STUDIES ON THE BEHAVIOURAL TENDENCIES OF SOME GRAPE VARIETIES FOR WHITE WINES IN MOLDAVIAN VINEYARDS, UNDER THE INFLUENCE OF CLIMATIC CHANGES

CERCETĂRI PRIVIND TENDINȚELE DE COMPORTARE A UNOR SOIURI PENTRU VINURI ALBE CULTIVATE ÎN MOLDOVA, SUB INFLUENȚA MODIFICĂRILOR CLIMATICE

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***Abstract**. The singular or cumulative effects of climatic risks and identification of most vulnerable areas are basic criteria in elaborating and founding a decisional system for long term agro-climatic management. In Romania, the highest occurring abiotic stress factors are deficit and excess of rains, low temperatures in winter and soaring temperatures in summer, hails and low fertility of soils. The biotic risk factors are represented by the attacks of diseases, pests and other competitive plants. Because of the global warming process, a change in the biological cycle of the vine is registered, a hastened pace of veraison and grape full maturity, not always in the benefit to the final product. This article presents some mathematical models of Fetească albă grape variety behavioural evolution in the some Moldavian vineyards, influenced by the recent climate changes.*
***Key words**: vine, global warming, mathematical modeling*

***Rezumat**. Cunoaşterea efectelor singulare sau cumulative ale riscurilor climatice şi identificarea arealelor agricole cele mai vulnerabile la producerea acestora sunt criterii de bază în elaborarea şi fundamentarea agroclimatică a unui sistem decizional de management durabil. În condițiile din România cei mai răspândiți factori de stres abiotic sunt deficitul şi excedentul pluviometric, temperaturile scăzute din perioada de iarnă, dar şi arşițele de vară, grindinele, fertilitatea scăzută a solurilor, iar dintre cele biotice, atacul bolilor, dăunătorilor şi a plantelor concurente. Datorită încălzirii globale la care asistăm în ultima vreme se constată o schimbare a evoluției ciclului biologic anual al viței de vie, cu parcurgerea mai rapidă a fenofazelor de pârgă şi maturare a strugurilor, aceasta fiind deseori forțată, iar implicațiile asupra calității produselor viticole sunt semnificative, însă nu întotdeauna în sens pozitiv. În lucrare sunt prezentate câteva modele matematice de evoluție a comportării soiului de viță de vie Fetească albă cultivat în podgoriile din Moldova, sub influența modificărilor climatice din ultima vreme.*
***Cuvinte cheie**: viță de vie, încălzire globală, modelare matematică*

INTRODUCTION

The climatic changes of the last years, more or less at random, can seriously harm the homogeneity of viticultural biocenotic conditions, with unpredictable implications on the quantity and quality of the grape harvest.

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Evaluating the impact of climatic changes on the management of the viticultural resources and areas regarding world-wide geo-viticulture are high-end aims of research in this specific field (Antle J.M., 2008, Deschenes O. and Greenstone M., 2007). Extending the vine culture or introducing grape varieties in a certain area requires the evaluation of ecological favourability of the allocated space towards this purpose. The optimal and restrictive factors are thus underlined, as well as imprinting a certain direction of production, as well as choosing the best adapted grape varieties to the existing environmental conditions.

The changes expected in the Romanian climatic regime are heralded by the global context, but with specificities of the geographical region (Jones G.V. et al., 2007). Compared to the North-West of Europe, for example, where the most accentuated heat is expected during winter, in Romania, an increase in temperature values is expected in summer months.

MATERIAL AND METHOD

The behaviour of Fetească albă grape variety within Cotnari, Iaşi and Dealu Bujorului vineyards, during 2010-2012 was studied, in close regard to the main aspects of quality and quantity of the grape harvest: grape production / trunk, average number of grapes/ vine trunk, average mass of 100 berries, sugar content and total acidity of must. For the eco-climatic characterisation, the following indices were used: useful thermal sum (BTU), rainfall quantity during vegetation period (Pp.pv), mean annual temperature (Tm), absolute minimal temperature (Min.abs.) and absolute maximal temperature (Max.abs.), real helio-thermal index (IHr), hydrothermal coefficient (CH), bioclimatic index of vine (Ibcv), oeno-climatic aptitude index (IAOe).

In order to establish the influence of the climatic factors on the quantity and quality of grape harvest, mathematical modelling was used, based on the Principal Components Regression (PCR), PLS (Partial Least Squares regression) and Correlated Component Regression (CCR) with the help of XL-STAT program.

PCR (Principal Components Regression) can be divided into three steps: first a PCA (Principal Components Analysis) is run on the table of the explanatory variables, then we run an OLS (Ordinary Least Squares regression) on the selected components, then we compute the parameters of the model that correspond to the input variables (Jobson J. D., 1999).

PCA allows to transform an X table with n observations described by variables into an S table with n scores described by q components, where q is lower or equal to p and such that (S'S) is invertible. An additional selection can be applied on the components so that only the r components that are the most correlated with the Y variable are kept for the OLS regression step. We then obtain the R table.

The OLS regression is performed on the Y and R tables. In order to circumvent the interpretation problem with the parameters obtained from the regression, XL-STAT transforms the results back into the initial space to obtain the parameters and the confidence intervals that correspond to the input variables.

PLS Regression: this method is quick, efficient and optimal for a criterion based on covariance. It is recommended in cases where the number of variables is high, and where it is likely that the explanatory variables are correlated (Bastien et al., 2005).

The idea of PLS regression is to create, starting from a table with n observations described by p variables, a set of h components with $h<p$. The method used to build the components differs from PCA, and presents the advantage of handling missing data. The determination of the number of components to keep is

usually based on a criterion that involves a cross-validation. The user may also set the number of components to use.

Correlated Component Regression (CCR) use fast cross-validation to determine the amount of regularization to produce reliable predictions from data with P correlated explanatory (X) variables, where multi-colinearity may exist and P can be greater than the sample size N. The methods are based on Generalized Linear Models (GLM). As an option, the CCR step-down algorithm may be activated to exclude irrelevant Xs (Tenenhaus M., 1998).

The linear part of the model is a weighted average of K components S = (S1, S2, … , SK) where each component itself is a linear combination of the predictors. For a continuous Y, these procedures provide an alternative to traditional linear regression methods, where components may be correlated (CCR-LM procedure), or restricted to be uncorrelated with components obtained by PLS regression techniques (CCR-PLS). Typically K<P, resulting in model regularization that reduces prediction error.

Traditional maximum likelihood regression methods, which employ no regularization at all, can be obtained as a special case of these models when K=P (the saturated model). Regularization, inherent in the CCR methods, reduces the variance (instability) of prediction and also lowers the mean squared error of prediction when the predictors have moderate to high correlation. The smaller the value for K, the more regularization is applied. Typically, K will be less than 10 (quite often K = 2, 3 or 4) regardless of P. M-fold cross-validation techniques are used to determine the amount of regularization K* to apply, and the number of predictors P* to include in the model when the step-down algorithm is utilized.

RESULTS AND DISCUSSIONS

Figure 1 presents the correlations circle of analysed variables. One notices that the information of the two main components regarding the segregation of registered observations, is very high, namely 92.24%, fact that reflects the high bind between them and the analysed climatic parameters.

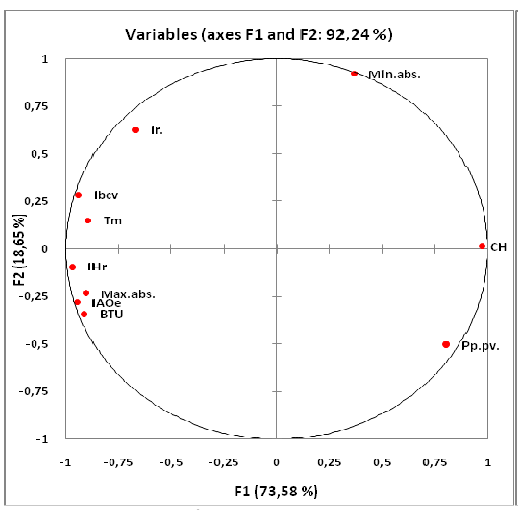

Fig. 1 – Correlations circle

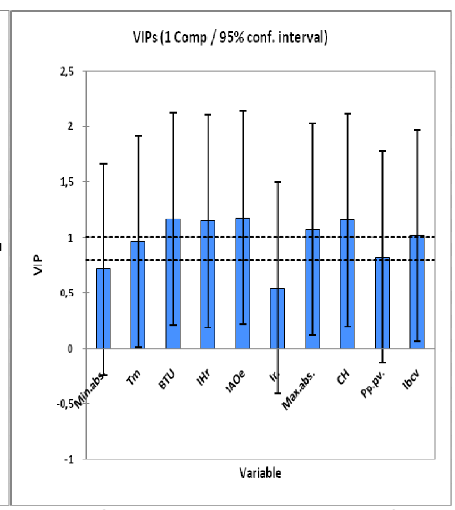

Fig. 2 – Climatic parameters that define the main component 1

Figure 2 presents the role of each climatic factor in defining the main component 1, with the highest segregation capacity of respectively 73,58%. It is registered that the correlations between the useful thermal sum, real helio-thermal index, oeno-climatic aptitude index, hydrothermal coefficient and last but not least the absolute maximal temperature and the viticultural bioclimatic index are positive.

Figure 3 describes the participation of the climatic factors on modelling the behaviour of the Fetească albă grape variety from the three before mentioned vineyards during 2010-2012.

The "production" variable is positively influenced by rainfalls during the vegetation period and negatively influenced by the values of the viticultural bioclimatic index. Therefore, the higher the values of this index (draught), the smaller the production will be.

Regarding the variable "number of grapes" it appears that the rainfall regimen and average temperatures have the maximum positive influence while the real helio-thermal index and real insolation values have the maximum negative effect. Therefore, high values of insolation can contribute to reducing the average number of grapes per vine.

Regarding the variable "average weight of a grape" one can notice that it is positively influenced by high values of the real helio-thermal index and of the hydrothermal coefficient.

A Fetească albă variety cultivated in an area with balanced temperature and water intake can lead to an increase of this variable, while culture in an area where the average annual temperature is low negatively contributes to a growth of this variable.

The "mass of 100 grape berries" variable is negatively influenced by high values of the real helio-thermal index. Corroborated with high values of the insolation regimen and low rainfall quantity within the vegetation period, lower positive values for the berries mass are registered.

In the case of "sugar content" variable, the positive influence of the thermic factor is underlined. The oeno-climatic aptitude index has the biggest influence on the above mentioned variable.

The influence of the useful thermal sum, as well as that of the absolute maximal temperature is beneficial, due to the high values of these two indices grater accumulations of sugar can be registered.

The variable "must total acidity" is influenced by many factors: the high values of useful thermal sum, oeno-climatic aptitude index, the absolute maximal temperature, being conditioned also by the insolation and hydric regimen.

Of all the studied variables, the highest influence has the real helio-thermal index, with a standardised value of the coefficient of 0,614, for the variable “mean mass of a grape”.

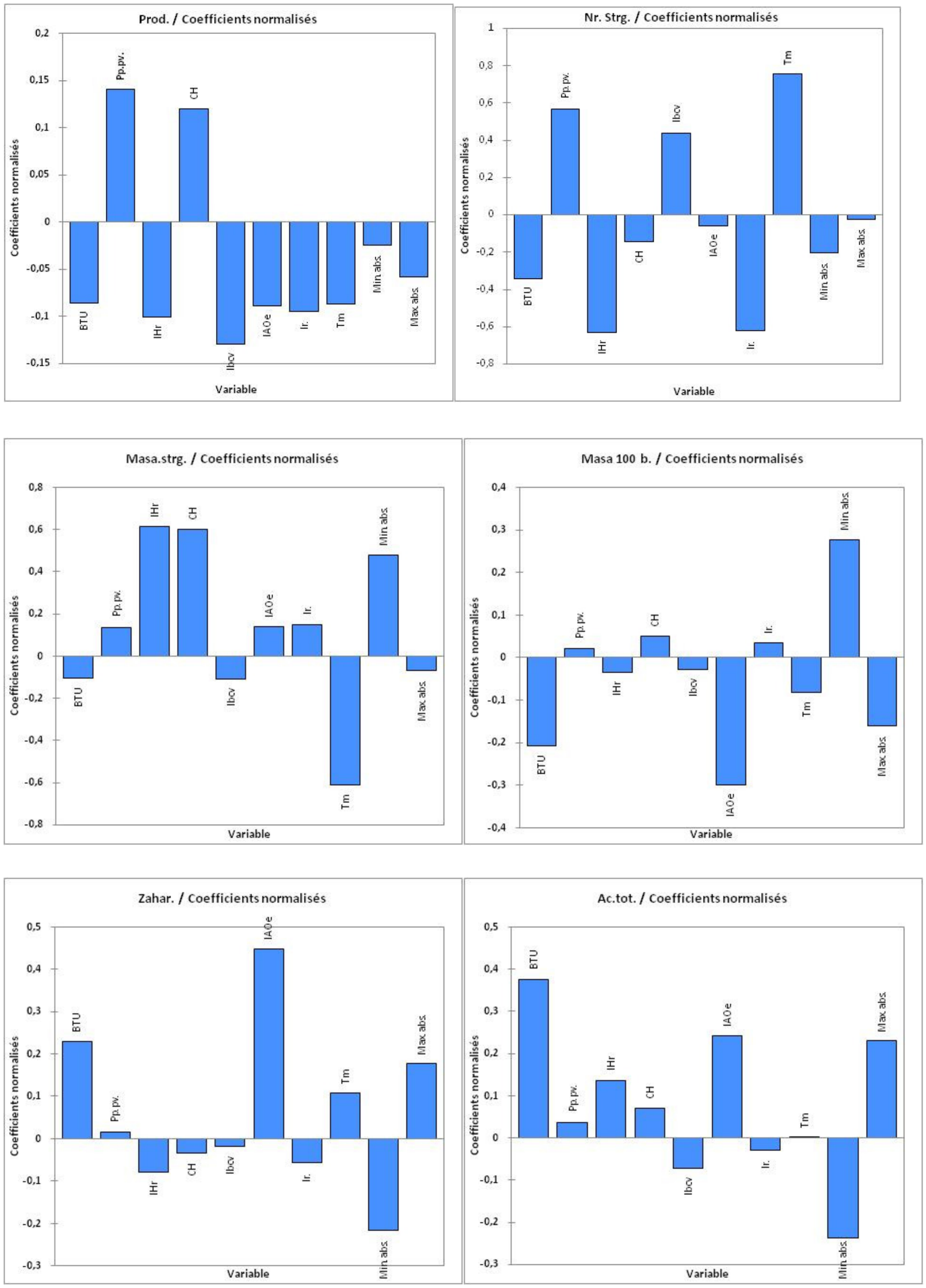

Fig. 3 – Establishing the influence of climatic parameters on modelling the quantitative and qualitative characteristics of Fetească albă grape production, in Cotnari, Iaşi and Dealu Bujorului vineyards, in 2010-2012

CONCLUSIONS

After applying a mathematical model regarding the behaviour of Fetească albă grape variety, from Cotnari, Iaşi and Dealu Bujorului vineyards during 2010-2012, the conclusion that the use of multi-variation statistics as a predicting method for the conduct of a grape variety in a viticultural area is beneficial.

The eco-climatic influence of a viticultural area is characterized through indices and climatic parameters by establishing the role of each on the vine, with the help of mathematical models based on multidimensional statistics.

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