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Variable neighborhood search for optimizing the transportation of agricultural raw materials

Ana Anokić [a,1] Zorica Stanimirović [b,2,5] Tatjana Davidović [c,3,5] Đorđe Stakić [b,4]

[a] *Faculty of Agriculture, University of Belgrade, Nemanjina 6, 11080 Belgrade, Zemun, Serbia*

[b] *Faculty of Mathematics, Studentski trg 16/IV, 11000 Belgrade, Serbia*

[c] *Mathematical Institute of the Serbian Academy of Science and Arts, Kneza Mihaila 36, 11000 Belgrade, Serbia*

Abstract

Low price of raw materials in sugar industry and characteristics of production method lead to the specific transport organization problem. A new variant of Vehicle Scheduling Problem (VSP) that arises from transportation of sugar beet is considered. The problem is formulated as a Mixed Integer Quadratically Constraint Programming (MIQCP) model, which reflects the objective and specific constrains from practice. Computational experiments are conducted on real-life instances obtained from a sugar company in Serbia and the set of generated instances of larger dimensions. The proposed MIQCP model is used within the framework of Extended Lingo 15 solver, providing optimal solutions on small-size instances only. In order to find solutions on larger problem instances, a metaheuristic method based on Variable Neighborhood Search (VNS) is designed. Obtained computational results show that the proposed VNS quickly reaches all known optimal solutions on small-size instances. On larger problem instances, for which Lingo 15 solver could not find even a feasible solution, VNS provides best solutions in relatively short running times.

Keywords: Vehicle Scheduling Problem, Mixed Integer Quadratically Constrained Programming, Lingo solver, Variable Neighborhood Search

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1 Introduction

This study deals with a real life problem of transport organization in sugar industry in Serbia. Sugar beet is an agricultural raw material with a very low price on market. Major costs in sugar production refer to the costs of transport, so every saving that could be made in this early phase of production is very important. Large companies that purchase raw materials from individual producers have an important task to keep them as business associates, and therefore, companies usually organize the whole transport of goods from each producer to the factory. An efficient scheduling of vehicles that includes all problem specific constraints with the minimum expenditure of time and money is valuable in this industry.

The considered problem is formulated as a variant of the well-known Vehicle Scheduling Problem (VSP). In general, the goal of VSP is to determine the set of trips for each available vehicle in order to reduce the total transportation costs, while respecting the conditions that arise from practical situation. VSP is usually related to public transportation systems in urban areas [4,9], but there are also applications of VSP in agriculture, for example, in optimizing the transportation of sugar cane [5,7].

In this paper, we propose a new variant of Vehicle Scheduling Problem that arises from the transport of sugar beet in Serbia. The considered variant of VSP differs from the ones presented in [5,7], due to the difference between sugar cane and sugar beet in their sustainability in the open air, type of vehicles needed and infrastructure necessary. We further introduce a Mixed Integer Quadratically Constraint Programming (MIQCP) model of the considered problem. By using the proposed MIQCP model, small-size real-life instances are solved to optimality within the framework of Lingo 15 solver, while for instances of larger dimensions, Lingo produced either feasible or no solution. Therefore, we have designed a Variable Neighborhood Search (VNS) heuristic in order to solve instances of larger dimensions. Optimal and feasible solutions obtained by Lingo 15 solver were used for evaluating the performance of the designed VNS. The behavior of the proposed VNS was further tested on larger problem instances unsolved by Lingo 15.

[1] Email: anokicana@agrif.bg.ac.rs
[2] Email: zoricast@matf.bg.ac.rs
[3] Email: tanjad@mi.sanu.ac.rs
[4] Email: djordjes@matf.bg.ac.rs
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