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Optimizing the Technology of Setting up Viticultural Plantations

The paper presents the results of the study made in the conditions of a viticultural centre for establishing the most adequate structure of the species of vine in keeping with the local pedoclimatic conditions on an area of 128 ha.

To obtain big and constant productions of high quality grapes it is necessary that upon the setting up of the vine plantations one should take into account a set of climatic, technological and economic elements which directly influence the efficiency of investments. The life of the plantation, its efficiency per surface unit greatly depends on the way in which, within the process of setting up viticultural plantations one takes into account the need of ensuring best concordance between the technological requirements of the plants and the local natural conditions. Naturally, with the intensification of viticultural production, this concordance cannot be achieved only on the basis of experts' experience and intuition, but one must apply to economic-mathematical modeling, the only giving complete and precise solutions for the efficient use of investments.

In this respect, the optimization of various components of the technological flow (the choice of the ground, the species, the form of management, the nutrition area, the sustainment system, etc.) is an action of special economic importance considering that for their setting up the vine plantations require big investments for a long period of time which can be recuperated in a shorter time through big and high quality productions of high economic efficiency.

A viticultural plantation once set up, it is very difficult to make essential transformations in its structure especially in the first half of its exploitation period, without registering any losses.

Due to these particularities, optimization can be achieved only in the case of the new plantations. Sometimes, this has to be achieved also in the case of old plantations liable to modernization. In this case, the results obtained have an orientative character being necessary in establishing the directions of action in the situation of partial clearings.

The optimization of species was achieved by using the classical general form of an economic-mathematical model with the following structure:

$$\left\{ \begin{matrix} min \\ max \end{matrix} \right\} f(x) = \sum_{i=1}^{m} c_i \cdot X_i$$

in the conditions:

$$\sum_{i=1}^{m} X_i = S \tag{1}$$

$$i = X_i \leqslant n_i \,\%_0 \cdot S \tag{2}$$

$$\sum_{i=1}^{m} q_i \cdot X_i \geqslant R \tag{3}$$

$$\sum_{i=1}^{m} b_{ui} \cdot X_i \leqslant B_u \tag{4}$$

$$X_i \geqslant 0, \tag{5}$$

$$u = 1,\ 2,\ 3,\ ...,\ w;\quad i = 1,\ 2,\ 3,\ ...,\ m$$

where:

X_i represents the area planted with species i;
S — the planned area to be planted;
$n_i\%S$ — the maximum share of species i per total area;
q_i — the average production per hectare of species i;
Q — the total production of grapes planned to be obtained
b_{ui} — consumption of resource u per surface unit of species i
B_u — the total quantity available from resource u;
C_i — the coefficients of the variables of the optimizing function

If the sense of the other constraints is known in general, in case of the second constraint, the specification is made that it is imposed by the necessity of classifying according to the ripening periods of the species of eating grape with a view to establishing an adequate relationship between the various assortments of wines in case of the species for wine.

In certain situations, this constraint is replaced by a constraint on the production which should be obtained from various species.

The optimization of species was achieved in two variants, following the use of two objective functions, namely:

— the maximization of the profit (V_1);
— the maximization of the net production (V_2).

As a result of a multilateral complex analysis of the behaviour of the species of the existent plantations in bearing and following the prospectin

of the possibilities of introducing new species adaptable to the specific local conditions, the following species of eating grapes: Perla de Csaba; Cardinal; Muscat Hamburg; Afuz-Aly; Italia; other species were proposed, in the long run, for the plantation of the 128 ha. of vineyards.

The main technical-economic coefficients necessary for drawing up the model are presented in table 1.

Table 1

Technical-economic coefficients of the model

Species	Variables (X_i)	Average production kg/ha	Days-Man consumption per hectare	Profit per hectare lei/ha	Net production per hectare lei/ha
PERLA DE CSABA	X_1	9,500	126	15,455	27,067
CARDINAL	X_2	13,200	159	8,864	38,824
MUSCAT HAMBURG	X_3	11,800	156	5,612	32,280
AFUZ-ALY	X_4	12,500	142	11,540	36,500
ITALIA	X_5	11,300	139	8,119	34,079
OTHER SPECIES	X_6	11,500	130	5,411	29,815

The other elements linked with the significance and size of the free terms will be presented directly in the model.

The analytical form of the economic-mathematical model drawn up is the following:

Maximization of the profit (V_1):

$$max\ f(x) = 15{,}455\ X_1 + 8\,864\ X_2 + 5\,612\ X_3 + 11540\ X_4 + 8\,119\ X_5 + \\ + 5411\ X_6.$$

Maximization of the net production (V_2).

$$max\ f(x) = 27{,}067\ X_1 + 38{,}824\ X_2 + 32{,}280\ X_3 + \\ 36{,}500\ X_4 + 34{,}079\ X_5 + 29{,}815\ X_6,$$

in the conditions:

— the planting of the total area planned for this purpose;

$$X_1 + X_2 + X_3 + X_4 + X_5 + X_6 = 128 \text{ ha.}$$

— the establishment of maximum limits on the planted area for certain species: $X_2 \leqslant 25$ ha; $X \leqslant 8$ ha;

— the obtaining of the planned total production;

$$9{,}500\ X_1 + 13{,}200\ X_2 + 11{,}800\ X_3 + 12{,}500\ X_4 + 11{,}300\ X_5 + \\ + 11{,}500\ X_6 \geqslant 1{,}455{,}000 \text{ kg};$$

— the spacing out of production, in minimum quantities, on ripening periods;

(early species) $9\,500\ X_1 + 13{,}200\ X_2 \geq 406{,}000$ kg;

(medium species) $11{,}800\ X_3 \geq 204{,}000$ kg;

(late species) $12{,}500\ X_4 + 11{,}300\ X^5 \geq 377{,}000$ kg;

(mixture) $11{,}500\ X_6 \geq 66{,}000$ kg.

— the use of manpower within the available limits

$$126\ X_1 + 159\ X_2 + 156\ X_3 + 142\ X_4 + 139\ X_5 + 130\ X_6 \geq 18{,}179$$

days-man.

Following the solving of the restrictive system the results in table 2 were obtained for each of the two objective functions.

Table 2

	V	V
X_1	13 ha	8 ha
X_2	22 ha	25 ha
X_3	17 ha	17 ha
X_4	70 ha	72 ha
X_5	0 ha	0 ha
X_6	6 ha	6 ha
planned total production	1,556,000 kg	1,576,000 kg
consumption of manpower	17,694 days-man	17,874 days-man
net production	4,489 thousand lei	4,544 thousand lei
profit	1,327 thousand lei	1,300 thousand lei

The results obtained enabled us to underline the following more important aspects.

First, it can be noted that in the conditions in which both objective functions had the same direction (were maximized) and were very close as regards their economic content, the structure of the species obtained in the two variants does not differ significantly.

Second, it is noted that irrespective of the variant used, the limits of the constraints have registered sensibly improved values. Thus, the total output is by over 100 tons bigger and the consumption of days-man is below the established limit by over 350 days-man.

These results also confirm the correctness of the statements that within the process of optimizing the structure of species the necessary conditions are achieved for turning to best account the production factors by ensuring full concordance between the requirements of the species and the local natural and economic conditions.

They also show very suggestively that the use of all reserves provided by the scientific organization of production and work are the simplest and most advantageous ways for increasing the viticultural production and its efficiency.

It results that the economic efficiency of the investment greatly depends on the establishment of an optimal structure of species on the viticultural plantations.

It must be specified that the resulting model was deliberately simplified so that the methodology of working out and analysing the results obtainned should be followed easier. As a rule, in such situations all the categories of resources and the conditions in which the viticultural production is carried out should be taken into consideration.

GENERAL MODEL FOR SETTING UP A VITICULTURAL PLANTATION

In spite of the importance, simplicity and advantages provided by the optimizing computation, in practice, however, one very seldom applies to mathematical modeling of this complex process before passing on to the setting up of a plantation.

Even in the situation in which this is done most often by researchers, the optimizing problems (just like in the case shown above) refer only to certain aspects of the technological process, of the viticultural production.

As was only natural, in these conditions the necessity appears of working out new optimizing problems for each case taken separately for including into the optimal limits the other technological links (forms of management, the planting distance, etc.) or the production factors. Naturally, the results obtained in this condition can reflect only certain aspects of the optimal problem, because the objective interconditionings between the various above-mentioned aspects are not taken into consideration.

The solving of separate, independent problems in connection with the optimizing of species, the optimizing of the planting distance, a.s.o. ensures in fact the obtaining of partial optimals for the respective elements and not the optimal level for the whole examined set.

Thus, it results from those shown above that on the setting up of a viticultural plantation especially on big areas, the basic optimal elements of the plantation (specialization, species, the form of management, the planting distance, a.s.o) should be established through a single optimizing problem based on the principles of mathematical modeling.

By starting from this desideratum, the general form of an economic-mathematical model which can be used in such situations is presented in the following. The general expression of this variant is the following:

$$\left\{ \begin{matrix} min \\ max \end{matrix} \right\} f(x) = \sum_{i=1}^{m} \sum_{j=1}^{n} \sum_{k=1}^{p} \sum_{l=1}^{r} C_{ijkl} \cdot X_{ijkl};$$

in the conditions:

1. The complete plantation of the area (planned)

$$\sum_{i=1}^{m}\sum_{j=1}^{n}\sum_{k=1}^{p}\sum_{l=1}^{n} X_{ijkl} = S.$$

2. The establishment of minimum or maximum limits of different species on the total area for ensuring the specialization of production, the classification according to ripening periods of eating grapes, for ensuring an adequate relationship between white and red wines, flavoured and dry wines, etc.

$$\sum_{j=1}^{n}\sum_{k=1}^{p}\sum_{l=1}^{r} X_{ijkl} \gtrless n_i\% \cdot S.$$

3. The maximum surface on which the form of management j can be applied. This constraint is imposed when due to the natural conditions not all forms of management proposed can be applied on the entire area.

$$\sum_{i=1}^{n}\sum_{k=1}^{p}\sum_{l=1}^{r} X_{ijkl} \leq S_j,$$

with the variant:

$$\sum_{k=1}^{p}\sum_{l=1}^{r} X_{ijkl} \gtrless n_i\% S_j.$$

4. The maximum surface on which the planting distance from variant k can be applied:

$$\sum_{i=1}^{m}\sum_{j=1}^{n}\sum_{l=1}^{r} X_{ijkl} \leqslant S_k,$$

with the variant:

$$\sum_{j=1}^{m}\sum_{l=1}^{r} X_{ijkl} \gtrless n_i \cdot S_k$$

5. The maximum surface on which the sustainment system from variant l can be applied:

$$\sum_{i=1}^{m}\sum_{j=1}^{n}\sum_{k=l}^{p} X_{ijkl} \leqslant S_l,$$

with the variant:

$$\sum_{j=1}^{n}\sum_{k=j}^{p} X_{ijkl} \gtrless n_i\% \cdot S_l \cdot$$

6. The achievement of the production of grapes (planned):

$$\sum_{i=1}^{m}\sum_{j=1}^{n}\sum_{k=1}^{p}\sum_{l=1}^{r} q_{ijkl} \cdot X_{ijkl} \geqslant Q,$$

with the variant:

$$\sum_{j=1}^{m}\sum_{k=1}^{p}\sum_{l=1}^{r} q_{ijkl} \cdot X_{ijkl} \geqslant Q_i.$$

7. The limitation of the consumption of resources at the level of the available quantities:

$$\sum_{i=1}^{m}\sum_{j=1}^{n}\sum_{k=1}^{p}\sum_{l=1}^{r} b_{uijkl} \cdot X_{ijkl} \leqslant B_u.$$

8. The condition of non-negativity of variables

$$X_{ijkl} \geqslant 0,$$

where:

X_{ijkl} represents the area of species $i = 1, 2, 3, ..., m$ on which the form of management $j = 1, 2, 3, ..., n$ is applied of planting $k = 1, 2, 3, ..., p$ by using the sustainment system $l = 1, 2, 3, ..., r$;

S — the total area;

S_j — the maximum surface on which the form of management j can be applied;

S_k — the maximum surface on which the planting distance k can be applied;

S_l — the maximum surface on which the sustainment system l can be applied;

q_{ijkl} — the average production per hectare of species i maintained in the management form j, at the planting distance k and using the sustainment system l;

Q_i — the total production of soil i;

b_{uijkl} — consumption from resource $u = 1, 2, 3, ... w$ per surface unit of soil i, maintained in the management form j, at the planting distance k and using the sustainment system l;

B_u — the total quantity available of resource u;

C_{ijkl} — the coefficients of variables of the optimizing function, the coefficient of investments efficiency, the net production, profit, the overall production, production expenses, material expenses, etc.

It should be pointed out that in keeping with the existent specific conditions both the number of variables and the number of constraints can be amplified or reduced according to requirements.

One of the more difficult problems cropping up in such situations is the establishment of the level of the technical-economic coefficients necessary for drawing up the model (the average production per hectare, the consumption of resources per hectare, on species, etc.). In the conditions in which such data cannot be gathered from the plantations in exploitation, in the respective area, they can be assimilated based on the experience of the viticultural research units and of other production units with relatively similar natural and economic conditions.

Due to the complex character of these models, in certain situations the phenomenon of incompatibility between different categories of constraints may appear. In this case, it is necessary to establish the nature of incompatibility and accocording to it, to analyse the economic and technical implications brought about by the change in the free terms, and to decide, in the long run, on the opportuneness, possibilities and directions of action.

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OPTIMISATION DE LA TECHNOLOGIE DE CREATION DES PLANTATIONS VITICOLES

On présente les résultats de l'étude effectuée dans les conditions d'un centre viticole en vue détablir les structures les plus adéquates des variétés de vigne, en concordance avec les conditions pédo-climatiques locales sur une superficie de 128 hectomètres carrés.

ОПТИМИЗАЦИЯ ТЕХНОЛОГИИ СОЗДАНИЯ ВИНОГРАДСКИХ ПЛАНТАЦИЙ

В работе приводятся результаты исследования, проведенного в условиях виноградского центра с целью определения найболее пригодной структуры пород винограда, в соответствии с педоклиматическими условиями на площадке 128 га.

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