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Optimization of the harvest planning in the olive oil production: A case study in Chile

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ABSTRACT

In this work, a mathematical programming model for aiding the decision-making process of olive harvest planning is proposed. The model aims at finding a harvest schedule of different land units that maximizes the total amount of the oil extracted in the mill. Such a harvest plan must ensure quality standards, respect technological limitations, coordinate operations between the field and the mill, and satisfy a budget associated with the harvest operations. Moreover, the presented approach considers the effect of climatological phenomena (rain and frost) during the harvest season, which results in a reduction of olive crops.

The model was tested on a real problem of a company located in the central zone of Chile. The experiments with the model show that it is able to obtain better solutions than those obtained by the traditional operation planning when it is tested with real datasets from the company. The optimization model is flexible, allowing the management of several parameters like the project budget and the risks generated by the climate. Thus, it can provide alternative harvest plans in a short time by simulating different climatological scenarios. From a managerial point of view, some lessons about the advantages and difficulties of the model were learned from its use in the company.

1. Introduction

Nowadays, olive oil is in high demand (see Fig. 1) due to its chemical properties, which make it a high quality and healthy product. According to the International Olive Council[1] in the 2013/2014 period, 3.25 million tons were produced in the world, Chile being the tenth principal producer with 32 thousand tons. This country had a big increase of olive oil production during the last years. The quantity of olives increased more than 500% from 2004 to 2014 and Chile is now positioned as a producer of high quality olive oil, obtaining recognition in international contests.[2] The olive oil production in Chile is concentrated in the north and central zones. With respect to the production and consumption in the world, the main activity is concentrated in the Mediterranean basin, see Figs. 2 and 3. Spain produces about half of the total production in the world. As a consequence of the increment in the international demand of olive oil, new planting areas have appeared in different countries which are benefited by having a Mediterrean climate, mainly in South Africa, USA, Australia, Argentina and Chile. Although olive crops exist around the world, the climate conditions strongly constrain their dissemination in many places.

Harvest planning is a fundamental task in the production of olive oil. An inefficient plan can seriously affect the production, either from a decrease in the quality/quantity of the oil or an increase of the harvest operative costs. In this context, the first important decision to be taken is to determine the moment at which each lot must be harvested. In the olive oil industry from the central area of Chile, two conflicting factors must be considered at the moment of making decisions about the harvesting operations (or phase): on the one hand, the oil accumulation process in the olives; and on the other hand, the adverse climatological factor for the olive trees in the harvesting season. The latter factor is expressed through different phenomena, like rain and frost, which can lead to a loss of olive crops, a decrease in the quality, and an increment in the operating costs (derived from a decrease in the productivity of the harvest resources). Note that in the north zone of Chile rain is rare and frost is infrequent.

Harvest planning consists of making a temporal assignment of productive resources to the olive trees that are grouped in lots.

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[1] www.internationaloliveoil.org.
[2] http://www.chileoliva.cl.

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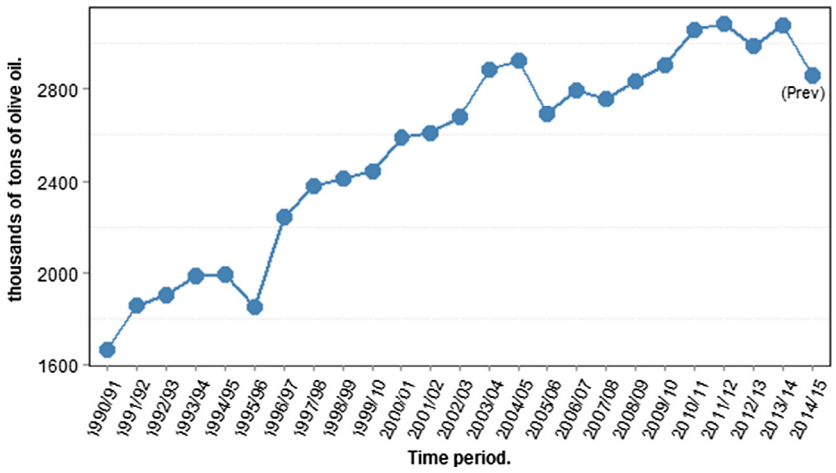

Fig. 1. Olive oil consumption worldwide in the last 25 years. *Source:* International Olive Council.

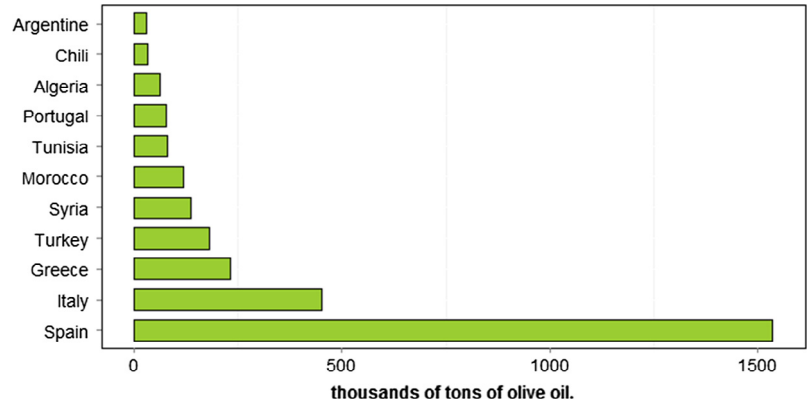

Fig. 2. Major producers (countries) of olive oil season 2013/2014. *Source:* International Olive Council.

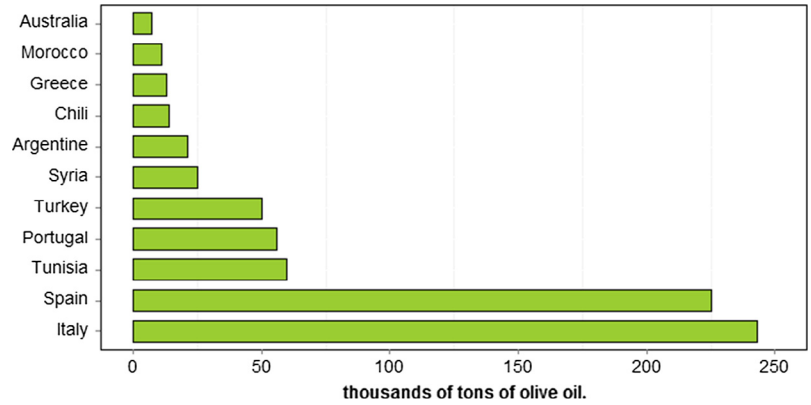

Fig. 3. Major consumption (countries) of olive oil season 2013/2014. *Source:* International Olive Council.

The decisions relate the productive resources selected for harvesting each lot, to the moment of starting the harvest, and to the quantity of olives to be harvested every day; moreover, such decisions must satisfy several constraints related to the harvest conditions in the field.

Another factor that influences the quality of the extracted oil is the level of synchronization between the field and the olive-oil mill. The olives must be rapidly processed after being harvested to maintain the oil content and, consequently, avoid the oxidation process. The synchronization is difficult since several productive resources are harvesting at the same time and due to oil extraction services for external producers.

1.1. Related works

Several reviews have been published in the general area of Farm Planning. In Glen (1987) a thorough review of mathematical models in Farm Planning was presented. Among the addressed issues are pesticide use, farm land use, equipment evaluation, harvest operations, machinery selection and irrigation scheduling. Some