SHORT COMMUNICATION

REVIEW OF SUGARCANE MATERIAL HANDLING FROM AN INTEGRATED SUPPLY CHAIN PERSPECTIVE

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Abstract

Agricultural supply chains are complex. They require a mixture of lean and agile principles and, in the sugar industry, infrastructures are generally over-capitalised. In this short communication, four aspects that pertain to an improvement in material handling are discussed briefly: (i) capacity utilisation can be improved when volumes and qualities become more consistent, (ii) insufficient risk management may exist, (iii) stockpiles need to be managed and reflect the health of the system and (iv) cane deterioration needs to be carefully measured and managed. Finally, it is proposed that the sugarcane supply chain will function better where more than one mode of operation exists.

Keywords: supply chain, sugarcane, risk, stockpiling, variability

Introduction

In sugarcane agriculture, supply chains are often more complex than those found in other commodities. Downstream the supply chain demands lean principles, while upstream a multitude of unsynchronised autonomous producers operate under diverse conditions of production (Bezuidenhout, 2008). The latter demands contradictory agile principles (Christopher, 2000). Upstream production is often over-capitalised. Le Gal *et al*. (2008) found 570% mechanical harvesting over-capacities, Giles *et al*. (2005) discovered transport capacity in excess of 167%, and Stutterheim *et al*. (2008) calculated between 113% and 185% over-capitalisation across the full supply chain. Agility comes at a cost which, similar to leanness, needs to be quantified in order to be justified.

Christopher (2005) suggests three methods to improve material handling: better capacity utilisation, higher asset turning, and improved supply synchronisation. Asset turning involves the reduction of expensive stock, such as electronics. In sugarcane, deterioration outweighs any asset turning opportunity costs (Stutterheim, 2007). In a sugarcane context Christopher's (2005) recommendations towards material handling improvement translates to (i) promoting capacity utilisation, (ii) mitigating risk, (iii) minimising stockpiling, and (iv) reducing cane deterioration. In this short communication, these four attributes are briefly unpacked and a possible intervention method is proposed.

Material handling improvement attributes

Capacity utilisation

Mill capacities are designed assuming specific cane qualities. Variable cane qualities will constrain different parts in the mill, e.g. fibre in the diffuser and sucrose and non-sucrose in the A- and C-pans, respectively. The daily rateable delivery (DRD) system promotes constant cane volumes, irrespective of quality. A true DRD system can, therefore, apply only where all processes in the mill run below capacity, or where cane qualities are kept constant.

The hypothetical comparison between two mills in Figure 1 illustrates the importance of consistency. Mill A experienced more fluctuations and probably reached a ceiling since efforts to increase capacity could cause negative rippling effects, also known as the 'bull whip' effect (Hugo *et al.*, 2007). Mill B has a 50 t/h spare capacity, it can better absorb unexpected events and can increase its weekly crush budget with ease. The supply chain principle of controlling system variability is widely accepted (e.g. Raisinghani *et al.*, 2005; Boute *et al.*, 2009) and seems under-emphasised in the sugar industry.

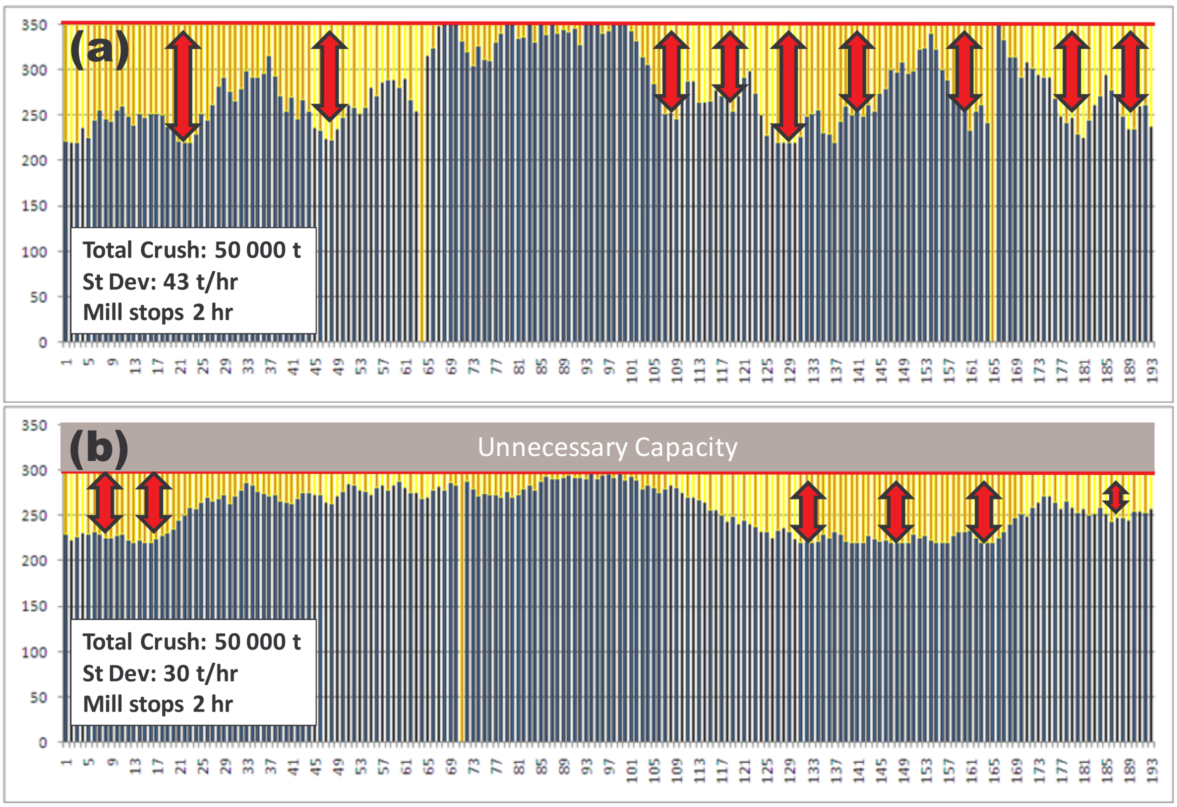

Figure 1. Hourly crushing rates (t/h) during each hour of a hypothetical week at two similar sugar mills.

Risk

Bezuidenhout and Baier (2010) conclude that sugar industries worldwide lack appropriate risk management strategies. Mills have different risk profiles and hence require unique mitigation plans. A risk profile includes uncertainties pertaining to the crush rate, harvesting and transport and the weather. In a risk model, Astika *et al.* (1999) balanced inventory losses and mill stops during unfavourable weather. Risk management involves:

- Quantifying the main risks and their impacts in the system.
- Agreeing on a level of risk to remain resilient.
- Developing an early warning system.
- Developing decision rules.
- Developing contingency plans.

Stockpiles

Table 1 sub-divides stockpiles into two groups: (a) deliberate and (b) unexpected stockpiles. Certain stockpiles are more appropriate than others (colour coded). Infield stockpiles are vulnerable to wet conditions, prohibit efficient night time transport operations and it is difficult to estimate stock levels. Loading zone stockpiles are generally valuable, but stock levels can be uncertain. Stockpiling on vehicles is highly inefficient, costly and may aggravate bull whip conditions. The mill yard is a logical place to stockpile; however, mill yards can become congested, will result in an under-utilisation of the transport fleet, and the first-in-first-out (FIFO) principle will sometimes be difficult to maintain.

Table 1. Stockpile categories in the sugarcane supply chain.
Colour bullets (bad, average, good) depict the appropriateness of each stockpile.

	Deliberate	Unexpected
Infield	● Rainfall and night time exposure	● Very poor inventory info
Loading zone	● Good but poor inventory info	● Poor inventory info
Vehicles (queue)	● Expensive and causing bull whipping	● Highly inefficient
Mill yard	● Congested, FIFO*	● Unnecessary double handling

*FIFO = first-in-first-out

Three reasons exist why deliberate stockpiles are maintained:

1. Risk mitigation, e.g. stock build-up prior to approaching wet weather.
2. Synchronisation, e.g. differences in operating times between harvesting and milling.
3. Cane maturity; in a few instances growers deliberately age cane to increase RV% (*cf.* Lyne and Meyer, 2005).

Unexpected stockpiles are caused by unsaturated and saturated conditions. Unsaturated conditions involve unnecessary changes in cane flow rates, such as large-scale driver shift changes. This points to severe violations of basic supply chain principles. Saturated conditions refer to capacity bottlenecks. Changes in flow rates will create small stockpiles, which could ripple further upstream and downstream. Stakeholders may attempt to correct these, but will cause bull whip effects, which cannot be fixed by merely changing the local component's processing speed (Chen, 1999). Fluctuations in stockpiles are probably one of the most robust indicators of overall system inefficiency.

Cane deterioration

Cane deterioration is a symptom of poor supply chain efficiency. It can potentially further constrain capacities in the mill. To date it has been difficult to find reliable measures and assumptions of cane deterioration (Wynne and van Antwerpen, 2004; Lyne and Meyer, 2005; Eggleston *et al.*, 2008). Should such a measure exist, it could be used effectively to identify and correct problems in the supply chain.

Discussion

Ashby's Law (1956) claims that a system exposed to various external conditions will cope better if the system has sufficient internal variety. A mode changing supply chain will create such a resilient system. Eskom, for example, undergoes several mode changes per day based on electricity supply and demand ratios. There is significant scope for the sugar supply chain to enter different modes under different conditions. Practically, fewer modes are easier to manage, but a single mode throughout the milling season is most probably sub-optimal. Further research to establish the potential benefits of changing modes is warranted.

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