Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
European Journal of Operational Research 170 (2006) 987–1000
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH
www.elsevier.com/locate/ejor

O.R. Applications

Scheduling of road vehicles in sugarcane transport: A case study at an Australian sugar mill

Andrew Higgins *

CSIRO Sustainable Ecosystems, Level 3, QBP, CRC for Sustainable Sugar Production, 306 Carmody Road, St. Lucia, Qld 4067, Australia

Received 5 January 2004; accepted 27 July 2004
Available online 18 September 2004

Abstract

Pressure to remain internationally competitive has forced Australian sugar mills to reduce capital and operational costs. Improved scheduling of road transport vehicles provides one such opportunity, as it would reduce vehicle queue and mill idle times and hence the number of vehicles needed. It is difficult for mill traffic officers to produce good transport schedules manually due to the need to service a large number of harvesters in different locations. To address this issue, research was undertaken participatively with a sugar milling company in Australia to produce and implement a mixed integer programming model that represents the road transport operations. Two meta-heuristics were applied to find a solution to the model, leading to potential cost savings of AU$240,000 per year versus schedules produced manually by the mill traffic officer. The model was also applied to explore regional planning options for a more integrated harvesting and transport system.

Keywords: Agriculture; Vehicle scheduling; Tabu search; Participatory research

1. Introduction

Decreasing international sugar prices has led to sugar industries around the world exploring opportunities to decrease costs of production. One such opportunity is a more efficient cane transport system that better integrates with harvesting activities. In advanced sugar producing countries such as Australia, Brazil, South Africa and the United States, sugarcane is transported from the farm to the mill via either rail or road transport, with a greater proportion being the latter. Costs of sugarcane transport in Australia is approximately AU$4.00 per tonne of cane, which is about 15% of total production costs. Addressing the harvesting and transport sectors of the

* Tel.: +617 3214 2340; fax: +617 3214 2308.
E-mail address: Andrew.Higgins@csiro.au

0377-2217/$ - see front matter © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.ejor.2004.07.055

sugar value chain has been regarded as the highest priority in an independent evaluation of the Australian sugar industry (Hildebrand, 2002).

Australia contains 30 mills for which the newer mill regions rely on road transport of sugarcane. A typical mill processes about 1.5 million tonnes of cane per year. A mill operates from about June to November as the sugar content of cane is at its highest during this period, while December to May are the main growing months for sugarcane. A mill region in Australia has on average 300 farms spread over about 15000 ha, which are serviced by an average of 30 harvesters. When sugarcane on the farm is harvested, infield haulout vehicles transport the cane to a nearby loading pad for which trailers will be waiting to be filled. In most Australian sugar mills that rely on road transport, there is more than one loading pad on each farm due to the need for infield haulout vehicles to travel short distances. Once the trailers at the loading pads are full, they are then transported to the mill by road vehicles, which are either owned or contracted out by the mill.

If the arrival time of vehicles at the mill were equally spaced apart and aligned with the mill throughput rate, there would be no queue at the mill and no mill idle time. This is difficult to achieve due to varying travel distances between the farms and the mill and the need for the time elapsed between when the cane is harvested and processed by the mill (i.e. cut-to-crush delay) to be within a certain threshold. Sugarcane deteriorates after being harvested and most Australian sugar mills aim to have the cut-to-crush delay less than 18 hours, though the average is about 9 hours. Another complexity is that in most Australian mills, harvesting is conducted in daylight hours only while both the mill and transport operates continuously. To accommodate this, there is up to 16 hours of infield storage in the trailers when waiting for transportation to the mill. In practice, mill traffic officers prefer to have a queue of vehicles/trailers in the mill yard rather than to risk idle time, as idle time can lead to an expensive mill stoppage. If the arrival time of vehicles to the mill were better scheduled, the mill could achieve a much shorter queue at the mill with minimal risk of mill stoppages.

Scheduling of sugarcane transport has received some attention in the literature. Abel et al. (1981) was the first to develop a sugarcane railway scheduling model for the pick-up and delivery of cane rail wagons from the rail sidings. Pinkney and Everitt (1997) transformed this model into a user-friendly tool for traffic officers. Scheduling road transport for sugarcane has mainly been attempted using simulation (Hansen et al., 2001). Such models have been used to test different transport operations scenarios to reduce the number of vehicles required. Milan et al. (2003) developed a linear programming model for the pick up of cane from different farms and storage locations to minimise costs, accounting for more than one mode of transport. The model does not directly address the operation level scheduling of individual transport vehicles.

This paper focuses on the development and implementation of a model to schedule road transport vehicles to pick up full trailers of cane from the loading pads located on the farms. The transport model was motivated and constructed with a case study sugar mill at Maryborough, located 250 km north of Brisbane, Australia. Two meta-heuristics, tabu search, and variable neighbourhood search, were applied to find solutions to the model. A comparison between the schedules produced by the meta-heuristics and those produced by Maryborough traffic officers will also be a focus of this paper, along with an application of the model for regional planning in harvesting and transport using participatory research principles.

2. Model formulation

The scheduling problem for sugarcane road transport involves the scheduling of several vehicles from the mill to pick up full trailers and return to the mill. If each vehicle was to pick up several trailers before returning to the mill and did not depart the mill again after arrival, the problem would be formulated as a vehicle routing