SHORT COMMUNICATION

IMPACTS OF HARVEST MECHANISATION ON MILL CANE SUPPLY: A MODELLING APPROACH

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Abstract

Mechanisation of the harvesting operation is increasing in the South African sugar industry to solve problems associated with labour shortages. A modelling approach has been developed and used to explore various impacts of mechanised harvesting on the integrated supply chain at the Noodsberg mill. Through coupling a supply planning tool (MAGI®) with a logistics simulation tool (ARENA™), two supply chain issues could be investigated, namely (i) how harvest mechanisation would impact on the length of the milling season (LOMS) and total production, and (ii) what infrastructure is required to harvest 75% of the crop mechanically, as opposed to the current 16%. The models suggest that it would be valuable to reduce the LOMS by four weeks at the beginning of the harvest season and four weeks at the end of the season, to avoid the rainy periods. Modelling showed that the current logistics configuration at Noodsberg (16 harvesters and 195 transport vehicles) is over-sized and inefficient as far as cane supply is concerned. It was estimated that between 7 and 13 harvesters, serviced by 17 to 28 trucks, would support a 75% mechanised harvesting scenario. This discussion also briefly explores a range of other issues that will need to be addressed should mechanical harvesting be increased in the Noodsberg area.

Keywords: logistics, supply planning, transport, sugarcane delivery, simulation, mechanical harvesting

Introduction

The move towards mechanised harvesting has been rapidly increasing in some South African mill areas, such as Noodsberg, where the harvester fleet doubled in 2007 to alleviate the increasing shortage of manual labour. Research estimated that 75% of fields in the Noodsberg area are suitable for mechanical harvesting. In response to this, the Mill Group Board (MGB) raised the following questions:

- Under different logistical arrangements, what would the ideal fleet sizes be for harvesters and transport vehicles?
- How would mechanical harvesting impact on the LOMS and total sugar production, assuming that mechanical harvesters have greater capacities than manual cutters, but require low rainfall periods to ensure mobility and avoid compaction?
- What other issues need to be considered?

The aim of this study was to address the abovementioned questions by (i) surveying and modelling the supply chain, and (ii) synthesising simulation output.

Modelling mill supply management

The questions posed relate directly to the inter-dependency between supply planning and daily logistics. The investigation was based on modelling and exploring various scenarios of management, which were presented to the MGB for their consideration. Two simulation tools were used to simulate the supply scenarios. First, seasonal supply planning was modelled by MAGI® (http://agri-logistique.cirad.fr, Lejars *et al*., 2008), which compares estimates of total annual sugar production under different supply planning regimes. Secondly, Hansen *et al*. (2002) found ARENA™ suitable for simulating sugarcane logistics systems in South Africa, and this software was used to simulate daily logistics. This was done by representing the various supply sub-chains that function concurrently in the area.

The two models used the production unit (PU) as a common modelling entity. A PU is defined as a cohort of farms characterised by relatively homogeneous logistical circumstances. Three differentiators were used to subdivide the mill area into PUs, *viz* (i) the type of harvest technique (manual vs mechanised), (ii) the distance to the mill (short distance <15 km; medium distance 15-35 km; long distance >35 km), and (iii) bundle cane system vs spiller cane system.

Several system properties were changed between simulations. The current regime, where 16% of cane is harvested mechanically, was changed to a future 75%, using either a bin system or an elevating trailer system (systems E and F respectively, in Figure 1). Scenarios were compared under different LOMS agreements while assuming the mill's current crushing capacity of 300 t/h, as well as an upgraded capacity of 340 t/h. Changes to the LOMS aimed at concentrating activities around the quality peak period, while simultaneously avoiding the rainy periods at the beginning and end of the season.

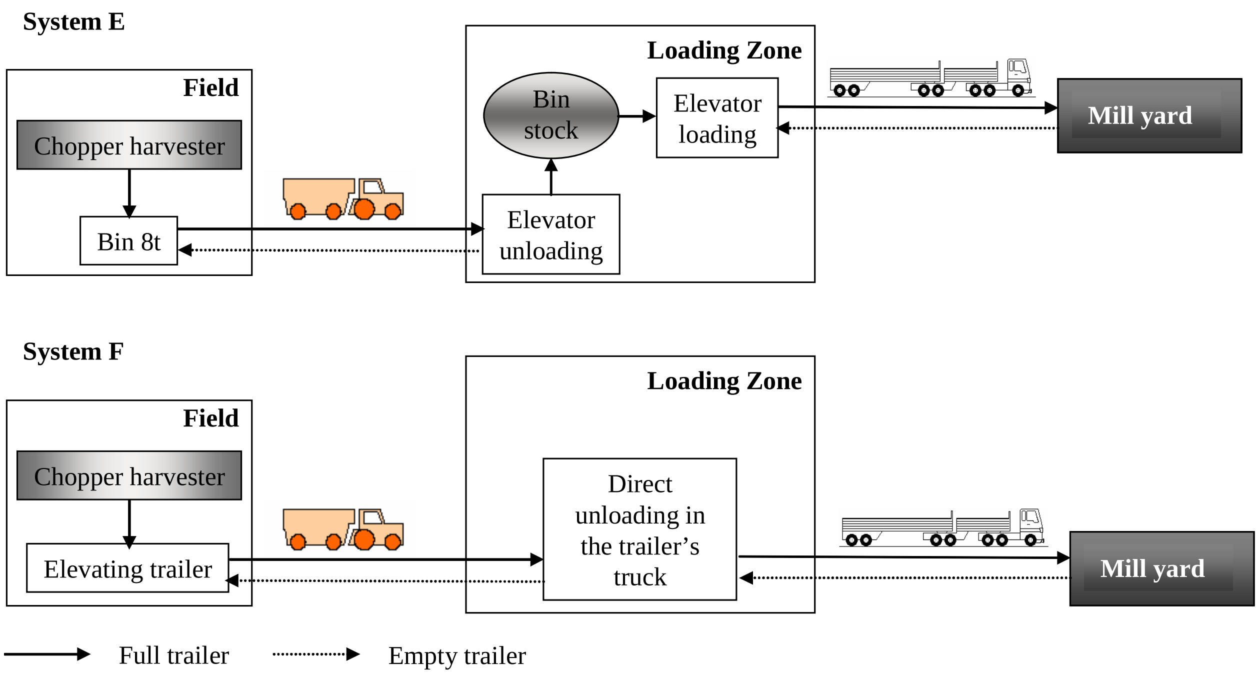

Figure 1. Two mechanised harvesting logistic chain types simulated at Noodsberg.

Distinctively different logistical scenarios were simulated according to (i) the mill capacity (300 vs 340 t/h), (ii) the mechanisation regime (16% vs 75%), the logistical system (E vs F, Figure 1) and an assumed time slot for mechanical harvesting (day only vs 24 h delivery). Five scenarios were selected. Scenario S_0 resembles the reference scenario since it is closest to the current context. S_1 transposes S_0 from 16% to a 75% mechanisation regime, while S_2 explores the impact of a 24 h operating period using the F system and a reduced harvest capacity at night to account for difficult working conditions (40 t/h from 6 pm to 6 am). S_3 and S_4 explore the impact of the E system applied to the two crushing capacities.

Results and Discussion

The MAGI simulations show little potential for gaining RV by reducing the LOMS. The best results are obtained when the mill crushing capacity is increased to 340 t/h and the LOMS is reduced by eight weeks. This amounts to a 1.5% increase in RV production, valued at R4.5 million. It is relatively low compared to a previous study conducted at Sezela mill, where changes in supply planning resulted in benefits of up to R8.1 million (Le Gal *et al.*, 2008). Noodsberg's RV values are relatively uniform throughout the milling season. This can be attributed to the relatively cool high altitude conditions demanding long growing cycles and little water usage, especially in the winter. Nevertheless, a reduction in LOMS could mitigate against harvesting during the rainy season and will release time to better maintain fields and equipment, which should impact positively on volumes and processing consistency.

Scenarios S_1 to S_4 show that the 75% mechanised harvesting regime may be reached with a relatively small harvester fleet size (7-13 machines). As expected, the smallest fleet coincides with a 24 h harvest operation (Scenario S_2). However, growers and contractors are reluctant to work at night, even though this scenario optimally synchronises the harvesting and milling components in the supply chain. In the other cases (S_1, S_3 and S_4), where harvesting occurred during the day only, the satisfying logistical configuration needs to address a cane storage issue in order to feed the mill at night. In the semi-direct delivery system (Scenario S_1) the trucks are used as storage facilities. Consequently, their numbers and the queue at the mill, and hence transport costs, increase significantly in order to maintain the same level of cane production. This solution is therefore economically unrealistic, and Scenario S_3 provides a more suitable alternative based on infield loading and storage at the loading zones using bins (E system). This sufficiently decouples the harvesting and transporting components in the chain. Under the constraint that growers and contractors are reluctant to harvest at night, Scenario S_3 appears to be the most appropriate. However, the miller objects, since the unloading of bins will require substantial new infrastructure and will increase labour requirements.

A synthesis

In addition to the model results presented in the previous section, the mill area will need to consider the following issues before shifting towards mechanisation:

- The impact of green cane harvesting on the supply chain.
- The way in which growers re-organise, knowing that a single harvester can service many growers. This should include the design of harvesting consortiums and harvest fronts.
- Investigating night time harvesting to improve flow consistency, and comparing this with stockpiling strategies that will avoid night time harvesting.
- Identifying grower and miller benefits and vulnerabilities and negotiating trade-offs and incentive schemes to promote an improved and more robust overall supply chain.

- The need for researchers to facilitate change in a participatory research approach.
- Coping with risk and designing supply chain capacities to manage certain levels of risk.
- Economics (in a broad sense); this includes economics of individual operators, economics of the overall supply chain and value adding and value sharing.
- Management issues and strengthening the relationship between stakeholders across the supply chain through, *inter alia*, information sharing.
- Improving systems to measure and benchmark the supply chain under different regimes.
- Quantifying the impacts of a LOMS reduction in terms of economics, agronomics and socio-political aspects.
- Equipment expansion and maintenance strategies for both the miller and the grower.
- Improving infield mechanical harvesting efficiency in terms of operator rules and field design.

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