

The valorization of viticultural resources taking into account the need to adapt to climate change

E. Alexandrov

The Institute of Genetics, Physiology and Plant Protection of the USM,
Republic of Moldova

*Corresponding author e-mail: alexandrov.eugeniu@gmail.com

ABSTRACT

Anthropogenic activity significantly disrupts the composition and quantity of greenhouse gases in the environment. The increase in the concentration of greenhouse gases in the atmosphere, as a result of industrial activity, contributes to the strengthening of the greenhouse effect, and finally, the additional warming of the atmosphere takes place. The amount of greenhouse gases in the atmosphere is determined by the difference between greenhouse gas emissions and sequestrations. Photosynthesis, respiration, transpiration, stomatal conductance, assimilation, etc. can be used in the plant breeding process, with the aim of identifying plant genotypes with an increased potential for capturing CO₂ from the atmosphere. In carrying out the study, grapevine genotypes of intraspecific origin *Vitis vinifera* L. and genotypes of interspecific origin (*Vitis vinifera* L. x *Muscadinia rotundifolia* Michx.) were used. Measurements were made during the period up to flowering, berry formation (growth) and mature berry (formed) period. Phytomonitoring was carried out by using the PTM-48A monitor, which is an automatic CO₂ exchange monitoring system. It was found that the interspecific grapevine genotypes have a much higher performance than the intraspecific genotypes in relation to the change of climatic factors. The respective methodology can be applied in the breeding process of other plant crops.

Keywords: genotype, rhizogen, grapevine, climatic changes, climatic factors

INTRODUCTION

Climatic changes require specific premises to review the techniques and methods of cultivating plants: horticultural, cereal, leguminous, medicinal, etc. The expenses for the production of planting material and the establishment of plantations, the procurement and use of chemical, necessary to combat diseases and pests, the agrotechnical works, etc. the end it influences the productivity and quality of the derived products, as well as the final marketing cost. Based on the above, it is necessary to create and select genotypes and vine cultivation technology, with the minimal application and/or exclusion of protective chemical products, which contribute to the maintenance of biological diversity, as well as the presence of these compounds in minimal quantities in grapes and in wine-derived products. The adaptation potential of plants to the environment represents a response to climatic factors, at the same time demonstrating a certain quantitative and qualitative capacity of productivity and derived products. The creation of grapevine genotypes with superior properties of productivity, quality, to biotic and abiotic factors, will significantly influence the health of the population and contribute to a sustainable development of society (HGRM No. 1009 / 10.12.2014.; HGRM No. 301 / 24.04.2014).

MATERIALS AND METHODS

Grapevine genotypes of intraspecific origin from the *Vitis vinifera* L. group were used as material for the study, such as: 'Muscat of Alexandria', 'Corna Neagră', 'Sauvignon', 'Cabernet-Sauvignon', etc. Genotypes of interspecific origin (*Vitis vinifera* L. x *Muscadinia rotundifolia* Michx.), such as: 'Amethyst', 'Alexandrina', 'Augustina', 'Nistreana', 'Malena', 'Sarmis', etc. (Alexandrov *et. al.*, 2020; Catalog, 2021). The measurements were made in the period up to flowering, the formation (growth) of berries and in the period of mature berries (formed) (Dobrei et al., 2021). Phytomonitoring was carried out by using the PTM-48A monitor, which is an automatic CO₂ exchange monitoring system. The system is equipped with four leaf-mounted cameras that operate sequentially. The working mechanism of this system consists in the analysis of the gas exchange based on the CO₂ concentration at the exit of the measuring chamber of the leaf in relation in the environment at the time of measurement.



Figure 1. Phytomonitor PTM-48A.

RESULTS AND DISCUSSIONS

Grapevine is a perennial crop that can be grown on soils which are impractical for other agricultural crops. The productivity of agricultural crops depends on climatic conditions, cultivar, and the technology applied in plant management and maintenance, fruit preservation and processing. The change in climate factors is ongoing and taking place significantly in a very short period of time, and the adaptation of living organisms to these changes requires a much longer period of time. So, as a result of the rapid change in climatic factors, we find that many species of plants and animals will not be able to adapt to the respective changes in the environment, and with time one species will disappear (Alexandrov E., 2023).

As a result of the study carried out, it was found that the amount of greenhouse gases (GHG) globally has reached the critical level. From the total volume of GHGs released into the atmosphere, it was found that CO₂ represent the largest amount, about 80%, and it is usually produced as a result of anthropogenic activities. Other GHGs are released in smaller quantities, but have a much higher heat-trapping capacity than CO₂. For example: methane is 80 times stronger than CO₂ over a 20 year period.

The trend of the average values for the air temperature on the territory of the Republic of Moldova in the last period was found to be. The average temperature average temperature of the air for the June - August 2023 period, where the studies were conducted, was found to be increasing (fig. 2). The amount of precipitation for the June - August period of 2023 was decreasing, and compared to the norm, a non-uniformity is observed (fig. 3.).

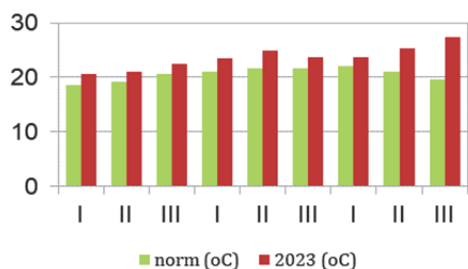


Figure 2. Average temperature per decade of air, (°C), June – August, 2023

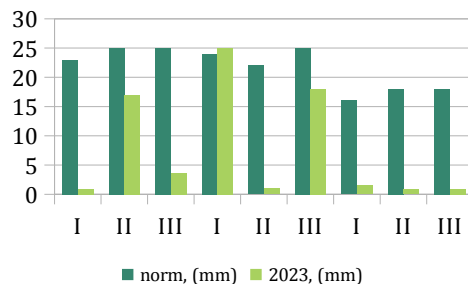


Figure 3. The amount of precipitation per decade (mm) for the period June - August, 2023

By analyzing the average monthly temperature indices for the January - September period of the years 2022 and 2023, and comparing with the normal temperatures, we come to the conclusion that these indices are increasing (fig. 4.). By analysing the amount of monthly atmospheric precipitation for the period January - September, of the years 2022 and 2023, and comparing it with the amount of normal precipitation, we find that it is decreasing and the phenomenon of non-uniformity is highlighted (fig. 5.).

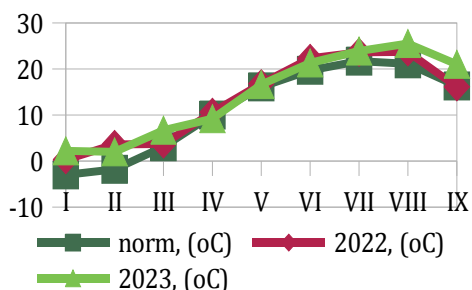


Figure 4. Amount of monthly precipitation (mm), (January-September 2022; 2023)

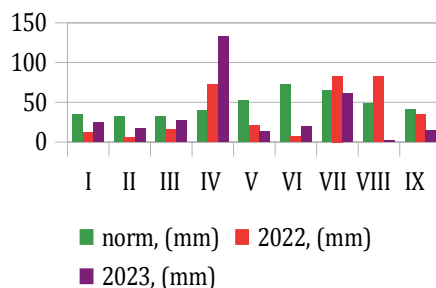


Figure 5. Average monthly temperature (°C), (January – September 2022; 2023)

Taking into account the fact that the average temperature, for the period January - September is 11.46 °C, and for the same period, in 2022 were recorded - 13.41 °C, respectively 14.26°C in 2023. Compared to the norm, we observe an increase of temperature with 2.8 °C, (fig.6.).

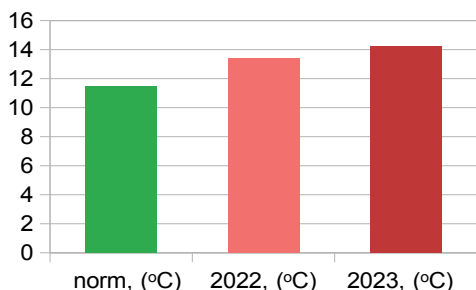


Figure 6. Average temperature (°C) for the period January - September, 2022; 2023

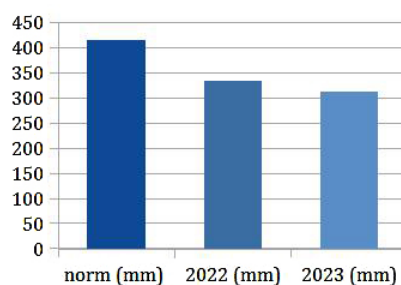


Figure 7. The amount of atmospheric precipitation (mm), for the period January - September, 2022; 2023

The amount of atmospheric precipitation for the period January - September, the norm, is 415 mm, for the same period of the year 2022, there were recorded 334 mm, and for the

year 2023 - 313 mm. Consequently, we find a deficit of 102 mm, so about 24.58% of the norm (fig. 7.). The amount of annual precipitation is uneven. In the future, this unevenness will be more pronounced. Calculating the total amount of annual precipitation, we come to the conclusion that in some cases we have the necessary annual rate of precipitation. If we distribute this amount of precipitation over weeks or months, we find that over a long period of time (3-6 months) no precipitation is reported, but in a very short time an abundant amount of precipitation can fall, far exceeding the norm for that period. Based on the situation that the atmospheric precipitation has an uneven character and with time it will intensify even more, actions are required to reduce the process of water evaporation and its preservation in the soil. Various techniques and methods are known for keeping water in the soil, one of them is mulching the soil with organic and inorganic materials. Stabilization of the climate change process could reduce the probability of the occurrence of extreme weather phenomena, but in this case urgent actions are required in all areas of society at the global level.

There are two real solutions for rectifying the situation:

- increasing the consumption of CO₂ from the atmosphere as a result of the activity of photosynthesis, thus contributing to the increase of forested areas;
- decrease of industrial emissions of CO₂ into the atmosphere by implementing eco-efficient technologies, protecting the environment and sustainable use of natural resources.
- The maintenance of life on Earth is ensured by the process of photosynthesis, and the effectiveness of this process depends on the degree of use of solar energy and the ability to capture carbon dioxide from the atmosphere. So, the green screen of land and oceans: tropical and continental deciduous forests, coniferous forests, grasslands, steppes, semi-deserts, marine and freshwater plankton, the benthos of the World Ocean, fields with field crops and perennial plantations (orchards, vineyards, etc.) – represents a gigantic environment for absorbing solar energy, thus summing up, a reactor of the photosynthesis process. Climate change does not depend on emissions from a particular year or the lifetime of a plantation, but on the CO₂ concentration from the atmosphere, which accumulates/deposits over a much longer period. The CO₂ molecules, unlike other substances, for example, methane, do not enter into chemical reactions with other substances in the atmosphere and are removed from it only when are absorbed by the planetary ocean or terrestrial ecosystems. The adaptability of organisms is a key issue in the process of evolution. The adaptation of plants to climatic factors is nothing more than the modification of the physiological-biochemical and morphological-anatomical characters of the organism in the process of ontogenesis and the creation of other new criteria in the phylogenetic process. The adaptation potential of plants represents their ability to survive, multiply and self-develop in the continuous change of climatic factors. An essential feature of the adaptation potential is the self-regulation capacity, i.e. maintaining a dynamic balance of the system: substance – energy – information. Plants ensure the exchange of substances with the environment; absorb, transform and use solar energy; perceive, process, store and transmit information about climate factors. Controlling the efficiency of the photosynthesis process of the green layer of the Earth, it would be possible by capturing CO₂ from the atmosphere and keeping the global average temperature within the limits, which would not lead to the intensification of the greenhouse effect process and the change of climatic factors.

In this case, it is necessary to apply the techniques and methods of plant breeding in the creation and selection of plant genotypes both for the expansion of forested lands, the stopping of desertification processes, the creation of protective forest strips, the valorization of agricultural lands, etc., which will demonstrate a performance of the process of photosynthesis in the new climatic conditions. Establishing the dependence of photosynthesis on solar radiation allows the evaluation of the effectiveness of the use of light energy by the plant organism. This principle being established in the genetic code,

represented by the mechanism of the use of light energy and the transformation of inorganic biogenic compounds into organic substances. The light saturation curve for photosynthesis allows the perception of the ecophysiological characters of a species, and in turn these indices give us the opportunity to compare different plant genotypes in more or less similar conditions, thus determining the productivity capacity and resistance to environmental factors.

In the pre-flowering stage, in the genotypes (fig. 7. - 8.):

- intraspecific ('Sauvignon', 'Muscat de Alexandria', etc.) it was found that:
 - at a light intensity of 1000-1500 micromol/m²*s, the photosynthetic activity in the environment is 7-9 micromol (CO₂)/m²*s, and from a sunlight intensity of 1500 micromol/m²*s, the intensity of photosynthesis activity is decreasing.
 - at a temperature of 15 °C, the intensity of transpiration is 4.5-6.0 mg/m²*s, and at a temperature of 30 °C the intensity of transpiration is - 25-30 mg/m²*s.
- interspecific ('Amethyst', 'Augustina', 'Alexandrina', 'Regent', 'Viorica', etc.):
 - at a light intensity of 1000-1500 micromol/m²*s, the photosynthetic intensity in the environment is 10-12 micromol (CO₂)/m²*s, these indices of photosynthesis are also maintained at a sunlight intensity of 2000-2500 micromol/m²*s.
 - at a temperature of 15 °C – transpiration - 3.75-5.25 mg/m²*s, and at - 30 °C, transpiration - 23-26.5 mg/m²*s.

In the fruit development stage, the genotypes:

- intraspecific ('Sauvignon', 'Muscat de Alexandria', etc.):
 - at a light intensity of 1000-1500 micromol/m²*s, demonstrates a photosynthesis activity of 8-10 micromol (CO₂)/m²*s, these indices are also maintained at a light intensity of 2000 micromol/m²*s, then the intensity of photosynthesis decreases.
 - at temperatures of 20 °C, perspiration - 4-5 mg/m²*s, and at - 35 °C – perspiration - 50-55 mg/m²*s.
- interspecific ('Amethyst', 'Augustina', 'Alexandrina', 'Regent', 'Viorica', etc.):
 - at a light intensity of 1000-1500 micromol/m²*s, demonstrates a photosynthesis activity of 8-11 micromol (CO₂)/m²*s, these indices are also maintained at a light intensity of 2000 micromol/m²*s, and at a light intensity of 2500 micromol/m²*s a decrease is observed.
 - at a temperature of 20 °C, transpiration - 5.75-7.75 mg/m²*s, and at - 35 °C, transpiration - 42.5-45 mg/m²*s.

In the fruit maturation stage, the genotypes:

- intraspecific ('Sauvignon', 'Muscat de Alexandria', etc.):
 - at a light intensity of 1000-1500 micromol/m²*s, demonstrates an activity of photosynthesis in the environment of 3-6 micromol (CO₂)/m²*s, these indices are maintained up to a light intensity of 1700 micromol/m²*s, then the trend is down.
 - at a temperature of 20°C, transpiration - 8-10 mg/m²*s, and at - 30°C, transpiration - 38-45 mg/m²*s.
- interspecific ('Amethyst', 'Augustina', 'Alexandrina', 'Regent', 'Viorica', etc.):
 - at a light intensity of 1000-1500 micromol/m²*s, demonstrates an average photosynthetic activity of 8-9 micromol (CO₂)/m²*s, these indices of photosynthesis are maintained up to a light intensity of 2000 micromol (CO₂)/m²*s, and at a stronger light intensity the photosynthetic activity shows a slight decrease.
 - at an air temperature of 20 °C, transpiration - 7.75-9.75 mg/m²*s, and at - 35 °C, transpiration - 35-40 mg/m²*s.

It was found that the interspecific grapevine genotypes have a much higher performance than the intraspecific genotypes in relation to the change of climatic factors. Taking into account the effectiveness of physiological processes, such as: photosynthesis, respiration, transpiration, stomatal conductivity, assimilation, etc. in the process of plant breeding, it is possible to identify plant genotypes with an increased potential for capturing carbon dioxide from the atmosphere, thus contributing to maintaining the global average temperature within the limits, which would not lead to the intensification of the greenhouse effect and the change of climatic factors. The respective methodology can also be applied in the improvement process of different plant crops.

CONCLUSIONS

Physiological processes, such as: photosynthesis, respiration, transpiration, stomatal conductivity, assimilation, etc. can be used as indicators in plant breeding, which allow the identification of plant genotypes with an increased potential for capturing carbon dioxide from the atmosphere, thus contributing to the reduction of CO₂ concentration in the environment. The respective methodology can also be applied in the improvement process of different plant crops.

In this case, it is necessary to apply the techniques and methods of plant breeding to create plant genotypes both for the expansion of forested lands, stopping desertification processes, the creation of protective forest strips, the sustainable utilization of agricultural lands and those not practiced for agriculture, etc., which they will demonstrate a performance of the photosynthesis process in the new climatic conditions.

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