IOSR Journal of Mathematics (IOSR-JM)
e-ISSN: 2278-5728, p-ISSN: 2319-765X. Volume 18, Issue 1 Ser. III (Jan. – Feb. 2022), PP 61-63
www.iosrjournals.org

Harvest Planning In the Maharashtra Sugarcane Industry by Mathematical Model

H.P. Thorat
Department of Mathematics, I.C.S. College of Arts, Commerece and Science, Khed 415 709, India

Abstract:
In this study, the harvest scheduling problem of a group of cane growers in Maharashtra is addressed. Each member in a group is required to consistently supply sugar cane to a mill for the entire harvest season. However, the current scheduling does not account for the time-variant cane production of each cane field, which leads to unequal opportunities for growers to harvest. A portion of growers could have the opportunity to harvest in periods that provide higher sugar cane yields, while others in the same group do not. This inefficient harvest scheduling causes conflicts between growers and unnecessary loss of sugar cane and sugar yields.
Keywords: *Sugarcane industry, Harvesting, optimization problem , Mathematical model*

Date of Submission: 13-02-2022 Date of Acceptance: 28-02-2022

I. Introduction:

Sugar Industry in Maharashtra is one of the most notable and large-scale sugar manufacturing sectors in the country. With more than 45 millions of sugar cane growers in the country, the bulk of the rural population in India depends on this industry. Sugarcane is one of the most widespread crops in the world and a great generator of residual biomass. Harvest scheduling has become one of the most important tasks in the sugar cane industry. It is obvious that an efficient harvest schedule could increase the sugar yield, which improves the profitability of the entire supply chain.

In this paper, an optimization model were developed to determine the most suitable sugar cane harvest schedule for a group of growers. Each grower owns a set of sugar cane fields that have different yield patterns depending on various cultivation factors. The objective was to maximize sugar cane harvest yields with equal returns for all growers in the group. On the level of sugar cane harvest planning, there are commonly two major planning objectives.

First, the highest possible profit in terms of quantity and quality of the harvested cane, respecting certain industrial, social and environmental constraints. Such constraints include limited cutting capacities as well as constant cane supply at the mills. Second, the reduction of all costs involved. The profit strongly depends on the sugar content when harvesting the cane. Due to limited resources and constraints, harvesting at each field at its maturation peak is commonly not feasible. In the following, we explain the problem in more detail and outline the structure of this paper.

II. Problem description

The problem, denoted by the Sugar Cane Cultivation and Harvest Problem (SCHP) throughout this work, is now described. One of its most important decisions is the moment to harvest the plantation fields. Clearly, it is desirable to harvest each field at the peak of its sugar content, as the sugar content indicated by the percentage of sucrose in the sugar cane (Pol) and the reduced sugar, vary as the cane grows. The cane at each field possesses a certain initial age and can only be cut within a given interval of its age.

I) Transportation

Once the sugar cane is cut, the harvest is immediately transported to the industrial sector, i.e. the sugar cane mills. In Brazil, transportation is mostly performed by trucks (a single mill is known which additionally uses river shipping). Fig. 1 exemplifies routes for cutting and transportation. Cutting crews commonly follow a certain route from one field to another harvesting the cane. Transportation crews commute between the fields and the mills. Each transportation crew possesses individual properties such as a transport capacity, speed and cost. Exactly one transportation crew must be assigned to each field that will be harvested.

II) Sugar cane mills

In the mills, the sugar cane is crushed and the cane juice is extracted, being further processed either to ethanol or sugar, also denoted by the total recoverable sugar (ATR, Açúcar Total Recuperável, in Brazil). The mills operation is one of the most important constraints as they must not interrupt sugar cane processing.

Minimum and maximum process capacities must be respected for each mill. Plantation fields that have been selected for harvesting are assigned to exactly one sugar cane mill. Furthermore, the processed sugar cane must contain a certain minimum quantity of fiber used to generate electricity to operate the mills. Some mills may not be available during certain periods (e.g., for maintenance). This is reflected in the capacities for such mills given in the input data.

III. Review Of Litreture

Singh S. P., Parashar Anil K. & Singh H. P. (1977), in their research entitled, "Econometrics and Mathematical Economics", have focused on Econometrics and Mathematical Economics. According to the authors, "Economics is a method now widely used in economic research. Today its study covers widespread fields of economic life and embrace a variety of economic problems. These methods consist of the application of modern statistical procedures to theoretical models formulated in mathematical terms. Econometric methods are of paramount importance to the verification of economic laws and are also potentially useful for the formulation of new economic laws and governmental policies."

1. Optimization model for the harvest plan

In this section, the optimization model is formulated to solve the scheduling problem. In the optimization model, the estimated cane yields (over the harvesting period for each field), which are required for the optimization model. The following notation is used in the model:

X_j = the level of the *j*th farm activity, such as the acreage of sugarcane grown. Let n denote the number of possible activities; then $j = 1$ to n.

c_j = the forecasted gross margin of a unit of the *j*th activity (e.g., rupees per acre).

a_{ij} = the quantity of the *i*th resource (e.g., acres of land or days of labour) required to produce one unit of the *j*th activity. Let m denote the number of resources; then $i = 1$ to m.

b_i = the amount of the *i*th resource available (e.g., acres of land or days of labour).

With this notation, the linear programming model can be written as follows :-

$$max\ Z = \sum_{j=1}^{n} c_j X_j \quad (4.1)$$

such that,

$$\sum_{j=1}^{n} a_{ij} X_j \leq b_i,\ all\ i = 1\ to\ m \quad (4.2)$$

and

$$X_j \geq 0, all\ j = 1\ to\ n \quad (4.3)$$

In words, the problem is to find the farm plan (defined by a set of activity levels X_j, $j = 1$ to n) that has the largest possible total gross margin Z, but which does not violate any of the fixed resource constraints (4.2.) or involve any negative activity levels (4.3). This problem is known as the basic linear programming problem.

IV. Result

It has been observed that, India as a whole had 1252 days of crushing period of sugarcane in the year 2015-16. However, in the year 2019-20 it recorded as 1365 days of crushing period of sugarcane. Thus there was increase of 113 days of crushing period of sugarcane during the period of 2015 to 2020 with a percentage rise of 9.03. Out of this Maharashtra had 126 days of crushing period of sugarcane in the year 2015-16. However, in the year 2019-20 it recorded as 137 days of crushing period of sugarcane. Thus there was increase of 11 days of crushing period of sugarcane during the period of 2015 to 2020 with a percentage rise of 8.73.

V. Conclusion:

An approach for the tactical and the operational planning of an important agricultural activity has been presented. The principal concern in both planning is to harvest the fields close to their maturation peaks, i.e., when the sugar content is highest. The evaluation of a near-optimal solution for an industrial instance showed that the proposed planning holds a significant potential to increase the total profit. By harvesting fields close to their maturation peaks, cutting crews increase their relocation distances.

Reference:

[1] Ahumada, O., Villalobos, J.R., 2009. Application of planning models in the agrifood supply chain: a review. European Journal of Operational Research 169, 1–20.

[2] Bezuidenhout, C.N., Baier, T.J.A., 2009. A global review and synthesis of literature pertaining to integrated sugarcane production systems. In: 82nd Annual Congress of the South African Sugar Technologists' Association, pp. 93–101

[3] Singh S. P., Parashar Anil K. & Singh H. P. (1977), Econometrics and Mathematical Economics, S. Chand and Company Limited, New Delhi.

[4] Higgins, A.J., 1999. Optimizing cane supply decisions within a sugar mill region. Journal of Scheduling 2, 229–244. Higgins, A.J., 2006. Scheduling of road vehicles in sugarcane transport: a case study at an Australian sugar mill. European Journal of Operational Research 170, 987– 1000..

[5] Higgins, A., Thorburn, P., Archer, A., Jakku, E., 2007. Opportunities for value chain research in sugar industries. Agricultural Systems 94, 611–621. Lopez Milan, E., Fernandez, S.M., Aragones, L.M.P., 2006. Sugar cane transportation in Cuba, a case study. European Journal of Operational Research 174, 374–386.

[6] Paiva, R.P.O., Morabito, R., 2008. An optimization model for the aggregate production planning of a Brazilian sugar and ethanol milling company. Annals of Operations Research 169, 117–130.

[7] Semenzato, R., 1995. A simulation study of sugar cane harvesting. Agricultural Systems 47, 427–437. 384 S.D. Jena, M. Poggi / European Journal of Op

H.P. Thorat. "Harvest Planning In the Maharashtra Sugarcane Industry by Mathematical Model." *IOSR Journal of Mathematics (IOSR-JM)*, 18(1), (2022): pp. 61-63.