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Agricultural planning for mechanized sugarcane harvesting

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1 Introduction

Sugarcane was introduced to Brazil in 1532 and currently represents an important factor to the Brazilian economy. Due to the growth in the consumption of ethanol and sugar, the production process has undergone important changes, mainly in harvesting methods. The manual and semi-mechanized harvesting systems once used have been replaced by fully-mechanized approaches. This change has occurred due factors as reduction in harvesting cost, the decreasing supply of skilled labor, among others.

Mechanized harvesting must be properly planned, starting with the preparation of the plots in the planting area. The main feature of sugarcane plots is that they must be rectangular for maximum efficiency of the harvesting machine, avoiding excessive number of maneuvers.

For [2], to obtain maximum efficiency, plots should have a rectangular form, at least 600 meters long, well-leveled ground, parallelism between rows and adequate spacing. [1] affirm that the plots should have a furrow length of 500-800 meters and width of 150-400 meters. The spacing between rows should be 1.5 meters.

This study proposes generating and allocating rectangular plots in planting areas in such a way as to minimize the number of harvesting machine maneuvers. Our methodology approximates the problem with a two-dimensional cutting stock problem and use technics to solve it to determine the allocation of the plots into the panting areas.

2 Solution strategy

The problem to be solved consists of dividing planting areas into rectangular plots, in order to increase yield, reduce traffic and minimize the maneuvers of the sugarcane harvesting machine. To solve this problem, firstly a nonlinear bi-objective mathematical model

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was proposed to generate the plots considering all recommendations about dimensions and area requirements.

With all possible plots generated, the selection and allocation of them were conduct using strategies to solve the two-dimensional cutting stock problem, which consists of allocating small rectangular pieces in larger rectangular plates. However, the real areas of sugarcane planting regions have irregular forms and some of them contain preservation areas, constructions projects, rivers, lakes or other areas that are not appropriate for plot allocation.

Due to the plot allocation restrictions in some areas, we consider a particularity of the two-dimensional cutting stock problem, which is the possibility of including a defect in the plate. To solve this problem, we use the modified AND/OR graph approach proposed by [3].

To present the plot allocation in sugarcane planting areas, a post-optimization was necessary to approximate the solution generated by the AND/OR graph approach to the real area. This was a simple process and is performed manually.

3 Conclusions

In this study was proposed a strategy for dividing the planting areas into rectangular plots for mechanized sugarcane harvesting. A bi-objective mathematical optimization model was also proposed to assist in the plot generation.

To allocate the generated plots to the planting areas, the problem was interpreted as two-dimensional cutting stock problem and a post-optimization was carried out to approximate the solution obtained by the AND/OR graph to the real sugarcane planting area.

Computational tests were performed into two real regions of a farm located in the interior of the State of São Paulo, Brazil. Our strategy to solve the problem presented good performance and met the expectations of the mill manager.

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