

DINAMICS OF SOME PHYSIOLOGICAL PROCESSES DURING THE SHOOT'S DEVELOPMENT IN CERTAIN GRAPEVINE VARIETIES IN THE CONTEXT OF CLIMATIC CHANGES

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Abstract

Climate changes and their impact on vineyards represent an extremely important issue for the researchers in various fields of activity. These changes are interesting for the specialists in the vine industry as the vineyards producing quality wines are extremely sensitive to any pedoclimatic changes. The general warming of the climate has disturbed the evolution of natural factors in the grapevine ecosystems: summers have become warmer and droughtier every year, autumns have become longer, winters shorter and rarely excessive, while drought periods have become more frequent and the damp ones excessively rainy. Global warming has severely disrupted the grapevine ecosystems, grapevine varieties being forced to modify their annual vegetation cycle, the consequences on the quality and the quantity of grape and wine production being most often negative. This paper consists in the study of the eco-physiological reaction of some grapevine varieties to the climatic conditions induced by global warming at Cotnari vineyard, the evaluation being based on the dynamics of foliar, photosynthetic and flavonoid pigments which were used as indicators for photosynthesis and stress resistance processes.

Key words: grapevine, eco-physiology, photosynthetic pigments

The study of the evolution of climatic factors, temperature and precipitation, at Cotnari vineyard demonstrates that in the last decades this area has experienced the effects of global warming consisting in the growth of the annual average temperature and the progressive decrease of the amount of precipitations (Mihăilă D., 2002). The eco-physiological reactions of various grapevine varieties in the climatic conditions from the North – Eastern part of Romania has represented the object of study of different years (Jităreanu et al., 2011; Jităreanu et al., 2012).

One of the most important physiological processes affected by drought is photosynthesis. The content of chlorophyll pigments in the leaves stands for an indicator of the plant's physiological condition (Steele et al, 2008). This paper focuses on the study of the eco-physiological reaction of various grapevine varieties, relying on the chlorophyll content in the leaves related to the drought conditions from the North of Moldavia.

MATERIAL AND METHOD

The research study was performed in 2012 during the vegetation season of the following varieties Fetească albă, Grasă de Cotnari, Tămâioasă românească and Frâncușă, all cultivated at Cotnari vineyard. The evolution of climatic conditions was estimated by recording the average temperatures and the monthly minimum and maximum values (°C) and the total amount of rain

fall in a month (mm), the data being compared to the normal values in the vineyard studied. As production indicators, we have used the grape production (kg/vine) and the sugar content in the must (g/l). The pigment content in the leaves was analyzed spectrophotometrically, being estimated in relation with the pigment acetic extract's capacity to absorb light (1%) in the visible spectrum (400-700 nm) and in the close UV (320 nm). The ecophysiological reaction of the varieties of grapevine was estimated based on the content of photosynthetic and flavonoid foliar pigments. Chlorophyll *a* 663 can evaluate the intensity of photosynthesis in the reaction centre and chlorophyll *a* 435 can assess the light absorption capacity in the light absorption centre of the photosynthetic systems; flavonoid pigments with absorption in close UV (320 nm) can assess the plants' reaction to different climatic stress factors.

RESULTS AND DISCUSSION

The evolution of climatic conditions at Cotnari vineyard

Referring to the temperatures recorded in 2012 they have been 1 degree higher than the normal for the region of Moldova. The monthly average of spring temperatures has been higher than the normal with values between +2.0°C and 3.0°C; the summer season has been very hot, the average temperature of the air being higher than the normal multiannual values with +2.7°C and

4.8°C, respectively. With a monthly average of 18.6°C the month of September was characterized by temperatures higher by 3.1°C than the multiannual average, which contributed at improving the production's quality as well as its quantity (fig. 1). As far as the pluviometric aspect is concerned, the values recorded in 2012 especially during the grapevine's vegetation period were deficitary, the hydric deficit during the summer recording values ranging between -31.5 mm in August and -56.8 mm in July (fig. 2).

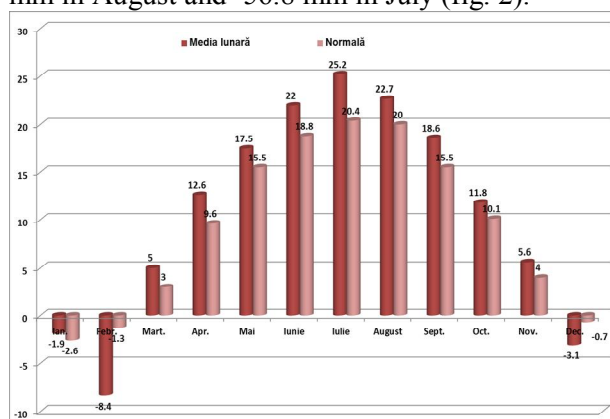


Fig. 1. The average monthly air temperatures (° C) and multi-annual means at the Cotnari weather station

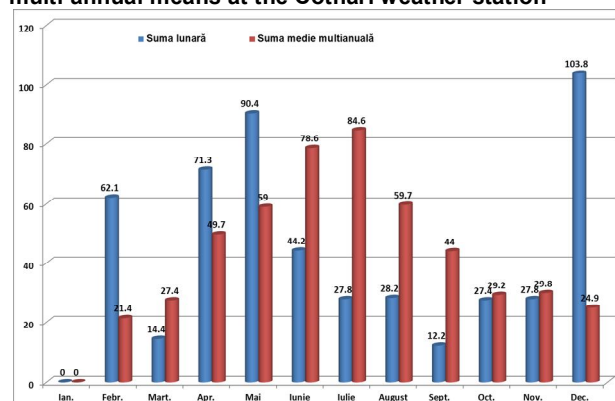


Fig. 2. Rainfall monthly and annual quantities (mm) in 2012 and multi - annual means at the Cotnari weather station

During the summer months, the presence of pronounced drought conditions has been noticed and they have been caused by the high temperatures recorded in June – temperatures higher with 3.2°C than the multiannual mean, but also by the hydric deficit of July, of 56.6 mm. In August and September the growth and the maturation of berries has been affected, the high temperatures making the fruits ripe faster while the hydric deficit reduced cellular elongation and influenced the berries' volume.

The effect of climatic conditions on some production indicators

In 2012, the qualitative and quantitative parameters of production have been estimated using the production resulted (t/ha) and the sugar content (g/l). In the Cotnari vineyard, the highest

production is recorded by Frâncușă variety (15t/ha), the resulting value being higher than the 10-14 t/ha mentioned in the specialized literature, with the lowest sugar content (193 g/l) obtained at the cultivars in this area, but corresponding to the characteristics of the variety analyzed (fig. 3). Average productions have been recorded at Fetească albă variety (9.2 t/ha) and Tămăioasă românească variety (9.8 t/ha), with high sugar content, superior to the values mentioned in the literature dealing with this subject (fig. 4).

The smallest production was recorded at Grasă de Cotnari variety (8 t/ha), the value being nonetheless, superior to those mentioned in the specialized literature (5-6 t/ha). At the same time, we must point out that this variety has accumulated the maximum sugar content (268 g/l), a lot higher than the one mentioned by the specialized literature.

We can conclude that the evolution of climatic conditions in 2012, characterized by pedological and atmospheric drought have had a positive influence on the quantitative parameters of production at most varieties included in the study, the data obtained corresponding or being superior to the values mentioned in the specialized literature, while the sugar content has been higher, in most cases significantly higher than the values foreseen in the specialized literature, some of them reaching the limit of over maturation.

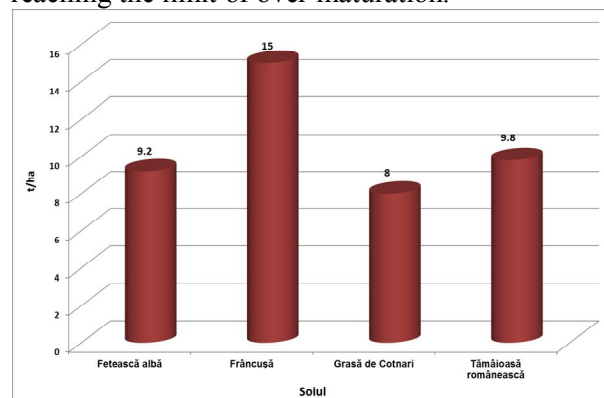


Fig. 3 Cotnari vineyard grape production (t / ha)

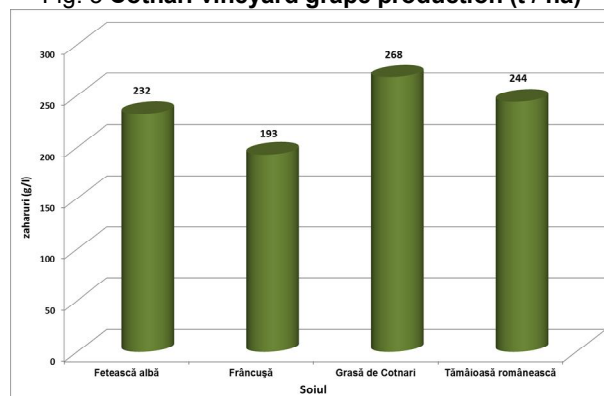


Fig. 4 Sugar content (%) of grapes in the Cotnari vineyard

Determining the content of photosynthetic pigments from the leaves of the analyzed grapevine varieties

The eco-physiological reaction of the experimented grapevine varieties in relation to the climatic conditions induced by global warming in Cotnari vineyard was estimated based on the dynamic of the content of foliar pigments, seen as indicators of the photosynthesis process and the plant's resistance to stress conditions. During the vegetation period, the process of photosynthesis intensifies until ripening when the maximum level is recorded, after which it decreases gradually, towards the end of the vegetation period. Photosynthesis intensifies along with the increase of the vine's foliar surface, while its decrease towards autumn is due to leaves ageing and the decrease of nitrogen content. At the fertile shoots, the photosynthetic activity is a lot more intense than at the sterile ones, this being due to the presence of fitohormones (Irimia L., 2012).

The dynamic analysis of photosynthetic and flavonoid pigments content based on the light absorption capacity in characteristic wave lengths demonstrates that the chlorophyll a 662-663 nm content, the component of the reaction center from photosynthetic systems, points out maximum values during the growth phenophase of the berries and minimum at flowering and maturation (fig. 5).

At Tămâioasă românească and Fetească albă chlorophyll a 662-663 nm acted as an uniapical curve, while at Grasă de Cotnari acted as a biapical curve, with maximum values in the grape flowering and maturation phenophases and minimum during the growth of berries.

The highest values of chlorophyll a 662-663 nm content during the flowering phenophase were recorded at Tămâioasă românească variety (1.45 nm) and the lowest at Fetească albă (1.13 nm). During the growth phenophase of berries, the chlorophyll a 662-663 content increases at Fetească albă, Tămâioasă românească and Frâncușă varieties, with values ranging between 1.34 nm and 1.84 nm, while at Grasă de Cotnari variety, the content analyzed presented a regress (0.98 nm).

At various grapevine varieties, plants react to the severe hydric deficit by reducing the stomatal conductance, under the control of ABA; the hydric deficit probably determines the decrease of ATP production and the activity of ATP enzyme in chloroplasts (Boseli M et al., 1998). This behavior demonstrates that this variety reacts to the dehydration determined by the hydric deficit by reducing the intensity of photosynthesis and by intensifying the absorption and dissipation capacity of the solar radiant energy capable of ensuring photo protection to the photosynthetic

apparatus in case of dehydration conditions. During the maturation phenophase of the fruits, lower values are recorded at the Fetească albă and Tămâioasă românească varieties, while Grasă de Cotnari presents a linear evolution compared to the growth phenophase of the berries. The chlorophyll a 431-432 nm content, the main component of the light absorption system from photosynthetic systems, generally presents the same behavior, with uniapical curves at Fetească albă and Tămâioasă românească, biapical at Grasă de Cotnari and ascendant at Frâncușă variety (fig. 6).

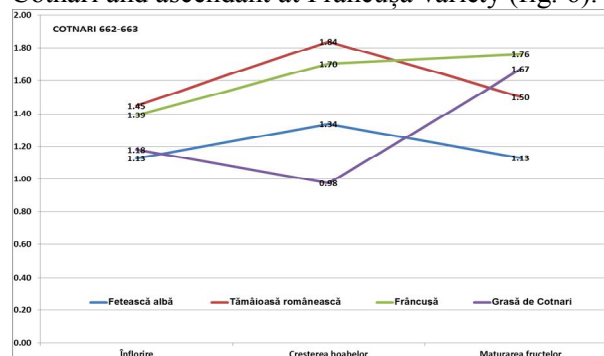


Fig. 5 Dynamics of a 662-663 nm chlorophyll content in the leaves of vine varieties at the Cotnari vineyard

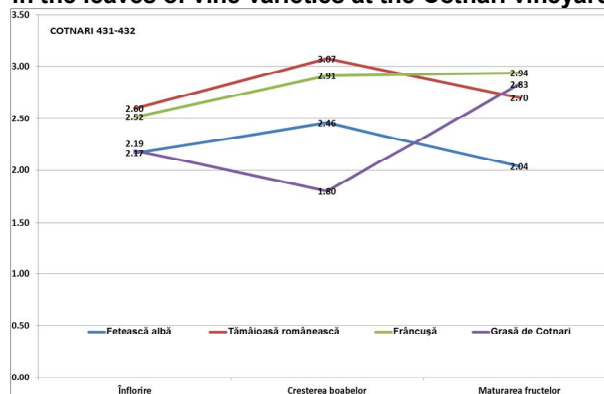


Fig. 6. Dynamics of a 431-432 nm chlorophyll content in the leaves of vine varieties at the Cotnari vineyard

From the data analyzed results that Grasă de Cotnari and Frâncușă have maximum values of chlorophyll a content during the fruit maturation phenophase both in the absorption and the reaction center. Tămâioasă românească and Fetească albă varieties have accumulated maximum chlorophyll a quantities during the growth phase of the berries, physiologically normal behavior, leading to productions corresponding to the normal limits mentioned in the specialized literature, but with the sugar content above the accumulation average of those exact varieties. During the grape maturation phenophase the negative effects of the severe drought from 2012 are extremely obvious at Fetească albă and Tămâioasă românească, while the positive effects are particularly obvious at Grasă de Cotnari and Frâncușă varieties, having the possibility to correlate them with the maximum quantitative and qualitative productions of these varieties. The plants' resistance to drought is

ensured by the content of flavonoid pigments, with maximum values during the growth of the fruits. During fruit maturation, photosynthesis takes place at more intense levels at Cotnari vineyard, based on the maximum reaction and light absorption capacity in photosynthetic systems, accompanied by good resistance to stress factors which is also responsible this year for the higher sugar content values in the fruits in the situation in which the quantitative values of production are similar to the average values of the area analyzed. The content of flavonoid pigments estimated in relation to the light absorption capacity in the 320 nm wave length presented low values, demonstrating the impact of severe drought conditions on the plants resistance capacity in situations of climatic stress.

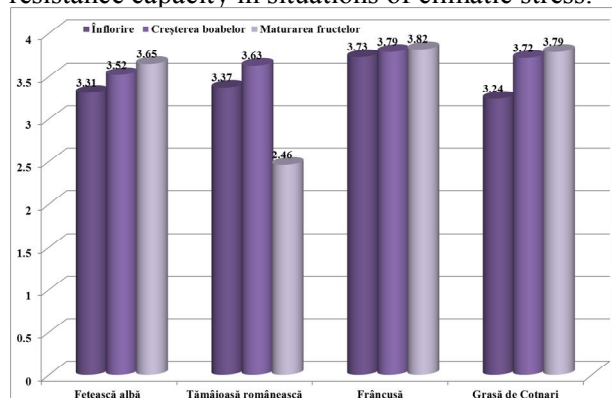


Fig. 7 Dynamics of flavonoid pigment content in the leaves of vine varieties at the Cotnari vineyard

From the data presented in figure 7 it can be noticed that Fetească albă, Frâncușă and Grasă de Cotnari recorded increasing values of flavonoid pigments, with minimum values during the flowering period and maximum values during fruit maturation, as a reaction of these varieties to the pedological and atmospheric drought of 2012.

While in the flowering phenophase, due to the humidity accumulated in the previous months at the level of the soil, the amount of flavonoid pigments was the lowest of those recorded, during the phenophases of fruit growth and maturation, the amount of flavonoid pigments increased along with the humidity deficit in the soil, as a plants' reaction to hydric and thermic stress.

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CONCLUSIONS

1. The analysis of the evolution of climatic conditions in 2012 points out the presence of intense drought conditions during the summer months, caused in June by the high temperatures which surpassed the multiannual mean by +3.2°C and also by the hydric deficit of -56.6mm in July,

which have negatively influenced the development of physiological processes.

2. The lower hydric deficit from August and September had a positive effect on the quantitative production parameters at most of the analyzed varieties, the data obtained corresponding or even being higher than the values mentioned in the specialized literature, while the sugar content was superior, in most cases much higher than the values indicated in the specialized literature.

3. The chlorophyll a 662-663 nm content, the component of the reaction center from the photosynthetic systems, points out maximum values during the growth phenophase of the berries and minimum during the flowering phenophase and the maturation of the berries.

4. The content of chlorophyll a 431-432 nm, the main component of the light absorption system from the photosynthetic systems recorded generally the same behavior, with unipical curves at Fetească albă and Tămâioasă românească, biapical at Grasă de Cotnari and ascendant at Frâncușă variety.

5. The plants' resistance to drought is provided by the content of flavonoid pigments, with maximum values at Cotnari vineyard during the fruit growth. During the maturation of the fruits, photosynthesis is a lot more intense at Cotnari vineyard, based on a maximum reaction and light absorption capacity in photosynthetic systems, accompanied by better resistance to stress factors which is responsible for the higher values of the sugar content in the fruits in the situation in which the quantitative values of the production are similar to the average of the area.

REFERENCES

- Boseli M., Di Vaio C., Pica B., 1998 - *The effect of soil moisture and transpiration on mineral content in leaves and berries of Cabernet Sauvignon grapevine*, J. Plant Nutr., 21(6), 1163-1178.
- Dragomir A., 2007 - *Climate change directly affects agriculture*, ABC Agricol, <http://www.smartfinancial.ro>.
- Irimia L. M., 2012 - *Biology, ecology and physiology of the vine*, Editura "Ion Ionescu de la Brad", Iasi.
- Jitäreanu Carmenica Doina et al., 2011 - *Studies about the dynamics of some physiological processes during the grape vine shoot growth*. Journal of Food, Agriculture & Environment Vol.9 (3&4); JFAE; 793 – 798.
- Jitäreanu Carmenica Doina, Slabu Cristina, Marta Alina Elena Simion Cristina, 2012 - *Dynamics of the content of foliar pigments in some grapevine varieties cultivated in Iași, Cotnari and Bujoru vineyards in the vegetation period of 2011*, Lucrări științifice, Seria Agronomie vol. 55, Iași, ISSN 1454-7376
- Mihăilă D., 2002 - *Moldavian Plain - climate survey*, doctoral thesis, Univ. „Al. I. Cuza”, Iași.
- Steele M., Gitelson, A., Rundquist, D., 2008 - *Nondestructive estimation of leaf chlorophyll content in grapes*. American Journal of Enology and Viticulture, 59. 3, 299/305.