coastal, Inland and Small-Scale Growers - and various harvest windows were allocated to each sub-area according to its specific quality curve. The objective was to benefit from the higher RV % cane of Inland cane at the beginning of the season (Figure 1).



Figure 1. Weighted weekly %RV for Coastal, Inland, Small Scale Growers and mill area (2000-2003).

Both the mill supply and the RV production were simulated for the overall season using a dedicated calculation tool (Guilleman *et al.*, 2003). 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 profile. The feasibility of the scenarios was assessed mainly by investigating the available capacities along the supply chain. Both harvest and transport capacities were measured and it was determined that the mill could crush 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 eager to investigate the impact these supply scenarios would have on the cane payment system. The question was whether the current payment system would share the RV gains equitably amongst the stakeholders? A third study was therefore conducted in 2004. It aimed at examining alternative cane payment

systems and simulating their impact on the stakeholders' revenues according to various supply scenarios (Le Gal *et al.*, 2005).

Problem statement

The Sezela mill supply area

The Sezela mill is supplied with sugarcane by a large variety of growers including its miller-cum-planter estate (13%), 180 large-scale farmers (72%) and 5000 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 tons of cane were crushed per year on average, with significant variations from one year to another (Table 1). 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 mill capacity is adjusted according to specific circumstances (e.g. high production level in 2000 and 2002), while the Length Of Milling Season (LOMS) remains around 37 weeks. This LOMS is within an economical range if the mill area is considered a single business entity (Moor and Wynne, 2001).

Table 1. Annual length of milling season (LOMS) and cane production in the Sezela mill area.

	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
Tons/week	56 428	59 117	62 740	57 317	58 925

The Mill Group Board (MGB) is responsible for managing the cane supply. Before the season starts growers submit their crop estimates to the MGB and in return receive a Daily Rateable Delivery (DRD) allocation. 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 cases of unforeseen events or better estimation of the remaining production.

The current cane payment system

The current cane payment system is based on three main components. The first component aims at sharing the value between millers and growers and covering production costs. The total annual sugar and molasses revenue is calculated by the South African Sugar Association (SASA). The net revenue is then shared between growers and millers using a fixed ratio, which is negotiated every 10 years to take into account relative technological and economic changes in the industry. The last negotiation was in 2004 and the current division of proceeds to approximately 36% to millers and 64% to growers.

The second component encourages growers to deliver good quality cane. Cane quality is a crucial parameter as it impacts on sugar production and stakeholder profitability. From the

millers' point of view, the higher the fibre and non-sucrose contents, the more difficult sucrose extraction becomes. Therefore, cane quality is measured as Recoverable Value (RV, derived from the Estimated Recoverable Crystal (ERC) formula (Murray, 2002; Moor, 2002)), which includes sucrose (S), non-sucrose (NS) and fibre (F) contents of cane as follows:

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

The 'c' factor reflects the sucrose trapped by fibre and lost during the milling process. The 'd' factor reflects both the sucrose trapped by non-sucrose and the molasses revenue earned from non-sucrose. The annual RV curves presented in Figure 1 vary largely because of climatic differences.

The third component encourages growers to deliver rateably. A relative payment system was implemented in 1975 in order to discourage growers from over-delivering when their cane quality is high (Buchanan, 1975). The principle is to 'flatten' the grower's RV curve by comparing the grower's deliveries to the overall mill area average. The comparison is made weekly as follows, where 'i' refers to grower 'i' and 'j' refers to week 'j':

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

This cane payment system is contracted between millers and growers within the Sugar Industry Agreement, 2000. Both components 1 and 2 cannot be changed without agreement by the industry, but the relative RV % cane calculation could potentially be changed at a local mill area level. The different supply scenarios simulated in 2002 and 2003 impacted growers' revenues. Hence, two subsequent issues were addressed: (1) How the gains obtained from a re-organization of harvest scheduling would be shared using the current payment system? (2) Would modifications to the relative payment formula provide a fairer share of these gains? A three stage methodology was adopted. 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 alternative payment system scenarios were defined and their impacts on the growers' revenues were simulated.

Methods

The mill supply was modelled using a simulation tool which enabled the assessment to be made of alternative supply scenarios, based on a simplified representation of the various operators in the supply chain, with their constraints and relationships. Changes in structure and capacities were 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.*, 2004). This modelling technique was preferred to optimisation tools developed in Australia (Higgins and Muchow, 2003) because the South African supply chain is less integrated.

A similar simulation technique was followed to compare scenarios of relative cane payment systems. A calculation tool was developed using spreadsheet software. The growers' economic gains were calculated according to (i) a mill supply scenario and (ii) a cane payment system. Input variables included both the weekly deliveries per grower and the weekly RV % cane per grower. The values were adjusted according to the selected supply scenarios, which defined the harvest windows per sub-area and per grower.

As deliveries were 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. A weekly DRD was calculated by dividing the total cane production by the number of delivery weeks assigned to the grower's sub-area. Because of management constraints growers delivered 20, 50 and 75% of their DRD during the three first weeks respectively, and then 50 and 20% during the two last weeks respectively.

A worksheet was then developed 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 tonnage delivered, modelled tonnage delivered, 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.

Results

Selection of supply scenarios

In a workshop environment, the stakeholders selected four scenarios from the former studies conducted in 2002 and 2003, because of their potential feasibility and value (Figure 2):

- Reference scenario: all zones deliver throughout the season.
- S1: Coastal deliveries are delayed (two weeks) and Inland deliveries stopped 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 stopping Inland deliveries before rain disrupts the deliveries.
- S2: Coastal deliveries are delayed four weeks and Inland deliveries stopped nine weeks before the end of the season. This scenario is based on the same objective as S1, but the supply system is pushed to its capacity.
- S3: Coastal deliveries are made throughout the season, while Inland deliveries begin two weeks after the season starts and stop six weeks before its end. S3 takes into account the necessity to harvest older Coastal cane at the beginning of the season to minimise the risk of yield loss due to *Eldana saccharina*, a cane stalk borer pest. Inland deliveries are 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 and Inland zones vary from 360 to 6000 tons RV per season (Figure 3), which equates to R0.45 and R7.44 million respectively. S2 systematically showed the best results, while the S1/S3 ranking varied according to the year. The largest differences between scenarios were associated with the climatic variations between seasons, which are reflected in the RV % cane curve profiles. The flatter the profile, the smaller the gain. For example, 2002 shows less gain than 2001 while its total production was bigger.

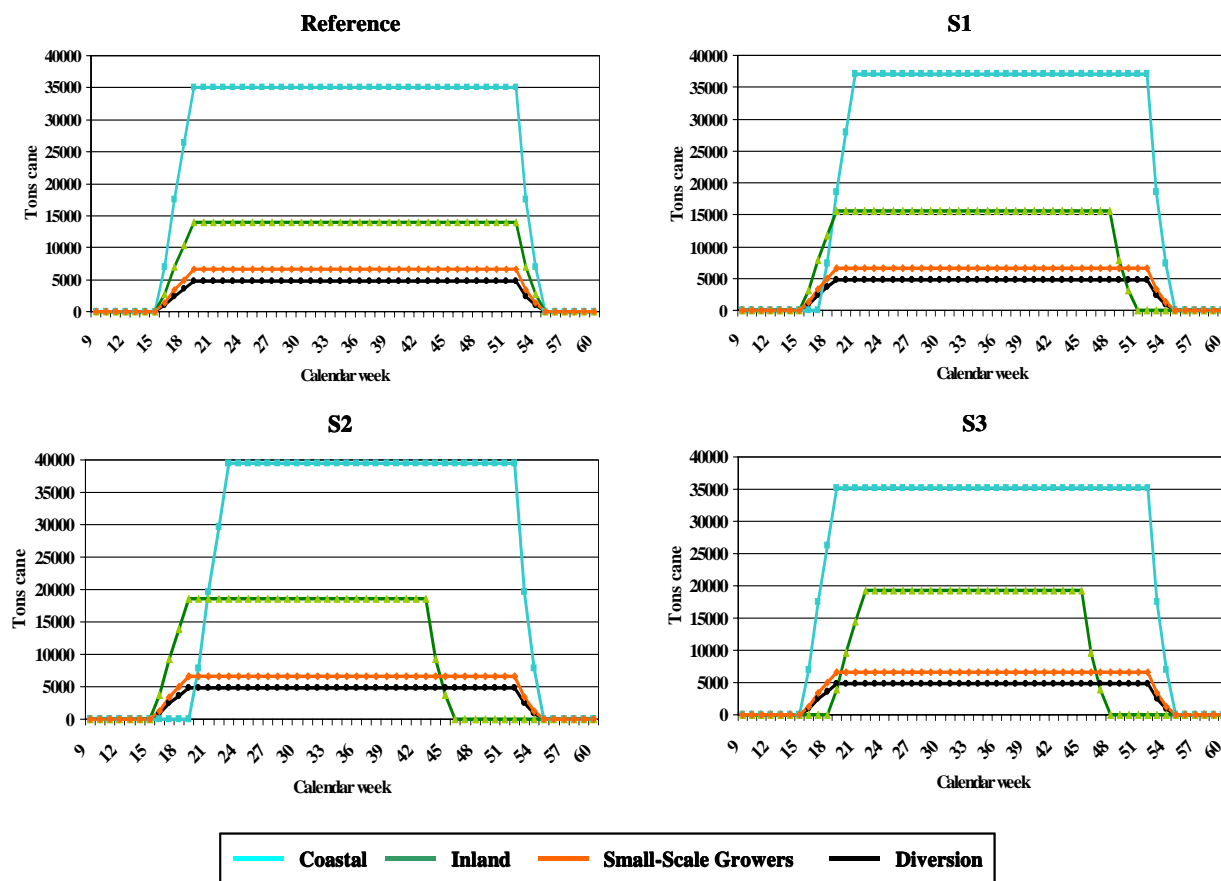


Figure 2. Simulated supply scenarios.

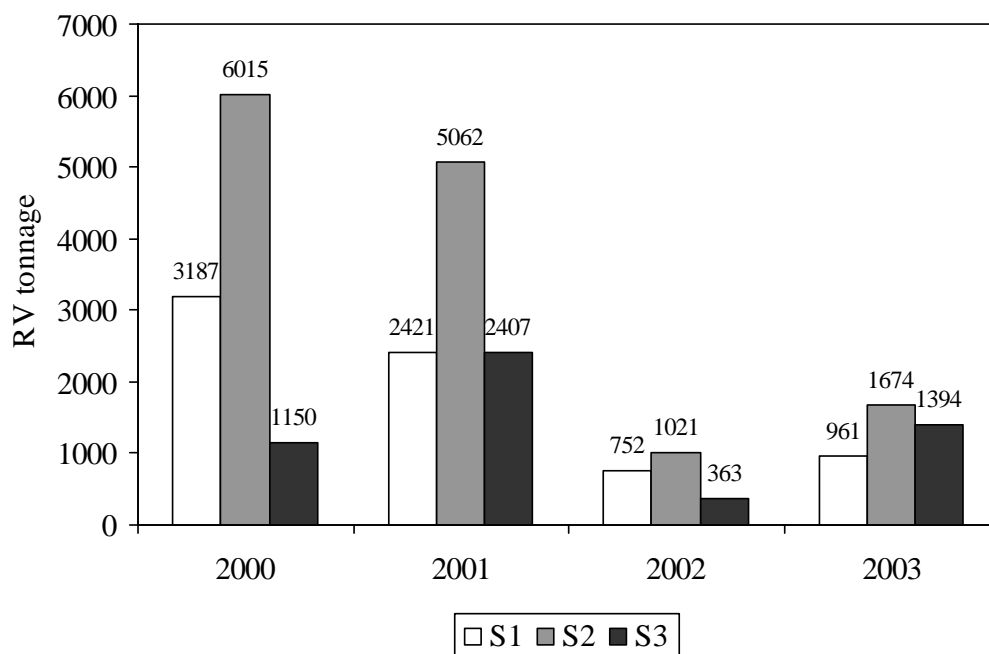


Figure 3. Simulated gains (tons RV) for each scenario from 2000 to 2003.

Changing the harvest schedule in each sub-area without changing the payment system impacts how the gains are shared between sub-areas (Figure 4). Inland growers lose some of their gains while Coastal and small-scale growers (SSG) gain more than their share, and this quantity varies between supply scenarios. It is maximised with the S2 scenario, where Inland grower revenues decrease compared with the reference scenario while Coastal grower revenues increase.

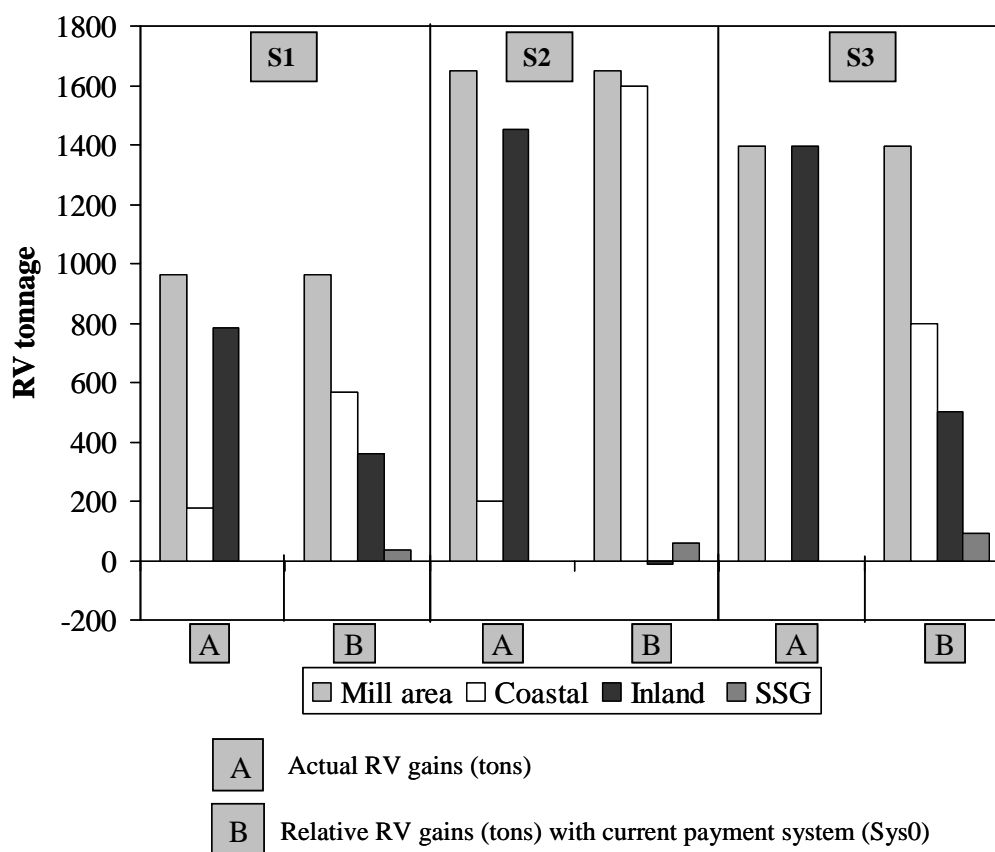


Figure 4. Sharing of RV gains between sub-areas according to the supply scenario (2003 season)

These results occur because the three alternative scenarios challenge the rateability of delivering between sub-areas.

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 because of the relative payment system. Alternative payment systems have been designed to correct the distortions created by the supply scenarios in the current situation.

Simulating alternative payment system scenarios

Two alternative payment systems were simulated using the calculation tool presented above, which uses the relative payment system to create an incentive to deliver, not only rateably, but also to maximise mill area cane quality. The first alternative, called Sys1, replaces the mill weekly %RV average by the sub-area weekly RV % cane average. The season average remains the same, i.e. calculated at the mill area level. The Sys1 formula is therefore defined as follows:

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

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:

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

The simulations carried out without changing the mill supply schedule show that Sys1 leads to a general transfer of RV from Inland to Coastal and SSG (Figure 5). This transfer amounts for 2000 to 6 000 tons RV, depending on year, i.e. from 3 to 8% of the total annual Inland revenue. This loss occurs through the Inland deliveries being compared with a higher average %RV, while Coastal deliveries are compared with a lower average. Stakeholders rejected this alternative because of these strong distortions and no other simulation was conducted using this method.

Comparatively, Sys2 leads to a very small transfer from Coastal and Inland to SSG (Figure 6). 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, as respectively 89% and 73% of these growers gain or lose less than 1% of their current revenue over four 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. The process is quite unpredictable but no grower wins or loses systematically from one year to another.

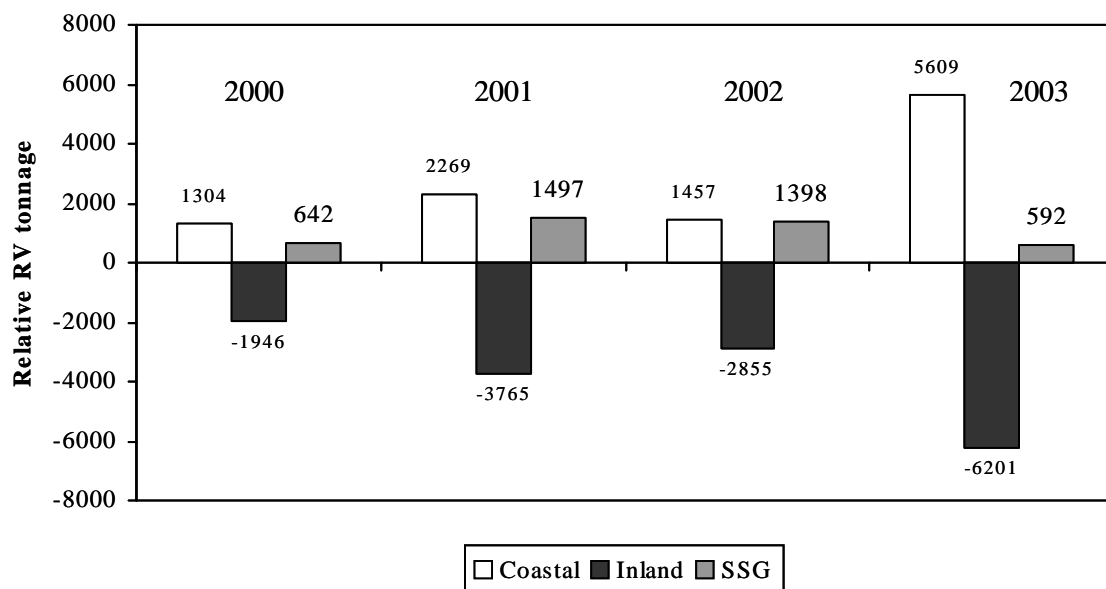


Figure 5. Variations in revenue per sub-area and per year with the Sys1 payment system compared with the existing situation.

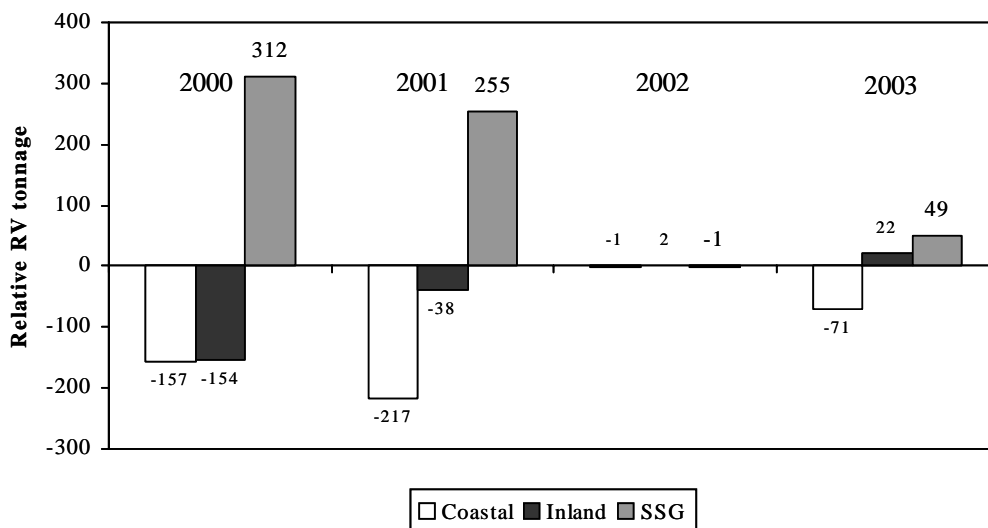


Figure 6. Variations in relative RV per sub-area and per year with the Sys2 payment system compared with the existing situation.

The Sys2 alternative rectifies the distortion noticed with the current payment system when applied to the alternative supply scenarios (Figure 7). The Sys2–S3 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 the effort to improve their cane quality.

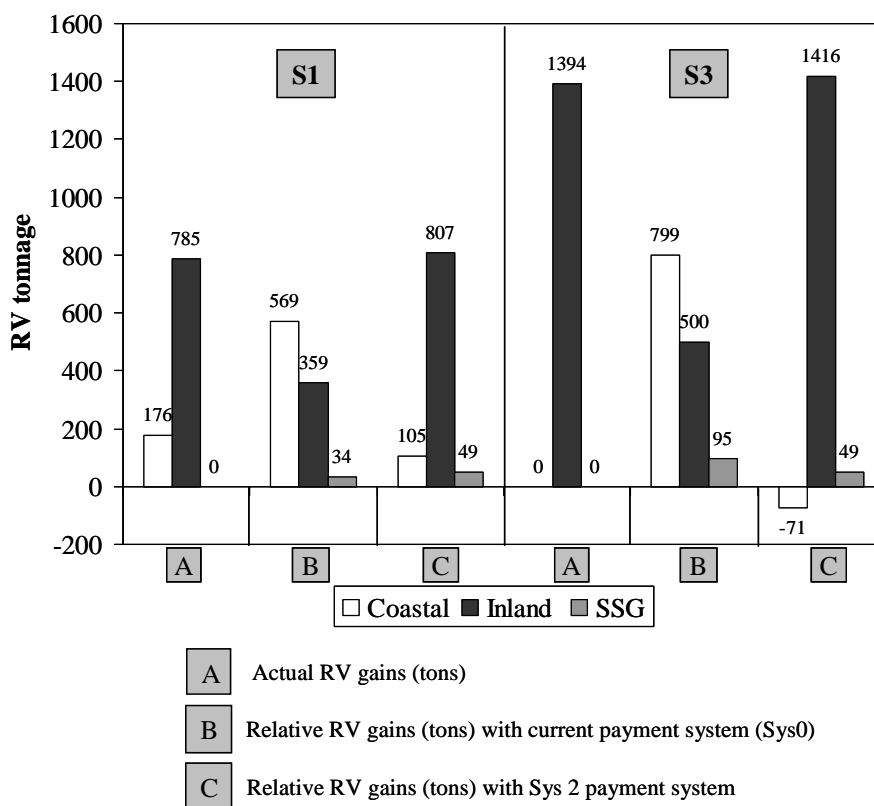


Figure 7. Combined impact of Sys2 payment system and supply scenarios on sub-area relative RV gains.

Gains obtained within a sub-area are then distributed between its growers using the same relative principle. The general trend consists of a majority of Inland growers gaining extra revenues, as the RV transfer between Inland and Coastal is almost cancelled. Eighty-six per cent of them would win over the last four years. However, both positive and negative variations remain in a narrow range for most of the growers ($\pm 2\%$), SSGs excepted ($\pm 5\%$).

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?

The answer is not obvious. For example Sys2 seems a fairer system than the current payment system (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 production area allow disadvantaged growers to remain active and the mill to operate at full capacity.

The S3–Sys2 combination may be challenged as well. There is apparently no reason for the Coastal growers to select this combination, as their revenue will remain similar. But S3 has been designed to take into account the risk of *Eldana saccharina* infestation on Coastal carry-over cane. S3–Sys2 could encourage Coastal growers to solve this problem in order to swap to a S1-type scenario and gain from the 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.

These results raise new issues to be investigated to improve profitability at various levels of the supply chain. At the field level the impact of reduced harvest windows on cane yield and %RV has to be assessed, as sugar gains could exceed the current results depending on locations and climatic conditions. Specific studies should be carried out using an agro-physiological model such as CANEGRO (Singels and Bezuidenhout, 2002). Similarly, a better understanding of the *Eldana saccharina* infestation process and its relationship with cane yield and cane quality would improve the risk assessment of delaying Coastal harvest windows (Way and Goebel, 2003).

It could be valuable to investigate how growers practically manage their harvest organisation and their cane crop at the farm level, in order to understand how such practices impact on their delivery scheduling and %RV. Labour availability in particular raises some critical issues. On one hand cutters are more difficult to find because of AIDS and because youngsters are not attracted to this activity. On the other hand their cost increases with the new labour legislation.

Conclusions

The studies conducted between 2002 and 2004 have shown that re-organising cane supply scheduling can improve profitability of a mill area by dividing it into homogeneous quality sub-areas such as Inland and Coastal, and allocating specific harvest windows to each of them. Expected gains depend on the annual RV curve profiles; the flatter the curves, the smaller gains.

Part of the RV gain is transferred from Inland to Coastal sub-area with the current relative payment system. Growers may accept this 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 Sezela stakeholders a good basis on which to make their decision regarding a change in supply organisation and payment system based on variations in the cane quality pattern. The methodology may also be used in other mill areas which show similar quality patterns. The collaborative research programme between CIRAD and SASRI can now address new topics emerging from the challenges facing the South African sugar industry in the future. Research will consist mainly of investigating the impact of innovative technologies and industrial outputs on both supply organisation and the three components of the payment system.

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